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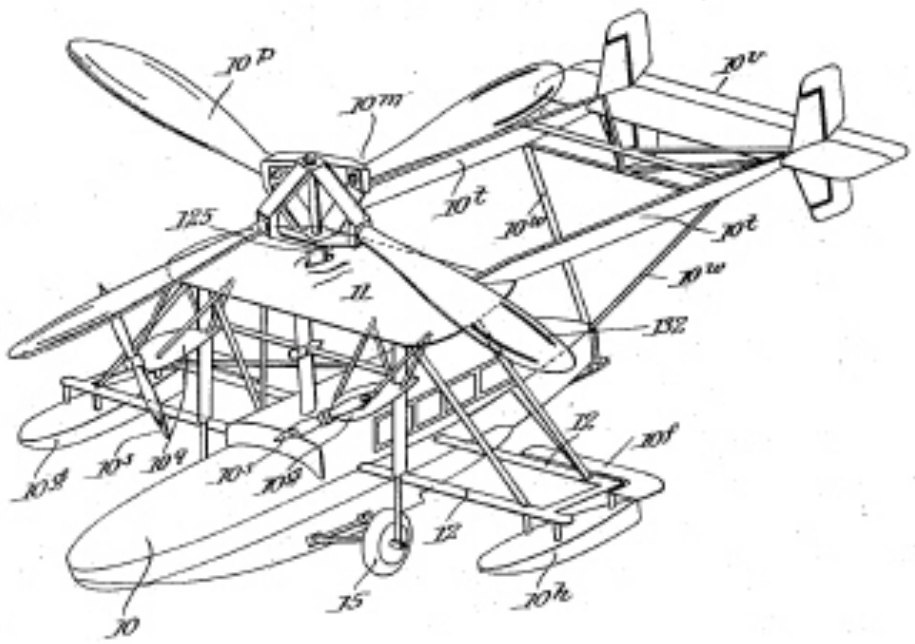

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Feb. 15, 1966 J. W. RYAN 3,234,689

DOLL CONSTRUCTION FOR NATURAL MOVEMENTS AND POSITIONS

Filed June 8, 1962 3 Sheets-Sheet 1

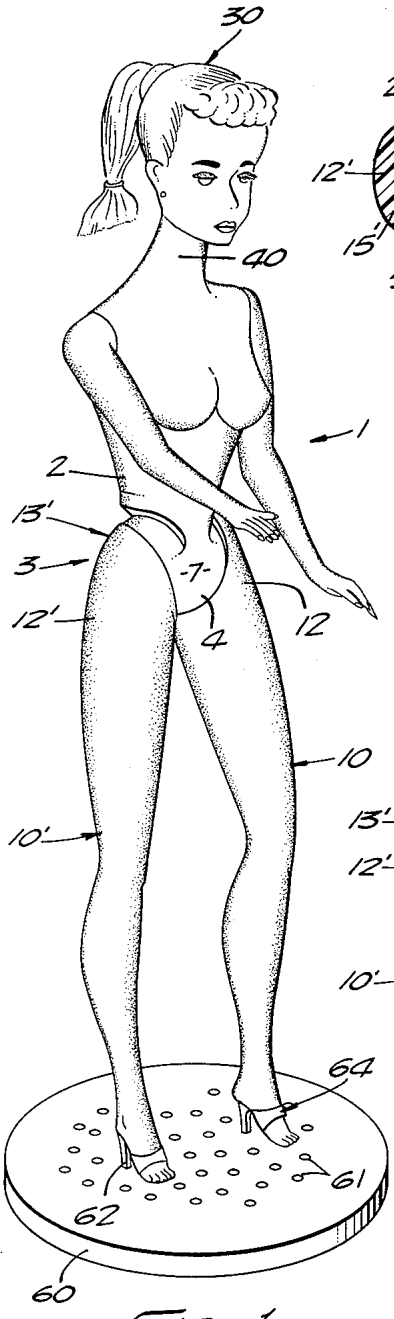
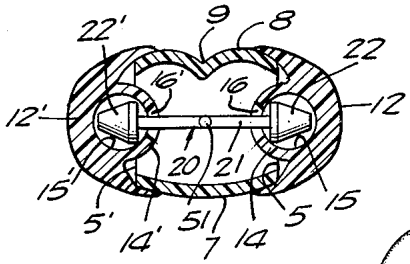


FIG. 1.

FIG. 8.



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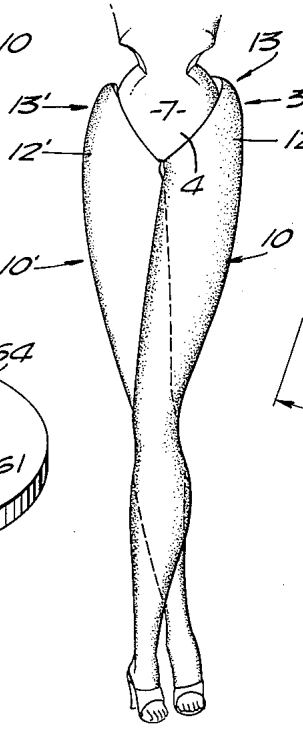

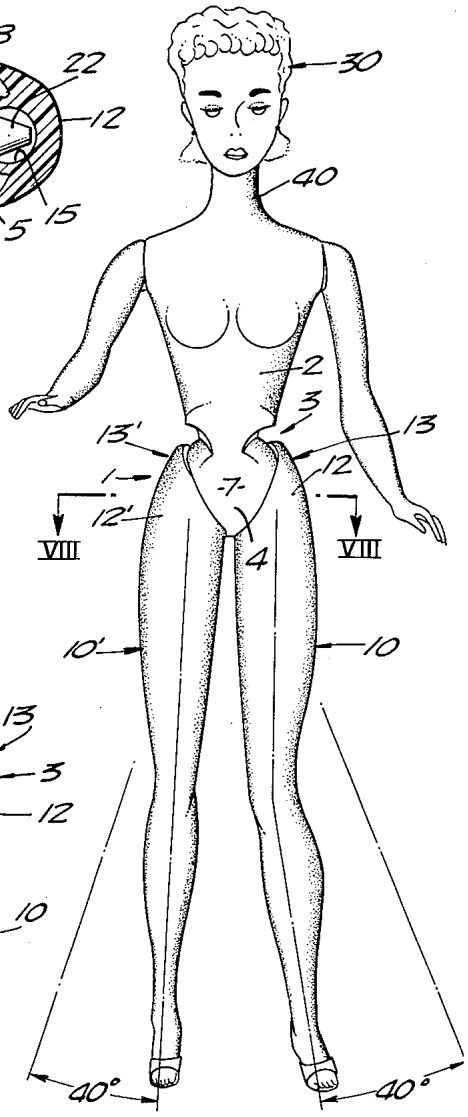

FIG. 2.

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Feb. 15, 1966 J. W. RYAN 3,234,689

DOLL CONSTRUCTION FOR NATURAL MOVEMENTS AND POSITIONS

Filed June 8, 1962 3 Sheets-Sheet 2

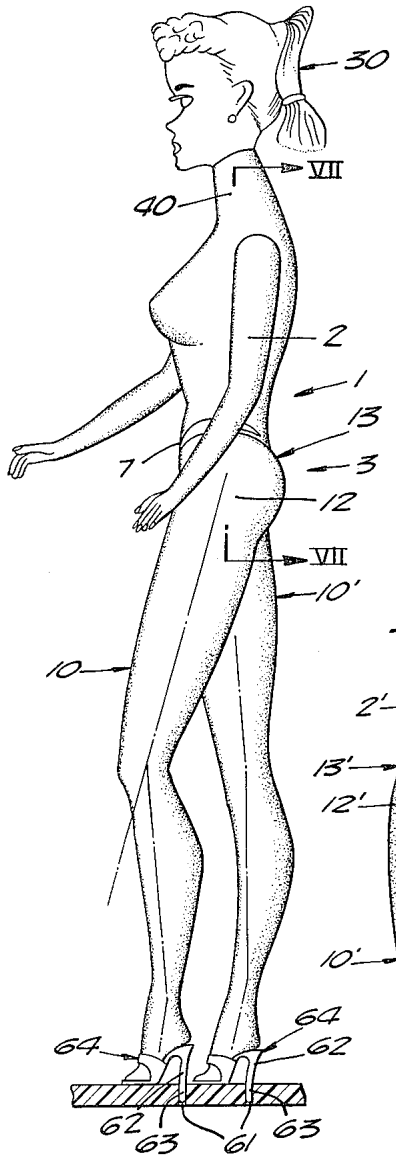

FIG. 3.

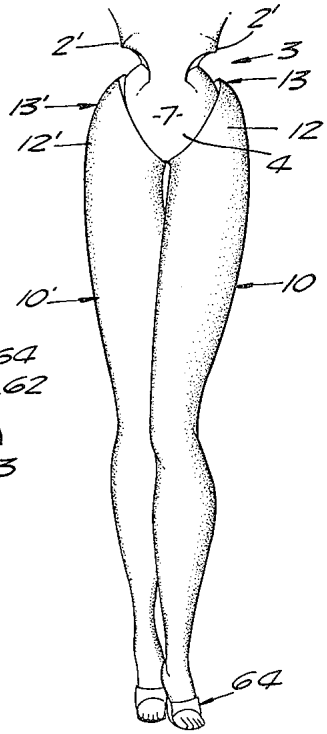

FIG. 6.

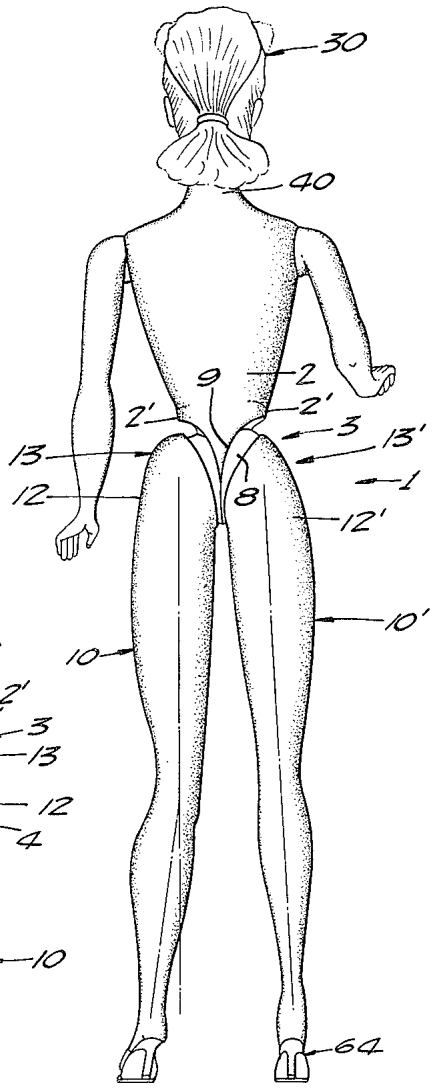

FIG. 4.

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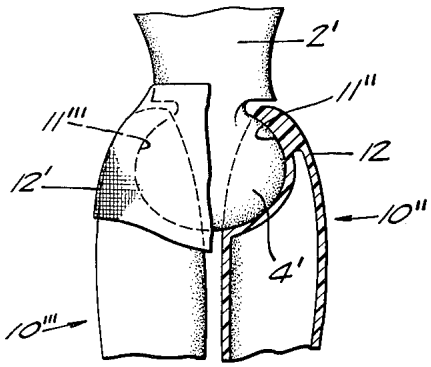
Feb. 15, 1966 J. W. RYAN 3,234,689

DOLL CONSTRUCTION FOR NATURAL MOVEMENTS AND POSITIONS

Filed June 8, 1962 3 Sheets-Sheet 3

FIG. 10.



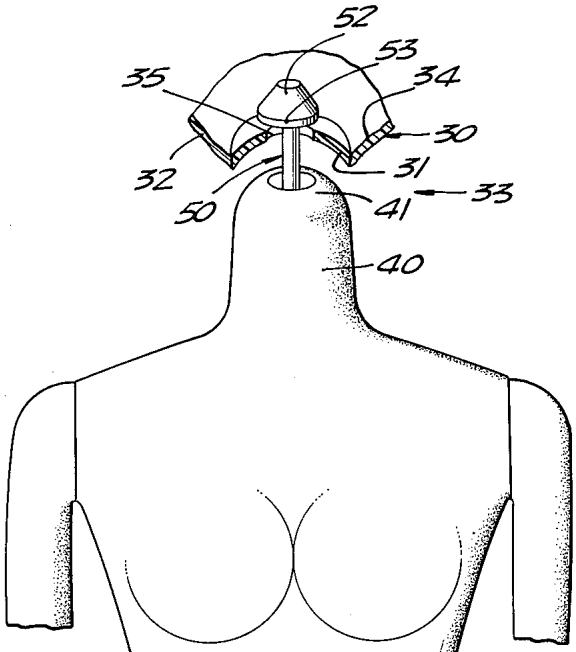
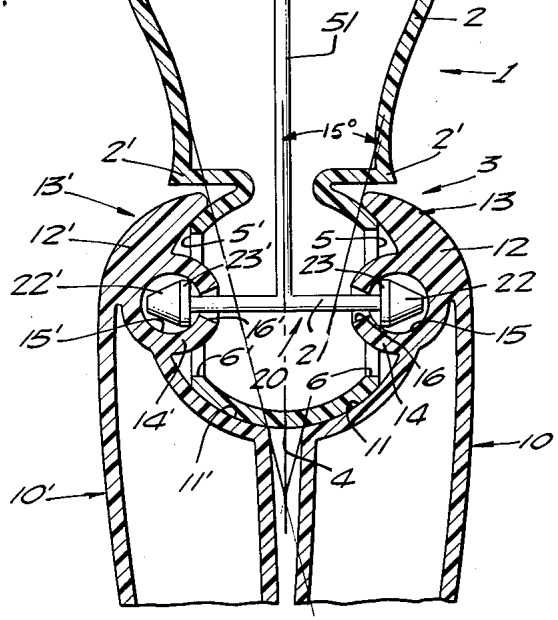


FIG. 7.



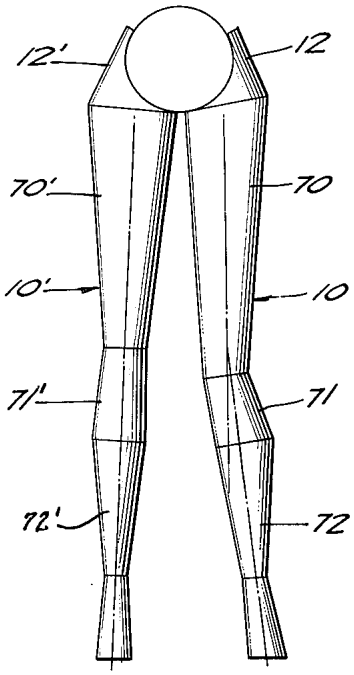


FIG. 9.

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United States Patent Office

3,234,689

Patented Feb. 15, 1966

3,234,689

DOLL CONSTRUCTION FOR NATURAL MOVEMENTS AND POSITIONS

John W. Ryan, Bel Air, Calif., assignor to Mattel, Inc., Hawthorne, Calif., a corporation of California

Filed June 8, 1962, Ser. No. 201,059
14 Claims. (Cl. 46—161)

The present invention refers to a novel doll construction adapted to attain numerous natural movements and positions. More particularly, the present invention relates to doll construction which is adapted to permit the doll trunk appandages, i.e. the doll's arms, legs, and head, to reproduce closely the movement and positions of the human body. The term "trunk" is used to designate herein the central portion or torso of the body.

As is generally known, the construction of dolls for children's toys is a well developed art with many varieties of dolls, both male and female, having been produced. One of the main problems involved in production of dolls has been the achievement of a realistic reproduction of humans, particularly the movements and positions of the human appendages. It has been found particularly difficult to reproduce the various movements and positions of human appendages simply and inexpnesively, since such appendages are normally free to move in many different directions and to obtain a wide range of positions. For example, the human leg may rotate parallel to a plane bisecting the human trunk up to an angle of at least about 40 degrees to said bisecting plane and about its longitudinal axis.

A common solution to the problem of simulating the movement of the human appendages, such as legs, is to rotate the leg about an axis perpendicular to a plane bisecting the human trunk and passing through the lower portion of the trunk. However, such a solution permits the rotation of the leg only in a plane parallel to the side of the body. Many other forms of joints have been utilized, but they normally have only a similarly limited degree of movement and consequently make such movement look very unnatural. Also, many of the prior art doll joints, in order to obtain even such limited freedom of movement required joint elements having sharp edges and other irregularities. Consequently, many of these joints bore little resemblance to the smooth contour of the corresponding joints of the human body. In addition, such prior art in all joints could maintain the positions of the human appendages over only a much more limited range of positions than the range of movement of the appendages. For example, prior art doll legs could be rotated sideways to a large angle but required external force to maintain such positions. Also, prior art dolls a straight-out position. Such leg positions combined normally utilized symmetrical pairs of legs rigidly set in with the limited movement of the hip joint made the doll assume very stiff and unnatural poses.

Consequently, an object of the present invention is a doll construction which is adapted to permit the doll appendages to reproduce closely the natural movements and positions of the human body appendages.

Another object of the present invention is a doll joint having a smooth contour closely resembling the corresponding portion of the human body over a wide range of positions of the appendage.

Still another object of the present invention is a doll construction which is simple and inexpensive to manufacture and yet result in a rugged, long-lasting construction.

Still another object of the present invention is a doll with legs adapted to permit the doll to assume numerous natural positions.

Other objects and advantages of the present invention will be readily apparent from the following description and drawings which illustrate exemplary embodiments of the present invention.

In general, the present invention involves a doll construction adapted to permit the doll appendages, particularly its legs, to reproduce closely the movements and positions of the human body appendages. The doll of the present invention involves an appendage attached to the doll trunk having a curved recess therein extending over substantially the whole inner surface of the portion of the appendage adjacent to the doll trunk. Such recess has substantially the same radius of curvature as has the trunk portion to which it is attached. The outer surface of said portion of the appendage preferably has substantially the same radius of curvature adjacent to the adjoining trunk portion as said trunk portion. The doll's trunk has a portion adjacent said appendage having a boss with a curved surface matingly received in said appendage recess and the recesses cover about 20% to 40% of the total surface area of said boss. The trunk portion is adapted to form with the appendage portion a joint having a substantially smooth contour closely resembling the corresponding region of the human body over a wide range of appendage positions and having substantially uniform frictional forces maintaining the appendage position over the entire range of appendage positions. The present invention also includes fastening means for maintaining said trunk boss and appendage recess in mating frictional relationship. The joint and fastening means are adapted to permit the appendage to independently rotate parallel to a plane bisecting the doll trunk, angularly to said bisecting plane up to an angle of at least about 40 degrees and about the longitudinal axis of said appendage. Also, the doll arms may be constructed and fastened to the doll the same way as the legs and head.

In order to facilitate an understanding of the doll construction of the present invention, reference will now be made to the appended drawings of specific embodiments of the present invention. Such drawings should not be construed as limiting the invention which is properly set forth in the appended claims.

In the drawings, FIG.1 is a perspective view of the preferred embodiment of the present invention.

FIG. 2 is a front view of the doll shown in FIG. 1.

FIG. 3 is a side view of the doll shown in FIG. 1.

FIG. 4 is a rear view of the doll shown in FIG. 1.

FIG. 5 is a variation of the front view shown in FIG. 2 wherein the legs are shown crossed.

FIG. 6 is another variation of the front view shown in FIG. 2 wherein the legs are shown with the feet placed on a substantially straight line.

FIG. 7 is an enlarged cross-sectional view of the hip portion of FIG. 3 taken along the lines VII—VII of FIG. 3.

FIG. 8 is a cross-sectional view of FIG. 2 taken along the lines VIII—VIII of FIG. 2.

FIG. 9 is a geometrical representation of the hip and leg portions of the preferred embodiment of the present invention.

FIG. 10 is a partial cross-sectional view of the hip portion of a doll showing another embodiment of the present invention.

In FIGS. 1–8, the doll **1** has legs **10** and **10'** respectively attached to its trunk **2**. Legs **10** and **10'** have substantially spherical recesses **11** and **11'** respectively therein extending over substantially the whole inner surface of the upper portions of the legs **10** and **10'** adjacent to the doll trunk **2**. The pelvic portion **3** of trunk **2** adjacent legs **10** and **10'** has a single generally spheroidal boss **4** matingly received in the leg recesses **11** and **11'** with

said recesses covering about 40% to 80% of the spheroidal surface defined by said boss **4**. The resulting edges of recesses **11** and **11'** are flexible and the edges of said recesses **11** and **11'** lie in planes at an angle in the range of about 5 degrees to 25 degrees to a fore-and-aft vertical plane bisecting the doll trunk when the axis of the doll trunk and the upper portions of the legs are oriented perpendicular to a flat surface on which the doll is standing (see FIG. 7, for example, where the angle is approximately 15°). More particularly, boss **4** has a horizontal cardioidal cross section as shown in FIG. 8 although it may also be described as generally elliptical. The pelvic portion **3** is adapted to form with the upper portions **12** and **12'** of legs **10** and **10'** joints **13** and **13'** respectively having substantially smooth contours closely resembling the corresponding hip joints of the human body over the usual range of leg positions and having substantially uniform frictional forces maintaining the leg position over the entire range of such leg positions. The recesses **11** and **11'** have substantially the same radius of curvature as the lateral portions of boss **4** and the outer surfaces of upper portions **12** and **12'** have substantially the same radius of curvature adjacent to the adjoining portions of boss **4** as said boss portions.

Recesses **11** and **11'** of legs **10** and **10'** have knobs **14** and **14'** respectively projecting inwardly from their central portions. Boss **4** has truncated portions **5** and **5'** with substantially circular holes **6** and **6'** respectively therethrough for receiving the recess knobs **14** and **14'** respectively. The holes **6** and **6'** and knobs **14** and **14'** are adapted to limit the rotation of legs **10** and **10'** angularly to a plane bisecting the doll trunk and to limit the rotation of the legs about their longitudinal axis to ranges natural to the human body. Thus the legs **10** and **10'** as shown in FIG. 2 may be rotated angularly to the plane bisecting the doll trunk to an angle of about 40 degrees. Similarly, the legs **10** and **10'** may be rotated about their longitudinal axis, either rearwardly or frontwardly, into abutting relationship.

Fastening means **20** for maintaining the pelvic boss **4** and the leg recesses **11** and **11'** in mating frictional relationship include an elastic bar **21** having frusto-conical end portions **22** and **22'** respectively with the bases of said end portions **23** and **23'** respectively being attached to the bar **21**. The end portions **22** and **22'** are received in substantially spherical cavities **15** and **15'** in the knobs **14** and **14'** respectively and the entrances **16** and **16'** of cavities **15** and **15'** respectively have frusto-conical shape slightly smaller than the conical end portions **22** and **22'**. Consequently, when the conical end portions **22** and **22'** are inserted in said cavities, they are compressed and then expanded to become engaged within the cavities. Such engagement permits rotation of the legs **10** and **10'** into numerous natural positions and forms sufficient frictional contact between the adjoining trunk and leg surfaces so that such positions are maintained without the aid of external force. The hip joints **13** and **13'** and the fastening means **20** are adapted to permit legs **10** and **10'** to independently rotate laterally of the doll trunk up to an angle of at least about 40 degrees and also about their own longitudinal axes into mutual abutting relationship.

The front section **7** of pelvic portion **3** has a radius of curvature substantially larger than the remaining portions of the pelvic boss so that the doll as a whole has only a slightly curved stomach which does not protrude beyond the front of the legs. The rear section **8** of pelvic portion **3** has a central vertical crevice **9** with rounded edges so that the crevice is adapted to receive the upper leg portions when the legs are rotated rearwardly about their longitudinal axis. The contour of front section **7** and rear section **8** forms a pelvic boss having a horizontal generally cardioidal cross-section as shown in FIG. 8.

The side waist portions **2'** of the doll trunk **2** flare outwardly and downwardly in the direction of the pelvic portions and are then undercut inwardly to permit the free rotation of legs **10** and **10'**. The undercut of the side waist portions **2'** is generally horizontal but preferably downward to fit the displacement of the upper portions of the legs **10** and **10'** when they are swung outwardly at an angle to a fore-and-aft vertical plane bisecting the doll trunk. The legs **10** and **10'** are rigid; however, preferably one of the legs, e.g. leg **10** is bent at an angle in the range of about 10 degrees to 30 degrees; for example, about 20 degrees in a plane parallel to a plane bisecting the doll trunk when the upper leg portion is maintained parallel to said bisecting plane. Preferably, the lower leg portion of said bent leg, i.e. the portion below the knee, is also bent at an angle in the range of about 1 degree to 15 degrees; for example, about 10 degrees in a plane angularly to a plane bisecting the doll body when the upper leg portion is maintained parallel to said bisecting plane. The combination of at least one bent leg and the hip joints of the present invention are adapted to permit the doll to assume numerous natural positions, such as being able to cross her legs (FIG. 5) or to assume the standard poses of fashion models, e.g. FIGS. 1–4 or placing the feet on a substantially straight line, one in front of the other (FIG. 6).

It has been found that the ratio of the length of the doll trunk to the diameter of the pelvic boss should fall within a definite range so that the doll may be able to closely reproduce the movement and positions of the human legs while retaining natural human proportions and contours. This range has been found to be about 2.4 to 4.0. Specifically, when the doll trunk is about 3–3½ inches in length, the pelvic boss should range about ⅞–1¼ inches in diameter, and preferably the diameter is about 1–1⅛ inches.

The head **30** attached to the doll trunk **2** has a spherical recess **31** in the portion **32** attached to the neck portion **40** of doll trunk **2**. The neck portion **40** of trunk **2** adjacent to the head **30** has a spherical top **41** matingly received in the head recess **31**. The neck portion **40** is adapted to form with the adjacent portion **32** of the head **30**, a joint **33** having a smooth contour closely resembling the corresponding neck joint of the human body. The neck top **41** and the head recess **31** are maintained in mating relationship by means of an elastic fastening means **50**. Fastening means **50** is adapted to permit the head **30** to rotate independently in a plane parallel to a plane bisecting the doll trunk, angularly to said bisecting plane up to an angle of at least about 40 degrees and about the longitudinal axis of the head **30**. Fastening means **50** includes an elastic bar **51** which may be attached to bar **21** or to means connecting the arms (not shown). Bar **51** has a conical end portion **52** with a base **53** attached to bar **51**. Conical end portion **52** is received in cavity **34** in the portion **32** of the head **30** matingly fitted to the adjoining neck portion **41**. The entrance **35** of the cavity **34** has a frusto-conical shape slightly smaller than the conical end portion **52** of bar **51**. Consequently, when the conical end portion **52** is inserted into cavity **34** it is compressed and then expanded to become engaged therewith while permitting the rotation of the head and maintaining of the head in any desired position.

In addition, doll **1** may stand on a platform **60** having a plurality of holes **61** therein. Conveniently the doll **1** is selectively engaged in holes **61** by means of elongations **63** of its shoe heels **62**. Alternatively, the shoes **64** may have additional downwardly directed pegs (not shown) thereon for rotatably mounting the doll **1** on platform **60**. By so mounting the doll of the present invention on a platform the various doll leg positions may be accurately arranged in any desired manner and the doll will remain standing in such position. Also many variations of each position may be obtained merely by rotating the doll trunk which causes the legs to adjust

to the trunk position while the feet remain in fixed positions. In other words, one or more pegs between the heel or sole and platform may be provided.

In FIG. 9, a geometrical representation of the legs of the preferred embodiment of the present invention is shown to illustrate their preferred proportions in relation to the hips and the result of bending the right leg. The thigh portions **70** and **70'** of legs **10** and **10'** respectively are frusto-conical in shape with their bases adjacent upper leg portions **12** and **12'** respectively. The ratio of the diameter of the base to the diameters of the apexes of the thigh portions **70** and **70'** is in the range of about 1.6 to 2.7, while the ratio of their heights to the diameters of their bases is in the range of about 2.2 to 3.3. The knee portions **71** and **71'** of legs **10** and **10'** respectively are frusto-conical in shape with their apexes at the knee adjacent the thigh portions **70** and **70'** respectively. The ratio of the diameter of the bases to the diameters of the apexes of the knee portions **71** and **71'** is in the range of about 0.8 to 1.9, while the ratio of their heights to the diameters of their bases is in the range of about 1.2 to 2.3.

Finally, the calf portions **72** and **72'** of legs **10** and **10'** respectively are frusto-conical in shape with their bases adjacent the bases of the knee portions **71** and **71'** respectively. The ratio of the diameters of the bases to the diameters of the apexes of the calf portions **72** and **72'** is in the range of about 2.1 to 3.2, while the ratio of their heights to the diameters of their bases in the range of about 2.0 to 3.1

In FIG. 10 is illustrated the doll construction of the present invention wherein the boss **4'** is substantially elliptical and the fastening means is an elastic garment **80** worm by the doll. The elastic garment **80** is stretched to cover the upper leg portions **12** and **12'** adjacent to the doll trunk **2'** and the adjoining portion of the doll trunk, i.e. boss **4'**.

Also, the recesses **11''** and **11'''** of the legs **10''** and **10'''** respectively are simply matingly received on the pelvic boss in such fashion that the legs can be rotated forward and backward and side to side or any combination of such movements. In addition, each of the legs may be rotated about its longitudinal axis while the hip joint maintains a substantially smooth contour closely resembling the hip joint of the human body. Similarly, the frictional forces are maintained substantially uniform for each leg position over the entire range of leg positions.

There are many features in the present invention which clearly show the significant advance the present invention represents over the prior art. Consequently, only a few of the more outstanding features will be pointed out to illustrate the unexpected and unusual results attained by the present invention.

One of the features of the present invention is the joint between the leg and the pelvic portion of the doll body. Such hip joint is adapted to permit the leg to reproduce closely the movement of the human leg while retaining a substantially smooth contour closely resembling the human hip joint. By utilizing a single, substantially spherical boss on the doll trunk fitted into recesses in the upper portions of the legs, the hip movement is closely reproduced and maintained over a wide range of leg positions. In addition, by utilizing a pelvic boss having a horizontal cardioidal cross-section, both the normal contour of the body and the normal movement of the hip joint are more closely obtained. By the use of such hip joint the legs may be moved quite freely to the front and to the back into abutting relationship, but their movement is more restricted from side to side and about their longitudinal axis. It should be noted that such action fits relatively close to the freedom of movement of the normal hip joint.

Another feature of the present invention is that the hip joint of the present invention in combination with the bent form of at least one of the legs permits the legs to obtain a wide range of positions, such as crossing the legs, putting the feet one in front of the other on a substantially straight line, and many other positions. In addition, the hip configuration permits the joint to maintain substantially the same frictional engagement over the whole range of its leg positions. For example, one of the legs may be bent upwardly to the side to an angle of, say, 30 degrees, and such position is maintained without the aid of external force.

Still another feature of the present invention, as illustrated in the drawings, is the proportion and location of the various parts of the doll of the present invention. Thus, for example, the proportions of the leg contours and the pelvic boss are preferably adapted to facilitate the movement and positioning of the legs. Similarly, the straight line connecting the pelvic boss to the horizontal axis between the doll shoulders is preferably located behind the doll trunk axis to facilitate the upright positioning of the doll trunk while the leg positions are varied over a wide range.

Still another feature of the present invention is the unusual fastening means which may be combined with the joint of the present invention. For example, by utilizing the fastening means illustrated in FIGS. 7 and 8, freedom of movement of the appendages is obtained very simply while maintaining uniform frictional engagement with the adjoining trunk portion. Also the fastening means shown in FIG. 10 permits simple exchange of legs on the doll, e.g. legs have different degrees of bending.

It will be understood that the foregoing description and drawings are only illustrative of the present invention and it is not intended that the invention be limited thereto. Many other specific embodiments of the present invention will be obvious to one skilled in the art in view of this disclosure. All substitutions, alterations and modifications of the present invention which come within the scope of the following claims or to which the present invention is readily susceptible without departing from the spirit of the scope of this disclosure are considered part of the present invention.

I claim:

1. In a doll construction: a body having a trunk; the lower extremity of said trunk comprising a single bulbous boss with substantially the entire outer surface thereof defining a smooth and continuously convex surface of generally spheroid shape; a pair of legs, each having a concave recess extending over substantially the entire inner surface of the upper portion thereof, each recess receiving a lateral portion of said bulbous boss and being substantially complementary in shape to the surface thereof with said recesses each covering about 20% to 40% of the external surface area of said boss; the juncture between the outer surface of the upper portion of each leg and the boundary edge of its recess defining a relatively thin edge and said outer surface being configured to substantially the same curvature as the adjacent exposed portions of said boss and adjacent portions of said body to define therewith a surface closely simulating the surface of the pelvic region of a human body; and fastening means holding said boss and recesses in frictional mating relation while permitting said legs to swing in any direction independently of each other on said boss and laterally outwardly from a fore-and-aft vertical plane bisecting said doll trunk up to an angle of at least about 40 degrees from said plane.

2. A doll construction as defined in claim **1** wherein the boundary edge of each recess lies in a plane at an angle in the range of about 5 degrees to 25 degrees to said fore-and-aft plane bisecting the doll trunk when the axis of said doll trunk and the upper portion of the legs adjacent to the doll trunk are oriented perpendicularly to a flat surface on which the doll is standing.

3. A doll construction as defined in claim **1** wherein said boss is substantially circular in vertical section in a plane extending laterally of said trunk.

4. A doll construction as defined in claim **1** wherein

said boss is formed with its laterally opposed sides truncated.

5. A doll construction as defined in claim 1 wherein said boss is generally elliptical in horizontal section.

6. A doll construction as defined in claim 1 wherein said fastening means is a removable elastic garment worn by the doll and stretched to embrace said upper portions of said legs and said bulbous boss.

7. A doll construction as defined in claim 1 wherein said boss has an opening extending laterally therethrough the lateral extremities of which are substantially circular, a knob projecting from the central portion of each leg recess and into said bore, said bore and knob functioning to limit the said swinging of the legs outwardly of said plane and about the longitudinal axes of said legs to ranges natural to the human body.

8. A doll construction as defined in claim 1 wherein the ratio of the length of the doll trunk to the diameter of said bulbous boss is in the range of about 2.4 to 4.0.

9. A doll construction as defined in claim 1 wherein the front surface of said bulbous boss has a substantially larger radius of curvature than the remainder thereof.

10. A doll construction as defined in claim 1 wherein the rear surface of said bulbous boss has a central vertical crevice with rounded edges adapted to receive the rear edges of said upper leg portions when the legs are rotated rearwardly about their longitudinal axes.

11. A doll construction as defined in claim 1 wherein said bulbous boss has a horizontal cardioidal cross section.

12. A doll construction as defined in claim 1 wherein the side waist portion of the doll trunk adjacent said bulbous boss is undercut inwardly to accommodate the upper portions of the legs when said legs are swung outwardly of said plane.

13. A doll construction as defined in claim 1 wherein said legs are rigid, with the lower portion of one of said legs being bent, at the knee thereof, at an angle in the range of about 10 degrees to 30 degrees relative to the upper portion thereof.

14. A doll construction as defined in claim 13 wherein the lower portion of the bent leg is further bent laterally outwardly at an angle in the range of about 1 degree to 15 degrees to said upper leg portion.

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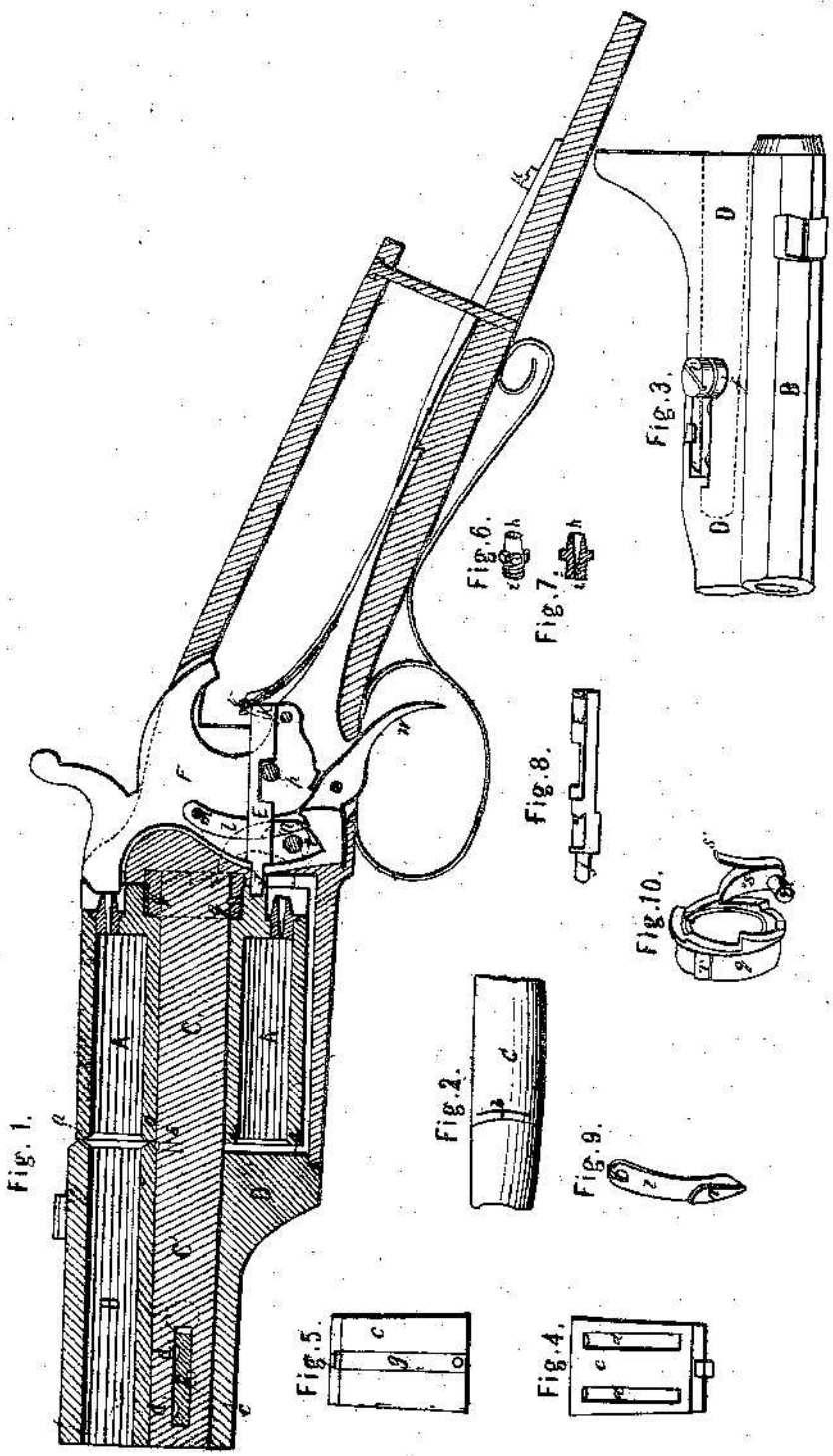
S. Colt.

3 Sheets.
Sheet 1.

Impt in Fire Arms.

No 1304.

Patented Aug 29. 1839.



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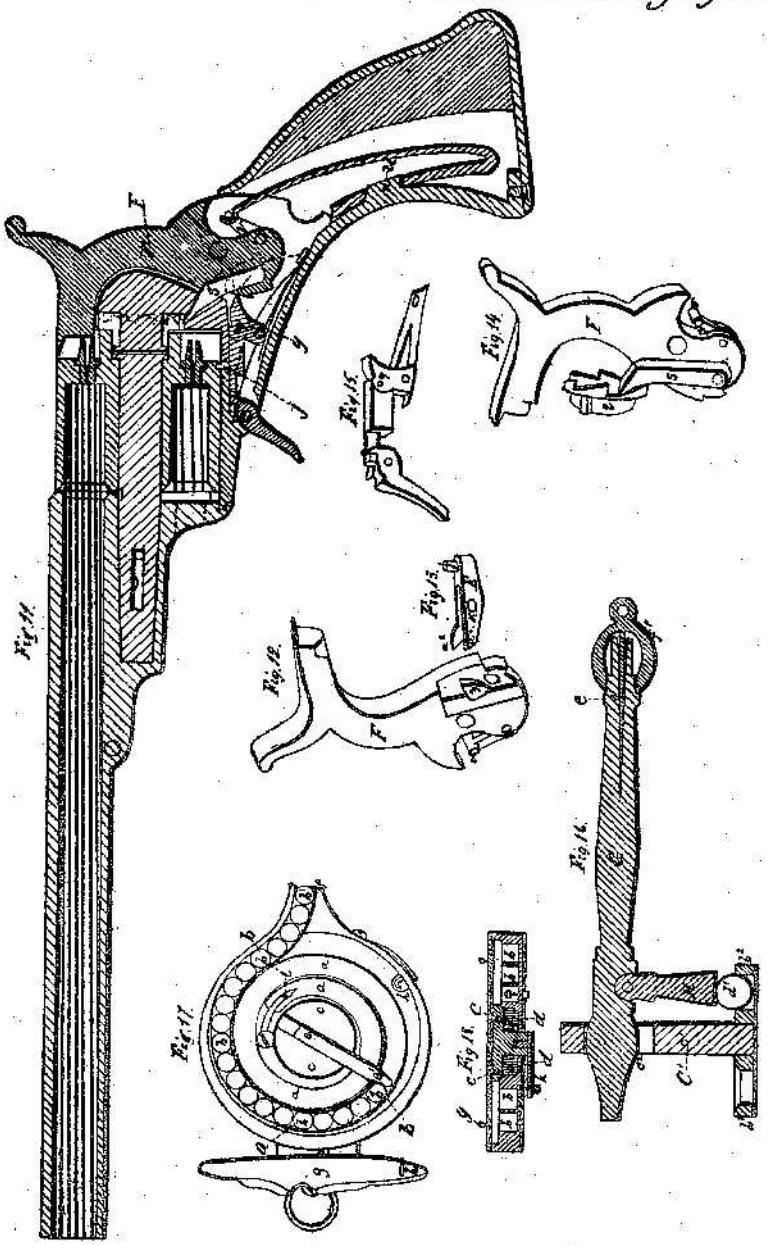
S. Colt.

Impt in Fire Arms.

No 1304.

Patented Aug 29. 1839.



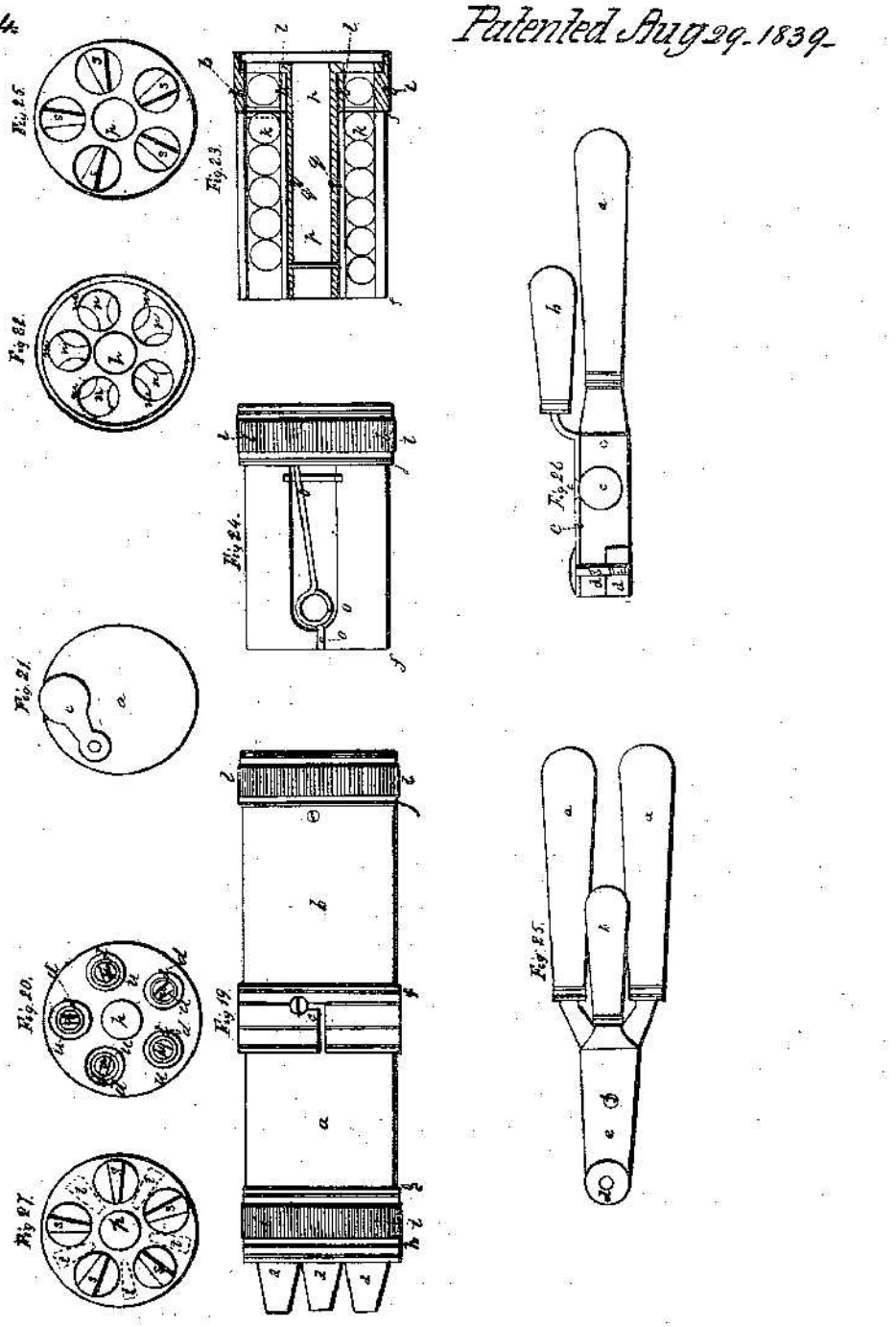
S. Colt.

3 Sheets
Sheet. 3.

Impt in Fire Arms.

No 1304.

Patented Aug 29. 1839.



UNITED STATES PATENT OFFICE.

SAMUEL COLT, OF PATERSON, NEW JERSEY.

IMPROVEMENT IN FIRE-ARMS AND IN THE APPARATUS USED THEREWITH.

Specification forming part of Letters Patent No. 1,304, dated August 29, 1839.

To all whom it may concern:

Be it known that I, SAMUEL COLT, of Paterson, in the county of Passaic and State of New Jersey, did obtain Letters Patent of the United States for an Improvement in Fire-Arms, which Letters Patent bear date on the 25th day of February, in the year 1836, and that I have made certain improvements in the construction of the said fire-arms, and also in the apparatus for loading and priming the same; and I do hereby delare that the following is a full and exact description of my said improvements.

My first improvements appertain to rifles, guns, and pistols; my second to the construction of a cap-primer for containing the percussion-caps and placing the same upon the nipples, and my third to a flask and other apparatus for loading the rifle or gun.

For the general construction of my fire-arms, as originally patented I refer to the Letters Patent first above named, the same being necessary to a perfect understanding of the improvements thereon, which I am now about to describe.

Figure 1 in the accompanying drawings represents a section through the lock and breech of my rifle or gun and two of the chambers of the revolving receiver, B being a part of the barrel of the gun. The mouths of the chambers and the end of the barrel have their edges chamfered or beveled, as shown at *a a* in the drawings. In all guns of this description there is necessarily a lateral discharge between the receiver and the barrel, and this lateral discharge may endanger the ignition of the powder in the loaded chambers not in contact with the barrel; but the ignited matter, by coming into contact with the beveled edge as it crosses said chamber, is effectually reflected off, and does not enter them. The beveling of the end of the barrel is not a thing of importance, it being intended merely to prevent its scraping or cutting the ball in its passage from the chamber.

Fig. 2 shows a part of the arbor upon which the receiver turns. *b* is the portion thereof which is immediately below the chamber in contact with the barrel, and in this part a channel or groove is made descending from the point *b* in both directions, so as to form two inclined planes meeting at the point *b*. These planes or sections of the grooves may form an angle at forty-five degrees with each other. This groove or channel serves as a chimney to conduct off the smoke of the lateral discharge, so that it shall pass directly between the receiver and the barrel and prevent its spreading, so as to pass in between the receiver and the arbor and the barrel and the arbor, and consequently from condensing there and rendering them foul. The barrel is connected with the receiver and with the stock of the gun by the aid of the arbor which at the rear end, is a solid piece with the shield or solid piece of metal which receives the recoil and constitutes a component part of the metallic frame-work or foundation of the lock and its appendages. The part C of the arbor is that upon which the receiver revolves, and the part C′ enters a cylindrical cavity in a mass of iron, D D, to which the barrel is brazed or otherwise attached.

Fig. 3 shows the piece of iron D D and a part of the barrel B which is attached to it. The dotted lines in this represent the cylindrical cavity which receives the outer end of the arbor C′. The two are keyed together by the passing of a suitable key through a mortise in the piece D D and a corresponding one in the arbor.

c, Figs. 1, 3, 4, and 5, represents the key. Fig. 4 shows its upper and Fig. 5 its under side. *d d* are two fluted channels along its upper side to receive the heads of two screws which are screwed into the piece D D close to the mortise and on the side opposite to that shown in Fig. 3. The heads of these screws lap a little over the mortise and are received into the fluted channels *d d*. These heads prevent the key from falling out and check it in either direction, and must be withdrawn in order to remove the key. As the key *c* is to act laterally as a wedge to draw the receiver and the barrel into proper contact, it is of importance that it should be checked when forced sufficiently far in, or the receiver might be wedged up and prevented from turning. For this purpose I insert a screw, *e*, Fig. 3, into the steel button *f*, which is attached to D D, to strengthen the end of the mortise and prevent the bruising of it by the recoil. The head of this screw, overlapping the end of the mortise,

receives the wedge and checks it. By turning this screw the force of the wedge may be tempered. In Fig. 5, *g* is a spring-latch on the under side of the key, which catches upon D when the key is forced in and prevents its accidental removal.

Fig. 6 represents a percussion tube or nipple, through which the fire from the percussion-cap is to be conducted to the chamber. Fig. 7 represents the same in section. The outer end, *h*, of the tube has the opening made as large as convenience will allow, and it goes tapering or conical until at the inner end, *i*, it is as small as a proper entrance of the flame from the percussion-powder will warrant. By giving the conical or funnel-formed opening to the tube the effect of the percussion-powder is greatly increased.

E, Figs. 1 and 8, is a bolt for locking the receiver when a loaded chamber is brought to coincide with the barrel, the rounded end *j* being forced into a hole in the receiver by the action of a spring on its outer end *k*. This bolt is drawn back by the hammer F in the act of cocking.

l, Figs. 1 and 9, is a spring-cam, which is screwed to the hammer at *m*. It is made of spring-steel, so that its cam end *n* may recede from or approach the hammer F. The cam *n* bears against the projection *o* on the bolt E on the side which lies against the hammer, and as the hammer is drawn back causes the bolt to recede. The bolt is notched to enable it to be withdrawn without interfering with the joint-pin *q* of the hammer. The lateral springing of the cam-piece *l* is necessary to admit of its passing by the projection *o* of the bolt when the hammer is made to strike upon a percussion-cap. To enable the spring-cam to pass the bolt E, the lower end of it, *n*, is made wedge-shaped, diminishing to a point or edge at its extremity, and as it is made to spring laterally it is received into a recess in the hammer as the latter passes the bolt in making the discharge.

Fig. 10 shows the ratchet-wheel and hand or pawl by which the receiver is made to revolve to the distance from one chamber to another in the act of cocking. The cylindrical periphery *q* of the ratchet-wheel fits into a corresponding cavity on the back end of the receiver, as shown at *q q*, Fig. 1. *r* is a projection to prevent its turning round, this being adapted to a notch made to receive it. S is a hand or pawl, which falls into the teeth of the ratchet-wheel, said pawl being forced forward by the spring S′. The arbor *t* on which the hand turns is received into the opening *t*. In the hammer, Fig. 1, the hand itself being on the opposite side of said hammer from that shown, its position is shown by the dotted lines surrounding its arbor *t*. The cocking of the gun causes it to act upon the ratchet-wheel, and when turned to the proper distance the bolt E is forced by its spring into the proper opening in the receiver. The mainspring is connected to the lock-plate at *u*, and to the hammer by a stirrup at V. The trigger is shown at *w*. These parts, not differing in their construction and operation from analogous parts in other gun-locks, need no particular description, and from the description above given of the structure and operation of those parts of the rifle or gun which are new, the action of the whole will, it is believed, be clearly understood.

Fig. 11 is a sectional view of a pistol, the general construction of which is the same with that of the rifle or gun already described, such modifications only being made as are rendered necessary by its size and other considerations. F is the hammer carrying the hand or pawl S, which operates on the ratchet-wheel, which wheel and hand are arranged in the same way with the same parts in the rifle; but the hand is as here represented on the reverse side. The bolt which holds the receiver is, however, differently constructed to enable it to act in the space which it must occupy.

Fig. 12 is a view of the hammer on the side the reverse of that shown in Fig. 11; and E, Fig. 13, is the bolt adapted thereto. *j* is the pin on the bolt, which holds the receiver by falling into openings on its periphery instead of in its end. The pin *j* is shown in place in Fig. 11. The bolt E vibrates on a joint-pin at *x*, which is nearly in the same line with the joint-pin *y* on the trigger, Figs. 11 and 15, by which it is hidden in those figures. *z* is a cam formed in a recess in the hammer, Fig. 12, which cam is to act upon the bolt E and to disengage it from the receiver. The ends a' a^2 of this bolt are capable of receding from or approaching toward each other, as they constitute two spring-cheeks formed by splitting or forking the bolts, as shown in the drawings. The end a^2 lies above the cam *z* on the hammer when the pistol is not cocked, and the lower end of a^2, as well as the upper end of *z*, being flat, the bolt E is lifted in the act of cocking until the pin *j* is disengaged, and the ends of a^2 and *z* then pass each other. The cam *z* is made wedge shape by sloping from its upper to its lower end, and the end a^2 of the bolt is similarly formed, but in the reverse direction, so that when the piece is discharged the end a^2 will be made to spring in, allowing the hammer to pass readily, when the end a^2 again rests upon *z* as before.

Fig. 14 shows the hammer with the hand S and ratchet *q*, which need no further description.

Fig. 15 shows the trigger and its appendages, which are formed in a way not presenting any claim to novelty. *u* is the attachment of the mainspring to the lock-plate, and *v* its attachment to the stirrup and hammer.

Fig. 16 shows the apparatus which I employ for forcing the balls into the chambers. b^2 b^2 are two of the chambers, shown in section; and C, the arbor by which the barrel is attached to the stock and upon which the receiver turns, as already explained. G is a lever carrying a rammer, H, by which the balls are to be forced

into the chambers. The forward end of the lever H passes into the mortise c^2, which receives the key by which the barrel is attached. The operation of the rammer H upon the ball d' will be apparent. In using this lever the receiver is to be turned upon the arbor, and the chambers brought in succession under the rammer. This lever, at its end e', constitutes a wrench for screwing and unscrewing the percussion-tubes, and also contains a picker attached to a screw-cap, f'. A fulcrum for the lever H may be formed on the barrel or otherwise, instead of using the mortise c^2, if preferred.

Figs. 17 and 18 are a top and sectional view of my improved cap-primer, which differs in some important particulars from the English and other cap-primers now in use. I make a spiral groove, $a\ a\ a$, in a plate of brass or other metal, which groove is of such depth and width as to receive the percussion-caps, and to allow them to move freely therein. $b\ b\ b$ are caps within said groove. In the center of the primer, under the plate $c\ c$, is a spiral spring, $d\ d$, operating like the mainspring of a watch upon its barrels and turning the plate $c\ c$. This plate has a groove across it which carries a sliding arm, $e\ e'$, having under its end e' a projecting piece which enters the groove, draws the arm out, and presses upon the row of caps. At the mouth of the spiral groove, where the the cap b' is seen, a steel spring, f, checks the cap and counteracts the pressure of the spiral spring $d\ d$; but when the cap b' is placed upon the tube or nipple the spring f will recede by the withdrawal of the cap, and a new one will be made to occupy its place, and so on until the whole are exhausted. The cover g, which in Fig. 17 is shown as raised, is held down by a spring-catch at h. There is a spring-catch at i, which holds the sliding arm e at its end e', when it is brought round to the inner end of the spiral groove, its use being to detain the arm while the groove is being filled with caps, when it is to be raised, and the arm left at liberty to operate. The spring $d\ d$ may be wound up by a small key, k, or by inserting a screw-driver in a notch made for that purpose, or simply by forcing the arm $e\ e$ round until it is caught by the catch i.

Fig. 19 is a representation of my ammunition-flask, by means of which all the chambers in my receiver may be simultaneously charged with powder and with balls. It consists of two separate chambers, one of which is a powder and the other a bullet magazine, a being the former and b the latter, the two being connected together by a bayonet-joint at c. $d\ d\ d$ are charging-tubes adapted in number and position to the mouths of the chambers of the receiver which they are to enter.

Fig. 21 shows the closed top of the powder-magazine, with a valve or turn cover, e, which closes a hole through which the magazine is to be filled. This magazine occupies the space from f to g, Fig. 19, where the powder is contained in bulk. The space from g to h is a receptacle which is divided by partitions into separate chambers, the same in number with the tubes $d\ d$, each of which chambers contains the quantity of powder required for the charge of a single chamber. $i\ i$ is the rim of this chambered receptacle, which is capable of being turned round to a short distance by the thumb and finger for the purpose of charging the chambers with powder. This turning round brings openings $u\ u$, Fig. 20, in the lower end of the chambered box to coincide with the openings in the tubes $d\ d$, so that the powder contained in the chambers in $i\ i$ may pass out therefrom into the chambers of the receiver. There are openings also in the upper plate or top of the receptacle $i\ i$ corresponding with openings in the bottom of the magazine a, which are closed by turning the rim $i\ i$, so as to prevent powder from falling through from the magazine while the receiver is being filled.

Fig. 27 is a section through the middle of the chambered receptacle $i\ i$, the circles $r\ r$ representing the chambers for containing the powder. $s\ s$ are the openings in the top plate of these chambers, through which the powder is admitted into them from the magazine a. The dotted lines $t\ t$ show the plan of the openings in the bottom plate of the chamber a, the chambered receiver being shown in the position in which those openings are covered.

In Fig. 28 the same parts are represented; but the chambered receiver is supposed to be turned round or standing in its ordinary position, so that the openings S S and $t\ t$ coincide. The chambered receptacle is restored to its place by means of a spring of any suitable form. The whole operation of this part will be more clearly made known by the sectional representation of the magazine for balls, which I am now about to describe.

The end of the flask, Fig. 19, is, I have said, the magazine for balls. Fig. 22 is an end view of this magazine, and Fig. 23 a section along its axis. The portion from f to j, Figs. 19, 23, and 24, is divided into as many tubular chambers as there are chambers in the receiver—say five. These are open at top and are to be filled with balls, as shown at $k\ k$ in the section Fig. 23. These tubes are also open at their lower ends, so that the balls may pass from them into a chambered receptacle, $l\ l$, similar to that for the powder. From this chambered receptacle they are to fall into the chambers of the receiver when the lower end of the flask, Fig. 22, is applied thereto for that purpose, the openings $m\ m$ in the lower end of the flask being adapted thereto. The rim of the chambered receiver $l\ l$ is to be turned round to allow the balls to escape through $m\ m$, as already described in the charging with powder. In Fig. 22, $n\ n$ are the divisions between the chambers of the chambered receiver, and which retain one set or tier of balls until the rim is turned around so as to cause the chambers to coincide with the openings $m\ m$. The balls will then pass through. The same motion of the chambered receiver causes the divisions be-

tween the tubes and the chambered receiver to pass under and sustain the balls in the magazine. In the case of the powder-magazine the action is the same; but the powder being in fine particles, the apertures at one end of the receptacles must be perfectly closed before those at the other begin to be opened, which is not necessary with the balls. In Fig. 24 a portion of the exterior of the magazine is removed to show how a spring, *o o*, may be placed within it so as to act upon *l l;* but spiral or other springs may be placed in many ways to answer the same purpose. The central part of both the magazines is tubular, as shown at *p p*, said tube fitting onto the arbor C′, Fig. 16, when the barrel is removed therefrom, and the receiver left on for the purpose of being charged, which operation does not require to be further explained. Upon the barrel of this tubular part the chambered receptacles are received and revolve.

Figs. 25 and 26 represent a top view and a side view of a part of an improved bullet-mold, which I describe without intending to make any claim thereto, but merely for the purpose of showing the whole of the apparatus employed in a complete and connected series. *a a* are the two handles of the mold, and *b* the handle of the knife by which the sprue is cut off. *c* is one-half of the mold, of which *d d* is the hinge-joint. *e* is a plate of steel, through which there is a hole, *f*, for pouring in the lead, the lower edges of which constitute a knife by which the sprue is cut off and the ball left perfect. This knife turns on the joint-pin *g*.

Having thus fully described the manner in which I construct and use my improved firearms, and the respective articles of apparatus appertaining thereto, it has been necessary in so doing to mention many parts which I do not claim as new, the same being similar to what has been before used and patented by me, or which are common property. I do hereby declare, therefore, that I limit my claim to the following particulars.

I claim—

1. The making of a groove or channel on the arbor, as represented at *b*, Fig. 2, for the purpose of conducting off the smoke from the lateral discharge, and thus preserving the arbor clean within the receiver, and the tube by which the barrel is connected.

2. The particular manner of forming and governing the key by which the barrel is attached to the stock by making the same with grooves in which the heads of overlapping screw-heads are received, and with a tempering-screw to check and regulate its action as a wedge, as set forth.

3. The making the aperture through the tubes or nipples (which receive the percussion-caps) conical or funnel-shaped, for the purpose of freely admitting the fire from the percussion-cap and concentrating it as it enters the chamber.

4. The manner of arranging the bolt E of the rifle and its spring cam *l n* for locking and unlocking the receiver, the same being constructed and operating as herein described.

5. The manner of constructing and arranging the bolt E and its spring-cam, operated upon by the cam or projecting piece *z* under that modification thereof adopted in the pistol, and herein fully made known.

6. The improved manner of arranging the ratchet-wheel and hand, as set forth, by which the hinge-joint to allow of the lateral motion of this hand, as described by me in my former patent, is dispensed with in consequence of the placing of the ratchet-teeth on the face instead of on the side of the wheel, and operating the same in the manner described, as applied to the rifle and to the pistol.

7. The combination of the lever with its rammer for forcing the balls into the chambers of the receiver, as described.

8. In the improved cap-primer, the making thereof with a spiral groove to receive the caps, and with the sliding arm acted upon by the spiral spring elongating itself and forcing the percussion-caps forward in the manner set forth.

9. The manner of constructing and arranging the respective parts of the magazines for powder and balls, in the flask, by means of which the powder and the balls are in turn supplied to all the chambers in the receiver at the same time, the whole being made with the chambered receptacles and other parts, as set forth.

SAML. COLT.

Witnesses:
THOS. B. JONES,
GEORGE WEST.

Disclaimer forming part of Letters Patent No. **1,304**, dated August 29, 1839.

To the Honorable Commissioner of Patents:

The petition of SAMUEL COLT, of Hartford, in the State of Connecticut, respectfully represents that he is the sole patentee and owner of Letters Patent granted to him on the 29th day of August, 1839, for an improvement in fire-arms and in the apparatus used therewith; that he has reason to believe that through inadvertence and mistake the claim made in the specification of said Letters Patent is too broad, including that of which the said patentee was not the first inventor, although he avers that he was an original inventor thereof, and had no knowledge when he applied for Letters Patent therefor that any other person had ever used the said improvement before that time.

Your petitioner therefore hereby enters his disclaimer to that part of the claim in the before-mentioned specification which is in the following words, viz:

"I claim making the aperture through the tubes or nipples (which receive the percussion-caps) conical or funnel shaped, for the purpose of freely admitting the fire from the percussion-cap and concentrating it as it enters the chamber," which disclaimer is to operate to the extent of the interest in said Letters Patent vested in your petitioner, the same being the whole right, title, and interest thereby granted to him, as aforesaid, he having paid ten dollars into the Treasury of the United States agreeably to the provisions of the act of Congress in that case made and provided.

Dated at Hartford this 5th day of August, A. D. 1853.

SAM. COLT.

In presence of—
L. P. SARGEANT.

(No Model.)

J. H. & H. H. DOW.

ROTARY STEAM ENGINE.

No. 403,335. Patented May 14, 1889.

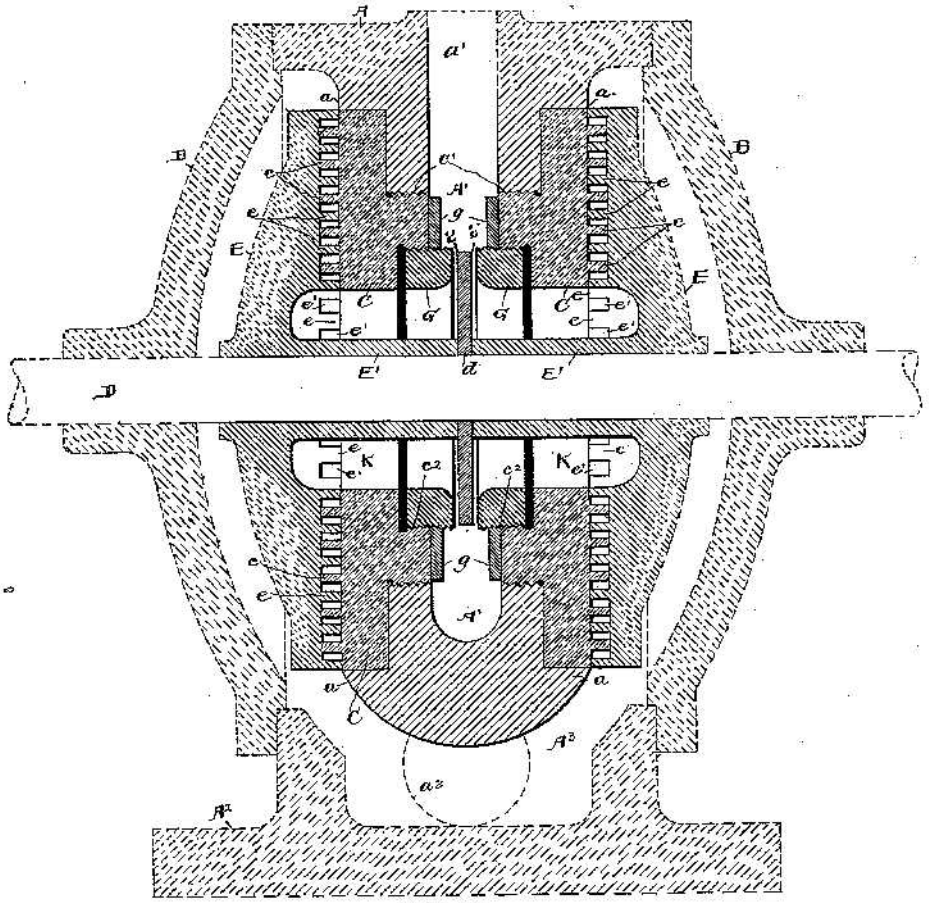


Fig. 1.

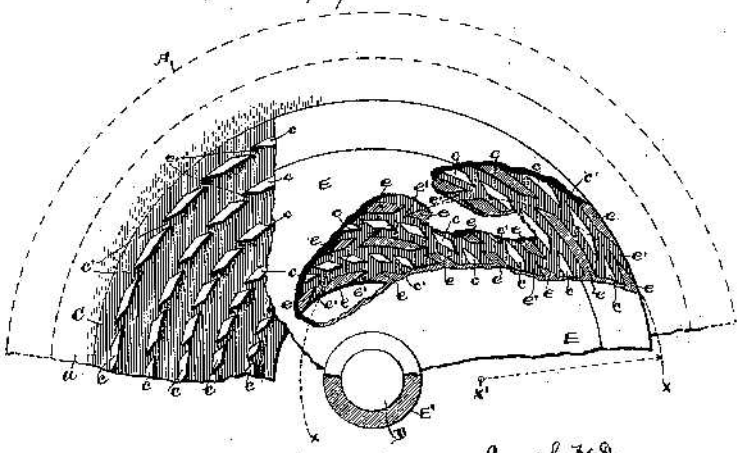


Fig. 2.

WITNESSES:
N. S. Auerbach
Geo. W. Kenyon

Joseph H. Dow,
Herbert H. Dow.
INVENTORS

BY Leggett & Leggett
ATTORNEYS.

UNITED STATES PATENT OFFICE.

JOSEPH H. DOW AND HERBERT H. DOW, BOTH OF CLEVELAND, OHIO; SAID HERBERT H. DOW ASSIGNOR TO WILLIAM CHISHOLM, OF SAME PLACE.

ROTARY STEAM-ENGINE.

SPECIFICATION forming part of Letters Patent No. 403,335, dated May 14, 1889.

Application filed August 25, 1888. Serial No. 283,751. (No model.)

To all whom it may concern:

Be it known that we, JOSEPH H. DOW and HERBERT H. DOW, of Cleveland, in the county of Cuyahoga and State of Ohio, have invented certain new and useful Improvements in Rotary Steam-Engines; and we do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it pertains to make and use the same.

Our invention relates to improvements in the rotary engine shown and described in Letters Patent No. 392,545, granted November 6, 1888; and it consists in certain features of construction and in combination of parts hereinafter described, and pointed out in the claims.

In the accompanying drawings, Figure 1 is an elevation in longitudinal section through the center of the engine. Fig. 2 is an end elevation, partly in section, the cylinder-head of the foreground being removed and portions being broken away to show the construction.

A represents the body or shell of the engine, to which are detachably secured heads B, the latter having suitable boxes, in which is journaled the engine-shaft D. The shell A is provided with internal flanges, *a*, these flanges being "faced off" and screw-threaded at the internal periphery to receive disks C, the latter being screw-threaded at C′ for engaging the aforesaid flanges. The two flanges and the backs of these disks are separated to form steam-chamber A′, the latter connecting with induction-pipes *a*′. The shell A terminates in a supporting-base, A^2, to which exhaust-pipe a^3 is attached, the latter connecting with exhaust-chamber A^3. The disks C, on the outer faces thereof, are provided, respectively, with series of curved wings or chutes *c*, each series being arranged in concentric order with the axis of the shaft D. The different wings *c* of a series are separated the one from the other to form ports *c*′, the latter being preferably arranged in the curved order shown in Fig. 2. (See dotted line *x x* with center *x*′.)

E are rotating disks or wheels, the same being mounted on and secured to shaft D. These disks have long hubs E′, projecting toward each other and nearly meeting on the shaft, leaving room only for the intermediate disk, *d*, the latter also being made fast to the shaft. The faces of wheels E are provided with series of curved buckets *e*, that alternate with wings *c*, a series of buckets operating between series of wings, and vice versa, the vents *e*′ being laid out on curved lines the reverse of line *x x*, and these vents *e*′ being less in aggregate area of discharge than the aforesaid ports *c*′, the object being to utilize the reactive force of steam rather than the impact of steam, and by means of the ports and vents being arranged on curved lines, deflecting in opposite directions, as shown, the openings of the different series of buckets and wings can be made to cross each other at substantially equal angles throughout the series and at such angles as will give the greatest effectiveness, such angles at present advised being approximately right angles. This class of engines is intended to run at a very high speed, and to avoid friction the disk C and wings *c* do not come in contact with the opposing wheels E and buckets *e*, although the clearance at the ends of the wings and buckets is very small—say a two-hundredth part of an inch, more or less.

Heretofore the great difficulty has been to hold the shaft D endwise. The high speed attained was such that ordinary collars caused too much friction, and were consequently worthless for such purpose.

Our improved mechanism is as follows: The aforesaid disk *d* overlaps in radial direction the inner periphery of the disks C. The latter are screw-threaded at c^2 to engage rings or collars G, the latter being screw-threaded externally. These rings are provided with lock-nuts *g*. The rings are adjusted toward or from disk *d* to leave suitable and equal passage ways or ports, *i* and *i*′, for the passage of steam from chamber A′ to chamber K, from which latter the steam passes between the disks C and opposing wheels E *via* ports *e* and vents *e*′ to the exhaust-chamber. Rings G having been adjusted and secured by the respective lock-nuts, so long as there is no disturbing cause spaces *i* and *i*′ will remain equal and an equal volume of steam will issue

to the two sides of the engine; but suppose from any cause the shaft were moved toward, for instance, what is the right-hand side, as shown in Fig. 1, such a movement would partially close the passage-way or port *i*, and would consequently shut off a portion of the steam to the right-hand side of the engine, and would at the same time further separate disk C and wheel E at this side of the engine. The reduction of steam-volume and the widening of steam-space between the disk and wheel would tend to diminish the endwise pressure on the shaft, while on the other side of the engine the reverse would take place—that is to say, steam-space *i'* would enlarge, thereby giving greater volume of steam on this the left-hand side of the engine, and the disk and wheel on the left-hand side of the engine would approach each other, thereby decreasing the steam-space between the two, and consequently giving greater steam-pressure to act in the opposite direction endwise of the shaft, all of which would tend to return the shaft to its central or normal position lengthwise of the engine. The apparatus whereby a steam-balance is thus had is very sensitive, by reason of which the buckets may run in close proximity to their seats without absolute contact, thus avoiding all friction except at the journal-bearings of the engine-shaft. In place of a single disk, *d*, rigidly secured to the shaft, two such disks might be employed, and these might be adjusted lengthwise of the shaft instead of the adjusting-rings G; also, the curved lines on which the vents and ports are laid out need not necessarily be on true circles.

What we claim is—

1. In a rotary steam-engine, the combination, with stationary disks with steam-chamber located between the disks and opposing rotating wheels located outside the disks, the wheels being mounted on the engine-shaft, substantially as indicated, of an engine-shaft, and a disk mounted on the engine-shaft between the line of the stationary disks, said rotating disk extending into and dividing the eduction of the said steam-chamber, substantially as set forth.

2. In a rotary engine, the combination of shaft carrying with it two wheels and a disk between them, these wheels being opposed inwardly by stationary disks, the central or revolving disks being opposed on opposite sides by rings connected with the stationary disks, leaving annular spaces between the central disk and rings that act as steam-ports, substantially as set forth.

3. The combination, with a rotary engine of the variety indicated, having stationary disks and movable disk, the latter being mounted on the engine-shaft and extending into the steam-space between the stationary disks, of rings mounted on such stationary disks and adjustable toward and from the rotating disk, substantially as set forth.

4. The combination, with stationary disks and intervening rotating disk, the latter being mounted on the engine-shaft, substantially as indicated, of screw-threaded rings engaging the stationary disks, such rings being adjustable toward and from the rotating disk, and lock-nuts mounted on the respective rings, substantially as set forth.

5. In a rotary engine, the combination of stationary disks and rotating wheels, the former bearing wings separated so as to form intervening ports and the latter bearing buckets separated so as to form intervening vents, the system of ports and vents being arranged in curved lines deflecting in opposite directions, the aggregate area of the vents being less than the aggregate area of the ports, substantially as set forth.

6. In a rotary engine, the combination, with stationary disks provided with a curved series of ports, and revolving wheels provided with a curved series of vents, the latter being arranged in curved lines deflecting in opposite directions to those of the ports, said revolving wheels being provided with inwardly-projecting limbs, of a revolving disk located on the shaft between the adjacent ends of said limbs and extending into and dividing the steam-outlet of the steam-chamber, substantially as set forth.

In testimony whereof we sign this specification, in the presence of two witnesses, this 15th day of May, 1888.

JOSEPH H. DOW.
HERBERT H. DOW.

Witnesses:
CHAS. H. DORER,
ALBERT E. LYNCH.

No. 608,845. Patented Aug. 9, 1898.

R. DIESEL.

INTERNAL COMBUSTION ENGINE.

(Application filed July 15, 1895.)

(No Model.) 2 Sheets—Sheet 1.

Fig. 1.

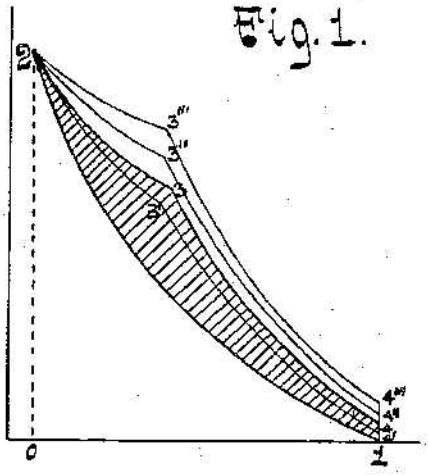
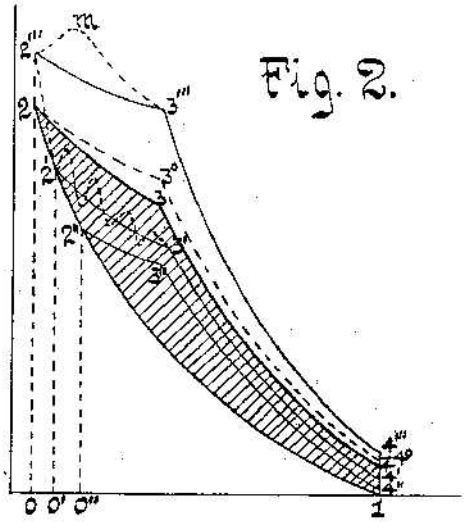


Fig. 2.



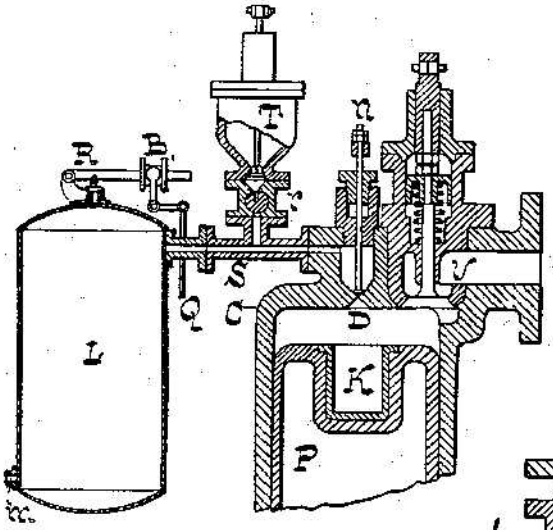


Fig. 3.

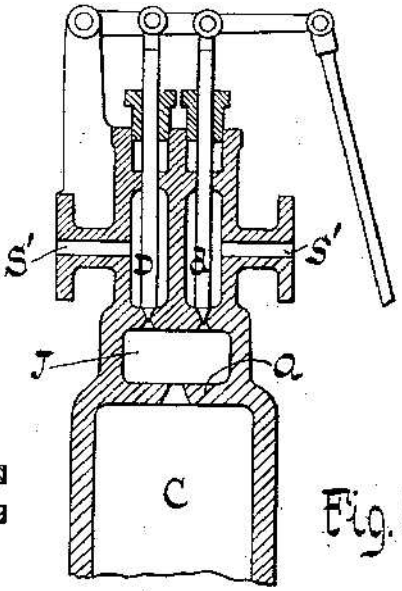


Fig. 5.

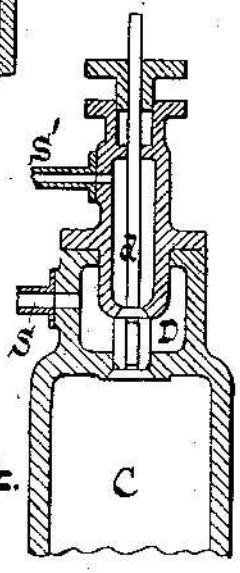


Fig. 4.

WITNESSES:

Chas. W. Thomas

Eugenie A. Persides

INVENTOR:

Rudolf Diesel,

BY

Albert du Bois

ATTORNEY

No. 608,845. Patented Aug. 9, 1898.

R. DIESEL.

INTERNAL COMBUSTION ENGINE.

(Application filed July 15, 1895.)

(No Model.) 2 Sheets—Sheet 2.

Fig. 6.

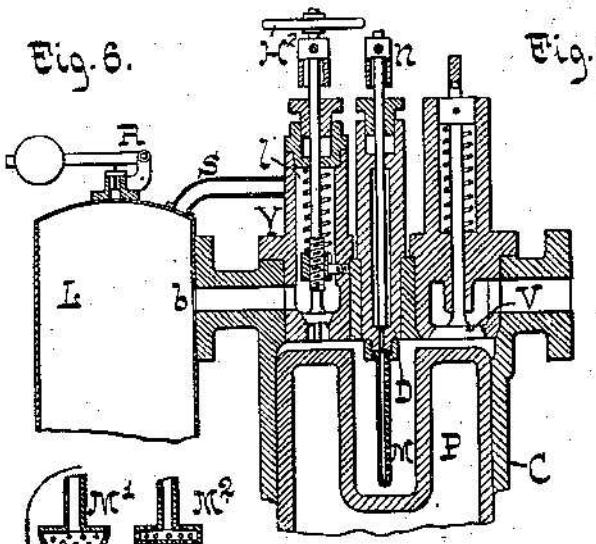


Fig. 8.

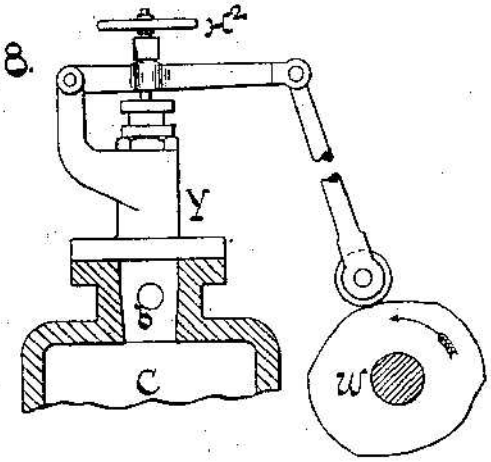
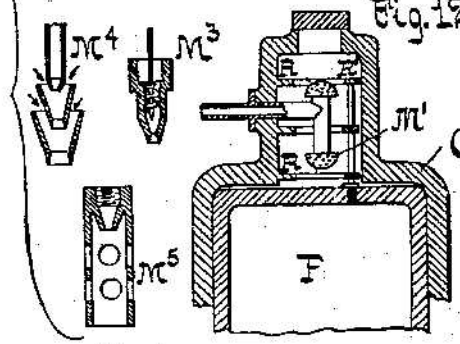
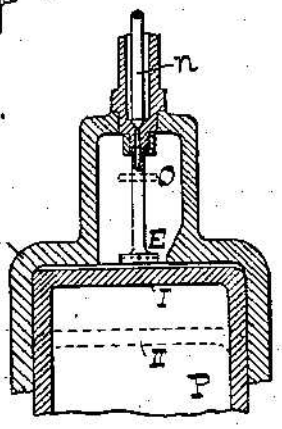


Fig. 12.





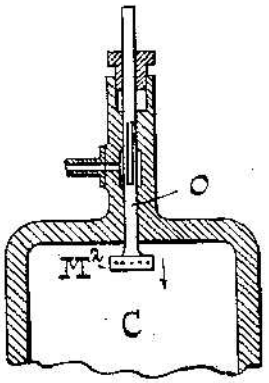


Fig. 7.

Fig. 11.

Fig. 13.

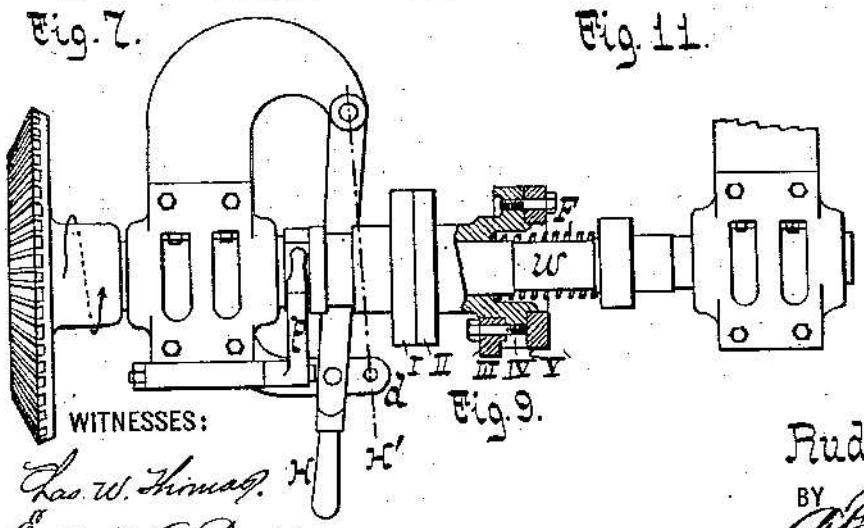


Fig. 9.

Fig. 10.

WITNESSES:

Las. W. Hinas.

Eugenie A. Persides.

INVENTOR:

Rudolf Diesel,

BY

A. Faber du Faur

ATTORNEY

UNITED STATES PATENT OFFICE.

RUDOLF DIESEL, OF BERLIN, GERMANY, ASSIGNOR, BY MESNE ASSIGNMENTS, TO THE DIESEL MOTOR COMPANY OF AMERICA, OF NEW YORK.

INTERNAL-COMBUSTION ENGINE.

SPECIFICATION forming part of Letters Patent No. 608,845, dated August 9, 1898.

Application filed July 15, 1895. Serial No. 556,059. (No model.) Patented in Spain December 3, 1894, No. 16,654; in France December 10, 1894, No. 243,531; in Belgium December 10, 1894, No. 113,139; in Luxemburg December 10, 1894, No. 2,192; in Italy February 21, 1895, LXXV, 132; in England February 27, 1895, No. 4,243; in Switzerland March 5, 1895, Nos. 10,134 and 10,135; in Germany March 30, 1895, No. 86,633; in Hungary November 23, 1895, No. 4,539, and March 20, 1897, No. 7,876; in Austria January 18, 1896, No. 46/203, and May 22, 1896, No. 46/2,038, and in Denmark February 12, 1896, No. 393.

To all whom it may concern:

Be it known that I, RUDOLF DIESEL, a subject of the King of Bavaria, and a resident of Berlin, in the Kingdom of Prussia, Germany, have invented certain new and useful Improvements in Internal-Combustion Engines, (for which I have obtained Letters Patent in Germany, No. 86,633, dated March 30, 1895; in France, No. 243,531, dated December 10, 1894, and patent of addition to the same, dated March 1, 1895; in Belgium, No. 113,139, dated December 10, 1894, and Patent of Addition No. 114,346, dated February 18, 1895; in England, No. 4,243, dated February 27, 1895; in Switzerland, Nos. 10,134 and 10,135, dated March 5, 1895; in Luxemburg, No. 2,192, dated December 10, 1894, and Patent of Addition No. 2,265, dated March 22, 1895; in Denmark, No. 393, dated February 12, 1896; in Austria, No. 46/203, dated January 18, 1896, and No. 46/2,038, dated May 22, 1896; in Hungary, No. 4,539, dated November 23, 1895, and No. 7,876, dated March 20, 1897; in Italy, LXXV, 132, dated February 21, 1895, and in Spain, No. 16,654, dated December 3, 1894, and Patent of Addition No. 17,085, dated March 4, 1895,) of which the following is a specification.

My invention has reference to improvements in apparatus for regulating the fuel-supply in slow-combustion motors, and in particular to internal-combustion engines adapted for carrying out the process described in my prior patent, No. 542,846, dated July 16, 1895, which process consists in first compressing air or a mixture of air and neutral gas or vapor to a degree producing a temperature above the igniting-point of the fuel to be consumed, then gradually introducing the fuel for combustion into the compressed air while expanding against resistance sufficiently to prevent an essential increase of temperature and pressure, then discontinuing the supply of fuel and further expanding without transfer of heat.

In ordinary combustion-engines the regulation of work done was performed either while the gas was at a constant pressure or, as in explosive engines, with the gas at constant volume.

The nature of my invention will best be understood when described in connection with the accompanying drawings, in which—

Figures 1 and 2 are diagrams illustrating the cycle of operation. Fig. 3 is a vertical section of an engine, illustrating one form of fuel-feed, part being broken away. Figs. 4 and 5 are similar views illustrating modified forms for the feed. Fig. 6 is a sectional elevation illustrating another modified form for the same. Fig. 7 shows sectional views of detail parts. Figs. 8, 9, and 10 illustrate in sectional elevation the arrangement of the mechanism for operating the valve. Figs. 11, 12, and 13 are sectional elevations illustrating different devices for mixing the air and fuel.

Similar letters and figures of reference designate corresponding parts throughout the several views of the drawings.

Referring now to Fig. 1 of the drawings, which illustrates a theoretical indicator-diagram of the engine, the curve 2 3 corresponds to the period of admission and consumption of fuel, the fuel being injected under a pressure greater than the pressure 0 2 at the point of highest compression.

By varying the excess of pressure under which fuel is injected and in the meantime the length or duration of admission of fuel the combustion-curve 2 3, Fig. 1, is changed both in its form or position, as in its length 2 3′, 2 3², &c., thus producing diagrams, such as 1 2 3 4 or 1 2 3′ 4′, &c. In all the diagrams shown in Fig. 1 the fuel is admitted at the point 2 of highest compression. In Fig. 2 the beginning of admission is variable, as will be hereinafter explained.

Referring now to Fig. 3 for a description of an apparatus for carrying out the regulation of the supply of fuel, the letter C designates

a cylinder provided with a piston P and with an air-valve V. D is a nozzle for regulating the supply of fuel, by means of which the periods of admission and cut-off, and consequently the length of the curve 2 3 or 2 3′, &c., are determined with the use of a needle-valve *n*, actuated by any well-known mechanism. Pulverulent solid fuel is contained in a hopper T, provided with a rotary distributing-valve *r*. L is a reservoir which is supplied with suppressed gas through a pipe *m*. The gas may be air, a combustible gas, or a mixture of combustible gas and air. The air or gas or the mixture of the same is held under a pressure (by means of a pump or other well-known means) in excess of the highest pressure in the cylinder C. Said reservoir L is connected with the cylinder C by a pipe S and with the hopper T by a suitable branch pipe in communication with the pipe S.

When the valve *n* is lifted to open the nozzle D, the excess of pressure in the reservoir L causes the gas to flow through the pipe S and the nozzle D into the cylinder C, carrying with it the pulverulent fuel discharged by the turning of the valve *r*. In this manner an intimate mixture of gas and fuel is obtained and injected into the cylinder and rapid and complete combustion is insured.

If the pressure in the reservoir L were fixed and constant, the same combustion-curve 2 3 would always result for a predetermined and fixed admission and cut-off and a predetermined or fixed highest compression in the cylinder C; but if under these conditions of admission and cut-off the curve of combustion is to be altered or varied then the pressure in the reservoir L must be changed. This change is effected by means of the pressure-regulating valve R, Fig. 3, the weight B of which can be shifted by means of the rod Q, suitably connected with the governor of the engine. (Not shown.) By the coöperation of the needle-valve *n*, which regulates fuel admission and cut-off and the adjustable excess of gas-pressure, the form of the working diagram is determined. In other words, both variations conjointly produce the variable form of the combustion-curve, distinctly marking the new method of regulating. Both can be effected by the governor, or one by the governor and the other by hand, according to the degree of sensitiveness required. The valve for regulating the pressure in the reservoir L may of course be of any other construction which will answer the purpose and may in the usual manner regulate the supply through the pipe *m*. The pressure regulation can also be applied, as desired, to the pump feeding the tube *m*. This latter method would be adopted should fluid fuel be exclusively used, in which case the reservoir L would act as the pressure vessel of the pump. The fuel-supply apparatus might be placed directly on the reservoir L, as the motion of the gas therein would keep the dust in suspension. The hopper T might also contain fluid fuel.

The mixture of fuel and gas may take place in the interior of the cylinder or a prolongation thereof, as shown in Fig. 4. In this case the reservoir L contains pure compressed air, and in addition to the nozzle D for pulverulent fuel I provide a nozzle *d* for liquid or gaseous fuel for the purpose of intensifying combustion. In this instance the nozzle *d* is arranged concentric with the nozzle D, the liquid or gaseous fuel being supplied to said nozzle *d* through the lateral pipe S′, while the air for combustion and the solid fuel are supplied to the nozzle D through the pipe S, leading from the reservoir.

The nozzles D and *d*, instead of being arranged concentrically, may be arranged side by side, as shown in Fig. 5, and caused to discharge into a common combustion-chamber J, forming a prolongation of the cylinder and separated from the bore proper of the same by a perforated partition *a*. The regulation may be rendered still more sensitive by changing the fixed point 2 of the diagram, for instance, to 2′ or 2^2, Fig. 2, thus varying at the same time the height of the ordinate 0 2, 0′ 2′, 0^2 2^2, &c., and the length 0 1, 0′ 1, 0^2 1, &c., as well as the expansion-curve 3 4, 3′ 4′, 3^2 4^2, &c. This regulation is easily effected by opening the fuel-valve *n* not when the piston is at the commencement of its return stroke, but somewhat later, in which case compression takes place from 1 to 2, Fig. 2, as before; but the compressed gas first expands on the return stroke from 2 to 2′ or 2 2^2, &c., before the commencement of the period of combustion 2′ 3′, 2^2 3^2, &c.

Of course in practice the lines of the diagram are not so regular as shown, but about as indicated in dotted lines between 2′ and 3′, Fig. 2. It is also evident that the lead may be given to the fuel-valve *n* on the compression stroke, whereby the upper end of the compression-line 2′ 2 is made steeper and the combustion-curve changed to 2^3 3^3, taking, under circumstances, even a form like $2^3 m$ 3^3. This lead of the valve may be effected by changing the position of the cam actuating said valve, so that the fuel will be introduced somewhat in advance of the end of the compression stroke of the piston and the valve kept open during part of the working stroke of the piston.

It is of particular importance that the fuel entering at the mouth should be thoroughly consumed and without the formation of soot. For this purpose all of the above-described devices for the admission of fuel may be provided within the cylinder with an additional burner similar in construction to those used for the same purpose for gas-burners—that is to say, the jet is not permitted to enter in solid cylindrical form, but is subdivided into thin sheets or jets. The construction may be similar to the Bunsen burner, which, as well known, gives a smokeless non-luminous

frame. Such burners, located within the compression-space, are shown in Figs. 6, 7, 11, 12, and 13.

Fig. 6 shows a burner which subdivides the flame into a large number of very small tongue-shaped slow-burning jets. M' and M² show other forms of the same. The principle of the Bunsen burner is embodied in M⁴ and M⁵, the jet leaving the lower end while burning slowly and without discoloration. A similar effect is produced by the use of the twyer M³.

The uniformity of diffusion of the heat throughout the whole mass of air in the compression-space is further increased by the peculiar arrangement of the burners—as, for instance, in Fig. 11, where owing to the lengthening of the twyer-pipe the burner is attached at E, so that while the piston is receding from I to II the greater part of the air is compelled to pass across the burner E. A second burner O may be provided.

Fig. 12 shows an arrangement for introducing the fuel laterally. The ribs R R on the left force the air on its way from the chamber to the cylinder and while expanding over the burners. The ribs R' R' to the right may be attached to the piston, so that the motion of the latter causes considerable agitation of the air. Finally, as shown in Fig. 13, the burner itself may be made movable for the purpose of obtaining more perfect distribution of heat. In this case the burner may be attached to the piston and the fuel supplied through a hollow piston-rod.

Figs. 6, 8, 9, and 10 show another way of carrying out the above-described method of regulation, the use of a special air-pump being dispensed with. In this instance the piston itself compresses the air necessary, not, however, in the usual way—by the momentum of the fly-wheel after cessation of combustion—but during the normal process of working without interrupting combustion and as an integral part of the working process itself.

In Figs. 6 and 8 the letter Y designates a valve through which during the regular working a small quantity of compressed air escapes at the end of each compressing stroke of the piston and passes by the tube *b*, Fig. 6, into the reservoir L. The air-pressure in the reservoir, therefore, equals the highest compression-pressure in the cylinder; but according to the previous description of the process an excess of pressure is required for the injection of the fuel. To obtain this result, the fuel-nozzle is not opened until the piston has slightly receded from the dead-point—that is to say, until the pressure in the cylinder has become somewhat lessened. As the opening of the nozzle by the governor occurs sooner or later, so the excess of pressure in the reservoir L varies. The injection of the fuel takes place, as previously described, S, Fig. 6, being the connecting-tube between the reservoir L and the nozzle, as in Fig. 3. The valve Y can also be arranged to be opened at the end of the stroke by the piston itself, or it might be a self-acting relief-valve, or for it might be substituted a cock or slide-valve.

Figs. 9 and 10 show the details of the gear for positively operating the valve Y. W is a cam-shaft provided with a number of cams I to V. Cam II works valve Y in normal working. Cam III works the fuel-valve for nozzle D, and cam IV operates the main valve V of the motor. This gear serves also in reverse order to start the motor, compressed air passing through valve Y from the reservoir L into the cylinder to drive the piston and then escapes through the valve V. During this very short starting period the lever H, Fig. 9, takes the dotted position II', so that the valve Y is moved by cam I instead of cam II, the valve V by cam IV instead of cam V, while the fuel-cam III is disengaged. After a few revolutions made in this manner the motor obtains its normal speed. At this moment the detent *p*, which retains the lever H in position, is removed. The lever is automatically pushed by spring F to the normal working position II, carrying with it the system of cams to continue the normal working without interruption. As the moving of the cams has to occur at the exact moment, it can only take place when a specially-arranged notch in the hub of the cams receives the detent *p*.

The valve Y (shown in Fig. 7) serves three purposes: first, to start the motor with compressed air; secondly, to fill the reservoir L during normal working, and, thirdly, to operate as a safety-valve, it being loaded by a spring *l*, so that on explosion in the cylinder the gases can pass to the reservoir L and thence through the safety-valve R.

To determine the maximum pressure in the cylinder, and consequently that in the reservoir L, a hand-wheel II² is applied, by means of which the spring *l* can be compressed more or less either while the engine is stopped or in motion.

It is evident that by adjusting the position of the cam III on the shaft W the time of opening of the fuel-supply valve can be varied—that is to say, by turning the cam either to the right or the left on the cam-shaft the time of admission will be made earlier or later. It is also evident that by interchanging cams a different timing of admission can be obtained.

What I claim as new is—

1. In an internal-combustion engine, the combination of a cylinder and piston constructed and arranged to compress air to a degree producing a temperature above the igniting-point of the fuel, a supply for compressed air or gas; a fuel-supply; a distributing-valve for fuel, a passage from the air-supply to the cylinder in communication with the fuel-distributing valve, an inlet to the cylinder in communication with the air-supply and with the fuel-valve, and a cut-off, substantially as described.

2. In an internal-combustion engine, the combination of a cylinder and piston constructed and arranged to compress air to a degree producing a temperature above the igniting-point of the fuel; a distributing-valve for fuel; a cut-off for varying the time and duration of the supply of fuel, and a burner placed in the combustion-space and constructed for slow and perfect combustion of the gradually-introduced stream of fuel, substantially as shown and described.

3. In an internal-combustion engine, the combination of a cylinder and piston constructed and arranged to compress air to a degree producing a temperature above the igniting-point of the fuel, a supply for compressed air or gas, a hopper, a distributing-valve for pulverulent fuel, a passage from the air-supply to the cylinder in communication with the fuel-distributing valve, an inlet-valve to the cylinder in communication with the air-supply and with the valve for pulverulent fuel, and a cut-off for the fuel-supply, substantially as shown and described.

4. In an internal slow-combustion engine, the combination of a cylinder and piston constructed and arranged to compress air to a degree producing a temperature above the igniting-point of the fuel, a supply for compressed air, a hopper and distributing-valve for pulverulent fuel, a supply-pipe for liquid fuel, a valve or valves leading to the cylinder and communicating with the pulverulent-fuel-distributing valve and the liquid-fuel-supply pipe, and a cut-off for the fuel-supply, substantially as specified.

5. In an internal-combustion engine, the combination of a supply for compressed air, a feed for pulverulent fuel placed in communication with the air-supply and with the cylinder, and an auxiliary feed for liquid fuel communicating with the cylinder, substantially as specified.

6. In an internal-combustion engine, the combination of a cylinder and piston, a supply for compressed air, a distributing-valve communicating with the air-supply and with a fuel-supply for gradually introducing a unitary, or mixed fuel, into the combustion-space, a valve placed between the air-supply and the cylinder, and a reversing-gear in cooperation with said valve for starting the motor with the compressed air from the air-supply, substantially as described.

7. In an internal-combustion engine, the combination with a cylinder and a piston constructed to compress air to a degree producing a temperature above the igniting-point of the fuel, of a fuel-feed, and a valve mechanism adapted to open the fuel-feed somewhat in advance of the end of the compression stroke of the piston and to keep it open during part of the working stroke, substantially as and for the purpose specified.

8. In an internal-combustion engine, the combination of a cylinder and piston constructed to compress air or a mixture of air and neutral gas, a storage-reservoir in communication with the combustion-space of the cylinder, a valve controlling this communication and opening to admit compressed air from the cylinder to the reservoir, and a fuel-feed in communication with said reservoir for the introduction of fuel to the combustion-space under the pressure of the compressed air or gas in the reservoir, substantially as described.

9. In an internal-combustion engine, the combination of a cylinder and piston constructed and arranged to compress air to a degree producing a temperature above the igniting-point of the fuel, a distributing-valve for fuel, and a cut-off for varying the time and duration of the supply of fuel by said valve, substantially as described.

In testimony that I claim the foregoing as my invention I have signed my name in presence of two witnesses.

RUDOLF DIESEL.

Witnesses:
WM. HAUPT,
CHR. KRÜGER.

United States Patent Office.

ALFRED NOBEL, OF HAMBURG, GERMANY, ASSIGNOR TO JULIUS BANDMANN, OF SAN FRANCISCO, CALIFORNIA.

Letters Patent No. 78,317, *dated May* 26, 1868.

IMPROVED EXPLOSIVE COMPOUND.

The Schedule referred to in these Letters Patent and making part of the same.

TO ALL WHOM IT MAY CONCERN:

Be it known that I, ALFRED NOBEL, of the city of Hamburg, Germany, have invented a new and useful Composition of Matter, to wit, an Explosive Powder;

The nature of the invention consists in forming out of two ingredients long known, viz, the explosive substance nitro-glycerine, and an inexplosive porous substance, hereafter specified, a composition which, without losing the great explosive power of nitro-glycerine, is very much altered as to its explosive and other properties, being far more safe and convenient for transportation, storage, and use, than nitro-glycerine.

In general terms, my invention consists in mixing with nitro-glycerine a substance which possesses a very great absorbent capacity, and which, at the same time, is free from any quality which will decompose, destroy, or injure the nitro-glycerine, or its explosiveness.

It is undoubtedly true, as a general rule, that nitro-glycerine, when mixed with another substance, possesses less concentration of power than when used alone; but while the safety of the miner (to prevent leakage into seams in the rock) prohibits the use of nitro-glycerine without cartridges, which latter must of course be somewhat less in diameter than the bore-holes which are to contain them, the powder herein described can be made to form a semi-pasty mass, which yields to the slightest pressure, and thus can be made to fill up the bore-hole entirely. Practically, therefore, the miner will have as much nitro-glycerine in the same height of bore-hole with this powder as with nitro-glycerine in its pure state.

This is the real character and purpose of my invention; and in order to enable others skilled in the art to which it appertains (or with which it is most nearly connected) to make, compound, and use the same, I will proceed to describe the same, and also the manner and process of making, compounding, and using it, in full, clear, and exact terms.

The substance which most fully meets the requirements above mentioned, so far as I know or have been able to ascertain from numerous experiments, is a certain kind of silicious earth or silicic acid, found in various parts of the globe, and known under the several names of silicious marl, tripoli, rotten-stone, &c. The particular variety of this material which is best for my compound is homogeneous, has a low specific gravity, great absorbent capacity, and is generally composed of the remains of *infusoria*.

So great is the absorbent capacity of this earth, that it will take up about three times its own weight of nitro-glycerine and still retain its powder-form, thus leaving the nitro-glycerine so compact and concentrated as to have very nearly its original explosive power; whereas, if another substance, having a less absorbent capacity, is used, a correspondingly less proportion of nitro-glycerine will be absorbed, and the powder be correspondingly weak or wholly inexplosive.

For example, most chalk will take but about fifteen per cent. of nitro-glycerine and retain its powder-form. Twenty per cent. will reduce it to a paste.

Porous charcoal has also a considerable absorbent capacity, but it has the defect of being itself a combustible material, and also of less elasticity of its particles, which renders it easy to squeeze out a part of its nitro-glycerine.

The two materials are combined in the following manner:

The earth, thoroughly dried and pulverized, is placed in a wooden vessel. To it is introduced the nitro-glycerine in a steady stream so small that the two ingredients can be kept thoroughly mixed.

The mixing may be effected by the naked hand, or by any proper wooden instrument used in the hand, or by wooden machinery

Sufficient of nitro-glycerine should be used to render the compound explosive, but not so much as to change its form of powder to a liquid or pasty consistency.

Practically, about sixty parts, by weight, of nitro-glycerine to forty of earth, forms the useful minimum,

and seventy-eight parts, by weight, of nitro-glycerine to twenty-two of earth, the useful maximum of explosive power. The former has a perfectly dry appearance, the latter is pasty.

Between these two extremes the composition will be explosive powder, and it will be more easily exploded, and its explosive power greater, as the relative proportion of the nitro-glycerine is greater.

The proportions, by weight, of seventy-five of nitro-glycerine to twenty-five of earth, gives a powder as well adapted to ordinary practical purposes as that from any proportions I am now able to name, and can be easily compressed to a specific gravity nearly equal to that of pure nitro-glycerine.

When the mass has been intimately mixed and thoroughly incorporated by stirring and kneading, it is rubbed through a hair, silk, or brass-wire sieve, (iron corrodes,) and any lumps which may remain are rubbed with a stiff-bristle brush till they are reduced and made to pass through the sieve.

The powder is then finished and ready for use.

The fineness desired for the powder will determine the fineness of the sieve to be used.

The chief characteristic of this powder is its nearly perfect exemption from liability to accidental or involuntary explosion.

It is far less sensitive than nitro-glycerine to concussion or percussion, and contained in its usual packing, (a wooden cask or box,) the latter may be smashed completely to pieces without any danger of an explosion.

Unlike gunpowder, in the open air or in ordinary packing, (a wooden cask or box,) it burns up, when set fire to, without exploding. It can, therefore, be handled, stored, and transported with less danger than ordinary gunpowder.

When confined in a tight and strong enclosure it explodes by heat applied in any form when above the temperature of 360° Fahrenheit. Under all other circumstances it may be exploded by some other explosion in it or into it.

The most simple and certain method known to me of exploding it is as follows:

The end of a common blasting-fuse is inserted into a percussion-cap, and the rim of the cap crimped tightly and firmly about the fuse by nippers, or other means, so as to leave the fulminating-powder of the cap and the end of the fuse tightly and firmly enclosed together. The end of the fuse, with the cap attached, is then embedded in the powder—the more firmly, the more certain the explosion.

In blasting, the powder is pressed tightly about the cap and fuse, and tamping, of sand or other proper material, added, and pressed but not pounded in. A tamping firmly pressed is as good as if rammed in the most solid manner.

The fuse explodes the cap, and this explosion explodes the powder.

I will add here that by carefully packing the end of a good fuse amidst the powder of a charge enclosed, like a blasting charge, in a tight place, the fuse alone will explode the powder, especially if the powder is strongly charged with nitro-glycerine. But this method of explosion requires too much care, and is too uncertain to be depended upon or generally used.

As before stated, the more strongly the powder is charged with nitro-glycerine the more easily it explodes. If, therefore, the powder contains a low proportion of nitro-glycerine, it is necessary to employ in its explosion a correspondingly long, strong, and heavily-charged percussion-cap, made especially for the purpose. For the sake of certainty of explosion it is better to use such a cap in all cases.

If the fire from the fuse comes in contact with the powder before the cap is exploded, which is liable to occur if the fuse is leaky and the cap extends too far into the powder, a portion of the powder will be burned before the explosion takes place. To guard against this, the cap should only be fairly inserted into the powder, and poor fuses wound next to the cap firmly with strong glued paper or hemp, or otherwise secured.

The bore-holes, as a practical but not absolute rule, should be about one-half the size, and the charge should be from one-fifth to one-tenth the quantity ordinarily used in gunpowder-blasting.

A very convenient form in which to use the powder is to pack it firmly in cartridges of strong paper.

Having thus described my invention, what I claim as new, and desire to secure by Letters Patent, is—

The composition of matter, made substantially of the ingredients and in the manner and for the purposes set forth.

ALFRED NOBEL.

Witnesses:

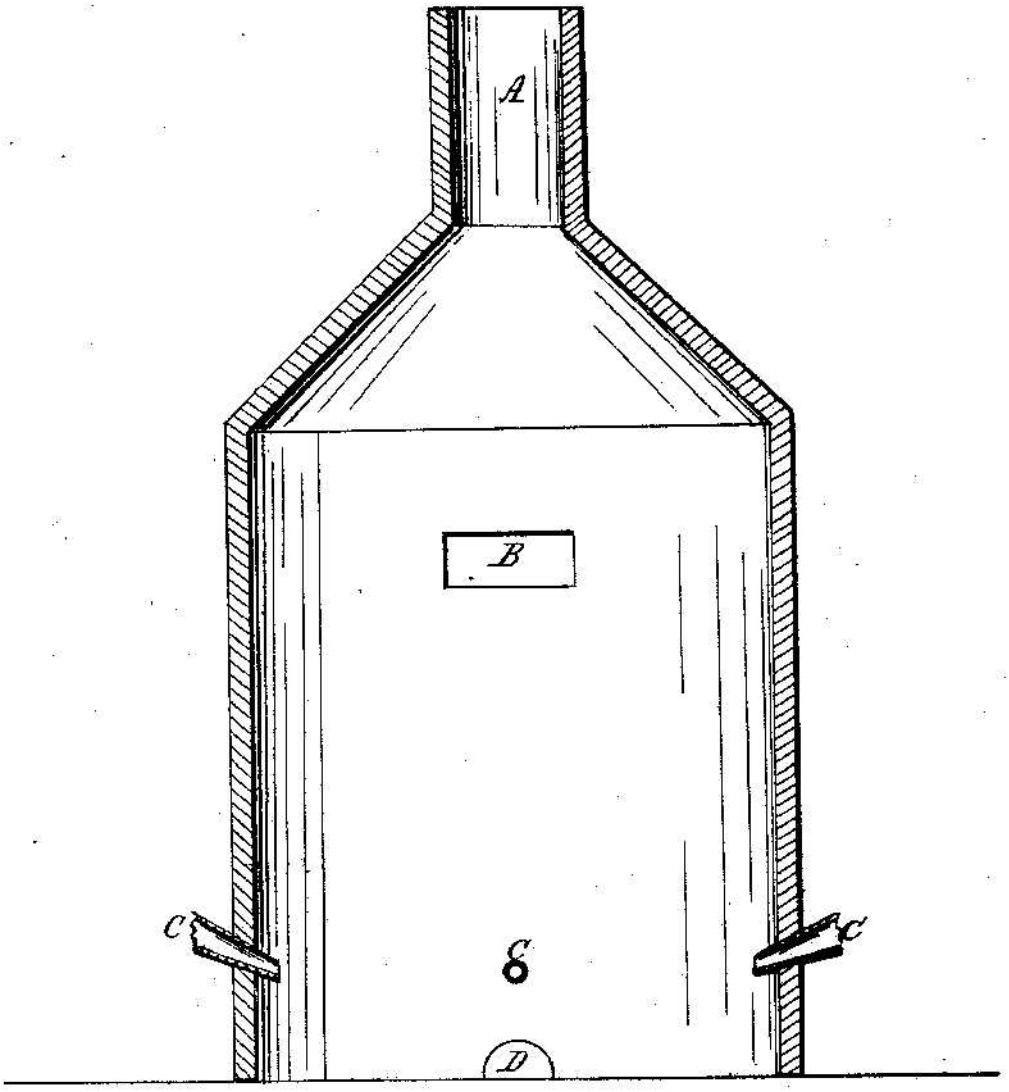
FR. T. PROHME,

HEINR. BARTELTSSEN

W. Kelly.

Manuf. of Iron & Steel.

No. 17,628. Patented June 23, 1857.



UNITED STATES PATENT OFFICE.

WILLIAM KELLY, OF LYON COUNTY, KENTUCKY.

IMPROVEMENT IN THE MANUFACTURE OF IRON.

Specification forming part of Letters Patent No. **17,628**, dated June 23, 1857.

To all whom it may concern:

Be it known that I, WILLIAM KELLY, of Lyon county, Kentucky, have discovered a new and Improved Method of Treating Iron, by which I am enabled to refine and decarbonize crude pig metal or iron in a fluid state without the use of fuel.

The nature of my invention consists in the discovery that the carbon mechanically combined with iron, and which is burned from the fuel while in the process of smelting in the blast-furnace, is of itself (the carbon) sufficient, when combined with the oxygen of the air, to create heat enough and of sufficient intensity to keep melted pig iron or metal in a fluid or lively state long enough to carry the metal through, without chilling, all the various manipulations of refining without the aid of any other heat than that obtained by the above-described chemical union of oxygen and carbon.

I am aware that it is well known that oxygen and carbon, when combined or brought together, produce heat; but it is not known that the amount of these chemical properties in air and iron is the required quantity necessary to produce heat sufficient to carry out the practical refining of crude pig-iron; hence the prevailing opinion among iron-workers that a blast of cold air driven into a body of liquid iron would chill it. Therefore, when iron is worked in the finery or run-out fire the presence of heat from other sources is deemed indispensable to prevent the chilling of the iron. The finery or run-out fire is usually open on three sides, sometimes closed except at top to receive the charge of coal and iron.

A furnace or cupola to work iron under my new process must be constructed as close as possible to prevent a loss of iron which would occur on account of its violent boiling, during which particles are thrown up and adhere to the sides and top of the chamber, but which during the process are remelted and flow down to the mass in the bottom. In the finery or run-out this loss is prevented by the iron being covered by fuel. It is also first charged with metal in a solid state. In my process the metal is taken in a fluid state from the blast-furnace and put in the cupola or furnace. In the finery or run-out the iron is brought to a fluid state by mixing it with large quantities of fuel, and when melted falls to the bottom of the finery, where it is decarbonized by strong blasts of air in connection with the fuel. In my process no fuel of any kind is used or required, as I rely exclusively on the heat created or generated by the chemical union of oxygen in the air and carbon in the iron.

In the accompanying drawings, Figure 1 represents a vertical section of cupola or furnace used in my process, being a close cylindrical chamber with a flue, A, at top to carry off the carbonic-acid gas formed in decarbonizing the iron.

B is a small opening to receive the charge of fluid iron.

C C C are the tuyeres placed around the sides of the furnace, pointing downward at an angle such that they sweep about three-quarters of the bottom of the chamber, the muzzles of the tuyeres being about six inches above the bottom of the chamber.

D is a tap-hole for letting out the metal when refined. The chamber should not exceed three or four times the space occupied by the fluid iron. The blast is first let on into this chamber or cupola; then the fluid iron is poured in, which, by the cause hereinbefore described, commences a violent ebullition or boiling, which continues until the iron is sufficiently refined, when the tap-hole is opened and the metal let out.

What I claim as my invention or discovery, and desire to secure by Letters Patent, is—

Blowing blasts of air, either hot or cold, up and through a mass of liquid iron, the oxygen in the air combining with the carbon in the iron, causing a greatly increased heat and boiling commotion in the fluid mass and decarbonizing and refining the iron.

WILLIAM KELLY.

Witnesses:

W. B. MACHEW,

JAS. N. GRACY.

P. LALLEMENT.

VELOCIPEDE.

No. 59,915. Patented Nov. 20, 1866.

Fig. 1.

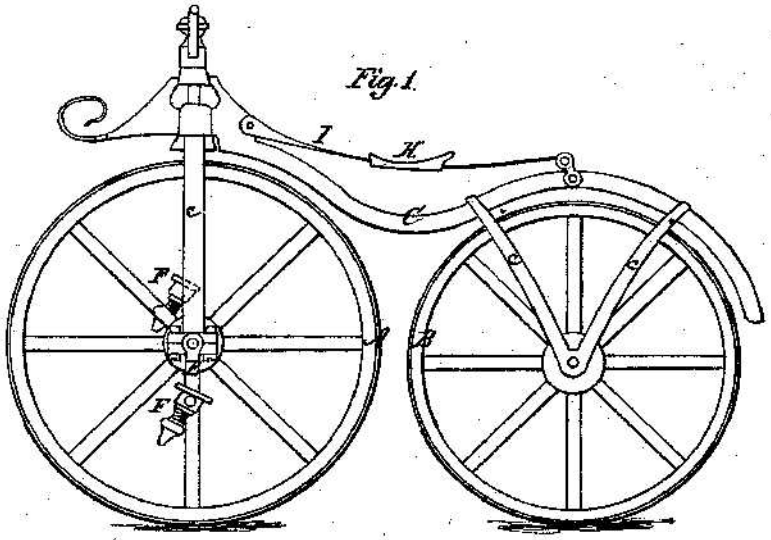


Fig. 2.

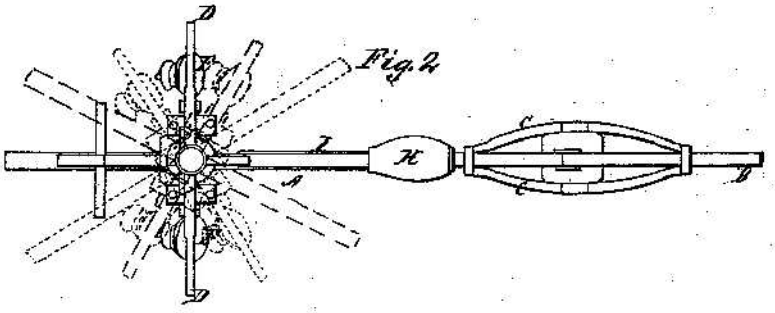
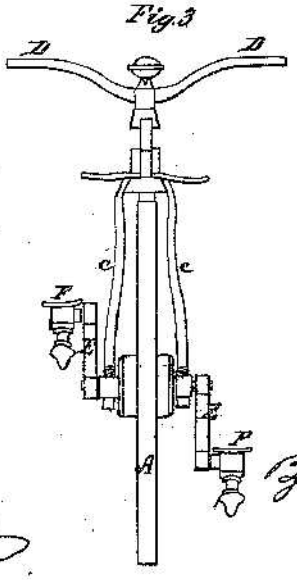


Fig. 3.



Witnesses
Alfred J. Libbits
John H. Shumway

Inventor.
Pierre Lallement
by his atty
John E. Earle

United States Patent Office.

PIERRE LALLEMENT, OF PARIS, FRANCE, ASSIGNOR TO HIMSELF AND JAMES CARROLL, OF NEW HAVEN, CONNECTICUT.

Letters Patent No. 59,915, *dated Nove*

IMPROVEMENT IN VELOCIPEDES.

The Schedule referred to in these Letters Patent and making part of the same

To all whom it may concern:

Be it known that I, PIERRE LALLEMENT, of Paris, temporarily residing at New Haven, in the county of New Haven, and State of Connecticut, have invented a new Improvement in Velocipedes; and I do hereby declare the following, when taken in connection with the accompanying drawings, and the letters of reference marked thereon, to be a full, clear, and exact description of the same, and which said drawings constitute part of this specification, and represent, in—

Figure 1, side view,

Figure 2, top view, and in

Figure 3, a front end view.

My invention consists in the arrangement of two wheels, the one directly in front of the other, combined with a mechanism for driving the wheels, and an arrangement for guiding; which arrangement also enables the rider to balance himself upon the two wheels.

To enable others to construct and operate my velocipede, I will proceed to describe the same, as illustrated in the accompanying drawings.

A and B are two wheels of common construction, each arranged upon separate axles, and placed, one directly in front of the other, as seen in figs. 1 and 2, the two connected together by a bar, C, passing over the two, as seen in fig. 1, with arms, *c*, extending down and supported on the axles of each wheel, as seen in fig. 3.

The arms of the forward wheel, A, are arranged upon a pivot on the bar C, so that, by means of handles, D D, the forward wheel may be turned to the right or left, as denoted in red and blue, fig. 2.

To the axle of the forward wheel A, I fix cranks E, to each of which I also fix a rocking-treadle, F, the same treadle being balanced by an extension below the crank-pin, so that the flat surface, as seen in fig. 3, will always be uppermost.

Above the bar C, and attached thereto in any convenient manner, I arrange a saddle-seat, H, upon a spring, I, as seen in figs. 1 and 2.

It is evident that, if left to its natural inclination, this carriage could not be made to stand upright. I will, therefore, proceed to describe how the carriage is put in motion, and, when in motion, an upright position maintained.

The rider, first setting the carriage upright, as in figs. 1 and 3, seats himself upon the saddle, in like manner as upon other carriages of this character, giving a forward movement to the carriage, either by his feet in contact with the earth or otherwise, immediately placing his feet, each, upon one of the treadles F, and each hand upon one of the guiding-arms, D, by his feet causing the forward wheel A to revolve, and by the hands guiding the carriage and maintaining his upright position.

If the carriage is inclined to lean to the right, turn the wheel as denoted in red, which throws the carriage over to the left; or, if inclined to the left, turn the wheel as denoted in blue.

Thus the carriage is maintained in an upright position, and driven with great velocity by means of the cranks in the forward wheel.

The greater the velocity, the more easily the upright position is maintained.

To turn the carriage either to the right or left, turn the guiding-wheel accordingly.

By this construction of a velocipede, after a little practice the rider is enabled to drive the same at an incredible velocity, with the greatest ease.

Having, therefore, thus fully described my invention,

What I claim as new and useful, and desire to secure by Letters Patent, is—

The combination and arrangement of the two wheels, A and B, provided with the treadles F, and the guiding-arms D, so as to operate substantially as and for the purpose herein set forth.

PIERRE LALLEMENT.

Witnesses:

JOHN E. EARL,

ALTSIE J. TIBBITS.

E. G. OTIS.

HOISTING APPARATUS.

No. 31,128. Patented Jan. 15, 1861.

Fig. 3

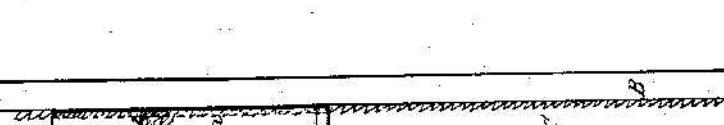
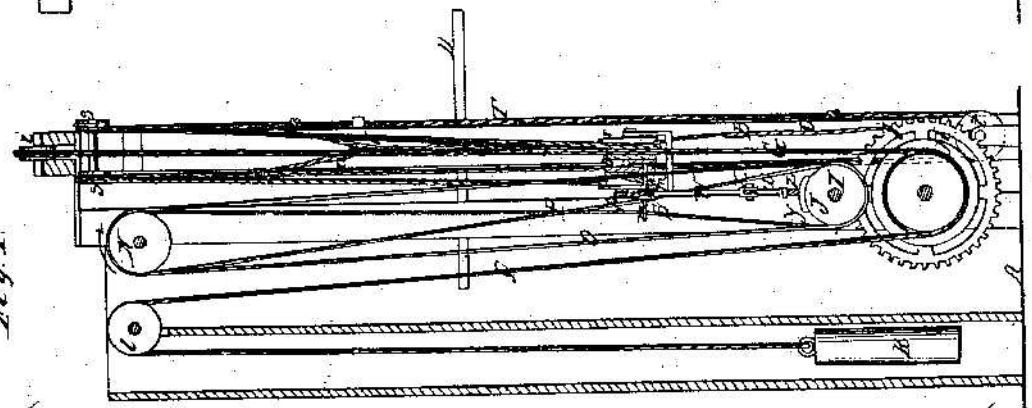


Fig. 2

Fig. 1



Witnesses.

Inventor.

E. G. Otis

UNITED STATES PATENT OFFICE.

E. G. OTIS, OF YONKERS, NEW YORK.

IMPROVEMENT IN HOISTING APPARATUS.

Specification forming part of Letters Patent No. **31,128**, dated January 15, 1861.

To all whom it may concern:

Be it known that I, E. G. OTIS, of Yonkers, in the county of Westchester and State of New York, have invented a new and Improved Hoisting Apparatus; and I do hereby declare that the following is a full, clear, and exact description of the same, reference being had to the annexed drawings, making a part of this specification, in which—

Figure 1 is a vertical section of my invention, taken in the line *x x*, Fig. 2; Fig. 2, a front view of the same; Fig. 3, a detached side view of the stop mechanism.

Similar letters of reference indicate corresponding parts in the several figures.

The object of this invention is to obtain a hoisting apparatus which may have its weight or load stopped at any desired point and a brake automatically and simultaneously applied with the stopping of the load or weight.

The invention also has for its object the sustaining of the load or weight in case of the breaking of the lifting-rope in such a way as to insure a certain effectual action or operation of the load-sustaining mechanism.

To enable those skilled in the art to fully understand and construct my invention, I will proceed to describe it.

A represents a base or platform, to which two uprights B B are secured, said uprights having each a rack C at its inner side. These racks C have teeth of hook form, or the teeth may be described as having an inclination upward, as shown clearly in Fig. 2.

Between the uprights B B a platform D is placed, the platform being secured to two uprights *a a*, which are grooved vertically to receive the racks C C. To each upright *a* a bent lever E is attached by a fulcrum-pin *b*, and the inner ends of the levers E E overlap each other and are fitted in an eye *c* at the lower end of a vertical bar F, which passes loosely through a rail or bar *d*, that connects the upper ends of the uprights *a a*. To the lower end of the bar F a spring *e* is attached, said spring having a tendency to keep the pawls *f*, which are attached to the lower ends of the levers E E, in gear with the racks C C. This will be fully understood by referring to Fig. 2, in which it will be seen that the pawls *f* are connected to the ends of the levers E by pivots, and have springs *g* attached, which springs have a tendency to keep the pawls pressed down into or between the teeth of the racks C. The pawls, it will be seen, fit or work in mortises *h* in the uprights *a a*. To the upper end of the bar F there is a rope G attached. This rope G passes over pulleys *i i*, and extending down is attached to a drum H, which is connected by gearing *j k* to a shaft I, having two idle-pulleys J K upon it and a working-pulley L between them.

The drum H and shaft I have their bearings attached to suitable uprights M M, and between these uprights there is placed a drum N, around which and the idle-pulleys J K belts O P pass, one of which P is a cross-belt. To the drum H a rope Q is attached. This rope winds on drum H in a contrary direction to the rope G, which is connected with the platform D. The rope Q passes upward over a pulley *l* and has a weight R attached to it, said weight serving as a counterpoise for the platform D.

The belts O P pass through eyes *m*, attached to the slide S, which forms a belt-shipper. This slide is fitted in suitable guides *n n* and has a rack *o* at one end, into which a pinion *p* gears. The pinion *p* is on a shaft *q*, which has a drum *r* placed on it, around which a rope T passes, said rope being secured to the drum *r* and wound around it in opposite directions. The rope T also passes over pulleys *s s* and down around a pulley *t* near the base A. To the portion of the rope T between the pulleys *s s* and *t* a rope U is attached by a branched end V, each part *u* of which is attached to a side of the rope T, as shown clearly in Fig. 3.

To the slide or belt-shipper S there is attached an arm W, the lower end of which is attached by a pivot to a bar X. This bar X is attached by a pivot *v* to one of the uprights M, and the bar X is provided with a pendent projection *w*, which bears on a bar Y, one end of which is attached by a pivot to one of the uprights M and the opposite end fitted in a guide *a'* on one of the uprights. To the bar Y at about its center a shoe Z is attached, which, when the bar Y is pressed downward, bears upon the working-pulley L.

The operation, which will be readily seen, is as follows: When the drum N is turned in the direction of the arrow and the belt P on the working-pulley L, the rope G will be wound on the drum H and the platform D

elevated, and in order to lower the platform the cross-belt P is moved on the working-pulley L, the belt O being moved on the idle-pulley J. The shifting of these belts is effected by actuating the rope T by hand, the movement of which turns the drum *r* so that the pinion *p* will, in consequence of gearing into the rack *o*, move the slide S. The rope U forms the stop, and when pulled down both parts *u u* of the branched end V of the rope U have their upper ends brought in the same horizontal plane, and the slide S will be so actuated that the belt O will be on the idle-pulley J and belt P on the idle-pulley K, the shoe Z being at the same time pressed down on the working-pulley L and serving as a brake. The branched end V of the rope U, it will be seen, actuates the rope T when the machine is in operation, but will have no effect on said rope when the brake is applied, as the upper ends of both parts *u u* of the end V will be in a horizontal line with each other. In order to raise the platform D, the rope T is moved by hand so as to throw the belt O on the working-pulley L, the shoe Z being simultaneously raised, and in order to reverse the movement of the platform D and allow it to descend, the rope T is moved so as to shift the cross-belt P on the working-pulley L.

In case the rope G should break in hoisting the loaded platform D, the pawls *f f*, in consequence of being released from the pull of said rope, will immediately be thrown in connection with the racks C C by the springs *e g g*, and in consequence of the teeth of the racks being of hook form or pointed upward the pawls *f f*, under the weight of the load on the platform, will have a tendency to draw the uprights B B toward each other instead of forcing them apart, and the pawls lock themselves with the racks, so that casual disengagement is impossible. By having the counterpoise R attached to the drum H instead of to the platform D the platform or load-sustaining mechanism is not at all interfered with, as would be the case were the rope Q attached directly to the cross-piece *d*. To one of the uprights *a* an arm $a^{\times}$ is attached, said arm having an eye at its outer end, through which the rope T passes, and said rope has a knot or projection $b^{\times}$ on it, against which the arm $a^{\times}$ acts when the platform reaches its lowest point of descent, and thereby throws the belt O off the working-pulley L and stops the descent of the platform, while the brake Z is simultaneously applied.

Having thus described my invention, what I claim as new, and desire to secure by Letters Patent, is—

1. Having the pawls *f f* and the teeth of the racks C C hook formed, essentially as shown, so that the weight of the platform will, in case of the breaking of the rope G, cause the pawls and teeth to lock together and prevent the contingency of a separation of the same, as herein set forth.

2. The arrangement of the ropes T, U, and V, combined and operating substantially as and for the purpose set forth.

3. The arrangement of the slide or belt-shipper S with the shoe or brake Z and rope T, substantially as shown, to admit of the simultaneous application of the brake and the shifting of the belts O P on the idle-pulleys J K, as set forth.

4. Attaching the rope Q of the counterpoise R to the drum H on the opposite side from the lifting-rope G, substantially as shown, so as to counterpoise the platform D without preventing or interfering with the action of the safety mechanism E *e f*.

E. G. OTIS.

Witnesses:
M. M. LIVINGSTON,
G. H. REED.

Aug. 26, 1930. P. T. FARNSWORTH 1,773,980

TELEVISION SYSTEM

Filed Jan. 7, 1927 4 Sheets-Sheet 1

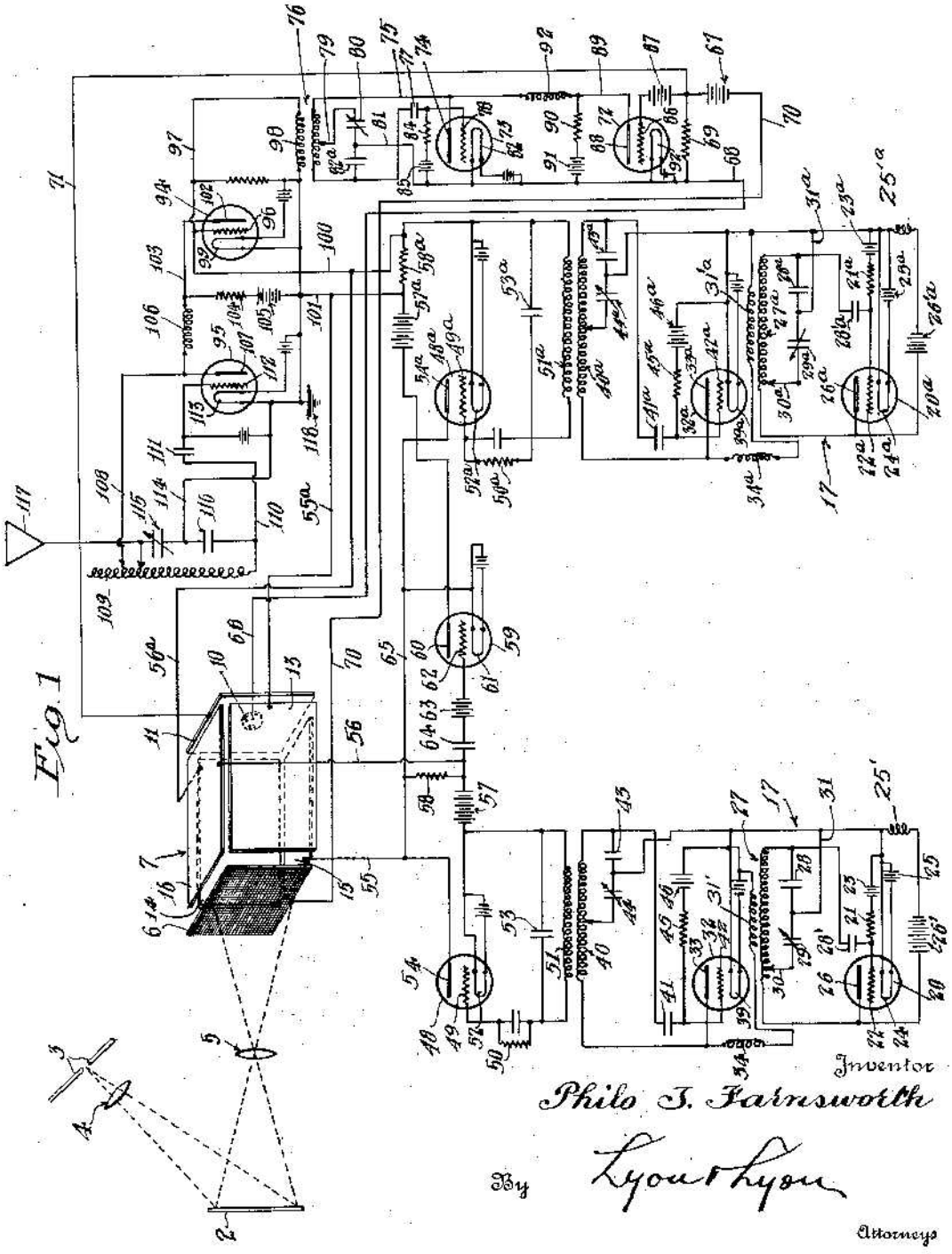


Fig. 1

Inventor

Philo T. Farnsworth

By Lyon & Lyon

Attorneys

Aug. 26, 1930. P. T. FARNSWORTH 1,773,980

TELEVISION SYSTEM

Filed Jan. 7, 1927 4 Sheets-Sheet 2

Fig. 2

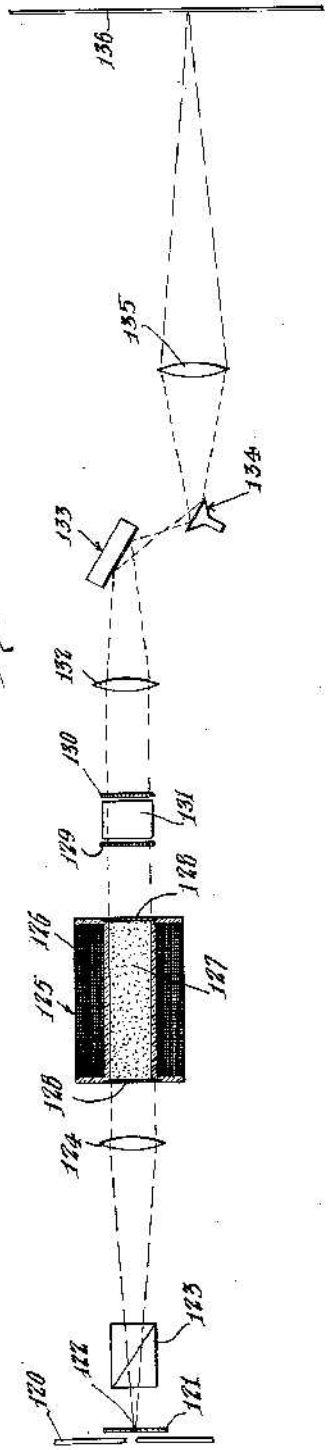
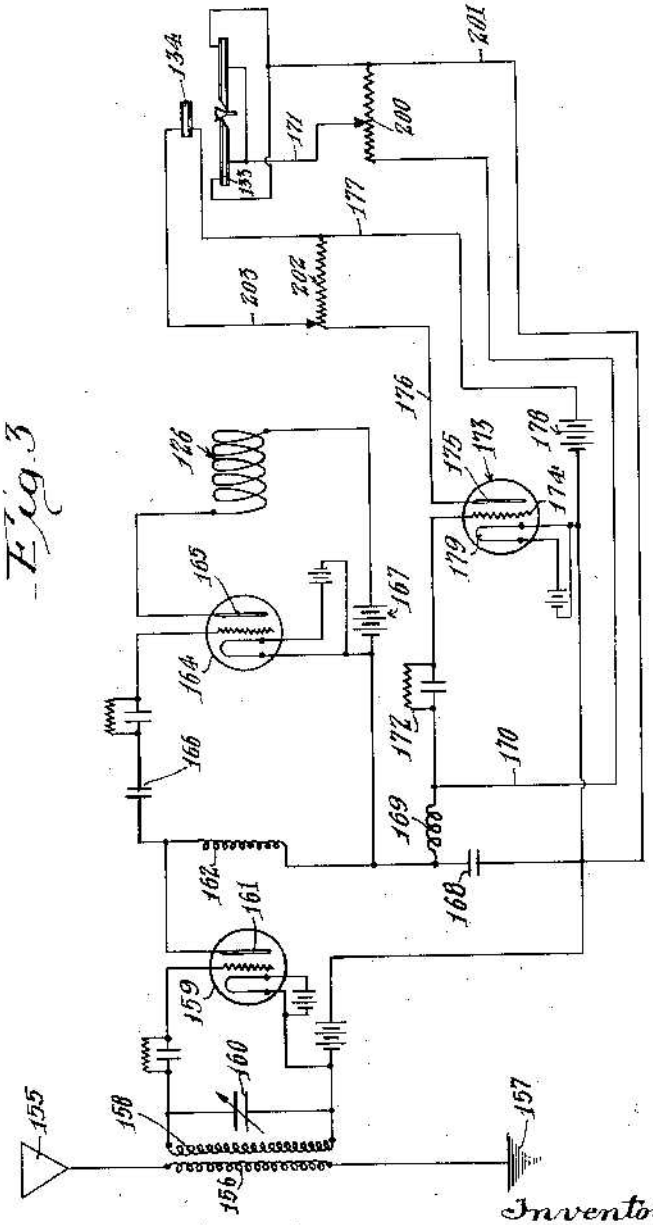


Fig. 3

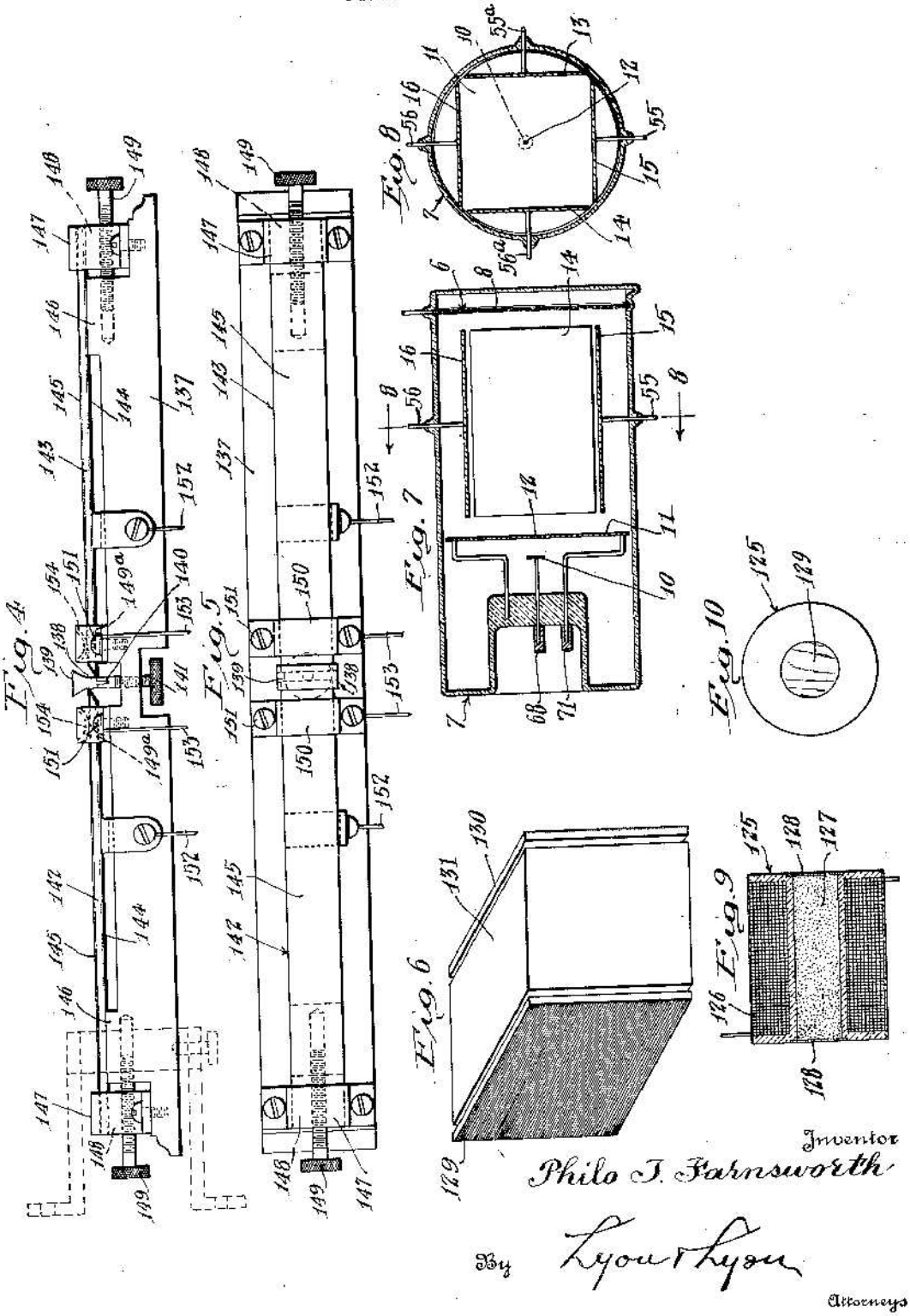


Inventor
Philo T. Farnsworth
By Lyon & Lyon Attorneys

Aug. 26, 1930. P. T. FARNSWORTH 1,773,980

TELEVISION SYSTEM

Filed Jan. 7, 1927 4 Sheets-Sheet 3



Inventor
Philo T. Farnsworth

By Lyon & Lyon

Attorneys

Aug. 26, 1930. P. T. FARNSWORTH 1,773,980

TELEVISION SYSTEM

Filed Jan. 7, 1927 4 Sheets-Sheet 4

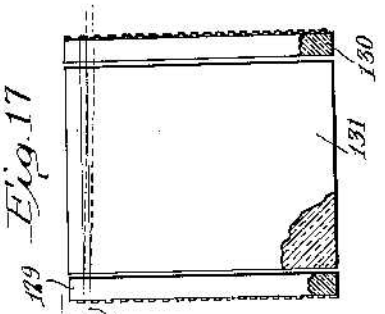


Fig. 17

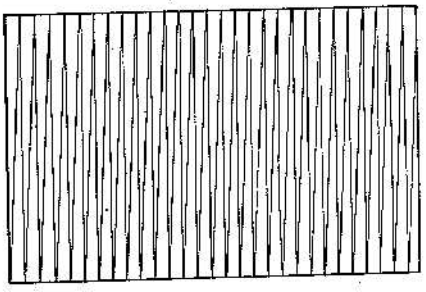


Fig. 14

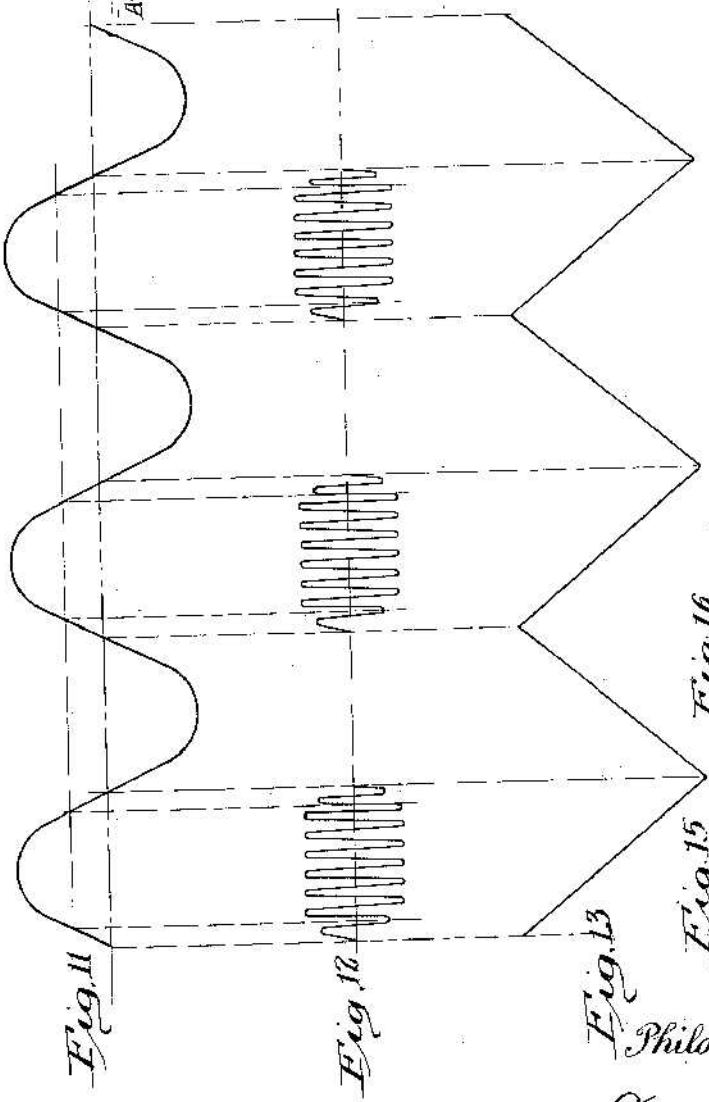


Fig. 11 Fig. 12 Fig. 13

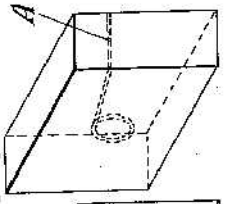


Fig. 16

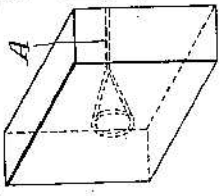


Fig. 15

Inventor
Philo T. Farnsworth

By Lyon & Lyon
Attorneys

Patented Aug. 26, 1930 1,773,980

UNITED STATES PATENT OFFICE

PHILO T. FARNSWORTH, OF BERKELEY, CALIFORNIA, ASSIGNOR, BY MESNE ASSIGNMENTS, TO TELEVISION LABORATORIES, INC., OF SAN FRANCISCO, CALIFORNIA, A CORPORATION OF CALIFORNIA

TELEVISION SYSTEM

Application filed January 7, 1927. Serial No. 159,540.

This invention relates to a television apparatus and process, that is, it is directed to an apparatus and process for the instantaneous transmission of a scene or moving image of an object located at a distance in which the transmission is by electricity.

Heretofore attempts have been made to transmit an image of an object by electricity so that the image of the object will instantaneously appear at a distance. These prior attempts at television have generally embodied an apparatus and method in which each particular elementary area of the image of the object is successively converted into an electrical current, the intensity of which is proportional to the intensity of the light at that particular elementary area; all the elementary areas of the image being covered in that fraction of a second during which the eye will retain a picture, hereafter referred to as the optical period. This is followed by a transmission of such current and a conversion of such current to light corresponding in intensity to the intensities of the light of the individual areas of the original image; the reconversion process likewise being performed within the optical period so that, by a proper coordination of the developed light, an image of the object to be transmitted appears as instantly formed at the receiving end of the apparatus and method.

The time during which the human eye will retain a picture is of such short duration that the conversion of the light shades of the original image of the object to electricity and the reconversion of said electricity to light and the proper coordination of such light must be performed at a very tremendous speed. All prior attempts at television have attempted to employ some mechanically moving part for dissecting the image of the original object during the process of forming an electrical current which varies in intensity in accordance with the light shades of the respective elementary areas of the image. None of these prior attempts at television have proven successful. They have resulted at best in the production of a crude moving silhouette of the object to be transmitted. This has generally been due to the fact that the mechanically moving parts of the prior apparatus have not been able to travel at the necessary speed requirements with the synchronism required in a television apparatus.

An object of the present invention is to provide a method and apparatus for television, which is adapted to transmit electrically a true moving image in full light shades of the object to be transmitted.

Another object of the present invention is to provide a method and apparatus for television in which the conversion and dissecting of the light shades of the object to be transmitted, to electricity and the reconversion of such electricity to form an image is accomplished in the following manner:

In the process and apparatus of the present invention, light from all portions of the object whose image is to be transmitted, is focused at one time upon a light sensitive plate of a photo-electrical cell to thereby develop an electronic discharge from said plate, in which each portion of the cross section of such electronic discharge will correspond in electrical intensity with the intensity of light imposed on that portion of the sensitive plate from which the electrical discharge originated. Such a discharge is herein termed an electrical image. An electrical shutter is then interposed between said sensitive plate and the anode of the photo-electrical cell, the shutter having a small aperture therein so that there can be received upon said anode at one instant, only the electrons which originate from one elementary area of the light sensitive plate. There is then imposed upon the electrical discharge a plurality of electrical potentials of different frequencies for causing the electrical discharge to bend in two directions, whereby the electrons from each elementary portion of the sensitive plate are successively directed through said shutter, this action taking place so as to completely cover the area of the sensitive plate within the optical period. The scene to be transmitted is thus analyzed or dissected to produce an electrical current or "light" current having variations in intensity in accordance with the light shades of the object to be transmitted and this is accomplished within the optical

period without the necessity of employing any mechanically moving parts.

The produced electrical current or "light" current may be transmitted to the receiving end of the apparatus by either wires or may be superimposed upon a wireless carrier wave. There is also transmitted at the same time and preferably superimposed upon the same carrier wave, the two electric potentials of different frequencies which are employed in analyzing the image so that such currents may be employed to synchronize the receiving apparatus and process.

At the receiving end of the apparatus and process, the "light" current is reconverted to light and the light coordinated to form an image of the object transmitted in accordance with the following apparatus and process.

Preferably a constant source of light is utilized which is directed, first, through a polarizing prism and hence through an apparatus or means by which the plane of polarization of the light may be rotated by the "light" current. In this manner an instantaneous response to the variations of such light current is obtained in the rotation of the plane of polarization of the light. The light is then directed through a suitable screen capable of shutting off the light in accordance with the rotation of its plane of polarization. In this manner, a beam of light is developed fluctuating in intensity to the variations of intensity of the "light" current transmitted without the necessity of employing any mechanically moving parts. This said beam of light is then projected by means of two cooperating oscillographs upon the screen where the image is to be transmitted, said oscillographs being operated by the synchronizing frequencies transmitted with the "light" current to correctly coordinate the light upon the screen to form a correct image.

The present invention, together with various objects and advantages thereof will best be understood from a description of a preferred form or example of a process and apparatus for television embodying the invention. For this purpose, I have hereinafter set forth one form of example of a method and apparatus for producing television in accordance with the present invention, and have illustrated said apparatus and method as it is adapted for television by wireless. It is to be understood, however, that the invention is capable of various and numerous modifications, changes, and substitutions, and is not necessarily limited to the transmission by wireless or radio.

The apparatus and method will best be understood from a description of the accompanying drawings, in which:

Figure 1 is a diagrammatic view of a complete television transmitter, including a circuit diagram therefor,

Figure 2 is a diagrammatic view of the television receiver,

Figure 3 is a circuit diagram of the electrical connections for the television receiver,

Figure 4 is an elevation of one of the oscillographs,

Figure 5 is a plan view of one of the oscillographs,

Figure 6 is a perspective view of the light diverting means,

Figure 7 is a sectional view of the photo-electric cell,

Figure 8 is a section on the line 8—8 of Figure 7,

Figure 9 is a section of the light rotator,

Figure 10 is an end view thereof,

Figure 11 is a representation of the form of electric current of the first oscillator employed in developing a potential for the photo-electric cell,

Figure 12 is a representation of the form of electric current produced in the second oscillator,

Figure 13 is a representation of the resulting straight lined potential,

Figure 14 is a view of the scanning path and also a view of the path of the light beam over the receiving screen,

Figure 15 is a perspective view of a bi-axial crystal showing the conical refraction of unpolarized light,

Figure 16 is a perspective view of a bi-axial crystal showing the refraction of polarized light, and,

Figure 17 is a diagrammatic illustration of the path of light through the gratings.

Referring to the drawings, 2 represents an object, an image of which is to be transmitted. Said object may be an actual scene or a photograph, a projection of a motion picture film, or any other object. The object 2 is preferably illuminated, for example, by means of an arc light 3 focused thereon by a lens 4. 5 indicates a lens for focusing an image of the object 2, upon the light sensitive plate 6 of a photo electric cell 7.

The photo-electric cell is preferably constructed as follows:

The light sensitive plate 6 or cathode of the cell is preferably made flat and is formed of a fine mesh screen 8, and said screen 8 is covered or coated with a light sensitive material such as sodium, potassium, or rubidium. 10 is the anode of the photo-electric cell positioned at the other end of the cell. Between the sensitive plate 6 and anode 10 and closely adjacent to anode 10 is placed an electric shutter 11 formed by a metallic plate in which there is a small aperture 12. Between the shutter 11 and light sensitive plate 6, four plates 13, 14, 15, and 16 are placed at right angles to each other and outside the path of electrons from the plate 6 to the shutter 11. Each opposed pair of the plates are connected to a source of electrical

potential of a different frequency. The photo-electric cell should be highly evacuated, such for example as to 10^{-7} cm. mercury to permit a high potential across the cell without ionization.

The necessity for employing a high potential across the cell arises from the fact that the photo electrons emitted from the cathode 6 have a small emission velocity which depends upon the color of the light causing their emission. This emission velocity is always small, of the order of that which an electron would acquire by falling through a volt or two, but it may have nearly any direction. This haphazard motion tends to distort the electric image and is only prevented from doing so by making the potential between the cathode 6 and the anode 10 high enough to insure that the time taken for an electron to traverse the distance between cathode 6 and anode 10 is so small that the small velocity transverse to this path produces no appreciable distortion. Hence the vacuum in the photo-electric cell 7 should be the highest obtainable.

The electrical potentials are provided by an oscillator 17, capable of developing two different high frequency electrical currents. Said oscillator 17 not only is required to provide a source of oscillating energy but is required to provide a form of oscillating energy, the wave form of which is composed of substantially straight lines, as will be hereinafter pointed out. Such a wave form is essential to accomplish a uniform lighting of all portions of the image which is to be produced.

The oscillator comprises a tri-electrode valve 20 connected in a circuit acting as an oscillator to produce an oscillating energy of low frequency, such for example as 10 cycles per second. It is understood that any customary or preferred form of circuit for this purpose may be employed, the particular circuit described being provided with a grid leak 21 connected with the grid 22 of the tube 20, and hence through a negative bias battery 23 to the filament 24. The filament 24 is indicated as heated by a battery 25. The plate 26 of the tube is connected through a battery 26′ and the choke coil 25′ to the filament 24. The plate 26 also connects through an inductance 27 and capacity 28′ with the grid. The inductance 27 is shunted by a fixed capacity 28 and a variable capacity 29 in series, one end of the series being connected to the end of the inductance 27 and the other end having a variable connection with said inductance. Between these capacities 28 and 29, a lead 31 is connected which connects with the filament 24 of the tube 20.

By this connection, the constants of the oscillating circuit may be any value of inductance and capacity to bring the oscillating circuit in resonance with the frequency of the desired circuit. Said oscillator in turn provides a source of potential for a second oscillating circuit of similar design, the second oscillator operating at a higher frequency such, for example, as 500 kilo-cycles. The second oscillator comprises the tube 32, the plate 33 of which is charged with the oscillatory energy of the first oscillator. The first oscillator is coupled thru the secondary coil 31′ to plate 33, the inductance 34 being included in series therewith. The inductance 34 may be any suitable radio frequency choke to prevent the high frequencies in the second oscillating circuit from being imposed on the first oscillating circuit. The plate 33 is connected through the primary 40 of a radio frequency transformer and hence through the capacity 41 with the grid 42. Capacities 43 and 44 are shunted around all or part of the primary 40 and a lead is connected from their midpoint to the filament 39 of the tube 32. The grid 42 of the tube is connected through a suitable leak 45 and negative bias battery 46 with filament 39. It is understood that the second oscillating circuit thus described is only one example of a circuit adapted for this purpose and the various constants of the circuit may be of any value suitable for bringing the circuit into resonance with the frequency of the oscillations (500 kilo-cycles) desired to be produced therein.

The voltage of the first oscillator is adjusted to be well above the value required for maximum plate current of the second oscillator. Hence, since the second oscillator will generate oscillations only when the plate voltage is positive, the current generated by the second oscillator will be similar to that shown in Figure 12. The harmonic oscillating current developed by the first oscillator is represented in Figure 11. This current, when imposed upon the second oscillator, develops a current such as illustrated in Figure 12, in which it will be seen that each positive cycle of the first harmonic current produces a series of harmonic oscillations in the second oscillator of substantially equal intensity, while during the negative period of the first harmonic current, substantially no oscillations are developed in the second oscillator.

The output from the second oscillator is then imposed upon an audion circuit having a tube 48 with its grid 49 connected by a line through the grid leak and grid condenser 50 to an inductance 51 inductively coupled to the inductance 40. Said secondary 51 is connected to the filament 52 of the audion 48. Shunted across the secondary 52 is a condenser 53 of value suitable to produce resonance with the oscillations developed in the second oscillator. The plate 54 and the audion 48 is connected by the lead 55 with the plate 15 of the photo-electric cell, and the opposed plate 16 of the photo-electric cell is connected by

a lead 56 through the battery 57 to the filament 52. The resistance 58 is shunted across the leads 55 and 56 to provide a potential for the plates 15 and 16.

The action of the audion circuit including the tube 48 is to produce an alternating current equal to the frequency developed in the first oscillator but the wave form of said frequency is of substantially straight lines such, for example, as indicated in Figure 13. In producing this wave form, the audion tube 48 operates due to the bias of the grid leak and condenser 50 to accumulate a charge during the passage of each wave train indicated in Figure 12, and such accumulated charge leaks off during the interval between successive trains, so that the output of the audion 40 into the plate circuit, indicated by the leads 55 and 56 (passing to the plates 15 and 16 of the photo-electric cells) assumes the straight line form of Figure 13.

There is also a duplicate form of audion circuit for supplying a similar wave form of electrical oscillations for the plates 13 and 14 of the photo-electric cell, said oscillations being, however, at a higher frequency such, for example, as 5000 cycles per second. Inasmuch as this circuit is identical except in value of constants to the circuit just described, the parts corresponding to those numbered 20 to 54 are numbered 20^a to 54^a. It is understood that the oscillating tube 20^a develops a harmonic oscillating current of 5000 cycles which will be imposed upon the oscillator including the tube 32^a, operating at 500 kilo-cycles producing a straight line alternating current in tube 48^a of a frequency of 5000 cycles per second. The output from tube 48^a to the plates 13 and 14 is from filament 52^a, through resistance 58^a, battery 57^a, and hence through a modulating tube 59 through the plate 60 thereof, and to the filament 61 thereof, and hence to the plate 54^a of the tube 48^a. The potential drop across resistance 58^a is utilized to provide the potential for plates 13 and 14 through leads 55^a and 56^a. The modulated tube 59 has its grid 62 connected through the negative bias battery 63 and condenser 64 with lead 56 while the filament 61 is connected to lead 65 with the lead 55. In this way, the tube 61 acts to modulate the low frequency from the first oscillator circuit upon the higher frequency of the second oscillating circuit.

The potential for the photo-electric cell is provided by a battery 67. The negative terminal of the battery 67 is connected by a line 70 with the light sensitive plate 6 of the photo-electric cell and the positive terminal of the battery 67 is connected through a resistance 69 to a lead 68 connecting with the anode 10 of the photo-electric cell. The battery 67 has preferably a high potential, such as the order of 1000 volts and the resistance 69 is of high resistance such, for example, as one megohm, in order that the drop across such resistance induced by the fluctuations of light in the photo-electric cell may be amplified before being transmitted. The shutter 11 of the photo-electric cell is connected by line 71 to the positive terminal of the battery 67 between the resistance 69 and the battery 67 so that it operates at the same potential as the anode 10 of the cell but its current supply does not pass through the resistance 69.

The effect of the potential applied to the plates 13 and 14 is to cause the electric discharge from the light sensitive plate 6 to be bent back and forth between the plates 13 and 14 at a frequency corresponding to the frequency of the electric potential imposed on the plates 13 and 14 (for example, 10 cycles per second). The effect of the potential applied to the plates 15 and 16 is to cause the electric discharge from the light sensitive plate to be bent back and forth between the plates 15 and 16 at a frequency corresponding to the frequency of the electric potential imposed on the plates 13 and 14, (for example, 5000 cycles per second). The resulting effect is the same as if the opening 12 of the shutter 11 was mechanically moved over the light sensitive plate in accordance with the line shown in Figure 14, in which the substantially parallel lines indicate the movement caused by the potential on the plates 15 and 16. The oscillations of the electric discharge in the direction at right angles to the lines of Figure 14 is caused by the potential on plates 13 and 14, causing the image on the plate 6 to be traversed once every 1/20th of a second with a 10 cycle per second potential. During this period of time, the 5000 cycle per second frequency imposed on plates 15 and 16 will have caused five hundred passages across the image as contrasted with the other television attempts which have succeeded in securing only about thirty-five lines across the image during the optical period. Moreover, it is understood that the frequencies imposed on the plates 13 to 16 inclusive may be increased without limit (up to at least ten thousand kilo-cycles per second), giving any desired number of passages over the image within the optical period, or to make the optical period as short as desired.

There will now be described the apparatus utilized for amplifying the light current and for transmitting such current on a wireless carrier wave, together with the two analyzing oscillator currents or potentials employed on the plates 13 to 16 inclusive, of the photo-electric cell. The transmitting means comprises the tube 72, said tube operating both as an amplifier of the light current and as a modulator of a further tube 73; it being illustrated as in a Heising modulating circuit. The tube 73 produces a first carrier wave of suitable frequency such, for example, as of

about 500 kilo-cycles. For this purpose, the tube is illustrated as having its plate 74 connected by lead 75 with an inductance 76, the opposite end of which is connected through the condenser 77 to the grid 78 of the tube.

The inductance 76 is tapped in the center by a variable tap 79 which connects to a variable condenser 80 and hence by a line 81 to the filament 82. The condenser 80 and the coil 76 may have any values provided that the condenser 80 and the inductance 76 are adapted to bring the circuit in resonance with the carrier wave to be produced. The line 81 is also connected with the line 77 by a condenser 82^a. The grid 78 is also connected with the filament 82 through a grid leak 84 and negative battery 85. The potential for the tube 73 is provided by the battery 91, through the resistance or choke 90. The tube 72 acts as a variable resistance across 90 and 91, increasing or decreasing the potential drop and thereby modulating the potential on plate 74 of the tube 73. The tube 72 has its grid 86 connected by a negative bias battery 87 with the resistance 69, across which there is imposed the "light" potential whereby said "light" potential is amplified in the tube 73. The plate 88 of the amplifying and modulating tube 72 is connected by a line 89 through a choke or resistance 90 and a battery 91, the negative side of which is connected with the filament 92 of the tube 72 and also with the filament 82 of the oscillating tube 73.

The choke 90 operates to fluctuate the potential supply to the plate of the oscillating tube in accordance with the amplified light current. In the lead between the choke 90 and plate 74 is provided a choke 92 which prevents the carrier wave produced in the oscillator 73 from being imposed upon the amplifying and modulating tube 72 by the circuit thus described. The carrier wave produced in the oscillator 73 is modulated by the amplified light current. This potential is then imposed upon a double modulating tube 94 which operates to modulate an oscillator 95 producing a second carrier wave of higher frequency, such for example as 1500 kilo-cycles, or the wave length to be transmitted.

Said double modulator tube 94 not only modulates the second carrier wave with the modulated first carrier wave from oscillator 73, but also modulates said carrier wave with the analyzing potentials from the modulator tube 59. The double modulating tube 94 has its grid 96 connected by lead 97 with a coil 98, the coil 98 being connected to the filament 99 of the double modulating tube. By this means, the output from the oscillator 73 is imposed upon the double modulating grid. The analyzing potentials are imposed upon the grid 96 by a lead 100 which connects across the resistance 58^a and hence by a lead 101 to the filament 99. The tube 94 is part of a Heising modulator that has its plate 102 connected by a lead 103 through a radio frequency choke or resistance 104 to the positive terminal of battery 105, the negative terminal of which is connected with the filament 99. The lead 103 also connects with the radio frequency choke 106 to the plate 107 of the oscillator tube 95. The choke 106 prevents the second carrier wave from being imposed upon the double modulating tube 94 while the choke or resistance 104 fluctuates the potential supply to the plate 107 of the oscillator 95 in accordance with the output of the double modulating tube 94. The plate 107 connects with the lead 108 to an inductance 109 producing the second carrier wave, said inductance being connected with the lead 110 through condenser 111 with the grid 112 of the oscillator tube 95. The filament 113 of the tube is connected by lead 114 through a variable condenser 115 to the inductance 109. There is also a condenser 116 between the lead 114 and the grid leak 110. The inductance is also connected with an antenna 117 or other means for radiating the output from the transmitter. The filament 113 is grounded as indicated at 118.

The receiver of the television apparatus and process is constructed and operates as follows: Preferably there is employed a source of light of constant intensity, such as an arc light 120 and to obtain a pencil of light therefrom, there is placed a shutter 121 with a small aperture 122 in front of the arc light. The light from said shutter is then passed through a polarizer 123. The polarizer is indicated as preferably in the form of a Nicol prism. The polarized light from the Nicol prism 123 is then passed through a lens 124 which parallels the polarized light and the paralleled light is then passed through a device 125 for rotating the plane of the polarized light. The device 125 may be any device suitable for rotating the plane of the polarized light in accordance with the fluctuations of the light current received at the receiver. The method of receiving and separating this light current from the transmitted wave will be hereinafter pointed out. The preferred form of such device is illustrated as comprising a means for producing a magnetic field fluctuating in accordance with the light current, such as the coil 126, surrounding an electrically optically active medium 127, such for example as a thin film of iron, cobalt, or nickel, or carbon disulfide, glass, or any other material in which a beam of polarized light rotates considerably when subjected to a magnetic field. I prefer to employ carbon disulfide and said carbon disulfide is held in the core of the coil 126 by glass plates 128.

The light from the light rotator 125 is then passed through a device adapted for restrict-

ing the passage of light in accordance with its degree of rotation. I preferably employ a combination of a pair of gratings 129 and 130 and a bi-axial crystal 131. The gratings 129 and 130 may be any usual form of light gratings, for example, ruled upon a silvered transparent surface, and are placed at opposite ends or sides of the bi-axial crystal with their gratings opposed. The bi-axial crystal employed between the gratings is adapted to produce a conical refraction of the light. As an example of a suitable crystal of this kind, I have employed a crystal of arragonite one centimeter thick between the gratings ruled with 100 lines per millimeter. With this combination, the rotation between complete extinction and complete restoration is of the order of two degrees. Thus with this analyzer, very small currents may be employed upon the rotator, permitting the use of a coil of very high natural period.

The operation of this analyzer will best be understood from Figures 15, 16 and 17, in which Figures 15, 16 and 17 there is disclosed how a rotation of a few degrees will change complete extinction to complete restoration. A indicates a beam of light passing through the first grating 129 and hence through the bi-axial crystal 131 to the second grating 130, the lines of which are opposed to the lines of the grating 129. If the beam of light passes directly through the bi-axial crystal, it is completely extinguished by the lines of the grating 130 but if the plane of polarization of the beam A is rotated slightly, the ray A will take the direction of the dotted lines through the crystal and pass between the lines of the grating 130, a slight difference in refraction of the light in the bi-axial crystal 131 being sufficient for this purpose.

In explanation of the action of the bi-axial crystal 131, it is understood that the light is directed on said crystal along one of its optic axes. When this is done, the light is refracted to an extent depending on the position of the plane of polarization. When unpolarized light from an aperture is directed on such a crystal along one of its axes, said light will appear as a circle from the other side of the crystal, but when a beam of polarized light is directed along one of the axes of the crystal, it appears as a point of light lying in the circle produced by the unpolarized light, but its position is dependent on the position of the plane of polarization of the beam of light. A 90 degree rotation of the plane of polarization of the beam of light will rotate the light from the crystal from one side of the circle 8 to the opposite side. The two extreme positions of a polarized beam of light are indicated in Figure 15, by the two branches of the beam of light A. During the passage of the light through the bi-axial crystal, the wave front of the beam of light remains parallel and the wave front of the beam passes through perpendicularly to the optic axis of the crystal.

By means of the polarizer 123, light rotator 125, and analyzer comprising the gratings 129 and 130 and the bi-axial crystal 131, the constant supply of light through arc light 120 is caused to produce a light of varying intensity, varying in accordance with the intensity of the light current supplied to the coil 126. Thereby, without the employment of any mechanical moving apparatus, the light current is reconverted into light.

Such light is then passed through a lens 132 by which it is focused upon a pair of cooperating oscillographs 133 and 134. Said cooperating oscillographs 133 and 134 are positioned at right angles one to the other and so that the light from one strikes the other oscillograph. Said oscillographs are operated at different frequencies with the result that the light is by said oscillographs projected in horizontal vibrations, which are successively lowered or raised vertically so that the light can pass through a lens 135 upon a screen 136 and covers successively an entire rectangular area of said screen. The oscillographs 133 and 134 are operated by electrical currents of the frequencies of the two analyzer currents applied to the plates 13 to 16 of the photo-electric cell so that the passage of the beam of light over the screen 136 is in synchronism with the bending of the electrical discharge from the sensitive plate 6 of the photo-electric cell and thereby each portion of light is properly coordinated to produce a correct image of the object being transmitted.

The details of the construction of the oscillographs 133 and 134 are shown in Figures 4 and 5, only one of the oscillographs being illustrated since they are of similar construction. The oscillographs comprise a base or body 137 of any suitable material. In the center thereof, is mounted a quartz strip 138 having a silvered mirror surface 139 at its top. Said quartz strip vibrator 138 is held in a holder 140 which is vertically adjustable by a set-screw 141. The quartz strip vibrator is engaged at opposite sides and at points spaced apart slightly vertically by a pair of quartz strips 142 and 143 laid horizontally and plated at the tops and bottoms by a metallic plating, such as copper, as indicated at 144 and 145. The outer ends of such quartz strips 142 and 143 engage guides 146 on the body, and hence engage clamps 147 by which they are held to carriers 148. The clamps 147 are connected by adjusting screws 149 to the body 137 by means of which the quartz strips 142 and 143 may have their pressure against the quartz strip vibrator 138 adjusted. At the inner ends of the quartz strips 142 and 143 are placed rests 149ª over which are placed a resilient material, such as rubber, and thereabove is placed a further quantity of rubber.

Clamps 150 are placed over the top of the inner ends of the quartz strips and connected with adjusting screws 151 by means of which the vertical positions of the ends of the quartz strips may be adjusted. It is understood that in the showing of Figures 4 and 5, the quartz strips are greatly exaggerated in thickness inasmuch as in practice such strips are very thin, approximating the thickness of a sheet of paper, and are cut with their thickness in the direction of the electric axis, their length in the direction of the axis of extension and their width along the optic axis of the crystal. The bottom sides of the strips 142 and 143 are connected by conductors 152 while the top plating on the strips is connected by conductors 153 connected with springs 154 at the top of the clamps 150.

Referring to Figure 3, the electrical apparatus for receiving the transmitted wave in the transmitter and correctly applying the light current and analyzing currents to the light rotator 125 and oscillographs 133 and 134 is as follows: 155 indicates a receiving antenna or other means for collecting wireless waves which antenna is connected through an inductance 156 to a ground indicated at 157. Inductance 156 forms a primary of a transformer in which the secondary 158 is in the grid circuit of a detector 159. 160 indicates a tuning condenser for bringing the receiver in resonance with the carrier wave of the transmitter. The plate 161 is indicated as connected to a plurality of filters, the first of which comprises the inductance 162, the voltage across which is applied to the grid of a second detector 164. The first filter comprising the inductance 162 should be in resonance with the first carrier wave developed in the transmitter or tube 159 thereof. There is thus imposed upon the grid of a detector tube 164 a current comprising the light current modulated upon the first carrier wave formed in the transmitter. In the detector 164, such carrier wave is detected to produce a current output from the plate 165, which is equivalent to the light current developed in the transmitter. In the second detector circuit 164, 166 indicates a condenser for passing the high frequency and blocking the low frequency currents, and 167 indicates a battery for supplying the plate potential. The plate 165 is indicated as connected with the coil 126 of the light rotator.

The complete circuit of the detector tube 159 also includes a condenser 168 of a capacity suitable for by-passing the high frequency of the first carrier wave which is detected by the tube 164 and of a capacity to block the frequency of the analyzing currents. Such analyzing currents are therefrom passed through a choke 169 and line 170 to one of the oscillographs 133, connecting for example with the top platings of both of the quartz strips thereof, the bottom plating of the quartz strips of said oscillographs 133 being connected by a line 171 with a resistance 200 shunted across line 170, and line 201 which line connects with the opposite side of the condenser 168. By this connection, the oscillograph 133 is operated by the higher analyzing frequency, i. e., the 500 cycles per second frequency. Said frequency also passes through the grid leak 172 to a grid 174 of a detector tube 173 wherein said frequency is detected to deliver from its plate 175 a potential of the frequency of the first analyzing current, or 10 cycles per second. The plate 175 is indicated as connected by the line 176 to the resistance 202 which is connected by a tap 203 to the top plating of the oscillograph 134 and the bottom plating of the oscillograph 134 is indicated as connected by line 177 through the battery 178 to the filament 179 of the detector 173. The filament 179 is also connected by the lead 180 with the condenser 168. The resistance 200 and 202 provide a means for controlling the potential of the currents applied to the oscillographs.

It will be readily apparent from the description of the apparatus and operation thereof, how the detected light current imposed upon the coil 126 modulates the light in accordance with the intensity of light at the particular point from which said light current originated from the light sensitive plate 6. It will also be seen that said light is projected upon the screen 136 by the oscillations of the oscillographs 133 and 134 to form a correct image of the object transmitted, the light being caused to travel back and forth across the screen similar to the action of the shutter 11 of the transmitter, making the example given 500 reciprocations across the screen in covering the complete area thereof, and said reciprocations are made within a period of 1/20th of a second. It is understood, however, that the process and apparatus of the present invention is not necessarily limited to the use of the particular frequencies given for the purpose of facilitating the description of a preferred process and apparatus.

The process and apparatus of the present invention permit the selection of such small elementary areas of the image to be transmitted that the produced image on the screen 136 follows all of the light shades of the object, producing a correct image thereof. This is accomplished without the employment of mechanically moving parts, excepting the vibrating strips of the oscillographs. The apparatus is thus free from mechanical problems.

While the process and apparatus for producing television herein described is well adapted for carrying out the objects of the present invention, it is understood that various modifications and changes may be made without departing from the invention, and

the invention includes all such modifications and changes as come within the scope of the following appended claims.

I claim:

1. The method of television which includes forming an electrical image, and traversing each elementary area of the electrical image by an electric shutter at a velocity sufficient to cover the entire image within the optical period.

2. The process of television which comprises forming an electrical image, moving said electrical image in more than one direction by an analyzing potential, and varying the intensity of an electric current in accordance with the position of the electrical image.

3. The method of television which comprises focusing an image of an object upon the sensitive plate of a photo-electric cell, imposing a shutter in the path of the electrical discharge from said plate, and forming transverse to the electrical discharge two electrical potentials of different frequencies.

4. An apparatus for picture dissecting comprising a cell having a plate of photo sensitive material, an anode, a plurality of plates positioned between the photo sensitive plate and anode, and means for imposing upon said plates a plurality of electrical potentials of different frequencies.

5. An apparatus for dissecting an image comprising a cell having a photo sensitive plate, an anode, a shutter between the anode and plate, and electrical means for bending the electrical discharge from said plate.

6. The method of television which comprises forming an electrical discharge which corresponds in cross section in electrical intensity to the light intensity of an image to be transmitted, transmitting successive portions of said electric discharge, and modulating light thereby.

7. A method of television which comprises analyzing an image into elementary areas, producing a train of energy varying according to the intensity of light of said areas, all of the elementary areas being covered within the optical period, causing said train of energy to modulate a source of light of constant intensity according to the light of said areas, and correlating successive portions of said light to reform said image, said latter operation being completed within the optical period.

8. A method of television which comprises producing an electrical oscillation having a substantially straight line wave form, utilizing said electrical potential to analyze an image into elementary areas, producing a train of energy varying according to the intensity of light of said areas, and converting said train of energy into light varying according to the light of said areas.

9. A method of television which comprises producing an electrical oscillation having a substantially straight line wave form, utilizing said electrical potential to analyze an image into elementary areas, producing a train of energy varying according to the intensity of light of said areas, converting said train of energy into light varying according to the light of said areas, and utilizing said electric potential of substantially straight line wave form to correlate successive portions of said light.

10. A method of television which comprises producing two electrical potentials of different frequencies, each of said electrical potentials having substantially straight line wave forms, causing said electrical potentials to analyze an image into elementary areas, producing a train of energy varying according to the intensity of light of said areas, and converting said train of energy into light varying according to the light of said areas.

11. A method of television which comprises producing two electrical potentials of different frequencies, each of said electrical potentials having substantially straight line wave forms, causing said electrical potentials to analyze an image into elementary areas, producing a train of energy varying according to the intensity of light of said areas, converting said train of energy into light varying according to the light of said areas, and causing said electrical potentials of different frequencies to correlate successive portions of said light to reform said image.

12. In a system of television, analyzing an image into elementary areas by causing a scanning device to scan all elements of said image successively at a substantially uniform velocity, over a continuous path reciprocating transversely of the image and the reciprocations having a slow motion transverse thereto.

13. A method of television which comprises forming an electrical image, moving the image in two directions over an electrical shutter having a small aperture, thus forming an electrical current which is a function of the intensity of the portion of the electrical image at said aperture.

14. A method of television which comprises forming an electrical image, impressing upon said image two electrical potentials of different frequencies, thereby causing said image to move in two directions respecting an electrical shutter and forming an electric current from the portion of the electrical image registered with the electrical shutter.

15. An apparatus for television which comprises means for forming an electrical image, and means for scanning each elementary area of the electrical image, and means for producing a train of electrical energy in accordance with the intensity of the elementary area of the electrical image being scanned.

16. An apparatus for television which comprises means for forming an electric image,

means for moving said electric image in more than one direction by an analyzing potential, and means for varying the intensity of an electrical current in accordance with the position of the electrical image.

17. An apparatus for television which comprises means for focusing an image of an object upon the sensitive plate of a photo-electric cell, said photo-electric cell having an anode therein to receive an electrical discharge from said plate, said cell having a shutter in the path of the electrical discharge from the sensitive plate, said cell having plates positioned transverse to the electrical discharge, and means for imposing upon said plates electrical potentials of different frequencies.

18. An apparatus of the class described, including an oscillator, an oscillator of higher frequency operated by the oscillations from the first oscillator, thereby producing successive trains of oscillations during the positive cycle of oscillations of the first oscillator, a device for accumulating and discharging said oscillations thereby producing oscillations having substantially straight lined wave form, similar means producing an alternating potential of straight lined wave form and higher frequency, means for utilizing said potentials to scan an image in two directions, means for modulating the lower frequency upon the higher frequency, means for producing a train of energy varying in intensity in accordance with the area scanned, means for modulating a carrier wave with said train of energy and said scanning potentials, means for receiving and detecting said train of energy and said analyzing potentials, means for modulating the light in accordance with said analyzing potentials, and means for correlating said light to form an image actuated by said potentials having straight line wave forms.

Signed at San Francisco, California, this 21st day of December, 1926.

PHILO T. FARNSWORTH.

N° 6732 A.D. 1904

(*Under International Convention.*)

Date claimed for Patent under Patents Act, 1901, being date of first Foreign Application (in United States), 23rd Mar., 1903

Date of Application (in the United Kingdom), 19th Mar., 1904

Accepted, 12th May, 1904

COMPLETE SPECIFICATION.

Improvements in Aeronautical Machines.

We, ORVILLE WRIGHT and WILBUR WRIGHT, both of 1127 W. Third Street, Dayton, County of Montgomery,, State of Ohio, United States of America, Manufacturers, do hereby declare the nature of our invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

Our invention relates to improvements in that class of aeronautical machines in which the weight is sustained by the reactions resulting when thin surfaces, or wings, are moved horizontally almost edgewise through the air at a small angle of incidence, either by the application of mechanical power, or by the utilization of the force of gravity.

The objects of our invention are, first, to provide a structure combining lightness, strength, convenience of construction, and the least possible edge resistance; second, to provide means for maintaining or restoring the equilibrium of the apparatus; and third, to provide efficient means of guiding the machine in both vertical and horizontal directions. We obtain these objects by the mechanism shown in the accompanying drawing, in which Fig. 1 is a view in perspective of the machine, Fig. 2 a side elevation, and Fig. 3 a top plan view.

The superposed horizontal surfaces 1, formed by stretching cloth upon frames of wood and wire, constitute the "wings," or supporting part of the apparatus. They are connected to each other through hinge joints by the upright standards 2 and the lateral stay wires 3, which together with the lateral spars 4 of the wing framing, form truss systems giving the whole machine great transverse rigidity and strength. The hinge joints admit of both flexing and twisting movements, and may be either ball and socket joints, or any joint of sufficiently loose construction to admit of the movements specified. The object of joints having both flexing and twisting movements is to permit superposed wing surfaces, or parts thereof, when joined together by upright standards, to be twisted or bent out of their normal planes for the purpose hereafter specified. We do not restrict outselves to the use of any particular form of joint, nor to its use at any particular number of places.

One end of the rope 5 is attached near the rear corner of the upper surface, passes diagonally downward around the pulleys 6, and diagonally upward to the corresponding corner at the opposite end of the machine. The rope 8 is attached to the front corner of the upper surface, passes around the pulleys 7 and back to the opposite upper corner. The movable cradle 9 is attached to

[*Price 8d.*]

the rope 5 at the point where the operator's body rests, and provides a means of imparting movement to the ropes 5 and 8. The operator lies prone on the lower surface, his hips resting in the cradle, and his hands grasping the roller 10, which actuates the front rudder. The ropes 5 and 8 maintain the fore and aft positions of the two surfaces 1 with respect to each other, and by their movement impart a twist to the entire structure, including the wings 1, as will be more fully described hereafter. We have shown the operating system by means of ropes, which we now prefer to use, but we do not restrict ourselves to the use of any particular method of imparting this twist to a structure formed in the manner specified.

The main frames of the wings 1 are formed by uniting the lateral spars 4 (Fig. 3) by means of end bows 11. The cloth for each wing, previous to its attachment to the frame, is cut on the bias and made up into a single piece approximately the size and shape of the wing, having the threads of the cloth 12 (Fig. 3) diagonal to the lateral spars 4 and the longitudinal ribs 13, with which they form truss systems. A wide hem is sewed in the rear edge to form a pocket for the insertion of the wire 14. By the combination of a frame work with a cloth covering, each formed in the manner described, we secure a surface of very great strength to withstand lateral and longitudinal strains, but capable of some twisting movement.

When the two surfaces 1 are joined together by the wire stays 3, the ropes 5 and 8, and the upright standards 2, as already described, a system is formed capable of sustaining great weight without distortion. But when the cradle 9 is moved to right or left by the operator, the motion is communicated through the ropes 5 and 8 and the upright standards 2 in such a manner that the wing surfaces are twisted, the rear edge of the wing tips being drawn downward at one end of the machine and drawn upward at the other; thus presenting the left set of wing tips to the wind at a greater or a less angle than the right. When in flight, the end having the greater angle will necessarily rise and the other end will sink, so that the lateral balance of the machine is under control through twisting movements of the wing tips by the operator, by means of the cradle 9.

The struts 15, together with the struts 16 (Fig. 2) in combination with the main frame, form trussed skids which prevent the machine from rolling over forward when it lands, and also relieves the jerk on the rope 8. They are also utilized as a part of the front rudder steering system.

The flexible front rudder 17 consists of the stiff cross sticks 18, 19, 20 and the thin ribs 21, over which is stretched a cloth covering. The rudder is mounted upon the struts 15 by attachment to the cross stick 18, which is located near the centre of pressure, so as to form a balanced rudder. The up and down motion of the front edge of the rudder is in part restrained by the springs 23. The rear edge is raised and lowered by means of the axles 10, 22, the bands 24 and the arms 25 and 26, or by any other suitable means. The restraining action of the springs 23 causes the ribs 21 to bend when the rear edge is raised or lowered, thus presenting a concave surface to the action of the wind, and very greatly increasing its power as compared with a plane of equal area. By regulating the pressure on the upper and lower sides of the rudder, through changes of angle and curvature, a turning movement is communicated to the main structure and the course of the machine is directed upward or downward at the will of the operator, and the longitudinal balance maintained.

Contrary to the usual custom, we place the horizontal rudder in front of the main surfaces or "wings" at a negative angle, and use no horizontal tail at all. By this arrangement we obtain a forward surface which is almost free from pressure under ordinary conditions of flight, but which, even if not moved at all, becomes an efficient lifting surface whenever the speed of the machine is accidentally reduced very much below the normal, and thus largely counteracts that backward travel of the centre of pressure on the main surfaces or

wings which has frequently been productive of serious injuries by causing the machine to turn downward and strike the ground head on. We are aware that a forward horizontal rudder of different construction has been used in combination with a supporting surface and a rear horizontal rudder, but this combination was not intended to effect and did not effect the object which we obtain by the arrangement of surfaces here described.

The vertical tail or rudder 27 is attached through universal joints to the two pairs of struts 28, which lie in parallel horizontal planes, and are connected to the rear edges of the main surfaces 1 by hinged joints. This combination secures the tail rigidly in a vertical position, but enables it to turn on a vertical axis, and also to rise bodily in case it strikes the ground, and thus escapes breakage. The cords 29 are tiller ropes which connect the rudder wheel 30 to the rope 8, which in conjunction with the rope 5 imparts the twisting motion to the wing tips as heretofore described. By this method of attachment the same motion of the ropes 8 and 5 which actuates the wing tips also presents to the wind that side of the vertical rear rudder which is toward the tip having the smaller angle of incidence. The wing tip presented to the wind at the greater angle, under the usual conditions of flight, has both greater lift and greater drift, or resistance, than the other. The wing with the greater angle therefore, tends to rise and drop behind, while the other sinks and moves ahead. Under these circumstances the longitudinal axis of the machine tends to turn toward the wing having the greater angle, while the general course of the machine through the air tends toward that wing which is the lowest with the result that a wide divergence soon arises between the direction which the machine faces and its actual direction of travel. By the use of a rear movable vertical rudder, so operated as to present to the wind that side which is toward the wing having the least angle, we obtain a turning force opposite to and greater than that arising from the difference in the resistance of the two wings, and thus are able to keep the longitudinal axis of the machine approximately in coincidence with the line of flight. We do not confine ourselves to the particular construction and attachment of the rear rudder hereinbefore described, nor to this particular construction of surfaces or wings, but may employ this combination in the use of any movable vertical rear rudder operated in conjunction with any wings capable of being presented to the wind at respectively differing angles at their opposite tips for the purpose of restoring the lateral balance of a flying machine and guiding the machine to right or left.

We are aware that prior to our invention flying machines have been constructed having superposed wings in combination with horizontal and vertical rudders; we therefore do not claim such combination broadly.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:

1. In a flying machine, the combination of superposed surfaces or "wings", with upright connecting standards one or more of which has its attachment by means of hinges or flexible joints, substantially as described and for the purpose specified.

2. In a flying machine, the combination of superposed surfaces or wings with upright connecting standards attached through flexible joints, and laterally extending stay wires, substantially as described.

3. In a flying machine, the combination of one or more supporting surfaces or wings with a device for imparting a twist to the said surfaces or wings for the purpose stated.

4. In a flying machine, the combination of superposed wings, upright standards attached by flexible joints, and laterally extending stay wires, with a device for imparting a twisting to the wings for the purpose specified.

5. In a flying machine, the combination of superposed wings, upright standards attached by means of flexible joints, and laterally extending stay wires, with actuating ropes attached and operated substantially as described.

6. In a flying machine, the combination of wings having their right and left tips capable of being adjusted so as to be presented to the wind at respectively differing angles, with a vertical adjustable rear rudder operating in conjunction therewith in the manner and for the purpose specified.

7. In a flying machine having wings capable of being twisted by actuating ropes, the combination therewith of a movable vertical rear rudder having tiller cords attached to said actuating ropes, substantially as described.

8. In a flying machine, the combination of superposed surfaces with a vertical rear rudder, and hinged connecting arms in parallel planes substantially as described.

9. In a flying machine having surfaces or wings composed of a cloth covered frame, the combination of laterally extending spars and longitudinal ribs, with a covering having the threads of the cloth diagonal to the main lines of the framing, substantially as set forth.

10. In a flying machine the combination of superposed surfaces with forwardly extending struts arranged in the manner and for the purpose specified.

11. In a flying machine, the combination of supporting wings with a smaller inert surface which becomes a supporting surface when the speed of the machine is greatly diminished, substantially as described and for the purpose specified.

12. In a flying machine, the combination of supporting wings and a horizontal rudder, having stiff lateral sticks, thin longitudinal ribs, and cloth covering, and a device for imparting a slight curvature to the rudder in the manner and for the purpose specified.

13. In a flying machine, the combination of supporting wings with a flexible horizontal rudder and a device for simultaneously regulating the angle of the rudder with the wind and imparting to it a slight curvature, substantially as described and for the purpose specified.

14. In a flying machine, the combination of superposed surfaces capable of being twisted with a forward horizontal rudder and an adjustable vertical rear rudder, substantially as described and for the purposes specified.

Dated this 19th day of March 1904.

HERBERT HADDAN & Co.,
Agents to Applicants.
18 Buckingham Street, Strand, W.C. London.

Redhill: Printed for His Majesty's Stationery Office, by Love & Malcomson, Ltd.—1904.

A.D. 1904. MARCH 19. No. 6732.

WRIGHT & *another's* COMPLETE SPECIFICATION. *(1 SHEET)*

Fig. 1.

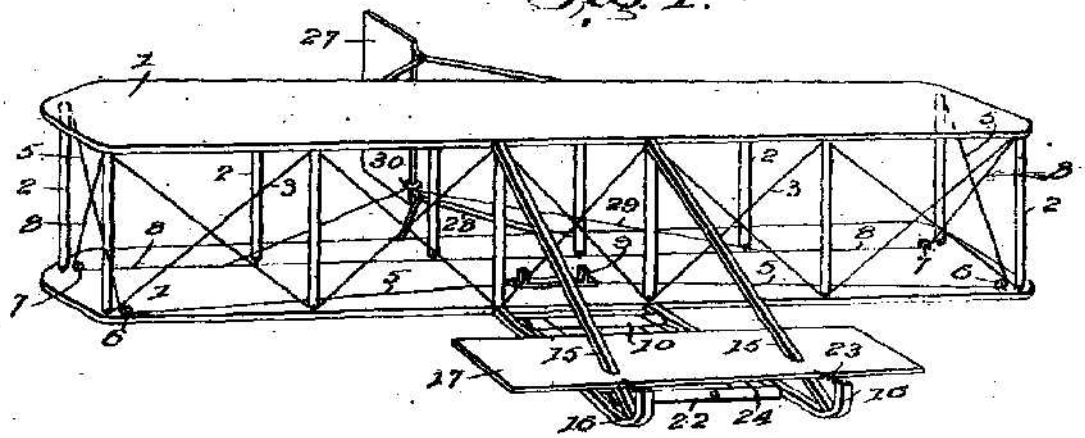


Fig. 2.

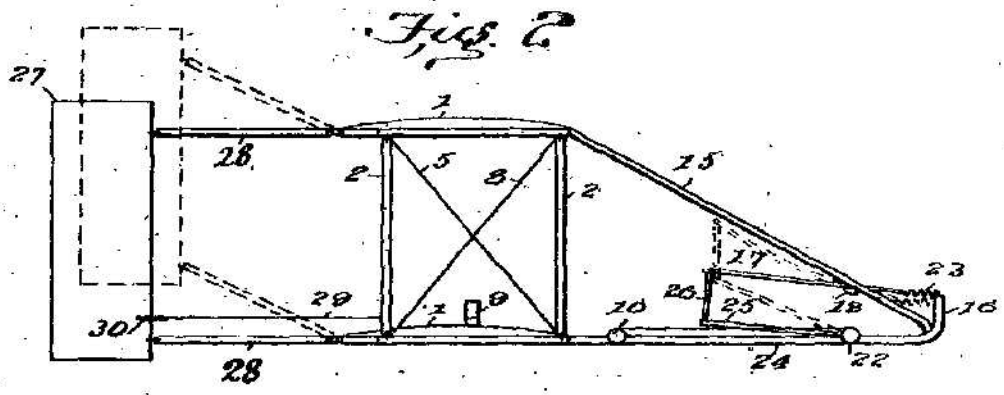
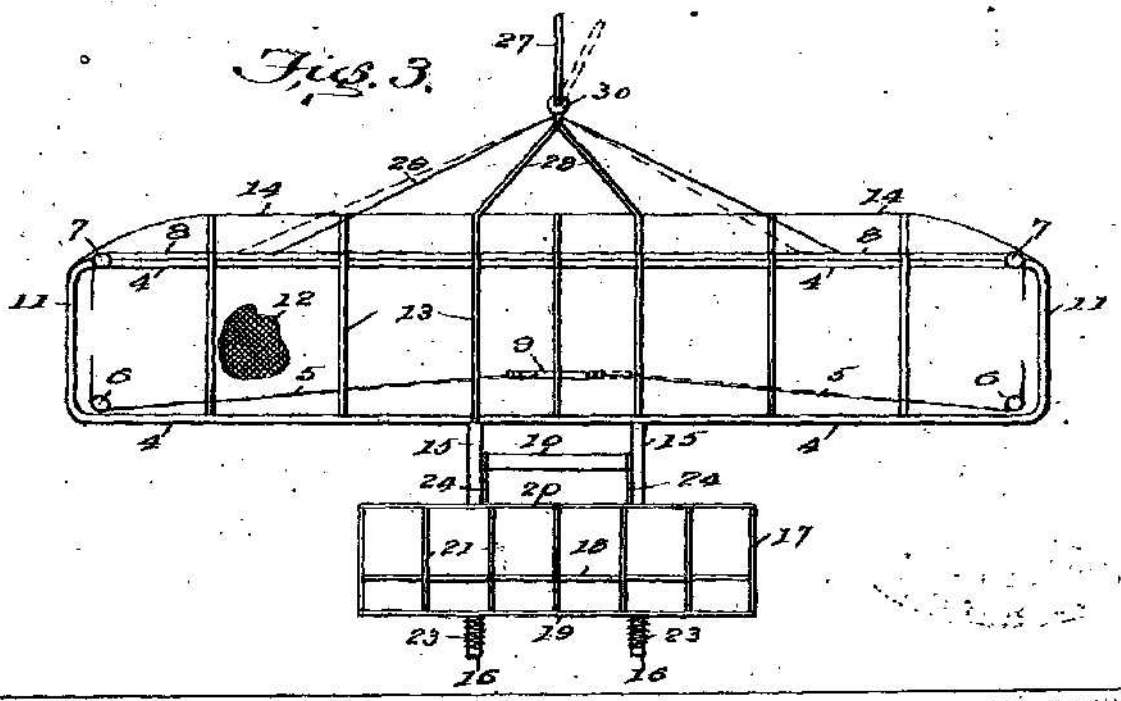


Fig. 3.



Malby&Sons, Photo-Litho.

[This Drawing is a reproduction of the Original on a reduced scale.]

DESIGN.

A. BARTHOLDI.

Statue.

No. 11,023. Patented Feb. 18, 1879.

LIBERTY ENLIGHTENING THE WORLD.

Witnesses:

E. F. Dick

J. E. Carpenter.

Inventor:

Auguste Bartholdi

by Pollok

atty.

UNITED STATES PATENT OFFICE.

AUGUSTE BARTHOLDI, OF PARIS, FRANCE.

DESIGN FOR A STATUE.

Specification forming part of Design No. **11,023**, dated February 18, 1879; application filed January 2, 1879.
[Term of patent 14 years.]

To all whom it may concern:

Be it known that I, AUGUSTE BARTHOLDI, of Paris, in the Republic of France, have originated and produced a Design of a Monumental Statue, representing "Liberty enlightening the world," being intended as a commenorative monument of the independence of the United States; and I hereby declare the following to be a full, clear, and exact description of the same, reference being had to the accompanying illustration, which I submit as part of this specification.

The statue is that of a female figure standing erect upon a pedestal or block, the body being thrown slightly over to the left, so as to gravitate upon the left leg, the whole figure being thus in equilibrium, and symmetrically arranged with respect to a perpendicular line or axis passing through the head and left foot. The right leg, with its lower limb thrown back, is bent, resting upon the bent toe, thus giving grace to the general attitude of the figure. The body is clothed in the classical drapery, being a stola, or mantle gathered in upon the left shoulder and thrown over the skirt or tunic or under-garment, which drops in voluminous folds upon the feet. The right arm is thrown up and stretched out, with a flamboyant torch grasped in the hand. The flame of the torch is thus held high up above the figure. The arm is nude; the drapery of the sleeve is dropping down upon the shoulder in voluminous folds. In the left arm, which is falling against the body, is held a tablet, upon which is inscribed "4th July, 1776." This tablet is made to rest against the side of the body, above the hip, and so as to occupy an inclined position with relation thereto, exhibiting the inscription. The left hand clasps the tablet so as to bring the four fingers onto the face thereof. The head, with its classical, yet severe and calm, features, is surmounted by a crown or diadem, from which radiate divergingly seven rays, tapering from the crown, and representing a halo. The feet are bare and sandal-strapped.

This design may be carried out in any manner known to the glyptic art in the form of a statue or statuette, or in alto-relievo or bass-relief, in metal, stone, terra-cotta, plaster-of-paris, or other plastic composition. It may also be carried out pictorially in print from engravings on metal, wood, or stone, or by photographing or otherwise.

What I claim as my invention is—

The herein-described design of a statue representing Liberty enlightening the world, the same consisting, essentially, of the draped female figure, with one arm upraised, bearing a torch, while the other holds an inscribed tablet, and having upon the head a diadem, substantially as set forth.

In testimony whereof I have signed this specification in the presence of two subscribing witnesses.

A. BARTHOLDI.

Witnesses:
C. TERINIER,
COTTIN.

T. A. EDISON.

Electric-Lamp.

No. 223,898. Patented Jan. 27, 1880.

Fig 1.

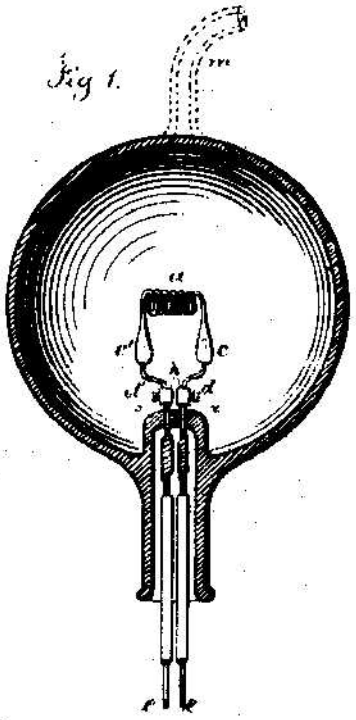


Fig. 2.

Fig. 3

Witnesses

Chas. H. Smith

Geo. T. Pinckney

Inventor

Thomas A. Edison

per Lemuel W. Serrell

atty.

UNITED STATES PATENT OFFICE.

THOMAS A. EDISON, OF MENLO PARK, NEW JERSEY

ELECTRIC LAMP.

SPECIFICATION forming part of Letters Patent No. 223,898, dated January 27, 1880.

Application filed November 4, 1879.

To all whom it may concern:

Be it known that I, THOMAS ALVA EDISON, of Menlo Park, in the State of New Jersey, United States of America, have invented an Improvement in Electric Lamps, and in the method of manufacturing the same, (Case No. 186,) of which the following is a specification.

The object of this invention is to produce electric lamps giving light by incandescence, which lamps shall have high resistance, so as to allow of the practical subdivision of the electric light.

The invention consists in a light-giving body of carbon wire or sheets coiled or arranged in such a manner as to offer great resistance to the passage of the electric current, and at the same time present but a slight surface from which radiation can take place.

The invention further consists in placing such burner of great resistance in a nearly-perfect vacuum, to prevent oxidation and injury to the conductor by the atmosphere. The current is conducted into the vacuum-bulb through platina wires sealed into the glass.

The invention further consists in the method of manufacturing carbon conductors of high resistance, so as to be suitable for giving light by incandescence, and in the manner of securing perfect contact between the metallic conductors or leading-wires and the carbon conductor.

Heretofore light by incandescence has been obtained from rods of carbon of one to four ohms resistance, placed in closed vessels, in which the atmospheric air has been replaced by gases that do not combine chemically with the carbon. The vessel holding the burner has been composed of glass cemented to a metallic base. The connection between the leading wires and the carbon has been obtained by clamping the carbon to the metal. The leading-wires have always been large, so that their resistance shall be many times less than the burner, and, in general, the attempts of previous persons have been to reduce the resistance of the carbon rod. The disadvantages of following this practice are, that a lamp having but one to four ohms resistance cannot be worked in great numbers in multiple arc without the employment of main conductors of enormous dimensions; that, owing to the low resistance of the lamp, the leading-wires must be of large dimensions and good conductors, and a glass globe cannot be kept tight at the place where the wires pass in and are cemented; hence the carbon is consumed, because there must be almost a perfect vacuum to render the carbon stable, especially when such carbon is small in mass and high in electrical resistance.

The use of a gas in the receiver at the atmospheric pressure, although not attacking the carbon, serves to destroy it in time by "air-washing," or the attrition produced by the rapid passage of the air over the slightly-coherent highly-heated surface of the carbon. I have reversed this practice. I have discovered that even a cotton thread properly carbonized and placed in a sealed glass bulb exhausted to one-millionth of an atmosphere offers from one hundred to five hundred ohms resistance to the passage of the current, and that it is absolutely stable at very high temperatures; that if the thread be coiled as a spiral and carbonized, or if any fibrous vegetable substance which will leave a carbon residue after heating in a closed chamber be so coiled, as much as two thousand ohms resistance may be obtained without presenting a radiating-surface greater than three-sixteenths of an inch; that if such fibrous material be rubbed with a plastic composed of lamp-black and tar, its resistance may be made high or low, according to the amount of lamp-black placed upon it; that carbon filaments may be made by a combination of tar and lamp-black, the latter being previously ignited in a closed crucible for several hours and afterward moistened and kneaded until it assumes the consistency of thick putty. Small pieces of this material may be rolled out in the form of wire as small as seven one-thousandths of a inch in diameter and over a foot in length, and the same may be coated with a non-conducting non-carbonizing substance and wound on a bobbin, or as a spiral, and the tar carbonized in a closed chamber by subjecting it to high heat, the spiral after carbonization retaining its form.

All these forms are fragile and cannot be clamped to the leading wires with sufficient force to insure good contact and prevent heating. I have discovered that if platinum wires are used and the plastic lamp-black and tar material be molded around it in the act of carbonization there is an intimate union by com-

material be molded around it in the act of carbonization there is an intimate union by combination and by pressure between the carbon and platina, and nearly perfect contact is obtained without the necessity of clamps; hence the burner and the leading-wires are connected to the carbon ready to be placed in the vacuum-bulb.

When fibrous material is used the plastic lamp-black and tar are used to secure it to the platina before carbonizing.

By using the carbon wire of such high resistance I am enabled to use fine platinum wires for leading-wires, as they will have a small resistance compared to the burner, and hence will not heat and crack the sealed vacuum-bulb. Platina can only be used, as its expansion is nearly the same as that of glass.

By using a considerable length of carbon wire and coiling it the exterior, which is only a small portion of its entire surface, will form the principal radiating-surface; hence I am able to raise the specific heat of the whole of the carbon, and thus prevent the rapid reception and disappearance of the light, which on a plain wire is prejudicial, as it shows the least unsteadiness of the current by the flickering of the light; but if the current is steady the defect does not show.

I have carbonized and used cotton and linen thread, wood splints, papers coiled in various ways, also lamp-black, plumbago, and carbon in various forms, mixed with tar and kneaded so that the same may be rolled out into wires of various lengths and diameters. Each wire, however, is to be uniform in size throughout.

If the carbon thread is liable to be distorted during carbonization it is to be coiled between a helix of copper wire. The ends of the carbon or filament are secured to the platina leading-wires by plastic carbonizable material, and the whole placed in the carbonizing-chamber. The copper, which has served to prevent distortion of the carbon thread, is afterward eaten away by nitric acid, and the spiral soaked in water, and then dried and placed on the glass holder, and a glass bulb blown over the whole, with a leading-tube for exhaustion by a mercury-pump. This tube, when a high vacuum has been reached, is hermetically sealed.

With substances which are not greatly distorted in carbonizing, they may be coated with a non-conducting non-carbonizable substance, which allows one coil or turn of the carbon to rest upon and be supported by the other.

In the drawings, Figure 1 shows the lamp sectionally. *a* is the carbon spiral or thread. *c c'* are the thickened ends of the spiral, formed of the plastic compound of lamp-black and tar. *d d'* are the platina wires. *h h* are the clamps, which serve to connect the platina wires, cemented in the carbon, with the leading-wires *x x*, sealed in the glass vacuum-bulb. *e e* are copper wires, connected just outside the bulb to the wires *x x*. *m* is the tube (shown by dotted lines) leading to the vacuum-pump, which, after exhaustion, is hermetically sealed and the surplus removed.

Fig. 2 represents the plastic material before being wound into a spiral.

Fig. 3 shows the spiral after carbonization, ready to have a bulb blown over it.

I claim as my invention—

1. An electric lamp for giving light by incandescence, consisting of a filament of carbon of high resistance, made as described, and secured to metallic wires, as set forth.

2. The combination of carbon filaments with a receiver made entirely of glass and conductors passing through the glass, and from which receiver the air is exhausted, for the purposes set forth.

3. A carbon filament or strip coiled and connected to electric conductors so that only a portion of the surface of such carbon conductors shall be exposed for radiating light, as set forth.

4. The method herein described of securing the platina contact-wires to the carbon filament and carbonizing of the whole in a closed chamber, substantially as set forth.

Signed by me this 1st day of November, A. D. 1879.

THOMAS A. EDISON.

Witnesses:
S. L. GRIFFIN,
JOHN F. RANDOLPH.

Order of Cancellation of Certificate of Correction of Letters Patent No. 223,898.

It is found that the following certificate has been attached to Letters Patent granted to Thomas A. Edison for improvement in "Electric Lamps," No. 223,898, dated January 27, 1880:

DEPARTMENT OF THE INTERIOR,

UNITED STATES PATENT OFFICE,

WASHINGTON, D. C., *December 18, 1883.*

In compliance with the request of the party in interest Letters Patent No. 223,898, granted January 27, 1880, to Thomas A. Edison, of Menlo Park, New Jersey, for an improvement in "Electric Lamps," is hereby limited so as to expire at the same time with the patent of the following-named, having the shortest time to run, viz.: British patent, dated November 10, 1879, No. 4,576; Canadian patent, dated November 17, 1879, No. 10,654; Belgian patent, dated November 29, 1879, No. 49,884; Italian patent, dated December 6, 1879, and French patent, dated January 20, 1880, No. 133,756.

It is hereby certified that the proper entries and corrections have been made in the files and records of the Patent Office.

This amendment is made that the United States patent may conform to the provisions of section 4887 of the Revised Statutes.

[SEAL.]

BENJ. BUTTERWORTH,
Commissioner of Patents.

Approved:
M. L. JOSLYN,
Acting Secretary of the Interior.

Now, in compliance with the request of the parties in interest, said certificate is hereby *canceled* and proper entries and corrections have been made in the files and records of the Patent Office.

In testimony whereof I have hereunto set my hand and caused the seal of the Patent Office to be affixed, this 15th day of March, 1893.

W. E. SIMONDS,
Commissioner of Patents.

Approved:
CYRUS BUSSEY,
Assistant Secretary of the Interior.

Correction in Letters Patent No. 223,898.

DEPARTMENT OF THE INTERIOR,

UNITED STATES PATENT OFFICE,

WASHINGTON, D. C., *December 18, 1883.*

In compliance with the request of the party in interest, Letters Patent No. 223,898, granted January 27, 1880, to Thomas A. Edison, of Menlo Park, New Jersey, for an improvement in "Electric-Lamps," is hereby limited so as to expire at the same time with the patent of the following named, having the shortest time to run, viz: British Patent dated November 10, 1879, No. 4,576; Canadian Patent dated November 17, 1879, No. 10,654; Belgian Patent dated November 29, 1879, No. 49,884; Italian Patent dated December 6, 1879; and French Patent dated January 20, 1880, No. 133,756;

It is hereby certified that the proper entries and corrections have been made in the files and records of the Patent Office.

This amendment is made that the United States Patent may conform to the provisions of Section 4887 of the Revised Statutes.

BENJ. BUTTERWORTH,
Commissioner of Patents.

Approved:
M. L. JOSLYN,
Acting Secretary of the Interior.

(No Model.)

E. BERLINER.

GRAMOPHONE.

No. 372,786. Patented Nov. 8, 1887.

Fig. 1.

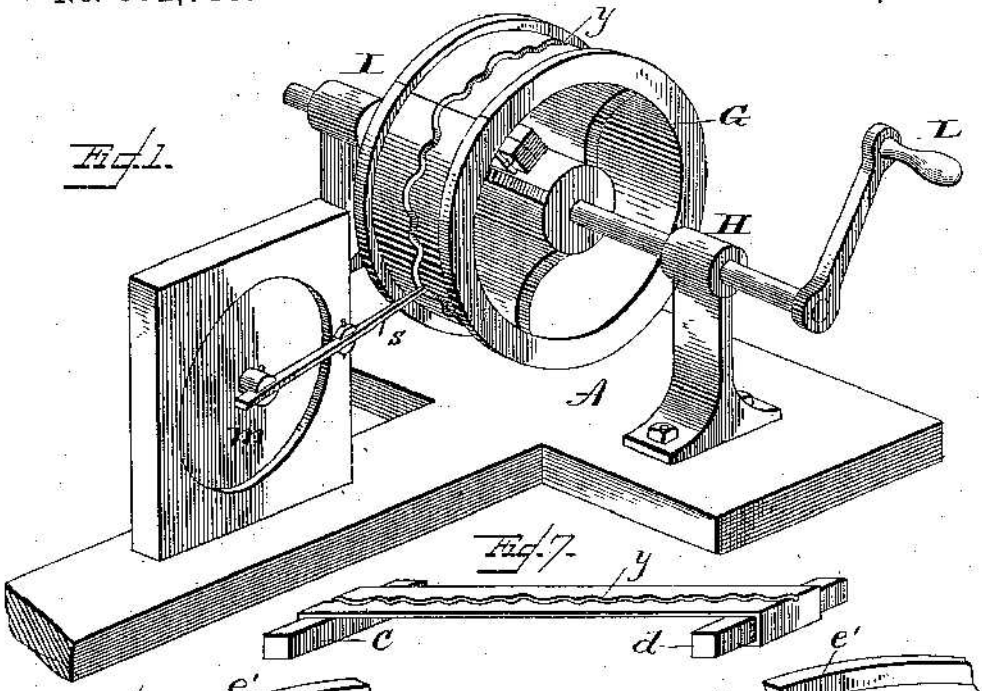


Fig. 7.

Fig. 3.

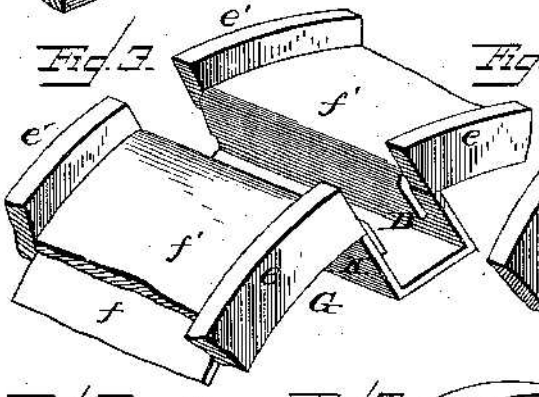


Fig. 4.

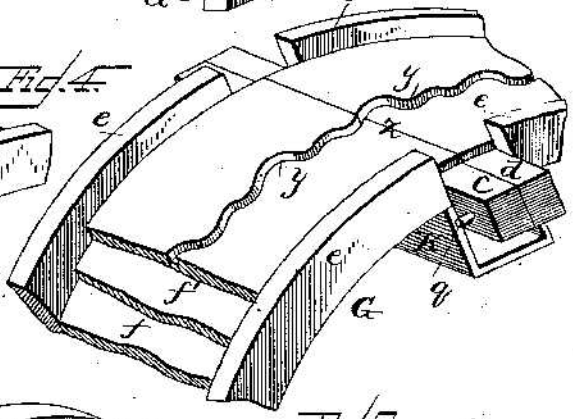


Fig. 5.

Fig. 2.

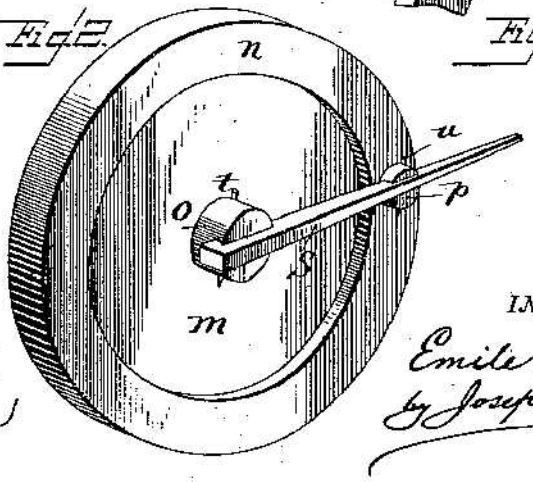
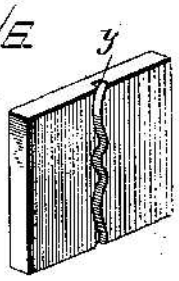


Fig. 6.



WITNESSES

J. D. Coleman

Wm. E. Schroeder

INVENTOR

Emile Berliner.

by Joseph Lyons

Attorney

UNITED STATES PATENT OFFICE.

EMILE BERLINER, OF WASHINGTON, DISTRICT OF COLUMBIA.

GRAMOPHONE.

SPECIFICATION forming part of Letters Patent No. 372,786, dated November 8, 1887.

Original application filed May 4, 1887, Serial No. 237,060. Divided and this application filed September 26, 1887. Serial No. 250,721.

(No model.)

To all whom it may concern:

Be it known that I, EMILE BERLINER, a citizen of the United States, residing at Washington, in the District of Columbia, have invented certain new and useful Improvements in Gramophones, of which the following is a specification.

This invention has reference to a novel method of and apparatus for recording and reproducing all kinds of sounds, including spoken words, and is designed to overcome the defects inherent in that art as now practiced and in the apparatus used therefor.

By the ordinary method of recording spoken words or other sounds for reproduction it is attempted to cause a stylus attached to a vibratory diaphragm to indent a traveling sheet of tin-foil or other like substance to a depth varying in accordance with the amplitudes of the sound-waves to be recorded. This attempt is necessarily more or less ineffective, for the reason that the force of a diaphragm vibrating under the impact of sound-waves is very weak, and that in the act of overcoming the resistance of the tin-foil or other material the vibrations of the diaphragm are not only weakened, but are also modified. Thus while the record contains as many undulations as the sounds which produce it, and in the same order of succession, the character of the recorded undulations is more or less different from those of the sounds uttered against the diaphragm. There is, then, a true record of the pitch, but a distorted record of the quality of the sounds obtained. The simple statement that the material upon which the record is made resists the movement of the diaphragm is not sufficient to explain the distortion of the character of the undulations, for if that resistance were uniform, or even proportional to the displacement of the stylus, the record would be simply weakened, but not distorted; but it is a fact that the resistance of any material to indentation increases faster than the depth of indentation, so that a vibration of greater amplitude of the stylus meets with a disproportionately greater resistance than a vibration of smaller amplitude. For this reason loud sounds are even less accurately recorded than faint sounds, and the individual voice of a loud speaker recorded and then reproduced by the phonograph cannot be recognized. With a view of overcoming this defect it has been attempted to engrave instead of indent a record of the vibrations of the diaphragm by employing a stylus shaped and operating like a chisel upon a suitably-prepared surface; but even in this case the disturbing causes above referred to are still present. In addition to this, if in the apparatus of the phonograph or graphophone type it is attempted to avoid the disturbing influence of the increase of resistance of the record-surface with the depth of indentation or cut as much as possible by primarily adjusting the stylus so as to touch the record-surface only lightly, then another disturbing influence is brought into existence by the fact that with such adjustment, when the diaphragm moves outwardly, the stylus will leave the record-surface entirely, so that part of each vibration will not be recorded at all. This is more particularly the case when loud sounds are recorded, and it manifests itself in the reproduction, which then yields quite unintelligible sounds.

It is the object of my invention to overcome these difficulties by recording spoken words or other sounds without perceptible friction between the recording-surface and the recording-stylus, and by maintaining the unavoidable friction uniform for all vibrations of the diaphragm. The record thus obtained, almost frictionless, I copy in a solid resisting material by any of the methods hereinafter described, and I employ such copy of the original record for the reproduction of the recorded sounds.

Instead of moving the recording-stylus at right angles to and against the record-surface, I cause the same to move under the influence of sound-waves parallel with and barely in contact with such surface, which latter is covered with a layer of any material that offers a minimum resistance to the action of a stylus operating to displace the same, all substantially in the manner of the well-known phonautograph by Leon Scott. All this will more fully appear from the following detailed description, in which reference is made to the accompanying drawings, which illustrate one of the numerous forms which my improved apparatus may assume, and in which—

Figure 1 is a perspective view of my recording and reproducing apparatus; Fig. 2, a like

view of the recording and reproducing diaphragm with its stylus; Fig. 3, a similar view of a portion of the support for the record-surface; Fig. 4, the same view with the record-surface applied; Fig. 5, a plan view of a phonautographic record; Fig. 6, a perspective of a phonautographic record copied in solid resisting material; and Fig. 7, the copied record mounted, ready for application to the support.

The general arrangement of the parts is best illustrated in Fig. 1, in which a T-shaped base-plate, A, is shown, upon which two standards, H I, serving as journal-bearings for the shaft of drum G, are mounted. The drum G may be constructed with flanges *e e'*, which project beyond the cylinder-surface *f*, and from the edges of a gap, B, left upon the cylinder-surface extend the side walls of box K, as shown. A thin layer of felt or other yielding elastic substance is placed upon the cylinder-surface and is bent over the edges of the gap and secured to the side walls of the box K. This layer of elastic material is designed to serve as the support for the record-surface both in recording and reproducing.

For recording I employ a thin strip of paper, parchment, metal, or any other suitable substance, which is secured at both ends to bars *c d*, in the manner shown in Fig. 7, with reference to a copy of a record, and is then placed upon the elastic support *f'*, with the bars *c d* entering into but projecting at both ends beyond the box K, as illustrated in Figs. 1 and 4, with reference to an engraved copy of a record. Bolts *q*, passing through the projecting ends of bars *c d*, are employed to draw the record-strip tightly about the drum, and the length of the strip is such that the ends of the same meet as nearly as practicable upon a straight line, *z*. The record-sheet is then prepared to receive the record by covering its surface with a thin layer of any substance which is easily removed by the action of the recording-stylus. I may use lamp-black, which is deposited by placing a smoky flame under the record-strip and by slowly turning the drum until all parts of the strip are covered with the deposit. It is well known that a layer of lamp-black thus deposited, while it adheres well to the surface of a solid body, is nevertheless easily removed from the same. It requires only an exceedingly small force to draw a plainly-visible line upon such surface, owing to the fact that the spicules of carbon of which lamp-black is composed are only loosely superimposed upon each other, and are exceedingly light. All this has long since been recognized and utilized in the production of phonautographic records, and I take advantage of these facts in my improved method of recording and reproducing sounds.

The diaphragm *m* is mounted in a frame, *n*, with its plane at right angles to the axis of drum G. A post, O, is fixed to the center of the diaphragm, and a slot in said post receives one end of stylus S, which is pivoted in the post by a pin, *t*. The stylus extends over and beyond the frame, with its free end barely in contact with the record-surface, and is also pivotally supported in a slot in a post, *p*, secured to the frame by means of a pin, *u*, as shown in Figs. 1 and 2. It will now be seen that the stylus is in effect a lever having its fulcrum in the pin *u*, and that its free end can only move in lines practically parallel to the record-surface. If it is now desired to produce a record of sounds the drum is slowly and uniformly rotated by means of crank L, or by any other suitable means, and sounds are uttered or directed against the diaphragm. Under the impact of the sound-waves the diaphragm is set into vibrations, whereby the free end of the stylus is also caused to vibrate to the right and left of its normal position, removing at the same time an undulating line, *y*, of lamp-black from the record-surface, as indicated, greatly exaggerated, in Fig. 5. Since in this operation the stylus only penetrates a uniform layer of loosely-heaped carbon spicules and barely touches the record-surface, it is clear that the slight friction at the free end of the stylus will be uniform, whatever be the amplitude of vibration. Consequently the vibrations of the diaphragm will not be modified or changed by the reaction upon the same of a sensible and varying resistance, as is the case in all other mechanical sound-recorders.

Having thus obtained an accurate phonautographic record, the same may be fixed by applying a thin solution of varnish of any kind which dries very rapidly and which does not obliterate or change the record.

If in this process the deposit of lamp-black be made thick enough, the line drawn by the stylus would represent a groove of even depth, preserving all the characteristics of the sounds which produced it and which may be handled and touched with impunity. The latter is then removed from the drum and may be preserved any length of time without danger of its being disfigured. This record I then copy in solid resisting material, preferably metal, either by the purely mechanical process of engraving, or by chemical deposition, or by photo-engraving. I prefer the last-named process, which enables me to produce the most accurate copy of the original record in copper, nickel, or any other metal without in any way or manner affecting the original record. The copy thus obtained, which may be multiplied to any desired extent, is a grooved wave-line upon a strip or sheet of copper or other metal, as shown in Figs. 1, 4, 6, and 7, and for the reproduction of the recorded sounds it has the advantage over the ordinary records in tin-foil, wax, &c., that it is not sensibly attacked by the reproducing-stylus, and will stand an indefinite number of reproductions without the slightest variation in the accuracy and loudness of the reproduced sounds.

The copied record is fixed at both ends to the bars *c d*, as shown in Fig. 7, and is placed

upon the elastic support f' upon the drum in the same manner as has been described with reference to the original record-strip, and as is illustrated in Figs. 1 and 4. Care must be taken that the two ends of the undulatory groove y meet exactly, as will be readily understood. This condition of the apparatus is shown in Fig. 1 with the engraven record upon the drum and the free end of the stylus entering the undulatory groove. If, now, the drum is rotated with uniform speed, the end of the stylus will be forced to follow the undulations of the groove y, and the diaphragm will be vibrated positively in both directions in strict accordance therewith, and will therefore reproduce the exact sounds which originally produced the record. This peculiarity of positive vibratory movement in both directions of the diaphragm is a feature which also distinguishes my method and my apparatus from others heretofore used.

In the phonograph and graphophone the end of the reproducing-stylus which bears upon the indented or engraved record has a vertical upward and downward movement. It is forced upwardly in a positive manner by riding over the elevated portion of the record, but its downward movement is effected solely by the elastic force of the diaphragm, which latter is always under tension. In my improved apparatus the stylus travels in a groove of even depth and is moved positively in both directions. It does not depend upon the elasticity of the diaphragm for its movement in one direction. This I consider to be an advantage, since by this method the whole movement of the diaphragm is positively controlled by the record, and is not affected or modified by the physical conditions of the diaphragm, which conditions necessarily vary from time to time and constitute some of the causes of imperfect reproduction of recorded sounds.

In practicing my method of recording and producing sounds I am not limited to the use of the identical apparatus herein shown and described. This apparatus may be varied indefinitely without seriously impairing its utility for the purposes in view. Thus it is not absolutely necessary that a diaphragm should be used for receiving the impact of sound-waves in recording and for remitting sounds in reproducing. Any sonorous body of whatever shape and material may be used in lieu of a diaphragm proper. The recording-surface need not be mounted upon a drum, but may be supported in any suitable manner upon a support of any description which is adapted to move the same under the stylus evenly and with approximately uniform speed. Nor do I confine myself to the use of lamp-black as a substratum for the phonautographic record, although I have found this substance to yield excellent results. Any other substance which adheres well to the support and may at the same time be removed from the same with a minimum force may be employed.

While I have found the process of photo-engraving to yield admirable copies of the phonautographic record, I do not mean to confine myself to this process to the exclusion of other processes for copying and multiplying the original record in solid resisting material; and it will be readily understood that the details of construction of my apparatus and the manipulations of the same may be greatly changed without departing from the fundamental idea of my invention.

I do not herein claim the apparatus shown and described, either generically or specifically, as a whole or in part, since the same forms the subject of another application for patent previously filed by me and of which this is a division.

What I do claim, and desire to secure by Letters Patent, is—

1. The method or process of recording and reproducing spoken words and other sounds, which consists in first drawing an undulatory line of even depth in a traveling layer of non-resisting material by and in accordance with sound-vibrations, then producing the record thus obtained in solid resisting material, and finally imparting vibrations to a sonorous body by and in accordance with the resisting record, substantially as described.

2. The method or process of reproducing sounds recorded phonautographically, which consists in copying the phonautographic record in solid resisting material, and then imparting vibrations to a sonorous body by and in accordance with the copy of the orignal record, substantially as described.

3. The method or process of reproducing sounds recorded phonautographically, which consists in copying the phonautographic record in solid resisting material by the process of photo-engraving, and then imparting positive to-and-fro movements to a sonorous body by and in accordance with the copy of the original record, substantially as described.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

EMILE BERLINER.

Witnesses:
JULIUS SOLGER,
JACOB G. COHEN.

Feb. 11, 1941. H. FORD 2,231,710

TRACTOR

Filed Feb. 23, 1939 2 Sheets-Sheet 1

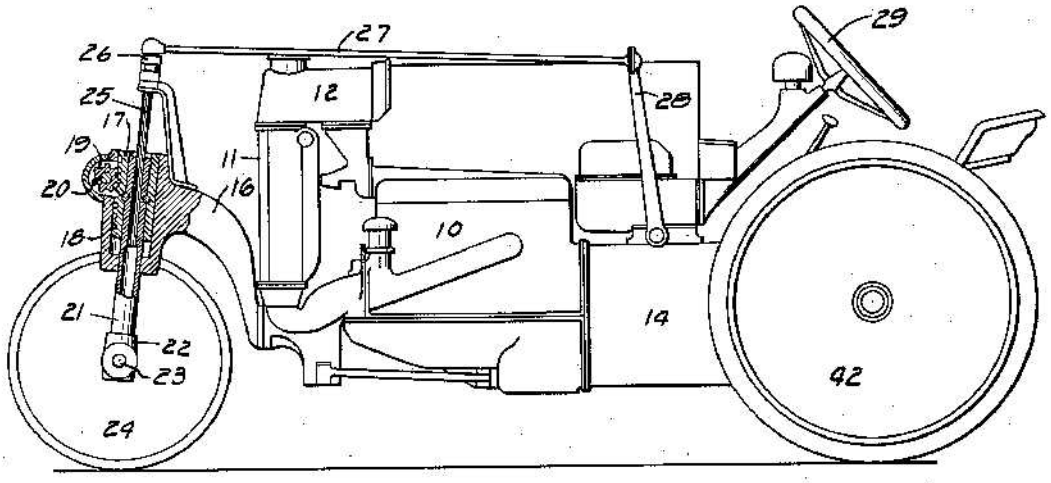


FIG. 1

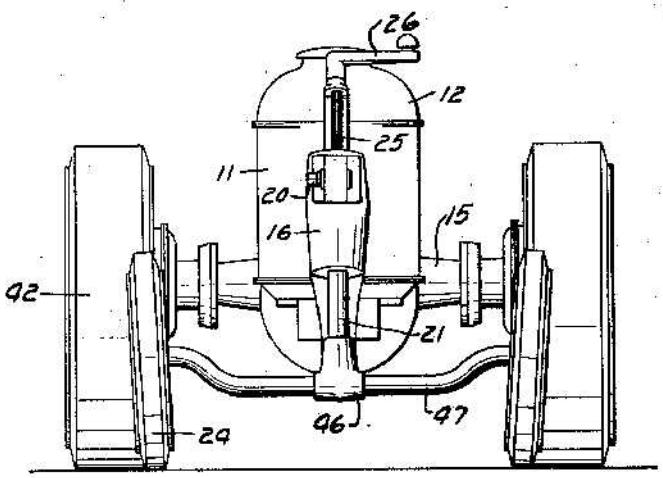


FIG. 5

WITNESS

E. Mitzke

INVENTOR

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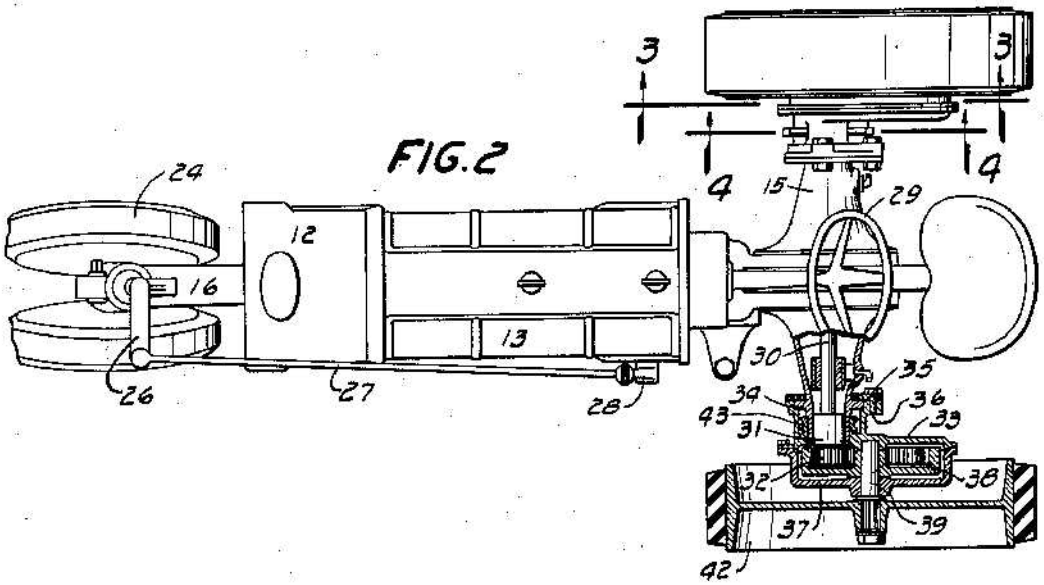
Feb. 11, 1941. H. FORD 2,231,710

TRACTOR

Filed Feb. 23, 1939 2 Sheets-Sheet 2

FIG. 2



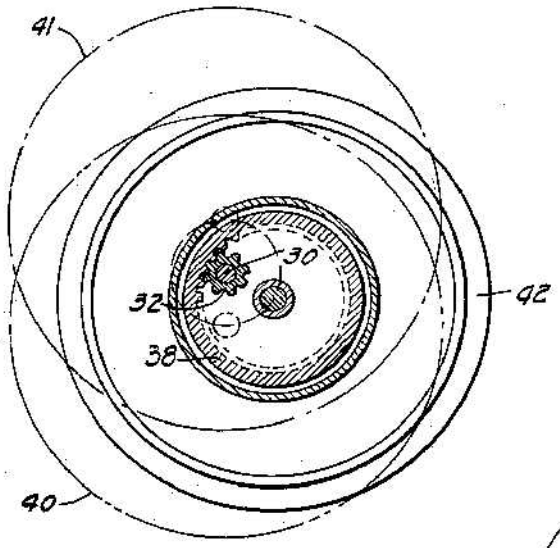
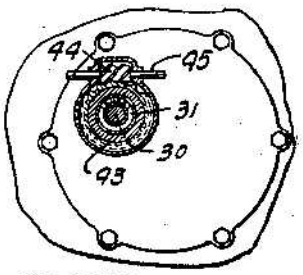


FIG. 3

FIG. 4



WITNESS

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BY E. J. Davis

E. C. McRae

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Patented Feb. 11, 1941 2,231,710

UNITED STATES PATENT OFFICE

2,231,710

TRACTOR

Henry Ford, Dearborn, Mich., assignor to Ford Motor Company, Dearborn, Mich., a corporation of Delaware

Application February 23, 1939, Serial No. 257,773

1 Claim. (Cl. 180—41)

The object of my invention is to provide a tractor of simple, durable and inexpensive construction.

A further object of my invention is to provide a tractor having a novel wheel suspension which differs from the conventional tractor in that all of the wheels may be raised or lowered relative to the tractor. When the wheels are in their lowermost positions, maximum clearance above the ground is provided so that the tractor may be used for cultivating relatively tall corn and similar crops. When the wheels are in their upper positions, the center of gravity of the tractor is lowered to thereby increase the draw-bar pull of the tractor.

With these and other objects in view, my invention consists in the arrangement, construction and combination of the various parts of my improved device, as described in the specification, claimed in my claim, and illustrated in the accompanying drawings, in which:

Figure 1 is a side elevation of my improved tractor, a portion of the steering mechanism being broken away to better illustrate the construction.

Figure 2 is a plan view of the tractor shown in Figure 1.

Figure 3 is a sectional view, taken upon the line 3—3 of Figure 2.

Figure 4 is a sectional view, taken upon the line 4—4 of Figure 2, and

Figure 5 is a front view of an alternate construction, this unit being supplied with an axle which is detachably secured to the front steering spindle in place of the axle shown in Figure 1.

Referring to the accompanying drawings, I have used the reference numeral 10 to indicate a conventional tractor internal-combustion engine having a radiator 11 secured to the forward end thereof. A water reservoir 12 is fixed to the upper portion of the radiator 11 and a fuel tank 13 extends from the rearward portion of the reservoir 12 rearwardly in the conventional manner. An axle and transmission housing 14 is fixed to the rear end of the engine 10, and axle tubes 15 extend outwardly from the respective sides of the rear portion of the housing 14.

A goose neck bracket 16 is fixed to the front end of the engine 10 and is adapted to support the tractor upon the front wheels. The upper end of the bracket 16 is provided with a vertical bore therethrough in which a quill 17 is reciprocally mounted. Gear teeth 18 are machined in the form of a rack upon one side of the quill 17, these teeth being in mesh with a pinion 19, which pinion is rotatably mounted in the upper end of the bracket 16 upon a shaft 20. One end of the shaft 20 is squared so that a wrench may be applied thereto to rotate the pinion 19 thereby raising or lowering the quill 17 in the bracket 16. A vertically extending king-pin 21 is rotatably mounted in the quill 17 but is prevented from axial movement relative thereto. Consequently, when the quill 17 is raised or lowered the pin 21 is correspondingly raised and lowered.

A head 22 is detachably secured to the lower end of the pin 21, which head is provided with a pair of wheel spindles projecting from the respective sides thereof, upon which spindles wheels 24 are rotatably mounted. The upper end of the pin 21 is provided with splined bore therein in which a splined shaft 25 is fixed. The upper end of the shaft 25 has a steering arm 26 secured thereto. Consequently, when the arm 26 is oscillated the wheels 24 will be turned to steer the tractor. A drag link 27 extends from the outer end of the arm 26 rearwardly where it is secured to the upper end of a steering arm 28. The lower end of the arm 28 is pivotally mounted upon the upper portion of the transmission housing 14 and a conventional steering reducion gear is provided which oscillates the arm 28 forwardly and back in accordance with the rotation of a steering wheel 29.

Referring to Figures 2 and 3 of the drawings, I have shown a reduction gearing through which the tractor is driven. Rear axle shafts 30 extend outwardly from the respective sides of a conventional differential, not shown, but which is mounted within the housing 14. The outer end of each shaft is supported upon a bearing 31 which is in turn supported by the outer end of the adjacent axle tube 15. Pinions 32 are fixed to the outer ends of the shafts 30.

It will be noted from Figure 2 that a housing 33 is rotatably mounted upon the outer end of each tube 15, which housings are held in place by a flange 34 formed on each tube against which a plate 35 is clamped by means of cap screws 36. Each housing 33 is formed of two parts with an outer drum 37 forming an enclosure for an internal gear 38, which gear is fixed to a stub-axle shaft 39. Each shaft 39 is rotatably mounted in suitable bearings in the drum 37 and in the housing 33 in such position that the internal gear 38 is in mesh with the pinion 32.

It will be noted that the axis of each shaft 39 is parallel to but is displaced rearwardly from the

axis of the pinion 32. Consequently, each housing 33 may be lowered to the position shown by lines 40 in Figure 3 or it may be swung upwardly to the position shown by lines 41. The housing may, of course, be retained in any intermediate position as shown by the full lines in Figure 3. A driving wheel 42 is fixedly secured to the outer end of each shaft 39 and swings up and down as the housing 33 is oscillated around the axle tube.

Inasmuch as the housings 33 are supported upon their respective axle tubes independently of each other, it will be readily seen that they both may oscillate simultaneously or independently, as desired. When the housings are moved to their lowermost position, as shown by lines 40, then the rear portion of the tractor is elevated a considerable distance above the position that it assumes when the housings are rotated to the positon shown by lines 41. The purpose of raising the rear end of the tractor is to obtain clearance under the axle tubes when it is desired to cultivate crops of a considerable height as the crops must pass beneath the axle tubes. When ploughing or doing other work requiring the maximum draw-bar pull by the tractor such pull may be increased by lowering the center of gravity. The front end of the tractor may be conveniently raised or lowered by means of the pinion 19 in accordance with the position of the rear end so that the tractor will remain on an even level over all ranges of adjustment.

Another important feature of this construction is that when ploughing is being done it is necessary that one of the drive wheels remain at the bottom of the furrow while the other rolls upon the unploughed surface. Consequently, all other tractors have a list to one side when being used for this work. With my improved tractor, the wheel which is riding in the furrow may be lowered thereby permitting the tractor to remain level. This also produces greater tractor effort on the wheels because the wheel treads remain flat on the ground.

In order to conveniently raise and lower each housing 33, I have provided a worm wheel 43 which is fixed on the outer end of each axle tube 15. A worm gear 44 is rotatably mounted in each housing 33 upon a shaft 45 in mesh with the worm 43 so that when the shaft 45 is rotated the housings are swung up and down at a reduced rate by the worms 44.

In the cultivation of certain crops it is necessary that the steering wheels 24 be spread as they interfere with the center row of crops. In this case I have provided an auxiliary head 46 which has a solid axle shaft 47 extending crosswise through the bottom thereof. The head 22 may be removed from the pin 21 and replaced by the head 46. The wheels 24 are then mounted upon suitable wheel spindles at the outer ends of the axle shaft 47 to thereby provide a standard tread for the front end of the tractor. A conventional front axle may also be used if desired.

Among the many advantages arising from the use of my improved construction, it may be well to mention that the principal advantage results in that the center of gravity of the tractor may be lowered close to the ground when heavy work is being done but if cultivating or work which requires considerable clearance over the axle is to be done then the tractor may be raised an appreciable distance to accomplish this purpose.

Some changes may be made in the arrangement, construction and combination of the various parts of my improved device without departing from the spirit of my invention and it is my intention to cover by my claim such changes as may reasonably be included within the scope thereof.

I claim as my invention:

A tractor comprising, an engine, an axle housing secured to one end of said engine, an axle tube extending transversely from the end of said axle housing opposite said engine, an axle shaft extending outwardly through said axle tube, a pinion disposed upon the outer end of said shaft, a gear housing having a cylindrical sleeve projecting from one side thereof, the axial center of said sleeve being spaced radially from the axial center of said gear housing, said sleeve being rotatably mounted upon the outer end of said axle tube, a flange formed on said axle tube which coacts with and supports the inner end of said sleeve, means disposed upon the inner end of said sleeve which operatively engages said flange to lock said sleeve in any one of a plurality of rotatable positions around said axle tube, a worm wheel fixed upon said axle tube within said sleeve, a worm shaft rotatably mounted in said sleeve transverse to its axial center, said worm shaft having a worm fixed thereon which meshes with said worm wheel so that rotation of said worm shaft rotates said sleeve and worm around said axle tube, a wheel shaft rotatably mounted within said housing upon its axial center, a driving wheel fixed to the outer end of said wheel shaft, and an internal gear fixed to said shaft within said housing, said internal gear being in mesh with said pinion.

HENRY [illegible]

March 22, 1960 A. L. SCHAWLOW ET AL 2,929,922

MASERS AND MASER COMMUNICATIONS SYSTEM

Filed July 30, 1958

FIG. 1

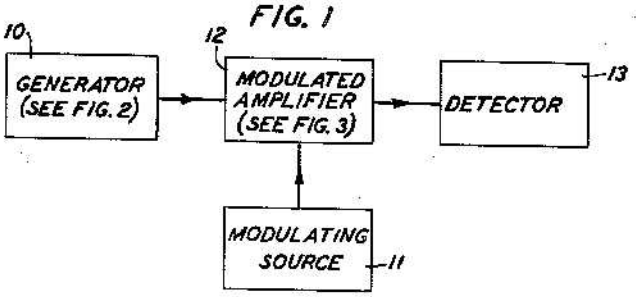


FIG. 2

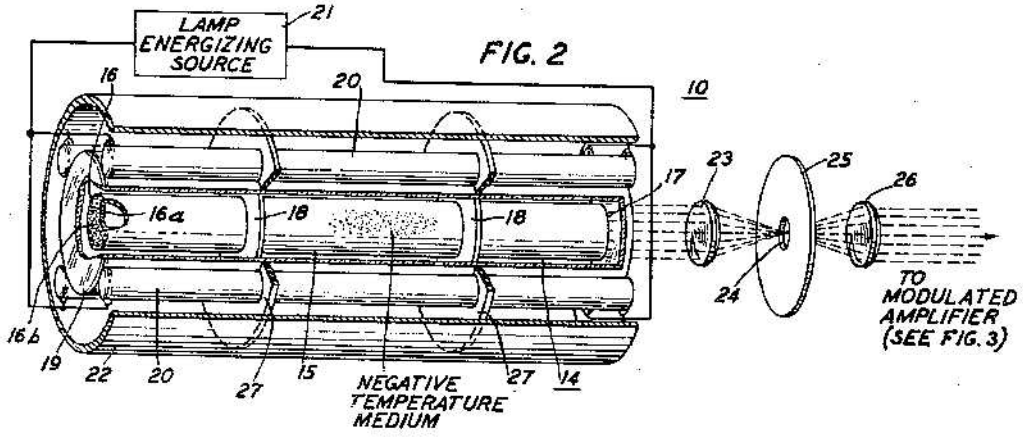
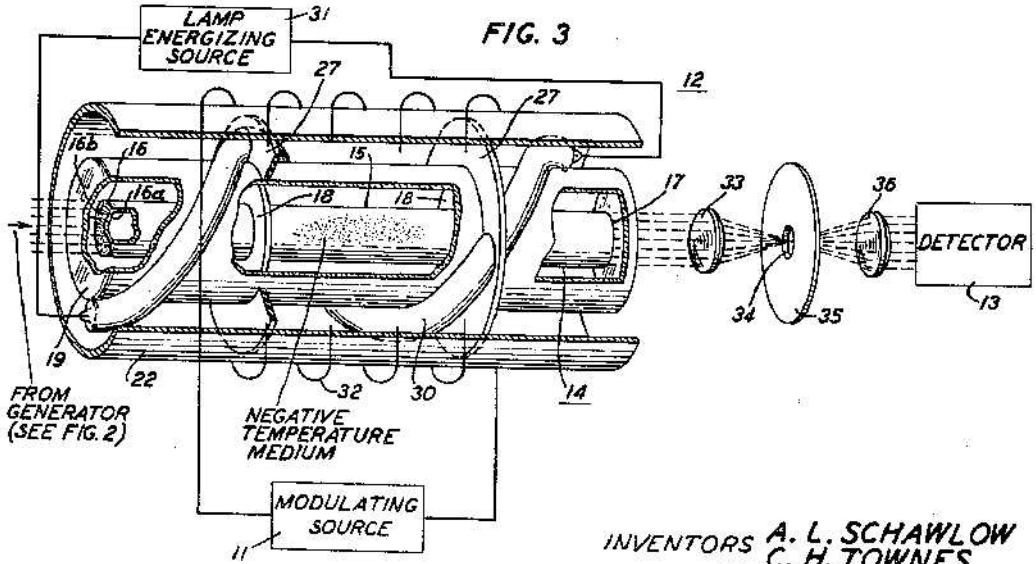


FIG. 3



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C. H. TOWNES
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ATTORNEY

United States Patent Office 2,929,922
Patented Mar. 22, 1960

2,929,922

MASERS AND MASER COMMUNICATIONS SYSTEM

Arthur L. Schawlow, Madison, N.J., and Charles H. Townes, New York, N.Y., assignors to Bell Telephone Laboratories, Incorporated, New York, N.Y., a corporation of New York

Application July 30, 1958, Serial No. 752,137

11 Claims. (Cl. 250—7)

This invention relates to the generation and amplification of infrared, visible, and ultraviolet waves, and more particularly to the generation and amplification of such waves by means of devices including media in which the stimulated emission of radiation occurs; devices of this type are now generally termed "masers."

It is characteristic of a maser that it employs a medium in which there is established at least intermittently a nonequilibrium population distribution in a pair of spaced energy levels of its energy level system. In particular, the population of the higher of the selected pair of energy levels may be made larger than that of the lower. It is now usual to describe a medium which is in such a state of nonequilibrium as exhibiting a negative temperature. It is known that a competing process known as relaxation tends to return the system to equilibrium.

It is characteristic that if there be applied to a medium which is in a negative temperature state a signal of a frequency which satisfies Planck's law with respect to the two energy levels which are in nonequilibrium

$$\left(\nu=\frac{E_2-E_1}{h} \text{ where } h \text{ is Planck's constant}\right)$$

then the applied signal will stimulate the emission of radiation at the signal frequency from the medium and the signal will be amplified.

Among the more promising forms of masers known is one which employs as the negative temperature medium a material whose energy level system is characterized by at least three energy levels, with the separations of these three energy levels falling within desired operating frequency ranges. To this material, there is supplied pumping power which effects transitions from the lowest to the highest of the selected three energy levels. By power saturation of the highest energy level, whereby the populations of the highest and lowest energy levels tend to be equalized, there is established in one of these two energy levels a nonequilibrium population distribution with respect to the intermediate energy level of the selected three, whereby a negative temperature results in the material. Thereafter a signal of appropriate frequency can be amplified by being applied thereto in a manner such that the emission of radiation is stimulated therefrom.

It is to be noted that the process of relaxation from randomly overpopulated states may give rise to spontaneous emission, that is, emission caused by radiative transitions in a mode other than the desired or stimulated one.

Generators and amplifiers employing atomic and molecular processes, as do the various known varieties of masers, may in principle be extended in operation far beyond the range of frequencies which have been generated and amplified by electronic processes. As, however, the maser concept is applied to the translation of wavelengths in the infrared, visible, and ultraviolet regions of the electromagnetic wave spectrum, it is found that conventional or microwave maser techinques and structures are suitable neither for the generation of monochromatic radiation nor to provide coherent amplification.

Accordingly, an object of the present invention is a system, including a maser, for translating infrared, visible, and ultraviolet energy.

A maser designed for operation in the microwave range of the spectrum might, for example, comprise a cavity having therein an ensemble of atomic or molecular systems, the cavity being characterized by being able to support only one mode near the frequency which corresponds to the desired radiative transitions of the systems. Alternatively, such an ensemble might be located in a waveguide, which similarly would be characterized by one, or a very few, preferred modes of propagation in the frequency range of interest.

Thus, the energy emitted by a maser operating in the microwave range is typically monochromatic, due to the energy produced by stimulated emission being very much larger than the background of radiation caused by spontaneous emission. In other words, such devices are inherently monochromatic because stimulated emission produces completely coherent amplification, and spontaneous emission, which is not so coherent, is characteristically small by comparison with the stimulated emission.

On the other hand, the maintenance of a single isolated mode is a maser cavity operating at frequencies above those in the microwave range requires an impractically small cavity structure (of the order of one wavelength) and/or a high and not easily realizable density of pumping power. Hence, one is led to consider, in these higher frequency ranges, cavities which are large compared to a wavelength, and which are accordingly capable of supporting a large number of modes within the frequency ranges of interest. A disadvantage of this approach, however, is that masers including such cavities must be operated at relatively high power levels in order that the emission stimulated therefrom be at least as large as that spontaneously emitted therefrom.

Accordingly, another object of this invention is a practically realizable, efficient, low-noise maser structure which is capable of the generation of monochromatic radiation, or coherent amplification, in the infrared, visible, and ultraviolet portions of the electromagnetic spectrum.

The above and other objects of the present invention are realized in an illustrative embodiment thereof wherein a negative temperature medium is disposed between two spaced parallel reflecting plates in a configuration which is of practical size and which may be pumped by readily available power sources, and wherein a single mode corresponding to the stimulated emission can be effectively isolated.

More particularly, one specific illustrative embodiment of the present invention comprises a maser including a chamber having reflective end parallel plates and side walls. Positioned within the chamber is a negative temperature medium, which is pumped by an energy source disposed about the chamber. The side walls are transparent to the pumping energy and either transparent to or absorptive of other energy radiated thereat. Further, an optical configuration is arranged adjacent to one of the end plates of the chamber for isolating the one mode of those supported within the chamber which it is desired to selectively utilize.

The principles of the present invention may illustratively be embodied in a communications system which comprises a maser device capable of generating monochromatic radiation, a second maser device capable of modulating and coherently amplifying the output of the maser generator, and a device for detecting the output of the second maser. Alternatively, such a system may

include a maser generator whose output is modulated by a nonamplifying device, or a system in which the maser generator itself is modulated.

Thus, a feature of the present invention is a system for communicating information by means of energy having wavelengths in the infrared, visible, or ultraviolet portions of the electromagnetic spectrum, comprising a monochromatic generator, a modulatable coherent amplifier, and a detector.

Another feature of this invention is a maser generator including a chamber comprising reflective parallel end members and side members, a negative temperature medium within said chamber, a pumping power source disposed about the side members, the side members being transparent to the pumping energy and either transparent to or absorptive of other energy radiated thereat, and a configuration arranged adjacent to one of the end members for abstracting from the chamber a selected one of the modes supported therein, whereby there is provided efficient, low-noise, monochromatic generation of infrared, visible, or ultraviolet waves.

A further feature of the present invention is a maser amplifier including a chamber comprising reflective parallel end members and side members, a negative temperature medium within said chamber, a pumping power source disposed about the side members, the side members being transparent to the pumping energy and nonreflective of other energy radiated thereat, and a configuration arranged adjacent to one of the end members for abstracting from the chamber an amplified replica of a wave fed through the other end member thereof, whereby there is provided an efficient, low-noise, coherent amplifier of infrared, visible, or ultraviolet waves.

A still further feature of this invention is an arrangement for modulating the signal output of a maser of the type herein-described comprising a structure for establishing a magnetic field parallel to the longitudinal axis of the chamber thereof, and an information source capable of varying the magnetic field in correspondence with the output of the source.

The principles of the present invention will be better understood from the following more detailed discussion taken in conjunction with the accompanying drawing, in which:

Fig. 1 is a block diagram of a communications system illustratively embodying aspects of the principles of the present invention;

Fig. 2 is a perspective view of a generator made in accordance with the principles of this invention; and

Fig. 3 is a perspective view of an amplifier embodying the principles of the present invention. Also, Fig. 3 depicts a modulating source and a detector, arranged in typical relationship to the amplifier.

Referring now to Fig. 1, there is shown a communications system in which the principles of the present invention are illustratively embodied. The system includes a generator or oscillator **10**, a modulating source **11**, a modulated amplifier **12**, and a detector **13**.

The generator **10**, which is shown in detail in Fig. 2, includes a chamber **14**, which typically may be about one centimeter in diameter and ten centimeters in length. The chamber **14** comprises a hollow cylinder **15** having its ends capped by two flat parallel assemblies **16** and **17**. Disposed within the chamber **14** is a negative temperature material whose radiative energy level separations correspond to frequencies in the ranges of interest, namely, the infrared, visible, and ultraviolet ranges.

Various materials are suitable for use as the active or negative temperature medium of maser devices of the general type described herein. For example, vapors of the alkali metals; namely, lithium, sodium, potassium, rubidium and cesium, and some solid rare earth salts, for example, anhydrous chlorides of europium and samarium, may be so used.

In particular, potassium maintained at a temperature of about 435 degrees Kelvin, at which temperature it exhibits a vapor pressure of about 0.001 millimeter, may advantageously be included in a specific illustrative embodiment of the principles of the present invention as the active medium thereof.

Each of the flat parallel assemblies **16** and **17** of the device shown in Fig. 2 advantageously includes as a component part thereof a material which reflects most of the energy incident thereupon. Thus, for example, an assembly comprising sapphire **16***a*, which material is characterized by good chemical inertness and excellent transmission properties, particularly for infrared wavelengths, and having a coating of gold **16***b*, typically about 500 angstrom units thick, on the outer surface of the sapphire member, may be included in specific embodiments of this invention. Such an assembly exhibits 97 percent reflectivity, 2 percent absorptivity, and 1 percent transmitivity to wavelengths in the infrared range.

The inner and outer parallel faces of each sapphire plate reflect a small portion of the radiation directed thereat. Therefore, the thickness of the sapphire plates should advantageously be chosen such that the reflections from the two faces of each plate add in phase.

It is noted that the phase angle between the reflections from the two faces or surfaces of each sapphire member depends on the thickness and refractive index thereof. Since sapphire is crystalline and the refractive index is different for ordinary and extraordinary rays, the thickness may be chosen to give constructive interference for one polarization and destructive interference for the polarization perpendicular thereto, in that manner discriminating between modes traveling in the same direction but having different polarizations.

The cylinder **15** of the chamber **14** is advantageously of a material which is transparent to the pumping energy and either transparent to or absorptive of other radiation impinging thereupon, thereby both to allow the negative temperature medium within the cylinder **15** to be pumped and to eliminate from the chamber radiation occurring in all modes except those corresponding to waves which travel back and forth between the reflective assemblies **16** and **17**. These reflected modes are coupled much more strongly to the excited atomic systems of the negative temperature medium than any other modes and hence would be strongly favored for maser oscillations.

In those specific embodiments of the present invention in which the negative temperature medium within the chamber **14** is at a pressure other than atmospheric, as in the case of the potassium vapor, for example, it is advantageous to support the chamber **14**, by means of spacer elements **18**, within a protective shell **19**, typically of glass, within which shell a pressure approximately equal to that within the chamber **14** is maintained. In this manner, the resultant forces acting on the opposing faces of the end assemblies **16** and **17** are made so small as not to be capable of distorting the assemblies and thereby disturbing their parallelism.

Arranged around the protective shell **19** are a plurality of pumping sources **20** which, in a maser generator including potassium vapor as the active medium thereof, may advantageously comprise an assembly of potassium lamps, which lamps **20** are energized by a source **21**.

The maser generator shown in Fig. 2 further includes a housing **22** in which the protective shell **19** is supported by spacer elements **27**. The inner surface of the housing **22** is of a material which is capable of reflecting a major part of the energy radiated thereupon from the pumping power sources **20**, thereby to aid in directing a substantial portion of the energy emitted by the sources **20** toward the chamber **14** and into the negative temperature medium therein.

The process of oscillation within a maser generator made in accordance with the principles of the present invention depends on the selective regeneration within the

chamber 14 of a component of the energy spontaneously emitted by the negative temperature medium therein.

Mode selection in the maser generator shown in Fig. 2 is based on the phenomenon that, when energy is radiated from a chamber of the type herein-described through an end plate member which is large compared to the wavelength of the radiation, each mode radiates in a characteristic direction. Thus, if the emitted radiation is focused by a lens, each point in the focal plane thereof will correspond to a mode of a particular direction, affording thereby a separation of modes. And, if radiation falling on a very limited area in the focal plane is detected, that radiation will represent spontaneous and stimulated emission from a selected and limited number of modes, the large background of spontaneous emission produced in other modes being thereby effectively isolated.

The principles of this phenomenon are utilized in the maser generator shown in Fig. 2. Radiation in the desired mode is transmitted through the end assembly 17 and focused by a double-convex lens 23 arranged such that the desired energy is directed through an aperture 24 in an absorptive sheet 25 which lies in the focal plane of the lens 23. A second double-convex lens 26 is employed to reconvert the selected energy to the form of a plane wave, in which form the desired energy radiates to the modulated amplifier 12.

The maser amplifier shown in Fig. 3 is similar in structure to the generator described above. The amplifier includes a chamber 14 comprising a hollow cylinder 15 supported within a protective shell 19 by supporting members 18 and within which cylinder 15 there is disposed a suitable negative temperature medium. The shell 19 is supported within a reflective housing 22 by spacer or supporting members 27.

Arranged about the protective shell 19 of the amplifier 12 shown in Fig. 3 is a pumping power assembly 30 which may advantageously comprise, in a specific illustrative embodiment of the present invention wherein the negative temperature medium is potassium vapor, a potassium lamp formed in the shape of a spiral, which spiral lamp is energized by a source 31.

Energy which is directed from the generator 10 through the left-hand end of the cylinder 15 of the amplifying device of Fig. 3 may be modulated by an assembly including a coil 32 for establishing a magnetic field parallel to the longitudinal axis of the cylinder 15 and a source 11 for varying the strength of the longitudinal magnetic field, whereby broadening or splitting of the spectral lines emitted by the device 12 in correspondence with the variation of the magnetic field results, which phenomenon is generaly termed the Zeeman effect.

The device 12 shown in Fig. 3 radiates through the right-hand end of the cylinder 15 an amplified counterpart of the energy directed at the device 12 by the generator 10. The radiated energy is directed by two lenses 33 and 36 through an aperture 34 in an absorptive member 35 and to a detector 13. The detector 13 may, for example, include a photomultiplier tube.

It is noted that the admission of a signal into the region between the two end parallel plates of the amplifying device 12 is similar to the process involved in a microwave cavity. More particularly, the partially reflecting surfaces of the end plates are analogous to coupling holes; and, if a monochromatic plane wave strikes the outside of one of the partially reflecting surfaces, energy will build up in the region between the plates, and the relations between input wave, energy in the "cavity," and output wave correspond to those for a microwave impinging on an appropriate cavity with input and output coupling holes.

Thus, it is seen that the principles of the present invention may illustratively be embodied in monochromatic maser generators of infrared, visible, or ultraviolet wavelengths. It is feasible to tune such generators by varying the pressure or temperature of the negative temperature media thereof. Alternatively, tuning of such devices may be based on the Stark effect (i.e., observed changes in the spectrum of a system when the system is subjected to an electric field) or on the Zeeman effect.

Further, it has been shown that embodiments of this invention include coherent maser amplifiers of infrared, visible, or ultraviolet wavelengths. It is to be noted that these devices are capable of amplifying energy of these wavelengths with no significant change in the wavefront or phase thereof.

It is to be noted that maser devices embodying the principles of the present invention may advantageously be utilized in various spectroscopy and measurement applications, as well as in the communications field.

It is to be understood that the various specific embodiments disclosed are merely illustrative of the general principles of the invention. Thus, although the amplifying chamber 14 has been shown and described as including a hollow cylinder, it is of course clear that any other transparent structure (more specifically, transparent to the pumping energy and transparent to or absorptive of other radiation) suitable for retaining the negative temperature medium and including reflective end assemblies may be easily substituted therefor.

What is claimed is:

1. A communications system for operation in the infrared, visible, or ultraviolet regions of the electromagnetic wave spectrum comprising a monochromatic maser generator, a coherent modulated maser amplifier, a modulating source, and a detector; said generator comprising a chamber having end reflective parallel members and transparent side members, a negative temperature medium disposed within said chamber, and means arranged about said chamber for pumping said medium; said amplifier comprising a chamber having end reflective parallel members and transparent side members, a negative temperature medium disposed within said chamber, means arranged about said chamber for pumping said medium, and coupling means for abstracting from one end of said chamber an amplified counterpart of the energy transmitted into the other end thereof and for directing said amplified counterpart at said detector.

2. A communications system for operation in the infrared, visible or ultraviolet regions of the electromagnetic wave spectrum comprising a monochromatic maser generator, a coherent maser amplifier, said generator and amplifier including means for modulating the output of said generator in accordance with signal information, and a detector; said generator comprising a chamber having a length which is substantially greater than its transverse dimension and having partially reflective parallel end members and nonreflective side members, a negative temperature medium disposed within said chamber and characterized by at least three distinct energy levels, two of which have a separation in the frequency range of interest, means for pumping said medium so that a population inversion is produced therein between said two separated energy levels, and means for abstracting from said chamber and directing at the amplifier input the energy of a particular mode of electromagnetic vibration; said amplifier comprising a chamber having a length which is substantially greater than its transverse dimension and having partially reflective parallel end members and nonreflective side members, a negative temperature medium disposed within said chamber and characterized by at least three distinct energy levels, two of which have a separation in the frequency range of interest, means for pumping said medium so that a population inversion is produced therein between said two separated energy levels, means for abstracting from said chamber the energy of a particular mode of electromagnetic vibration representing an amplified and modulated replica of the generator output, and means for directing said replica at said detector.

3. A communications system for operation in the in-

frared, visible, or ultraviolet regions of the electromagnetic wave spectrum comprising a monochromatic maser generator, a coherent modulated maser amplifier, a modulating source, and a detector; said amplifier including means defining an amplifying chamber, and means for establishing a magnetic field parallel to the longitudinal axis of said chamber, said modulating source being coupled to said magnetic means, the radiative output of said generator being directed at said amplifier, and the radiative output of said amplifier, constituting an amplified and modulated counterpart of the energy radiated thereinto, being directed at said detector.

4. A maser generator comprising a chamber having end reflective parallel members and side members, a negative temperature medium disposed within said chamber, and means arranged about said chamber for pumping said medium, said side members being transparent to the pumping energy and transparent to or absorptive of other energy radiated thereat.

5. A maser generator for operation in the infrared, visible or ultraviolet regions of the electromagnetic wave spectrum comprising a chamber having a length which is substantially greater than its transverse dimension and having partially reflective parallel end members and non-reflective side members, a negative temperature medium disposed within said chamber and characterized by at least three distinct energy levels, two of which have a separation in the frequency range of interest, means for pumping said medium so that a population inversion is produced therein between said two separated energy levels, and means for abstracting from said chamber and directing at an amplifier input the energy of a particular mode of electromagnetic vibration.

6. A maser generator as in claim 5 wherein said mode selecting means includes an absorptive member having an opening therethrough, said absorptive member being positioned adjacent to one end of said chamber, and means for directing a selected portion of the energy radiated by said generator through said opening.

7. A maser generator as in claim 5 wherein said negative temperature medium comprises potassium, and said pumping means comprises an assembly of potassium lamps.

8. A maser amplifier comprising a chamber having end reflective parallel members and said members, a negative temperature medium disposed within said chamber, means arranged about said chamber for pumping said medium, said side members being transparent to the pumping energy and non-reflective of other energy radiated thereat, and coupling means for abstracting from one end of said chamber an amplified counterpart of the energy directed into the other end thereof.

9. A maser amplifier for operation in the infrared, visible or ultraviolet regions of the electromagnetic wave spectrum comprising a chamber having a length which is substantially greater than its transverse dimension and having partially reflective parallel end members and non-reflective side members, a negative temperature medium disposed within said chamber and characterized by at least three distinct energy levels, two of which have a separation in the frequency range of interest, means for pumping said medium so that a population inversion is produced therein between said two separated energy levels, and means for abstracting from said chamber and directing at a detector the energy of a particular mode of electromagnetic vibration.

10. A maser amplifier as in claim 9 wherein said negative temperature medium comprises potassium, and said pumping means comprises an assembly of potassium lamps.

11. A modulated maser amplifier comprising a chamber having end reflective parallel members, a negative temperature medium disposed within said chamber, means arranged about said chamber for pumping said medium, means coupled to and under the control of a modulating source for establishing a magnetic field parallel to the longitudinal axis of said chamber, and means for abstracting from one end of said chamber an amplified counterpart of the energy directed into the other end thereof, which counterpart is modulatable in accordance with the output of said source.

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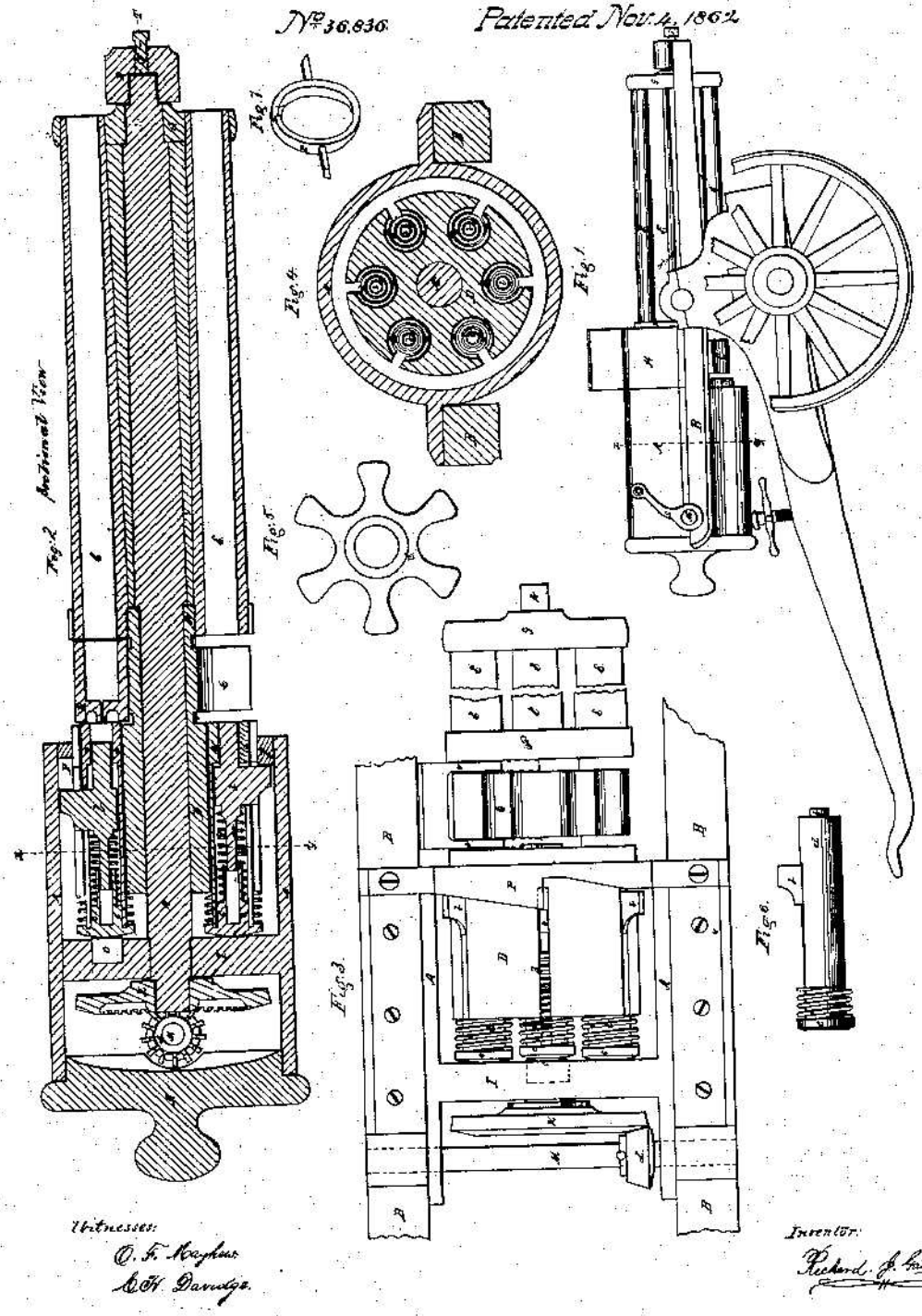
2,836,722 Dicke et al. ---------- May 27, 1958

R. J. Gatling.

Machine Gun.

No. 36,836. Patented Nov. 4, 1862.



Witnesses:
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UNITED STATES PATENT OFFICE.

RICHARD J. GATLING, OF INDIANAPOLIS, INDIANA.

IMPROVEMENT IN REVOLVING BATTERY-GUNS.

Specification forming part of Letters Patent No. **36,836**, dated November 4, 1862.

To all whom it may concern:

Be it known that I, RICHARD J. GATLING, of Indianapolis, county of Marion, and State of Indiana, have invented new and useful Improvements in Fire-Arms; and I do hereby declare that the following is a full and exact description thereof, reference being had to the accompanying drawings, making part of this specification, in which—

Figure 1 is a side elevation of the gun with the upper portion of the wheels cut away. Fig. 2 is a vertical longitudinal section through the center of the gun. Fig. 3 is a top view of the gun with the top half of the external casing, A, left off and the middle portion of the barrels cut away to shorten the drawing. Fig. 4 is a transverse section through lock-cylinder on line *x y* in Figs. 1 and 2. Fig. 5 is an end view of the grooved carrier C which receives the cartridges or cartridge-chambers. Fig. 6 is a side view of one of the tubes containing the mainspring and hammer of one of the locks. Fig. 7 is a perspective view of the ring P which surrounds the forward end of the lock-cylinder D, having inclined planes on its rear edge for cocking and drawing back the hammers to their proper position.

The object of this invention is to obtain a simple, compact, durable, and efficient fire-arm for war purposes, to be used either in attack or defence, one that is light when compared with ordinary field-artillery, that is easily transported, that may be rapidly fired, and that can be operated by few men.

The invention consists in a singularly-constructed revolving lock cylinder or breech, in combination with a grooved carrier and barrels all rigidly fixed upon the same shaft, and all of which revolve together when the gun is in operation, the locks and grooves in the carrier and the barrels all being parallel with the axis of revolution.

The invention also consists in the novel means employed in cocking and firing the gun without the use of a trigger by means of the inclined plane on the rear edge of the ring P, which surrounds the forward end of the lock-cylinder, and also in the novel use of the inner tubes (which contain the locks) to press the cartridge-chambers firmly against the rear ends of the barrels while being discharged, and in the outer casing and disk, which protects the locks from injury.

Similar letters of reference indicate corresponding parts in the several figures.

To enable others skilled in the art to make and use my invention, I will proceed to describe its construction and operation.

I construct my gun usually with six ordinary rifle-barrels, E, fixed at their rear and forward ends into circular plates F and G, which are rigidly secured to a shaft, N, upon which is also rigidly fixed the grooved carrier C and lock-cylinder D and cog-wheel K. A case or shield, A, covers and protects the lock-cylinder and cog-wheel. All of these several parts are mounted on a frame, B, and are supported by an ordinary gun-carriage. The lock-cylinder D is perforated longitudinally with six holes, (corresponding to the number of barrels,) as shown in Fig. 4, and has slots cut through from the surface of the cylinder to the holes to admit the projecting portion of the hammers *b*. In the perforations or holes in the lock-cylinder the locks (one of which is shown in elevation in Fig. 6) are placed.

The locks are constructed of the tubes *a a*, &c., having a flanged breech-pin, *c*, secured in their rear ends and provided with hammers *b* and mainsprings *d*, all formed and arranged as clearly shown in section in Fig. 2.

C is a grooved carrier for conveying the cartridge-chambers from the reservoir or hopper H up to the position in which they are fired, and thence on around until they fall out by their own weight; but that the cartridge-chambers may be removed with certainty from the grooved carrier C a comb or rake is provided and attached to the frame, as shown by the red lines in Figs. 2 and 3.

P, Figs. 2, 3, and 7, is a ring encircling the forward end of the lock-cylinder D, and is rigidly secured by lugs to the frame B. The rear edge of this ring is formed into two inclined planes, as clearly shown in Fig. 3, the greater inclined plane serving to push back or cock the hammers *b* as they are successively revolved, while the lesser inclined plane serves to push the hammers back into their proper places within the tubes *a* after they have struck the percussion-cap, so as to allow the cartridge-chambers to drop from the carrier.

The disk I forms a division in the case A, the forward portion of the case forming a shield or covering for the locks, while the rear division contains and protects the cog-wheel K and L. In the forward face of the disk I a small steel plug, O, is inserted, having its forward face rounded or swelled out slightly beyond the face of the disk. This swell is for the purpose of pressing the tubes *a* forward against the cartridge-chambers R, and thus pressing the cartridge-chambers firmly against the rear end of the barrel at the time of each and every discharge, thereby preventing the escape of gas from the ignited powder. The forward motion of the tubes *a*, caused by the swell O on disk I, also assists in compressing the mainsprings *d*, thereby increasing the force of the blow from the lock-hammers *b* upon the percussion-caps on the nipples of the cartridge-chambers.

The rounded heads of the breech-pin *c* bear against the forward face of the disk I, being kept in their position by the coiled springs *e e*, &c., which surround the rear ends of the tubes *a a*, &c., the springs *e* bearing against the rear end of the lock-cylinder and against the flange of the breech-pin *c*. By this arrangement the forward ends of the locks are kept flush with the forward face of the lock-cylinder until they are revolved opposite the swell *o*, when they are pressed forward, as before described.

The shaft N, upon which the lock-cylinder D, carrier C, barrels E, and cog-wheel K are rigidly secured, has a bearing near its rear end in disk I and a bearing at its forward end in a box on the frame B. A crank-shaft, M, runs through the rear part of case A and has fixed upon it the small cog-wheel or pinion L and crank S.

An adjusting-screw, T, is placed in the box opposite the forward end of shaft N, for regulating the pressure upon the cartridge-chambers R. The cartridge-chambers R, (any desired number of which may be used,) being loaded, are placed in the hopper or reservoir, with their nipple or cap ends toward the hammers, over the grooved carriers C, when, by rotating the crank S, which carries with it the shaft M, and pinion L, which meshes into the large cog-wheel K, thereby revolving the shaft N, lock-cylinder D, carrier C, and barrels E, the cartridges drop or rather roll into the grooves of carrier C and are carried by it up to the position in which they are discharged. The hammers, cartridge-chambers, and barrels all being on a line parallel to the axis of revolution, it is impossible for the cartridges to be out of place when discharged.

The hammers *b* are pushed back by the large inclined plane on the rear edge of the ring P, and when they have passed the highest point of the inclined plane they are driven forward against the percussion-cap on the nipple of the cartridge-chamber by the coiled mainspring *e* with sufficient force to explode the cap and discharge the cartridge, after which the cartridge-holder is carried on around until it drops out of the carrier by its own weight, when it is ready to be taken up and reloaded.

I do not claim the use of the grooved or fluted revolving carrier C, separately considered, and when the same is made to revolve separately and independently of the barrels and breech, the same being an old device; neither do I claim the direct combination thereof with an automatic revolving gear or with a device for pressing the cartridge-chamber against the barrel when used alone for that purpose; but

What I do claim as new and as my invention, and desire to secure by Letters Patent, is—

1. The combination of the lock-cylinder or breech D with the grooved carrier C, circular plate F, and barrels E E, &c., the lock-cylinder or breech, carrier, and circular plate being firmly fastened upon the main shaft N, and the locks, grooves in the carrier, and barrels being arranged on a line parallel with the axis of revolution, the whole revolving together when the gun is in operation, substantially as described.

2. In the construction of revolving fire-arms, the use of as many locks as there are barrels, said locks revolving simultaneously with the breech and barrels, and being arranged and operated substantially as set forth.

3. The stationary ring P, provided with inclined planes on its rear edge, in combination with lock-cylinder D and locks, when constructed and operated for the purposes substantially as set forth.

4. The tubes *a a*, &c., furnished with the flanged breech-pins *c c*, &c., and springs *e e*, &c., and which contain the lock-hammers *b b*, &c., and mainsprings *d d*, &c., in combination with the revolving breech D, disk I, and swell *o*, when constructed, arranged, and operated for the purposes substantially as set forth.

5. The disk I, in combination with the external breech-piece or casing, A, which forms a shield or covering for the lock-cylinder and which protects the locks and cog-wheels from injury.

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Telegraph Signs.

No. 1647. Patented Jun. 20, 1840.

Example 1st — 1st For Numerals

First mode

Second mode

Third mode

Fourth mode

Example 2d — For Compound Numerals

Showing the numerals combined together

First mode — Third mode

Second mode — Fourth

Example 3d — 2d For Letters

The System of Type

Example 4th — 1st For Numerals

Fig. 1.

Fig. 2.

Long Space — Rest — Cypher — Stop

Example 5 — 2d For Letters

Example 6. — Type for Circular Port Rule

Fig. 1

Fig. 2.

Fig. 3.

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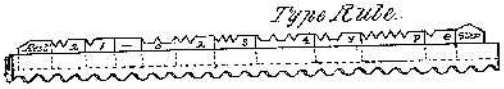
Telegraph Signs.

No. 1647. Patented Jun. 20, 1840.

Example. 7.

Type Rule.



Example. 8.

Fig. 1. Straight Port Rule

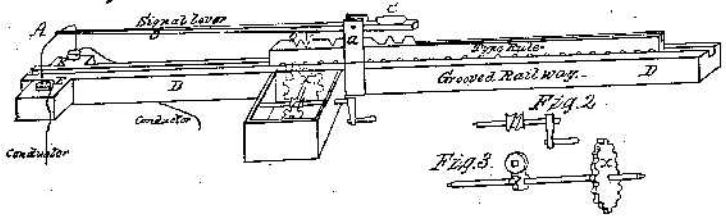


Fig. 2.

Fig. 3.

Example. 9.

Circular Port Rule.

Fig. 1.

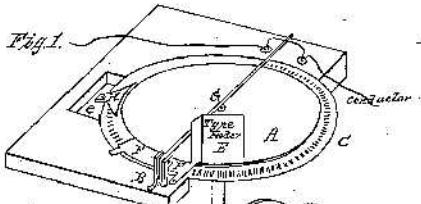
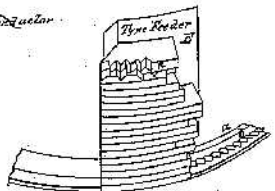


Fig. 2.



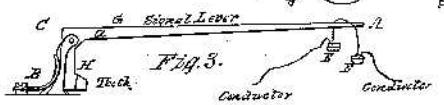
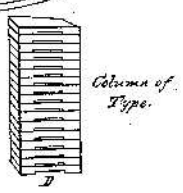


Fig. 3.

Fig. 4.



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Telegraph Signs.

No. 1,647. Patented Jun. 20, 1840.

Example 10.
Register

Fig. 1.

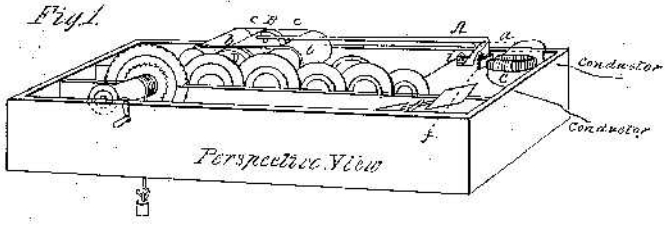


Fig. 2.

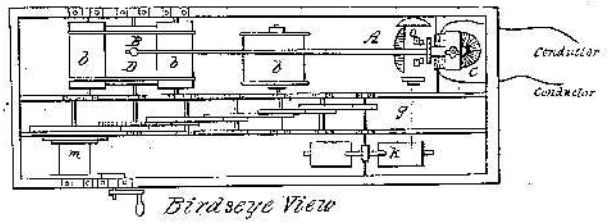


Fig. 3.

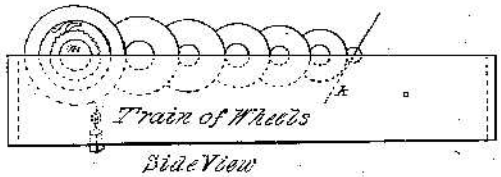


Fig. 4.

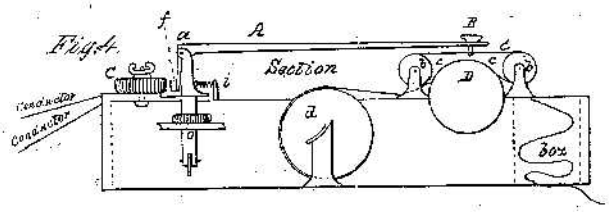
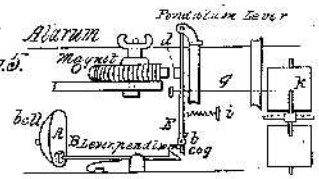


Fig. 5.



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UNITED STATES PATENT OFFICE.

SAMUEL F. B. MORSE, OF NEW YORK, N. Y.

IMPROVEMENT IN THE MODE OF COMMUNICATING INFORMATION BY SIGNALS BY THE APPLICATION OF ELECTRO-MAGNETISM.

Specification forming part of Letters Patent No. 1,647, dated June 20, 1840.

To all whom it may concern:

Be it known that I, the undersigned, SAMUEL F. B. MORSE, of the city, county, and State of New York, have invented a new and useful machine and system of signs for transmitting intelligence between distant points by the means of a new application and effect of electro-magnetism in producing sounds and signs, or either, and also for recording permanently by the same means, and application, and effect of electro-magnetism, any signs thus produced and representing intelligence, transmitted as before named between distant points; and I denominate said invention the "American Electro-Magnetic Telegraph," of which the following is a full and exact description, to wit:

It consists of the following parts—first, of a circuit of electric or galvanic conductors from any generator of electricity or galvanism and of electro-magnets at any one or more points in said circuit; second, a system of signs by which numerals, and words represented by numerals, and thereby sentences of words, as well as of numerals, and letters of any extent and combination of each, are communicated to any one or more points in the before-described circuit; third, a set of type adapted to regulate the communication of the above mentioned signs, also cases for convenient keeping of the type and rules in which to set and use the type; fourth, an apparatus called the "straight port-rule," and another called the "circular port-rule," each of which regulates the movement of the type when in use, and also that of the signal-lever; fifth, a signal-lever which breaks and connects the circuit of conductors; sixth, a register which records permanently the signs communicated at any desired points in the circuit; seventh, a dictionary or vocabulary of words to which are prefixed numerals for the uses hereinafter described; eighth, modes of laying the circuit of conductors.

The circuit of conductors may be made of any metal—such as copper, or iron wire, or strips of copper or iron, or of cord or twine, or other substances—gilt, silvered, or covered with any thin metal leaf properly insulated and in the ground, or through or beneath the water, or through the air. By causing an electric or galvanic current to pass through the circuit of conductors, laid as aforesaid, by means of any generator of electricity or galvanism, to one or more electro-magnets placed at any point or points in said circuit, the magnetic power thus concentrated in such magnet or magnets is used for the purposes of producing sounds and visible signs, and for permanently recording the latter at any and each of said points at the pleasure of the operator and in the manner hereinafter described—that is to say, by using the system of signs which is formed of the following parts and variations, viz:

Signs of numerals consist, first, of ten dots or punctures, made in measured distances of equal extent from each other, upon paper or any substitute for paper, and in number corresponding with the numeral desired to be represented. Thus one dot or puncture for the numeral 1, two dots or punctures for the numeral 2, three of the same for 3, four for 4, five for 5, six for 6, seven for 7, eight for 8, nine for 9, and ten for 0, as particularly represented on the annexed drawing marked Example 1, Mode 1, in which is also included a second character, to represent a cipher, if prefered.

Signs of numerals consist, secondly, of marks made as in the case of dots, and particularly represented on the annexed drawing marked Example 1, Mode 2.

Signs of numerals consist, thirdly, of characters drawn at measured distances in the shape of the teeth of a common saw by the use of a pencil or any instrument for marking. The points corresponding to the teeth of a saw are in number to correspond with the numeral desired to be represented, as in the case of dots or marks in the other modes described, and as particularly represented in the annexed drawing marked Example 1, Mode 3.

Signs of numerals consist, fourthly, of dots and lines separately and conjunctively used as follows, the numerals 1, 2, 3, and 4 being represented by dots, as in Mode 1, first given above: The numeral 5 is repesented by a line equal in length to the space between the two dots of any other numeral; 6 is represented by the addition of a dot to the line representing 5; 7 is represented by the addition of two dots to said line; 8 is represented by prefixing a dot to said line; 9 is represented by two dots prefixed to said line; and 0 is represented by two lines, each of the length of said

line that represents the number 5; said signs are particularly set forth in the annexed drawings, marked Example 1, Mode 4.

Either of said modes are to be used as may be preferred or desired and in the method hereinafter described.

The sign of a distinct numeral, or of a compound numeral when used in a sentence of words or of numerals, consists of a distance or space of separation between the characters of greater extent than the distance used in separating the characters that compose any such distinct or compound numeral. An illustration of this sign is particularly exhibited in the annexed drawing marked Example 2.

Signs of letters consist in variations of the dots, marks, and dots and lines, and spaces of separation of the same formation as compose the signs of numerals, varied and combined differently to represent the letters of the alphabet in the manner particularly illustrated and represented in the annexed drawing marked Example 3.

The sign of a distinct letter, or of distinct words, when used in a sentence, is the same as that used in regard to numerals and described above.

Signs of words, and even of set phrases or sentences, may be adopted for use and communication in like manner under various forms, as convenience may suggest.

The type for producing the signs of numerals consist, first, of fourteen pieces or plates of thin metal, such as type-metal, brass, iron, or like substances, with teeth or indentations upon one side or edge of ten of said type, corresponding in number to the dots or punctures or marks requisite to constitute the numerals respectively heretofore described in the system of signs, and having also a space left upon the side or edge of each type, at one end thereof, without teeth or indentations, corresponding in length with the distance or separation desired between each sign of a numeral. Another of said type has two indentations, forming thereby three teeth only, and without any space at either end, to correspond with the size of a cypher, as heretofore described by reference to Example 1, Modes 1, 2, 3, of drawings in said system of signs. One other of said type is without any indentation on its side or edge, and being in length to correspond with the distance or separation desired between distinct or compound numerals, and with the sign heretofore described for that purpose. One of the remaining two of said type is formed with one corner of it beveled, (system of type, Example 4, Fig. 1,) and is called a "rest," and the other is in a pointed form and called a "stop."

Each of said type is particularly delineated on the annexed drawing marked Example 4, Fig. 1, and numbered or labeled in accordance with the purpose for which they are designed respectively, and are used, in like manner, for producing each of the several signs of numerals heretofore described in the system of signs.

The type for producing the signs of numerals consist, secondly, of five pieces or plates of metal first described above, four of which are the same as are numbered 1, 2, 3, and 4 in the annexed drawing marked Example 4, Fig. 1, and the fifth one being the same as is denominated in the same example "the long space," and heretofore alluded to; also, of six other pieces or plates of said metal, varied in indentations and teeth and spaces, as represented on the annexed drawings marked Example 4, Fig. 2, to produce signs of the denominations described in the fourth mode of the beforementioned system of signs, Example 1.

The type for producing the signs of letters are of the same denomination with those used in producing signs of numerals, and only varied in form, from one to twenty-three, as exhibited in the annexed drawing marked Example 5.

The type for producing both signs of numerals and signs of letters are adapted for use to either a straight rule, called the "straight port-rule," and are in that case made straight lengthwise, as described in the drawings annexed and heretofore referred to in Example 5, or to a circular port-rule, in which case they are lengthwise circular or formed into sections of a circle, as represented in the drawings annexed marked Example 6, Figs. 2 and 3, and as will be further understood by the descriptions hereinafter contained of the straight and circular port-rules. On the under side of the type for the circular port-rule (which type are of greater thickness than those for the straight port-rule) is a groove (system of type, Example 6, A in Figs. 1 and 3) about midway of their width, and in depth about half the thickness aforesaid, and extending from the space ends, as B, Example 6, Fig. 3—that is, the ends without indentation—of said type, along the length, and conforming to the curve thereof, to a point, D D, equal in distance from the opposite ends to half the width of the pointed teeth cut upon their edges. For a delineation of these type reference is made to sections thereof in Figs. 1 and 3 upon the annexed drawings marked Example 6.

The type-cases are wood, or of any other material, with small compartments of the exact length of the type, for greater convenience in distributing, and resembling those in common use among printers.

The type-rules are of wood or metal, or other material that may be preferred, and about three feet in length, with a groove, into which the type, when used, are placed. On the under side of each type-rule are cogs, by which they are adapted to a pinion-wheel having corresponding cogs and forming part of a port-rule. The type-rule in use is moved onward as motion is given to the said wheel. A delineation of the type-rule is contained in the annexed drawing marked Example 7.

The straight port-rule consists of a pinion-wheel, before mentioned, turned by a hand-crank attached to a horizontal screw that plays into the cogs of the pinion-wheel as the latter do into the cogs of the type-rule, or by any

other power in any of the well-known methods of mechanism. It is connected with a railway or groove, in and by which the type-rule, from the motion imparted to it by said wheel, is conveyed in a direct line beneath a lever that breaks and connects the galvanic circuit in the manner hereinafter mentioned. A delineation of said wheel, crank, and screw is contained in the drawings hereunto annexed marked Example 8, Figs. 1, 2, 3.

The circular port-rule is a substitute, when preferred, for both the type-rule and the straight port-rule, and consists of a horizontal or inclined wheel, Example 9, Fig. 1, A, of any convenient diameter, of wood or metal, having its axis connected on the under side of the wheel, with a pinion-wheel, K, and as in the case of the straight port-rule. It is moved by the motion of the pinion-wheel, as is the type-rule in the former description. On the entire circumference of said horizontal or inclined wheel, and upon its upper surface, is a shoulder or cavity, *a*, Figs. 1, 2, corresponding in depth with the thickness of the type used, and in width, *b*, equal to that of the type, exclusive of their teeth or indentations. Near the outer edge of the surface of said shoulder or cavity are cogs *c*, throughout the circumference of the wheel, projecting upward at a distance from each other equal to one-half of the width of the teeth or indentations of the type, and otherwise corresponding in size to the width and depth of the groove D D, Fig. 4, in the under side of the circular type before described and illustrated by reference to Example 6, Figs. 1 and 3. Directly over said shoulder or cavity and cogs, and at one or more points on the circumference of said wheel, is extended from a fixture outside of the orbit of the wheel a stationary type-feeder, E, Fig. 1, formed of one end, *e*, and one side, E, perpendicular, of tin or brass plate or other substance, and of interior size and shape to receive any number of the type which are therein deposited with their indentations projecting outward, as in Fig. 2, and their grooves downward, as in Fig. 4. Said type-feeder is so suspended from its fixture F F over the shoulder or cavity of the wheel A, before described, as to admit of the passage under it of said wheel in its circuit as near the bottom of the feeder as practicable, without coming in contact therewith. The type deposited in the feeder as before mentioned form a perpendicular column, as in Fig. 2, the lower type of which rests upon the surface of the before-named shoulder of the wheel *b*, Fig. 2, and the cog of the wheel, projecting upward, enters the groove D D, Fig. 4, of the type hereinbefore described.

The operation of said circular port-rule in regulating the movement of the type in sue is as follows: When the wheel A is set in motion the type resting immediately upon the shoulder of the wheel, in the manner mentioned above, as in Fig. 2, is carried forward on the curvature of the wheel from beneath the column of type resting upon it in the stationary type-feeder by means of one of the before-named cogs coming in contact with that point D, Fig. 3, Example 6, in the groove of the type, hereinbefore described as forming the termination of said groove, and which is particularly delineated at the points D D in the annexed drawings, marked Example 6, Fig. 3. As by said process the lower type in the column that is held by the stationary feeder is carried forward and and removed, the next type settles immediately upon the shoulder of the wheel, and, after the manner of the removed type, is brought in contact with another cog of said shoulder within the groove of the type, and thence carried forward from beneath the incumbent column, as was its predecessor. Then follows consecutively in the same method each type deposited within the feeder so long as the wheel is kept in motion. The deposit of the type in the stationary feeder is regulated by the order in which the letters or numerals or words they represent are designed to be communicated at any distant point or points. After the type are respectively carried forward on the curvature of the wheel in the manner stated above, beyond the point where they are acted upon by the signal-lever, as is hereinafter described, they are lifted, each in its turn, from the shoulder of the wheel A and cast off into a box or pocket, G, below the wheel by means of a slender shaft or spindle, H, made of any metal, and resembling in form a common plow-share, extending downward from a fixture, *o*, placed outside of the wheel, into a groove, K, within the before-named shoulder of said wheel A, and on the inner side of the cogs *c*, already described. By means of said groove the downward point of said shaft or spindle H is brought within the curvature and below the surface of said shoulder *b*, Fig. 2, and consequently under the approaching end of the type, so that each type successively, as it is carried forward on said curvature, in the manner before described, is lifted from the shoulder and forced upward on the inclined shaft or spindle by the type in contact with it at the other end until turned off into the before-named box or pocket G below, ready for a redistribution.

For a more particular delineation of the several parts of said circular port-rule reference is made to the annexed drawings marked Example 9, Figs. 1 and 2.

The signal-lever, Example 9, Fig. 3, consists, first, for use with the straight port-rule, Example 8, Fig. 1, A, of a strip of wood of any length from six to twenty-four inches, resting upon a pivot, *a*, or in a notched pillar formed into a fulcrum by a metal pin, *a*, passing through it and the lever. At one end of the lever a metallic wire, bent to a semicircular or half-square form, as at A, or resembling the prongs of a fork distended, is attached by its center, as described in the annexed drawings, Example 8, at the point marked A. Between said end of the lever and the fulcrum *a*, and near the latter, on the under side of the lever

A, is inserted a metallic tooth or cog, *b*, curved on the side nearest to the fulcrum, and in other respects corresponding to the teeth or indentations upon the type already described. On the opposite extremity of the lever is a small weight, C, to balance or offset, in part, when needed, the weight of the lever on the opposite side of the fulcrum. The lever thus formed is stationed directly over the railway or groove D D, heretofore described as forming a connected part of the straight port-rule. The movement of the type-rule brings the tooth of each type therein set in contact with the tooth or cog of the lever, and thereby forces the lever upward until the points of the two teeth in contact have passed each other, when the lever again descends as the teeth of the type proceeds onward from the tooth of the lever. This operation is repeated as frequently as the teeth of the type are brought in contact with the tooth of the lever. By thus forcing the said lever upward and downward the ends of the semicircular or pronged wire are made alternately to rise from and fall into two small cups or vessels of mercury, E E, in each of which is an end or termination of the metallic circuit-conductors, first described above. This termination of the metallic circuit in the two cups or vessels breaks and limits the current of electricity or galvanism through the circuit; but a connection of the circuit is effected or restored by the falling of the two ends of the pronged wire A attached to said lever into the two cups, connecting the one cup with the other in that way. By the rising of the lever, and consequently the wire upon its end, from its connection with said cups, said circuit is in like manner again broken, and the current of electricity or galvanism destroyed. To effect at pleasure these two purposes of breaking and connecting said circuit is the design of said motion that is imparted in the before-mentioned manner to said lever, and to regulate this motion, and reduce it to the system of intelligible signs before described, is the design and use of the variations in the form of the type, also before described. A plate of copper, silver, or other conductor connected with the broken parts of said circuit of conductors, and receiving the contact of the wire attached to said lever, may be substituted, if preferred, for said cups of mercury. For a particular delineation of the several parts of said lever, reference is made to the annexed drawing marked Example 8.

The signal-lever consists, secondly, for use with the circular port-rule, Example 9, Fig. 3, of a strip of wood, G, with a metallic wire, A, at one end, of the form and for the purposes of the lever already described above. It turns on a pivot or fulcrum, *a*, placed either near the middle or in the end of the lever. At the end of the lever, at C, opposite to the metallic wire A, an elbow, *c*, is formed on a right angle with the main lever, and extending downward from the level with the pivot or fulcrum sufficiently for a metallic tooth, H, in the end thereof, corresponding with the teeth or indentations of the type, already described, to press against the type projecting from the shoulder or cavity of the wheel A, Fig. 1, that forms the circular port-rule, before described. Said wheel is placed beneath the said lever, as seen at G, Fig. 1, in a position to be reached by the extremity or tooth H of the arm of the lever just mentioned. The tooth H in the arm of the lever is kept in constant contact with the type of the circular port-rule by the pressure of a spring, B, upon it, as described in the annexed drawings marked Example 9, at B. Figs. 1 and 3 in the same example exhibit sections of the said lever. The action thus produced by the contact of the teeth of the type in the port-rule, when said wheel is in motion, with the tooth in the arm of the lever, lifts up and drops down the opposite extremity, A, of said lever, having the metallic wire upon it, as the tooth of said lever passes into or out of the indentations of the type, and in the same manner and to the same effect as the first-described lever rises and falls, and accordingly breaks and closes the circuit of conductors, as in the former instance. In the use of this circular port-rule and its appropriate lever, Fig. 3, type may be used having the points of their teeth and their indentations shaped as counterparts or reverses to those delineated in the annexed drawings heretofore referred to and marked Examples 4, 5, and 6, and thereby the forms of the recorded signs will be changed in a corresponding manner.

The register consists, first, of a lever of the shape of the lever connected with the circular port-rule above described, and is delineated in the annexed drawings marked Example 10, Figs. 1, 2, and 4, at A. Said lever A operates upon a fulcrum, *a*, that passes through the end that forms the elbow *a*, upon the lower extremity of which, and facing an electro-magnet, is attached the armature of a magnet, *f*. In the other extreme of the lever, at, B is inserted one or more pencils, fountain-pens, printing-wheels, or other marking-instruments, as may be seen in the Fig. 4 of the example last mentioned, at letter B. The magnet is at letter C in the same figure.

Secondly, of a cylinder or barrel of metal or wood, and covered with cloth or yielding coating, to turn upon an axis and occupying a position directly beneath the pencil, fountain-pen, printing-wheel, or other marking-instrument to be used, as exhibited in the last-mentioned example of drawings, Fig. 4, D. Two rollers, marked *b b* in said figure of drawings, are connected with said cylinder, on the upper-side curvatures thereof, and being connected with each other by two narrow bands of tape passing over and beneath each, near the ends thereof, and over the intervening surface of the cylinder, in a manner to cause a friction of the bands of tape upon the latter when in motion, as delineated in the last-named example, Fig. 4, at points marked *c c c*. The distance between said bands of tape on the roll-

ers is such as to admit of the pencil, or other marking instrument in the lever, to drop upon the intervening space of the cylinder. Near by said cylinder is a spool to turn on an axis, and marked *d* in the said figure, to receive any desired length of paper or other substance formed into slips or a continuous ribbon, and for the purpose of receiving a record of the signs of intelligence communicated. When the register is in motion one end of the paper on said spool being inserted between the under surfaces of said two rollers, under the strips of tape that connect them and the cylinder, it is drawn by the friction or pressure thus caused upon it forward from said spool gradually, and passed over said cylinder, and is thence deposited in a box on the opposite side, or is cut off at any desired length as it passes from the cylinder and rollers.

Thirdly, of an alarm-bell, A, Example 10, Fig. 5, which is struck by means of a lever-hammer, B, that is acted upon by a movable cog, *b*, placed upon an axis or pin, *b*, that confines it in the lower extremity of a pendulum-lever, (marked E in Fig. 5 of Example 10,) having an armature of a magnet attached to it at *a*, and acted upon by an electro-magnet, *o*, placed near it and the before-named magnet, and in the same circuit of conductors with the latter. Said cog *b* moves in a quarter-circle only, as the motion of said arm of the lever passes backward and forward in the act of recording, as hereinafter described. When forced into a horizontal position in said quarter-circle it ceases to act upon the hammer; but when moved from a perpendicular position it presses upon the projection in the end of the hammer, causing the opposite end of the hammer to be raised, from which elevation it again falls upon a stationary bell, A, as soon as said cog reaches a horizontal position, and ceases, as before mentioned, to press upon the hammer. Thus a notice, by sound or an alarm, is given at the point to which intelligence is to be communicated as soon as the register begins to act, and such sound may be continued or not, at pleasure, for the purpose mentioned or for any other uses, as the hammer shall be suspended or not from contact with the bell, or with any number of bells that may be employed. Fig. 5 of said example, marked 10 in the annexed drawings, represents sections of said hammer and bell.

Said several parts of the register are set in motion by the communication to or action upon the before-named armature of a magnet, attached to the lever of the register, of the electric or galvanic current in the circuit of conductors, and from an electro-magnet in said circuit, as before described, stationed near the said armature. As said armature is drawn or attracted from its stationary and horizontal position toward the said magnet when the latter is charged from the circuit of conductors, said lever is turned upon its fulcrum, and the opposite end thereof necessarily descends and brings the pen, or marking-instrument which it contains, in contact with the paper or other substance on the revolving cylinder directly beneath it. As said armature ceases to be thus drawn or attracted by said magnet, as is the case as soon as said magnet ceases to be charged from the circuit of conductors, or as the current in said circuit is broken in the manner hereinbefore described, the said armature is forced back by its own specific gravity, or by a spring or weight, as may be needed, to its former position, and the pen or marking-instrument in the opposite end of the lever is again raised from its contact with the paper or other substance on the before-named revolving cylinder. This same action is communicated simultaneously from the same circuit of conductors to as many registers as there are corresponding magnets provided within any circuit and at any desired distances from each other.

The cylinder and its two associate rollers are set in motion simultaneously with the first motion of the lever by the withdrawal of a small wire or spindle, *g*, Example 10, Figs. 2 and 5, from beneath one branch of a fly-wheel, *k*, that forms a part of the clock machinery hereinafter named. Said wire *g* is withdrawn by the action upon said wire of a small electro-magnet, *o*, Figs. 2 and 5, stationed in the circuit and near the large magnet before named, as delineated in Fig. 5 of Example 10. Said cylinder and rollers are subsequently kept in motion by a train of wheels similar to common clock-wheels, as in Figs. 2 and 3, acted upon by a weight, raised as occasion may require by a hand-crank, and their motion is regulated by the same wheels to correspond with the action of the registering-pen or marking-instrument. Said train is represented in Figs. 1, 2, and 3 of said Example 10.

The electro-magnet thus used is made in any of the usual modes, such as winding insulated copper wire, or strips of copper, or tin-foil, or other metal around a bar of soft iron, either straight or bent into a circular form, and having the two extremities of the coils connected with the circuit of conductors, so that the coils around the magnet make part of the circuit.

To extend more effectually the length of any desired circuit of conductors, and to perpetuate the power of the electric or galvanic current equally throughout the same, I adopt the following mode, and also for connecting and using any desired number of additional and intervening batteries or generators of said current, and for connecting progressively any number of consecutive circuits, viz: Place at any point in a circuit an electro-magnet of the denomination already described, with an armature upon a lever of the form and structure, and in the position of that used at the register to hold and operate the marking-instrument, with only a substitution therein for such marking-instrument of a forked wire, A, Example 9, Fig. 3, like that upon the end of the signal-lever here-

tofore described. Directly beneath the latter wire place two cups of mercury, E E, or two metallic plates joined to terminations of a circuit leading from the fresh or additional battery or generator of said circuit in the same manner as they are to be provided in the first circuit of conductors at the points where the cups of mercury are hereinbefore described. As the current in the first circuit acts upon the magnet thus provided the armature thereof and lever are thereby moved to dip the forked wire A into the cups of the second circuit, as in the circuit first described. This operation instantly connects the break in said second circuit, and thus produces an additional and original power or current of electricity or galvanism from the battery of said second circuit to the magnet or magnets placed at any one or more points in such circuit, to be broken at pleasure, as in the first circuit; and from thence by the same operation the same results may again be repeated, extending and breaking at pleasure such current through yet another and another circuit, *ad infinitum*, and with as many intervening registers for simultaneous action as may be desired, and at any distances from each other.

The dictionary or vocabulary consists of words alphabetically arranged and regularly numbered, beginning with the letters of the alphabet, so that each word in the language has its telegraphic number, and is designated at pleasure, through the signs of numerals.

The modes which I propose of insulating the wires or other metal for conductors, and of laying the circuits, are various. The wires may be insulated by winding each wire with silk, cotton, flax, or hemp, and then dipping them into a solution of caoutchouc, or into a solution of shellac, or into pitch or resin and caoutchouc. They may be laid through the air, inclosed above the ground, in the ground, or in the water. When through the air they may be insulated by a covering that shall protect them from the weather, such as cotton, flax, or hemp, and dipped into any solution which is a non-conductor, and elevated upon pillars. When inclosed above the ground they may be laid in tubes of iron or lead, and these again may be inclosed in wood, if desirable. When laid in the ground they may be inclosed in iron, leaden, wooden, or earthen tubes, and buried beneath the surface. Across rivers the circuit may be carried beneath the bridges, or, where there are no bridges, inclosed in lead or iron, and sunk at the bottom, or stretched across, where the banks are high, upon pillars elevated on each side of the river.

What I claim as my invention, and desire to secure by Letters Patent, is as follows:

1. The formation and arrangement of the several parts of mechanism constituting the type-rule, the straight port-rule, the circular port-rule, the two signal-levers, and the register-lever, and alarm-lever, with its hammer, as combining respectively with each of said levers one or more armatures of an electro-magnet, and as said parts are severally described in the foregoing specification.

2. The combination of the mechanism constituting the recording-cylinder, and the accompanying rollers and train-wheels, with the formation and arrangement of the several parts of mechanism, the formation and arrangement of which are claimed as above, and as described in the foregoing specification.

3. The use, system, formation, and arrangement of type, and of signs, for transmitting intelligence between distant points by the application of electro-magnetism and metallic conductors combined with mechanism described in the foregoing specification.

4. The mode and process of breaking and connecting by mechanism currents of electricity or galvanism in any circuit of metallic conductors, as described in the foregoing specication.

5. The mode and process of propelling and connecting currents of electricity or galvanism in and through any desired number of circuits of metallic conductors from any known generator of electricity or galvanism, as described in the foregoing specification.

6. The application of electro-magnets by means of one or more circuits of metallic conductors from any known generator of electricity or galvanism to the several levers in the machinery described in the foregoing specification, for the purpose of imparting motion to said levers and operating said machinery, and for transmitting by signs and sounds intelligence between distant points and simultaneously to different points.

7. The mode and process of recording or marking permanently signs of intelligence transmitted between distant points, and simultaneously to different points, by the application and use of electro-magnetism or galvanism as described in the foregoing specification.

8. The combination and arrangement of electro-magnets in one or more circuits of metallic conductors with armatures of magnets for transmitting intelligence by signs and sounds, or either, between distant points and to different points simultaneously.

9. The combination and mutual adaptation of the several parts of the mechanism and system of type and of signs with and to the dictionary or vocabulary of words, as described in the foregoing specification.

In testimony whereof I, the said SAMUEL F. B. MORSE, hereto subscribe my name in the presence of the witnesses whose names are hereto subscribed, on the 7th day of April, A. D. 1838.

SAML. F. B. MORSE.

Witnesses:

B. B. FRENCH,

CHARLES MONROE.

E. Howe, Jr.

Sewing Machine.

No 4750 Patented Sep. 10, 1846.

Fig. 1

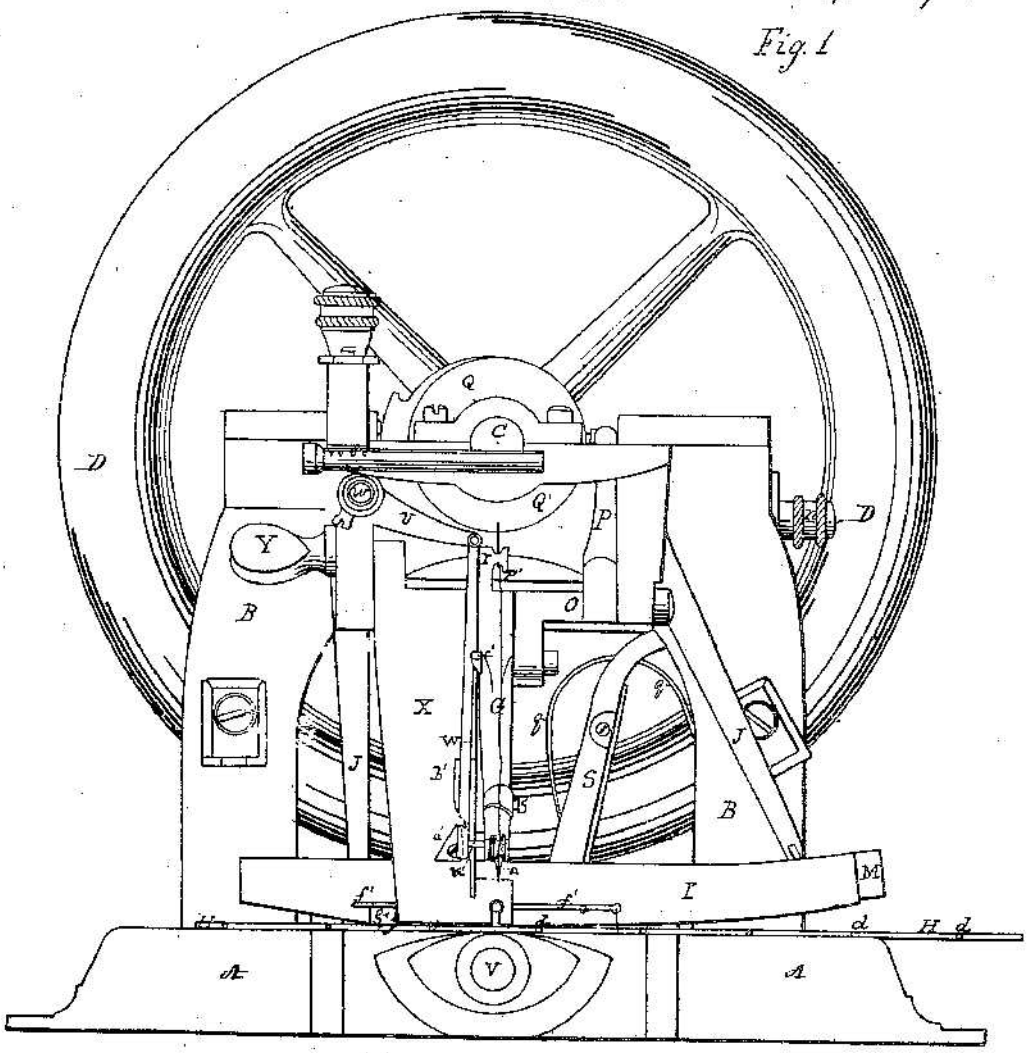


Fig. 4

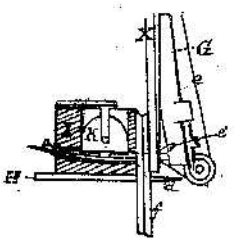
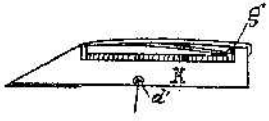


Fig. 7



Sheet 2
3 Sheets

E. Howe, Jr.

Sewing Machine.

No 4750 Patented Sep. 10, 1846.

Fig 2

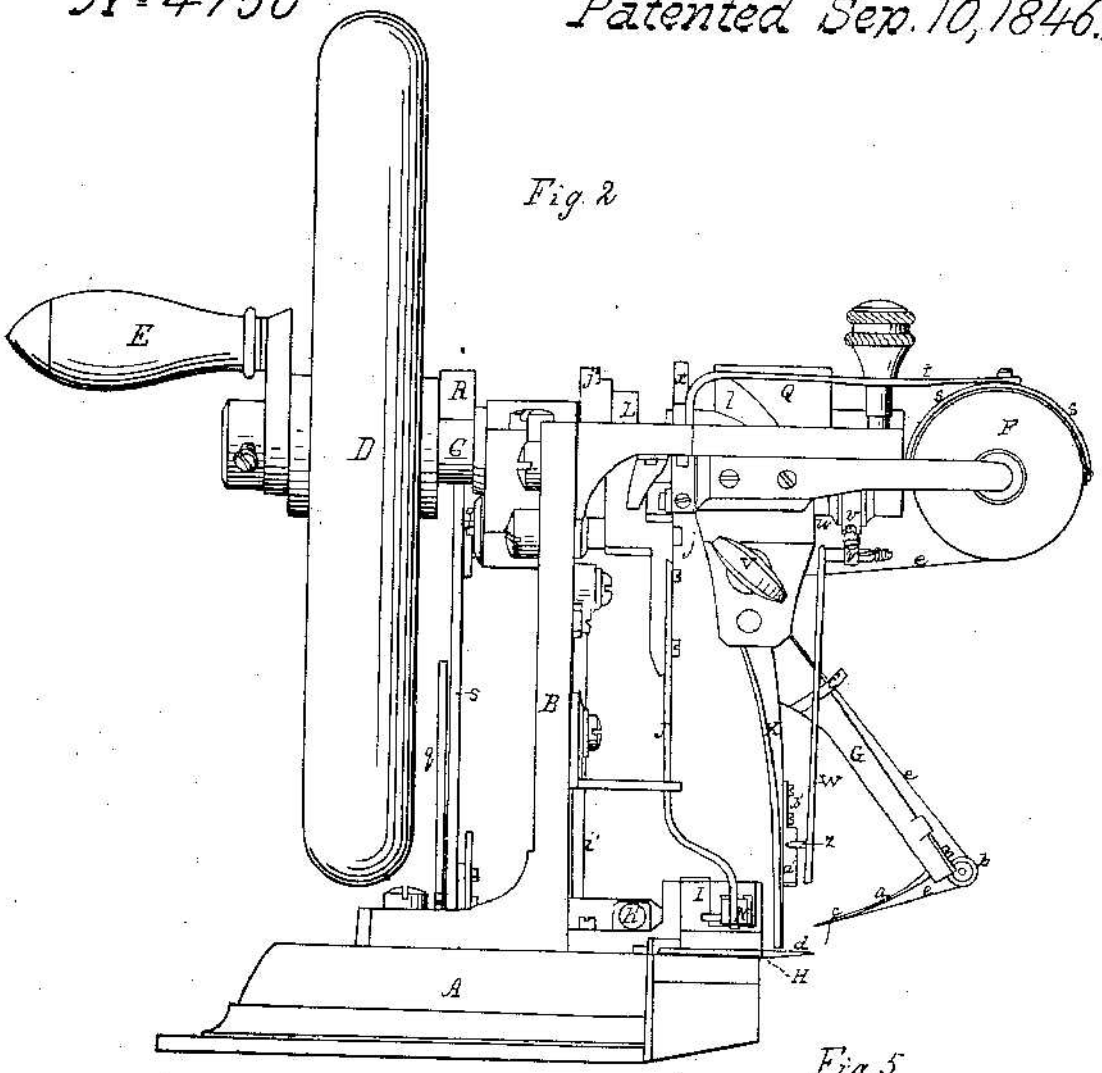
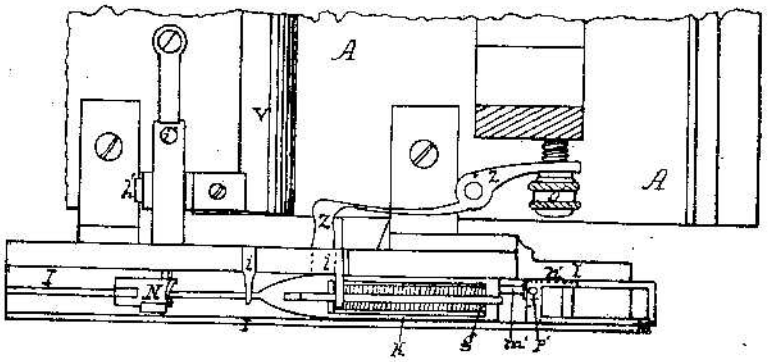


Fig 5



Sheet 3
3 Sheets

E. Howe, Jr.

Sewing Machine.

No. 4750 Patented Sep. 10, 1846.

Fig. 3

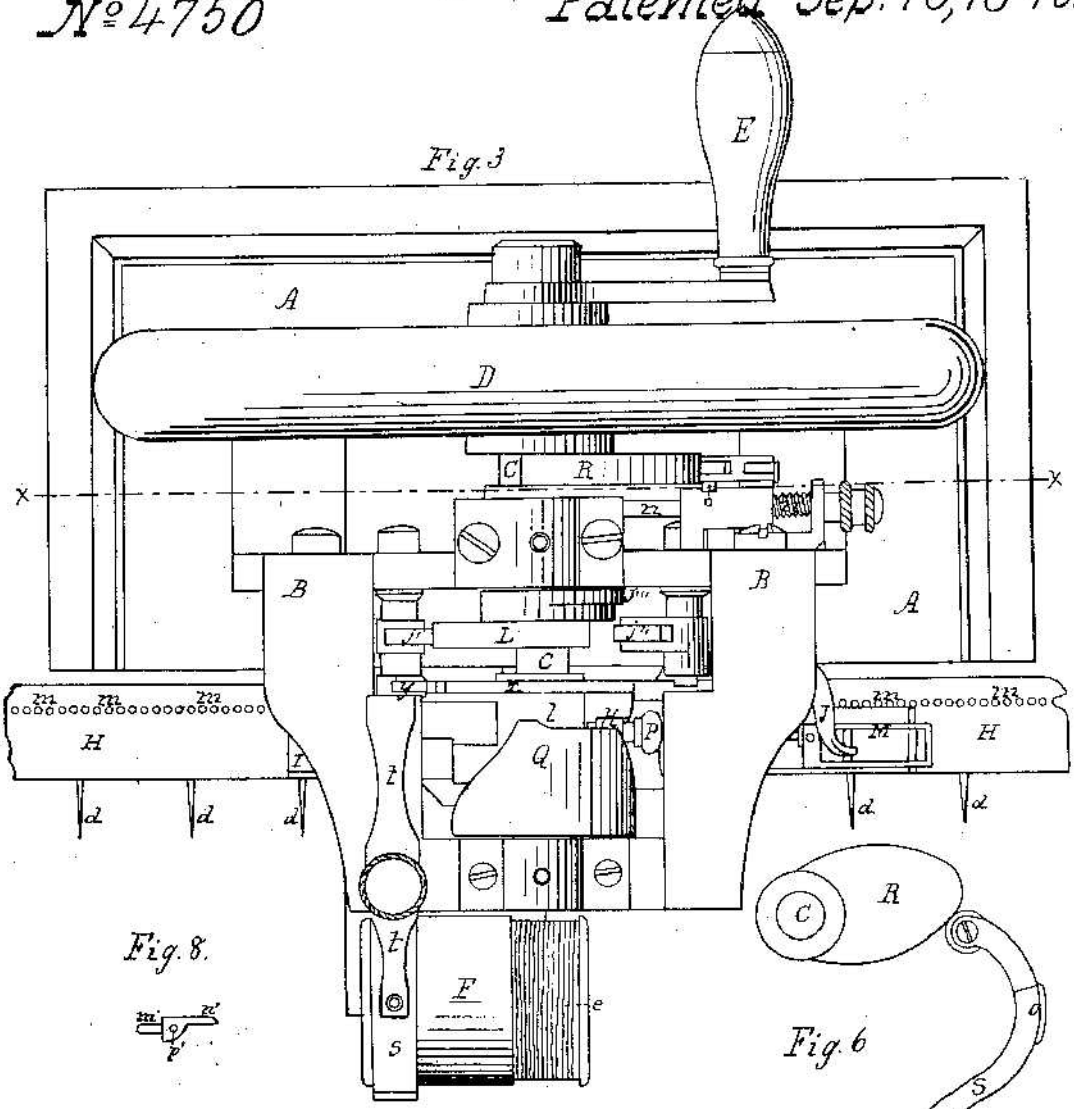


Fig. 8.

Fig. 6

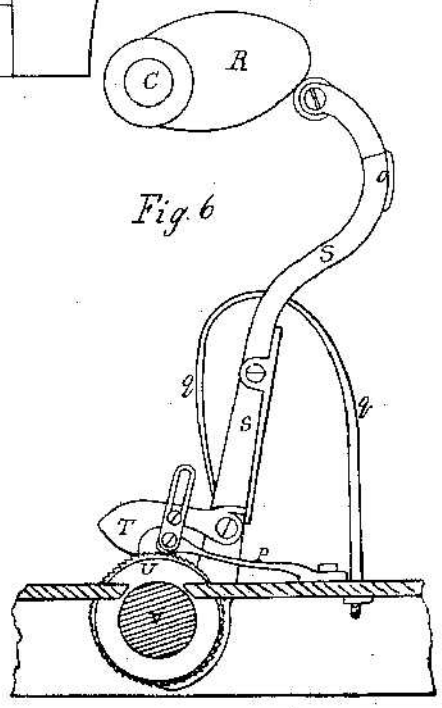
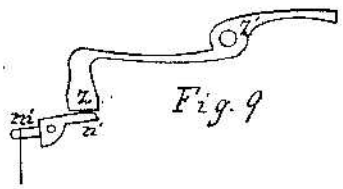


Fig. 9



UNITED STATES PATENT OFFICE.

ELIAS HOWE, JR., OF CAMBRIDGE, MASSACHUSETTS.

IMPROVEMENT IN SEWING-MACHINES.

Specification forming part of Letters Patent No. **4,750**, dated September 10, 1846.

To all whom it may concern:

Be it known that I, ELIAS HOWE, JR., of Cambridge, in the county of Middlesex and State of Massachusetts, have invented a new and useful machine for sewing seams in cloth or other articles requiring to be sewed; and I do hereby declare that the following is a full and exact description thereof.

In sewing a seam with my machine two threads are employed, one of which threads is carried through the cloth by means of a curved needle, the pointed end of which is to pass through said cloth. The needle used has the eye that is to receive the thread within a small distance—say, an eighth of an inch—of its inner or pointed end. The other or outer end of the needle is held by an arm that vibrates on a pivot or joint pin, and the curvature of the needle is such as to correspond with the length of the arm as its radius. When the thread is carried through the cloth, which may be done to the distance of about three-fourths of an inch, the thread will be stretched above the curved needle, something in the manner of a bow-string, leaving a small open space between the two. A small shuttle carrying a bobbin filled with silk or thread is then made to pass entirely through this open space between the needle and the thread which it carries, and when the shuttle is returned, which is done by means of a picker-staff or shuttle-driver, the thread which was carried in by the needle is surrounded by that received from the shuttle, and as the needle is drawn out it forces that which was received from the shuttle into the body of the cloth, and as this operation is repeated a seam is formed which has on each side of the cloth the same appearance as that given by stitching, with this peculiarity, that the thread shown on one side of the cloth is exclusively that which was given out by the needle, and the thread seen on the other side is exclusively that which was given out by shuttle. It will therefore be seen that a stitch is made at every back-and-forth movement of the shuttle. The two thicknesses of cloth that are to be sewed are held upon pointed wires which project out from a metallic plate, like the teeth of a comb, but at a considerable distance from each other—say three-fourths of an inch, more or less—these pointed wires sustaining the cloth and answering the purpose of ordinary basting. The metallic plate from which these wires project has numerous holes through it, which answer the purpose of rack-teeth in enabling the plate to be moved forward by means of a pinion as the stitches are taken. The distance to which said plate is moved, and consequently the length of the stitches, may be regulated at pleasure.

In the accompanying drawings, Figure 1 is a front elevation of the machine; Fig. 2, an end elevation thereof, and Fig. 3 a top view. The other figures represent sections and parts in detail, which will be presently explained.

A A is the bed or base of the machine, and B B standards rising therefrom, which sustain the main shaft and other parts of the apparatus.

C C is the main shaft, which carries the cams that operate the needle, the shuttle-drivers, and other parts of the machine. D is a fly-wheel, and E a winch, on said shaft.

F is a bobbin on which the silk is wound that is to supply the needle.

G is the needle-arm, that carries the curved needle *a*. This is seen most distinctly in the end elevation, Fig. 2. The thread from the bobbin F passes round a small friction-roller, *b*, or round a smooth groove in the situation of said roller, then up through the eye of the needle at *c*, which eye is situated near to the needle-point. The cloth is stuck on the points *d d*, that project from the metallic plate H, which I will call the "baster-plate." This plate is shown most distinctly in the top view, Fig. 3. When the thread *e* is carried through the cloth by the needle *a*, the upper portion of said thread will be above the needle and will allow the point of the shuttle (to be presently described) to pass between them. To enable it to enter readily, the needle, after entering the cloth, is immediately drawn back to a short distance, which opens the loop slightly. The cam which operates the needle-arm being so formed as to cause such drawing back, the shuttle will, in order to give itself the necessary room, draw a portion of the thread which had been given out by the needle through the cloth, said thread having been left in a loop or slack state for that purpose.

Fig. 4 represents a part of the same portion of the machine that is shown in Fig. 2, but with the needle-arm down and with the needle passed through the cloth. *f* is the cloth, (seen

in section, but not shown in any of the other figures.) *e'* is the loop or slack thread formed on the outside of the cloth, and which is to be drawn through it by the passing of the shuttle.

I in the respective figures is the shuttle box or trough, within which the shuttle is moved back and forth by means of the picker-staves or shuttle-drivers J J. In Fig. 5 I have given a top view of this box with the shuttle K within it. This shuttle is in its general construction similar to the larger shuttle used in weaving, and its spool *g* is capable of containing an ordinary skein of silk. The shuttle-box I is represented as made convex on its under side, by which it is adapted to admit a baster-plate that may be in a curved form, although for most purposes a straight baster-plate may be used. The pieces marked *i i* are light springs above the shuttle, which bear slightly upon it and serve to steady its motion. The shuttle-drivers work on joint-pins, as shown at *j*, Fig. 2, there being a corresponding fixture for the drivers on the other side.

L, Fig. 3, is the cam that operates the shuttle-drivers, on the upper ends of which drivers there may be friction-rollers *j' j'*. The cam L acts upon the shuttle-drivers alternately.

M, Fig. 5, is a sliding box fitted into the shuttle-box and moved back and forth in the rear of the shuttle by one of the drivers, and N is a corresponding sliding piece moved by the other driver and adapted to the fore or pointed end of the shuttle. The needle-arm is attached to the rock-shaft O, Fig. 1, which vibrates on a center pin or pivots, and from this shaft rises an arm, P, that carries a pin and friction-roller, *k*, which enters a space, *l*, in the cam Q, which space operates as a zigzag groove, and is of course so formed as to give the proper vibration to the needle-arm. There is a groove or narrow channel made across the bottom of the shuttle-box to receive the needle, in order that its upper part may be even with said bottom and allow the shuttle to pass freely over it.

The baster-plate H, Fig. 3, which receives the cloth to be sewed, is furnished with a row of small holes, *m m*, drilled at a regular distance from each other, serving the purpose of rack-teeth, and into these round pinion-teeth enter for the purpose of carrying the plate forward to a proper distance at every stitch.

Fig. 6 shows the principal portion of the feeding apparatus as it would appear were a vertical section made through the machine in the line *x x* of Fig. 3. R is a cam on the cam-shaft C, that vibrates an arm, S, carrying a feeding-claw, T, that takes into a ratchet-wheel, U, on the shaft V, which shaft crosses the bed A of the machine, its fore end being seen at V, Fig. 1. This shaft has on it near its fore end the pinion that carries the pins or teeth that take into the holes *m* in the baster and cause it to advance between every stitch. The length of the stitch may be regulated by regulating the play of the arm S, and this is effected by the regulating-screw *n*, Fig. 3, that moves a pin back and forth that serves as a stop to said arm. The pin is represented by the dot *o*, Fig. 6, and is seen at *o*, Figs. 2 and 3. *p* is a spring that retains the ratchet-wheel in place as the claw is taking a new hold. *q* is a spring for holding the arm S against the cam.

In sewing with this machine, the thread from the bobbin F is passed over a notch, *r*, Fig. 1, at the upper end of the needle-arm, and is returned through the notch *r'*. It then passes down in front of said arm, then around the roller *b*, and through the needle-eye. To regulate the giving out of the thread from the bobbin, friction is made on it by the semicircular clasp *s*, that is made to press on it by a spring, *t*, regulated by a tempering-screw. Before the needle passes through the cloth the thread, which extends from the needle-eye to said cloth, is raised or drawn up by a lifting-pin, so as to form the loop or slack, which is subsequently to be drawn in by the passing of the shuttle between the thread and the needle.

W, Figs. 1 and 2, is a lifting-rod, from the side of which projects the lifting-pin *u*. The lifting-rod is attached at its upper end to a crank-arm, *v*, which works on a shaft, *w*, and this shaft is made to vibrate by means of the cam *x* on the cam-shaft. This cam operates on a friction-roller, *y*, on a short arm on the inner end of the shaft *w*. The lifting-rod stands in front of a plate, X, Figs. 1 and 2, which is attached at its upper end to the frame of the machine, and between the lower end of this plate and the shuttle-box the cloth is to pass. The plate X is furnished with a hinge-joint at its upper end, in order that its distance from the shuttle-box may be regulated to suit cloth of different thicknesses.

Y, Fig. 1, is a set-screw, by which it is held in place. From the back part of the lifting-rod proceeds a guide-pin, *z*, that moves the lifting-rod laterally, so as to govern the action of the lifting-pin *u*. This guide-pin works against guide-pieces *a' b'*, affixed on the front of the plate X. The dotted lines show the groove formed by the pieces *a' b'*, along which the guide-pin is to pass. The lifting-rod is carried toward the piece *b'* by means of a spiral spring around its shaft, or in any other convenient mode. In the position in which the apparatus is shown in Fig. 1 the lifting-pin is partially raised, and will have lifted the thread. In raising it the guide-pin passes through the groove between *a' b'*, (shown by dotted lines,) and when at the upper end of this groove the needle-arm acts and carries the needle through the cloth. On the side of the needle-arm there is a projecting piece, *c'*, the inclined edge of which, coming in contact with the lifting-rod, pushes it laterally over the angular point of the piece *a'*, and the crank-arm *v* descending at this moment, the lifting-pin is withdrawn from the thread, which is thereby left slack to a sufficient extent for the purpose designated.

The shuttle (shown separately in Fig. 7) has a hole, d', through its side for the thread to pass from the spool; and a slot, f' f', is made through the side of the shuttle-box to allow of the play of the shuttle-thread back and forth. At the time when the shuttle has completed its passage between the needle and its thread, the needle is to be withdrawn from the cloth; and when this is taking place, it is necessary that the shuttle-thread should be held firmly, or the withdrawing of the needle, instead of drawing the shuttle-thread firmly into the body of the cloth and making a perfect seam, would draw a portion of it from the spool and cause it to pass entirely through said cloth.

In Fig. 1, g' is the outer end of a lever which is made to rise at the proper moment, and to clip the thread between it and the upper edge of the slot f'. This lever is seen in Fig. 2, its fulcrum being at h'. The rod i' serves to depress the inner end of said lever and to raise its outer end, the cam j'' on the cam-shaft performing this office.

The sliding box M does not bear directly against the rear end of the shuttle-box, but has a pin, m', projecting from its fore end, which pin acts against the shuttle. The pin m' constitutes a part of a small lever shown separately in Fig. 8. The part n' of this lever is received within a suitable slot in the sliding box M, and it turns on a fulcrum-pin, p'. When the shuttle has passed through the loop formed by the needle-thread, it is received upon the pin m', and as the needle is retracted the thread will be drawn taut upon said pin. At this time the head of an adjustable spring-piece, z z', bears against the end n' of the small lever, and the force of its pressure has to be overcome before the thread escapes from the pin, which it does by drawing over against the power of the spring. As the loop then escapes, it will draw up the filling-thread from the shuttle firmly against the cloth and embed it within it. The head of the spring Z passes through a mortise in the shuttle-box, as shown by the dotted lines. o' is an adjusting-screw by which the force of the spring Z may be regulated.

Having thus fully described the manner in which I construct my machine for sewing seams, and shown the operation thereof, what I claim therein as new, and desire to secure by Letters Patent, is—

1. The forming of the seam by carrying a thread through the cloth by means of a curved needle on the end of a vibrating arm, and the passing of a shuttle furnished with its bobbin, in the manner set forth, between the needle and the thread which it carries under a combination and arrangement of parts substantially the same with that described.

2. The lifting of the thread that passes through the needle-eye by means of the lifting-rod W, for the purpose of forming a loop of loose thread that is to be subsequently drawn in by the passage of the shuttle, as herein fully described, said lifting-rod being furnished with a lifting pin, u, and governed in its motions by the guide-pieces and other devices, arranged and operating substantially as described.

3. The holding of the thread that is given out by the shuttle, so as to prevent its unwinding from the shuttle-bobbin after the shuttle has passed through the loop, said thread being held by means of the lever or clipping-piece g', as herein made known, or in any other manner that is substantially the same in its operation and result.

4. The manner of arranging and combining the small lever m' n' with the sliding box M, in combination with the spring-piece Z, for the purpose of tightening the stitch as the needle is retracted, as described.

5. The holding of the cloth to be sewed by the use of a baster-plate furnished with points for that purpose, and with holes enabling it to operate as a rack in the manner set forth, thereby carrying the cloth forward and dispensing altogether with the necessity of basting the parts together.

ELIAS HOWE, JR.

Witnesses:
THOS. P. JONES,
GEORGE FISHER.

4 Sheets—Sheet 1.

N. A. OTTO.

GAS-MOTOR ENGINES.

No. 194,047. Patented Aug. 14, 1877.

Fig. 1.

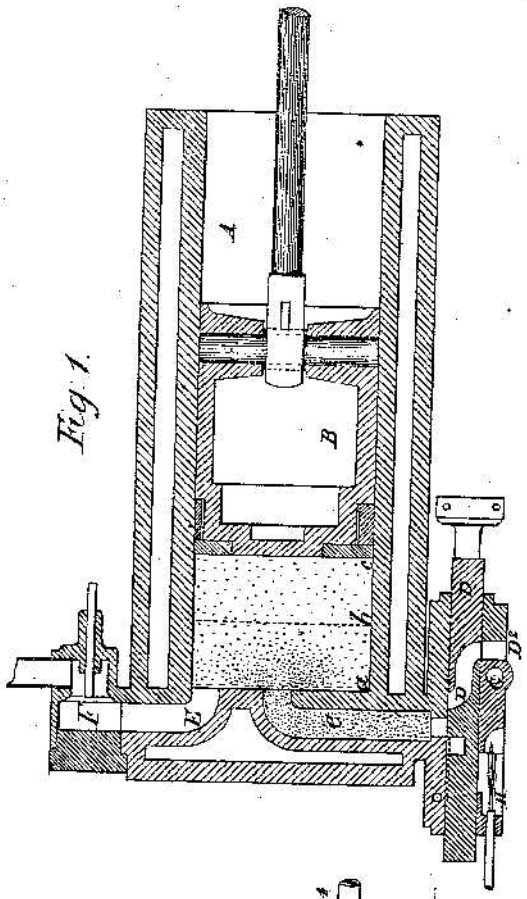
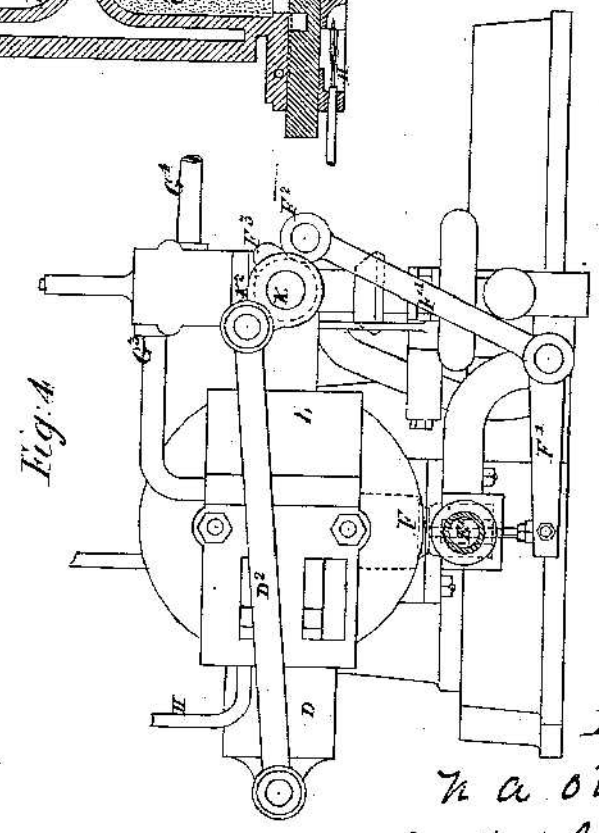


Fig. 4.



Witnesses

B. C. Pole

H. B. Whitman

Inventor

N. A. Otto by

C. S. Whitman

atty

4 Sheets—Sheet 2.

N. A. OTTO.

GAS-MOTOR ENGINES.

No. 194,047. Patented Aug. 14, 1877.

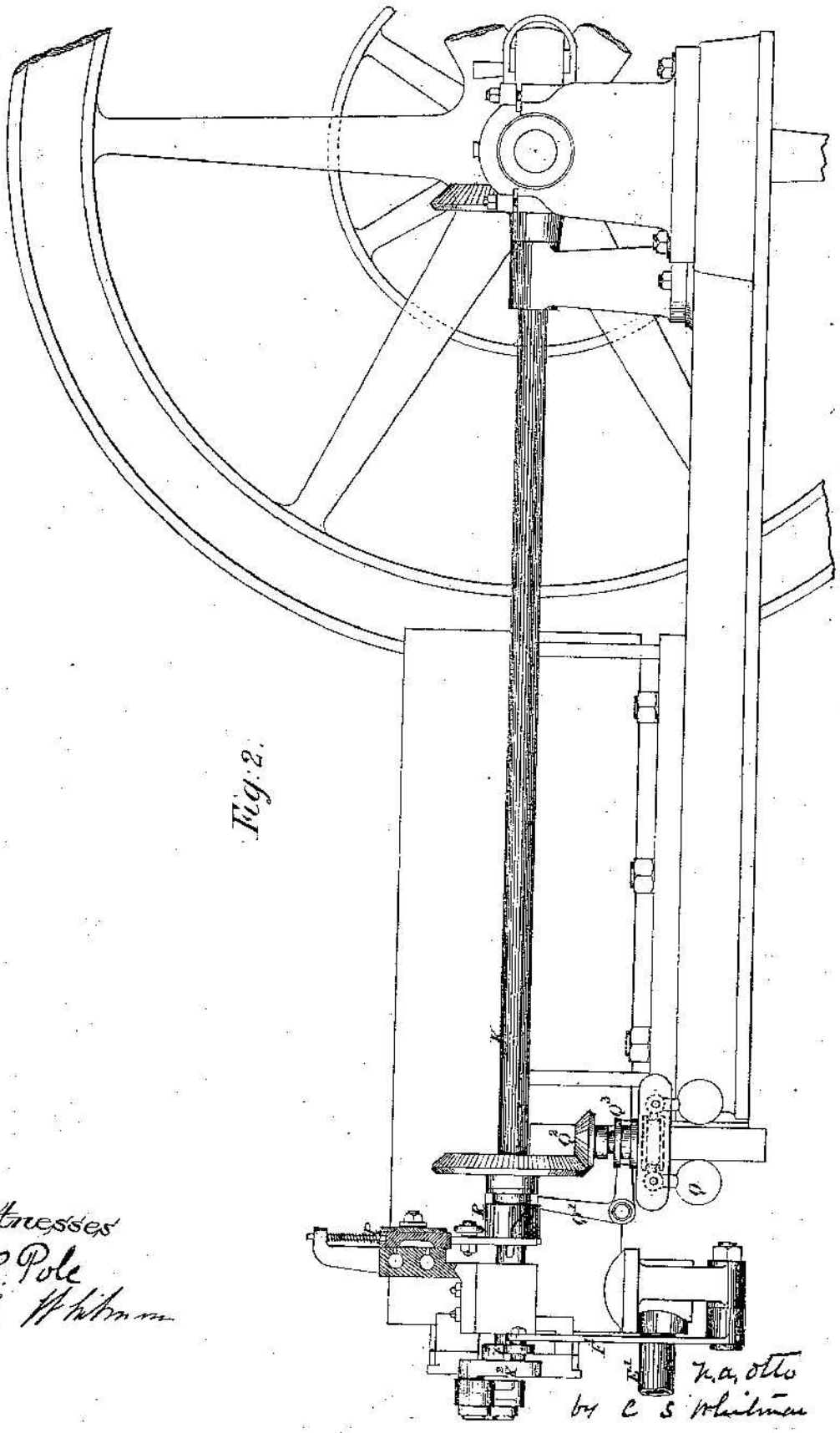


Fig. 2.

Witnesses
B. C. Pole
E. B. Whitman

N. A. Otto
by C. S. Whitman

4 Sheets—Sheet 3.

N. A. OTTO.

GAS-MOTOR ENGINES.

No. 194,047. Patented Aug. 14, 1877.

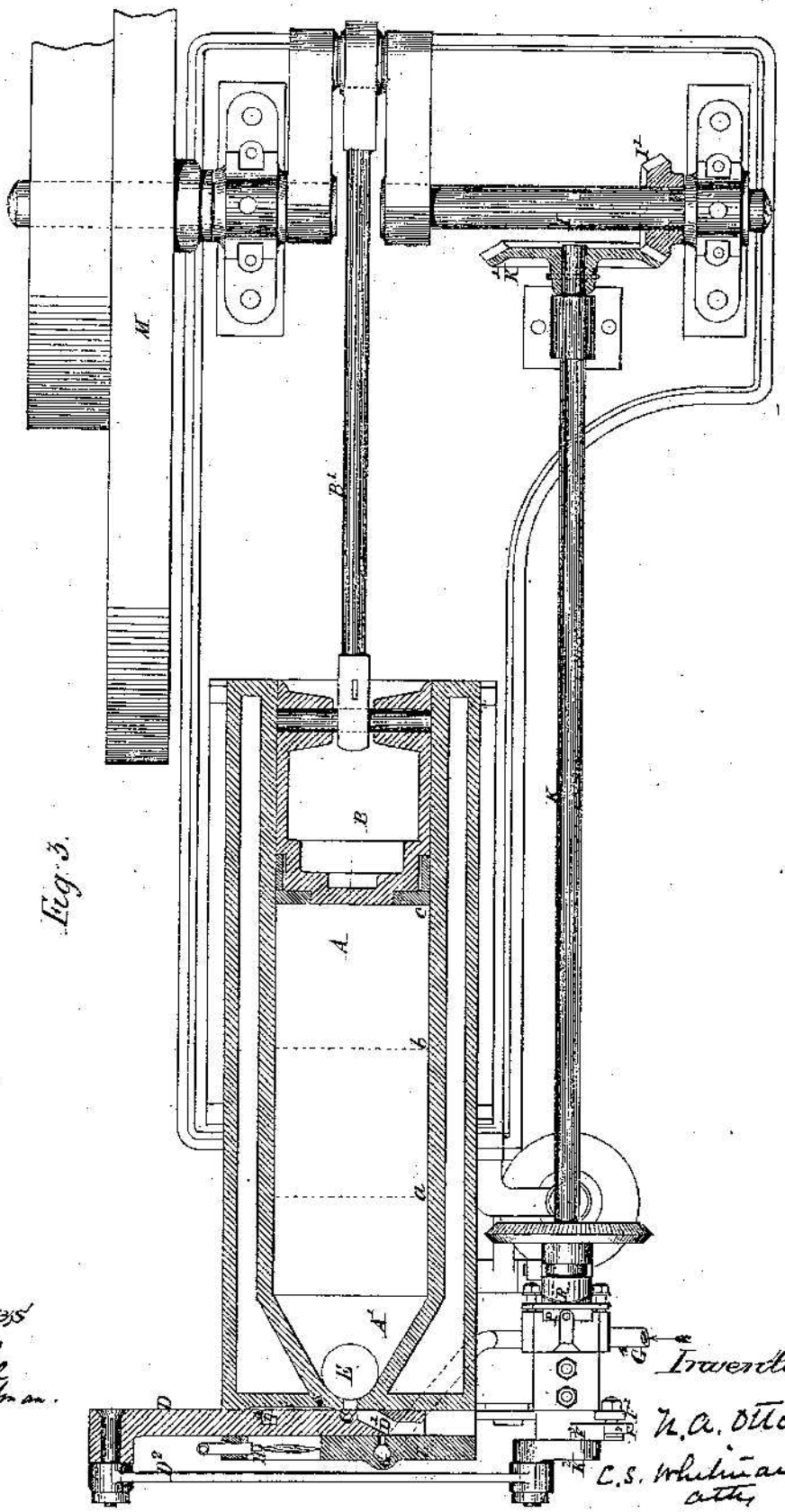


Fig. 3.

Witnesses
B. C. Pole
N. B. Whitman.

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N. A. Otto by
C. S. Whitman
atty.

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N. A. OTTO.

GAS-MOTOR ENGINES.

No. 194,047. Patented Aug. 14, 1877.

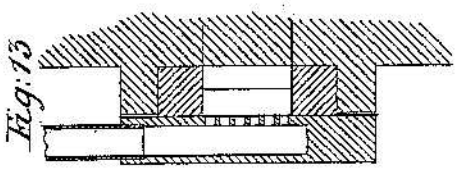
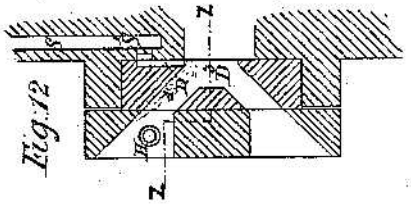


Fig. 13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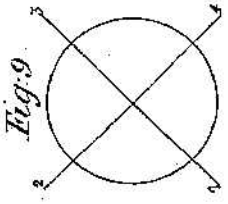


Fig. 9

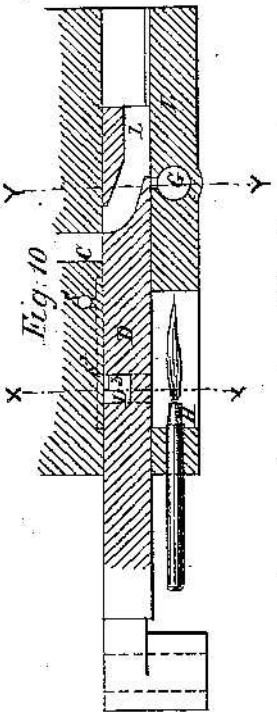


Fig. 10

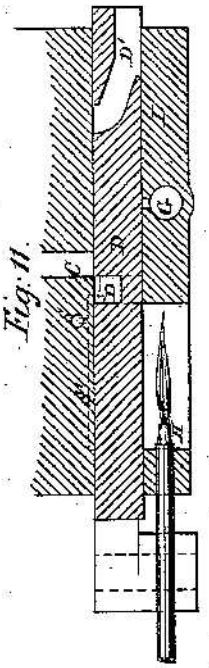


Fig. 11

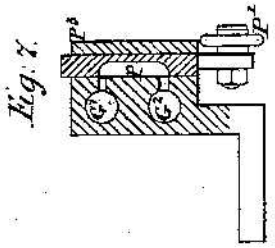


Fig. 7

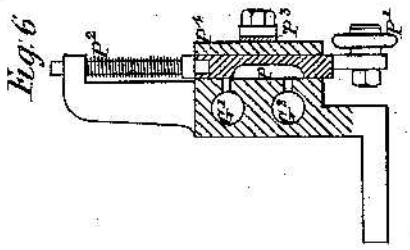


Fig. 6

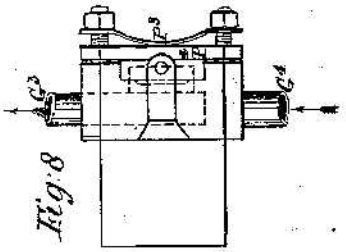


Fig. 8

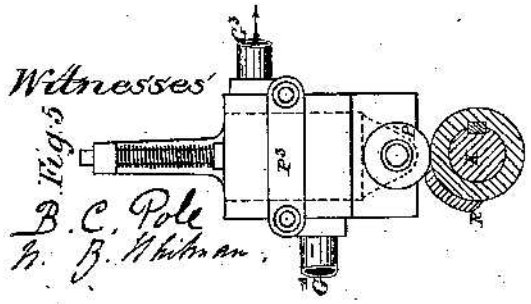


Fig. 5

Witnesses'
B. C. Pole
B. B. Hutchinson.

Inventor
N. A. Otto by
C. S. Whitman,
Atty

UNITED STATES PATENT OFFICE.

NICOLAUS A. OTTO, OF DEUTZ, GERMANY.

IMPROVEMENT IN GAS-MOTOR ENGINES.

Specification forming part of Letters Patent No. **194,047**, dated August 14, 1877; application filed July 13, 1876.

To all whom it may concern:

Be it known that I, NICOLAUS AUGUST OTTO, of the Gas-Motoren Fabrik-Deutz, at Deutz, in the German Empire, have invented an Improved Gas-Motor Engine; and do hereby declare that the following description, taken in connection with the accompanying sheets of drawings, hereinafter referred to, forms a full and exact specification of the same, wherein I have set forth the nature and principles of my said improvement, by which my invention may be distinguished from others of a similar class, together with such parts as I claim and desire to secure by Letters Patent—that is to say:

In gas-motor engines as at present constructed, an explosive mixture of combustible gas and air is introduced into the engine-cylinder, where it is ignited, resulting in a sudden development of heat and expansion of the gases, a great portion of the useful effect being lost by absorption of heat, unless special provisions are made for allowing the gases to expand very rapidly.

According to my present invention an intimate mixture of combustible gas or vapor and air is introduced into the cylinder, together with a separate charge of air or other gas, that may or may not support combustion, in such a manner and in such proportions that the particles of the combustible gaseous mixture are more or less dispersed in an isolated condition in the air or other gas, so that on ignition, instead of an explosion ensuing, the flame will be communicated gradually from one combustible particle to another, thereby effecting a gradual development of heat and a corresponding gradual expansion of the gases, which will enable the motive power so produced to be utilized in the most effective manner.

In order more clearly to describe my invention, I will refer to the accompanying drawings, in which Figure 1 shows a longitudinal section of an engine-cylinder, A, having a piston, B, connected to a fly-wheel shaft, and a port or passage, C, for the admission of combustible gaseous mixture and air, controlled by the slide D, and having also a passage, E, for the emission of the products of combustion, closed by a valve, F. Assuming the piston to be at the end of its instroke, its bottom surface being represented by the dotted line *a*, while the slide D is in such a position that its passage D^1 establishes a communication between the outer air through the aperture D^2 and the port C, then, on the piston commencing its outstroke, it will draw in atmospheric air until it arrives at the point indicated by the dotted line *b*, when the slide will have been moved so as to cut off the air-supply and establish a communication between the passage G in the slide-cover, for an intimate mixture of coal-gas or petroleum vapor and air, (in such proportions that the mixture will burn of itself, but, owing to the presence of the first admitted air, will not explode,) and the port C through the passage D^1. On the continued motion of the piston, combustible gaseous mixture will consequently be drawn in until the piston has arrived at a point, *c*, when the slide will have moved into the position shown, cutting off the gas-supply, and about to establish a communication between the small gas-flame H and the charge in the cylinder, for the purpose of igniting the latter.

The combustible gaseous mixture, in entering the cylinder behind the charge of air previously admitted, will, to a certain extent, mix with the latter, the particles of the combustible mixture being close together in and near the port C, and becoming more and more dispersed in the air as they approach the piston, as indicated by the dots in the drawing, which represent the combustible particles. Thus, on the ignition of the charge in the port C, the gaseous mixture will at first burn with comparative rapidity, the flame spreading from particle to particle; but as the ignition extends toward the front end of the charge, it will proceed more and more slowly, owing to the combustible particles being farther and farther apart.

The burning particles impart their heat to the surrounding air, producing a gradually increasing pressure in the cylinder, which causes the piston to complete its outstroke. Motion being thus imparted to the fly-wheel by the piston-rod, its momentum causes the piston to perform its return stroke, whereby the products of combustion are expelled through the valve F, and, the fly-wheel also

causing the piston to commence its next outstroke, a fresh charge of air and combustible mixture is drawn in, as before described.

In order to vary the power of the engine, the charge of combustible mixture (represented by the space *a* to *b*) may be varied, as may also the proportions of air and coal-gas or vapor of which it is composed, and such variation may be controlled by connecting the valve-gear with any suitable construction of governor, as will be presently described.

From the foregoing general description it will be seen that as in the improved mode of operating there is no sudden explosion of the gaseous charge, but a gradual development of heat and expansion of the gases, there will be no such losses of effect as result in gas-engines of present construction through shocks produced by the sudden development of motive power, and by the absorption of heat consequent upon the inability of the gases to expand with sufficient rapidity.

The above-described beneficial effect of the improved mode of working will be further increased by the fact that the charge of air interposed between the combustible mixture and the piston will operate as a cushion or buffer in still further reducing the suddenness of the expansive force generated as it transmits it to the piston.

Engines operating according to my invention may either be single-acting—the return stroke being effected by the momentum of the fly-wheel—or they may be double-acting, a gaseous charge being introduced at each end of the cylinder. They may also operate with the gases either at atmospheric pressure or compressed to any desired degree. In the latter case the engine may be arranged in a similar manner to that above described, the gases being compressed by any suitable known means before being introduced into the engine; but, by preference, I dispense with any such additional compressing mechanism by arranging the engine to operate in the manner I will now proceed to describe with reference to Figs. 2 to 13 of the drawings, of which—

Fig. 2 shows a side elevation; Fig. 3, a sectional plan; Fig. 4, a back-end view, and Figs. 5 to 13 details of the valve-gear.

The engine is here represented as being single-acting, the cylinder A being open to the atmosphere at its front end. At its closed back end it has a space, A′, beyond the stroke of the piston B, which space is, by preference, made conical at the end, as shown, tapering to the inlet-port C for combustible gas and air, and also communicating by the passage E with the escape-valve F, Fig. 3, for the products of combustion.

The piston B is connected by the rod B′ to the crank-shaft I, on which is a bevel-pinion, I′, in gear with a bevel-wheel, K^1, on a shaft, K. On the other end of this shaft is a crank, K^2, connected by a link, D^2, to the slide D, governing the admission of gas and air to the cylinder. The gearing I′ K^1 is so proportioned that the crank K^2 makes one revolution, and, consequently, the slide one to-and-fro motion, while the piston makes two double strokes.

The mode of operating with this engine is as follows: Assuming the piston to be at the end of its instroke (represented by the dotted line *a*, Fig. 3,) and about to be moved through its outstroke by the momentum of the fly-wheel M, then, the slide D (the construction of which will be presently explained) being in position to admit atmospheric air through the passage D^1 and port C, air will be drawn into the cylinder until the piston has reached the point represented by the dotted line *b*, when, the slide having established a communication with the combustible-gas supply and the cylinder, combustible gas intimately mixed with air will be drawn in until the piston has arrived at the end of its outstroke, the position shown at Fig. 3. As before explained with reference to Fig. 1, the combustible gaseous mixture, in entering, will mix to a certain extent with the air previously introduced, the particles of gaseous mixture being close together at the back end of the cylinder, and more and more separated from each other toward the front end. The slide having moved so as to close the inlet-port C, the piston is caused, by the momentum of the fly-wheel, to perform its instroke, whereby the charge of gaseous mixture and air that filled the cylinder at atmospheric pressure will be compressed into the space from the line *a* to the back end of the cylinder, the particles of gaseous mixture remaining in much the same unequally-distributed condition in the air as they did before compression. The slide now establishes a communication between the gas-flame H and the interior of the cylinder, so as to ignite the charge, resulting in a gradual development of heat and expansion of the gases, as before explained, whereby the piston will be caused to perform its outstroke, imparting fresh momentum to the fly-wheel. This momentum will again cause the piston to perform its instroke, whereby the products of combustion will be expelled through the valve F, which has been opened by the lever N, acted on by a cam, O, on the shaft K. As the piston only moves back to the line *a*, it will be seen that a certain portion of the products of combustion will remain in the cylinder, and will consequently mix to a certain extent with the air drawn in behind them at the next outstroke; but as the mixture of combustible gas and air afterward introduced will burn independently of the air or other gas surrounding its particles, it will be seen that the presence of such products of combustion in the charge will be of no consequence.

As before stated, the power of the engine may be regulated by regulating the quantity of combustible gas introduced at each charge. This is effected by the gas-slide P, controlled by the governor Q, operating on the sliding cam R as follows: Fig. 5 shows an enlarged front

view of the gas-slide; Figs. 6 and 7, vertical sections, and Fig. 8 a plan, of the same. In the casing of the slide are formed two passages, G^1 and G^2, the former communicating with a pipe, G^3, leading to the gas-passage G in the slide D, and the other with the gas-supply pipe G^4. These passages have small side openings, as shown, which, when the slide is in the position shown in Fig. 7, both communicate with the cavity of the slide P, so that gas can pass from G^2 into G^1, and thence into the passage G of the slide D. When the slide is moved into the position shown in Fig. 6, this communication, and consequently the gas-supply, is cut off. The slide P rests with a small roller, P^1, upon a cam, R, which revolves with, but can slide somewhat upon, the shaft K, the raising of the slide being effected by the cam, while its downward motion is effected by the spring P^2. According as the cam is shifted relatively to the roller P^1 by the action of the governor Q and lever Q^1, (which has a fork taking into a collar on the cam, as shown,) the slide is made to establish the communication between G^1 and G^2 for a longer or a shorter period, thus allowing a greater or less quantity of the combustible gas for one charge to pass into the cylinder A independently of the action of the slide D. The gas-slide P is held against the face of the casing by a spring, P^3, pressing against a cover, P^4, on the back of the slide.

The construction and mode of operating of the engine-slide D will be understood on reference to Figs. 10 to 13, of which Figs. 10 and 11 represent two longitudinal sections of the slide and casing on line Z Z, Fig. 12, with the slide in two different positions, and Figs. 12 and 13 show transverse sections, respectively on lines X X and Y Y, Fig. 10.

From the previous description of the action of the engine, it will be seen that there are four strokes of the piston required for one complete operation—namely, an outstroke for drawing in the charge of combustible mixture and air, an instroke for compressing the gases, a second outstroke when the piston is propelled on the ignition of the gases, and a second instroke for expelling the products of combustion. The slide D consequently has to perform one to-and-fro motion while the piston is performing the above-mentioned four operations, for which purpose, as before stated, the slide-crank K^2 makes one revolution while the engine-shaft makes two. The circle at Fig. 9 represents a diagram of the path of the crank K^2, in which the part from 1 to 2 represents the motion of the slide during the time of drawing in the gaseous charge, the part from 2 to 3 the motion during the compression of the charge, 3 to 4 the motion during the working stroke, and 4 to 1 the motion during the expulsion of the products of combustion. Figs. 10 and 11 each show two positions of the slide, Fig. 10 showing, first, its position at the point 1 of the crank-path when the air-passage D^1 is just about to communicate with the port C, and, secondly, its position at point 2, the gas and air supply having just been cut off. It will be seen that in the first position the gas-passage G is also about to open; but the before-described action of the gas-slide P will prevent the admission of combustible gas until the requisite charge of air is introduced. Fig. 11 shows, first, the position of the slide at the point 3 when the flame of the gas jet H is about to be communicated to the gaseous charge by a small quantity of inflamed gas in the passage D^3, and, secondly, its position at the point 4 when the escape-valve F is about to be opened.

For effecting the ignition of the charge, a small quantity of combustible gas is made to pass down a pipe, S, into a recess, S′, in the end of the cylinder, whence it issues through a small channel, D^4, in the slide into the passage D^3. Here it is ignited by the jet H, and the flame is, by the motion of the slide, conveyed to the port C, the slide-cover L being made to close the outer opening of D^3 before its inner opening communicates with C, as shown at Fig. 11.

The gas-passage G communicates with the air-passage D^1 through a number of small openings, as shown at Fig. 13, so that the gas, in issuing in small divided jets into D^3, becomes intimately mixed with the air therein in the requisite proportions for producing the combustible mixture before described.

The opening of the escape-valve F at the commencement of the second instroke of the piston (point 4 at Fig. 9) is effected by the bell-crank lever F^1, connected at one end to the stem of the valve, and having at the other end a roller, F^2, which is acted upon by the cam F^3 on the shaft K. E′ is the pipe for conducting away the products of combustion.

The governor Q is driven by bevel-gearing from the shaft K, its arms being made to move a sliding collar, Q^3, up or down, thus imparting motion through the lever Q^1 to the cam R, as before described.

The cylinder A is, by preference, provided with a jacket, as shown.

As before stated, the engine may be arranged double-acting by providing the requisite valve-gear for each end of the cylinder. It may also be arranged in a vertical or inclined position, instead of horizontal; and if single-acting, or if great regularity of motion be required, two or more engines may be connected to one and the same crank-shaft.

Having thus described the nature of my invention, and in what manner the same is to be performed, I wish it to be understood that I do not claim generally the separate introduction of combustible gas and air into the cylinder of a gas-engine, as I am aware that is to a certain extent described in the English Patents No. 1,655 of 1857, and 335 of 1860; but,

I claim—

1. A gas-motor engine wherein an intimate mixture of combustible gas or vapor and air is introduced into the cylinder, separate from a charge of air or other incombustible gas, in such manner and in such proportions that the particles of combustible mixture will be close together at the point of ignition, but will be more and more dispersed in the charge of air forward of that point, whereby the development of heat and the expansion or increase of pressure produced by the combustion are rendered gradual, substantially as herein described.

2. A gas-motor engine wherein an intimate mixture of combustible gas or vapor and air is introduced into the cylinder separate from and subsequent to a charge of air, such introduction being effected through an aperture or apertures in the end surface of the cylinder, in order to cause the charge of air to move forward in the cylinder as the combustible mixture is introduced, substantially as and for the purposes set forth.

3. A gas-motor engine wherein, by one outstroke of the piston, separate charges of combustible gaseous mixture and of air are drawn into the cylinder, which charges are compressed by the instroke and then ignited, so as to propel the piston, which, by its return stroke, expels the products of combustion, substantially as herein described with reference to Figs. 2 to 13 of the drawings.

4. In gas-motor engines wherein charges of combustible gas and air are introduced separately into the cylinder, regulating the power of the engine by controlling the gas-supply by means of a valve operated by a governor, substantially as herein described.

5. In gas-motor engines, the shaft K, driven from the engine-shaft, with crank K^2, imparting motion to the slide D, cam R, for regulating the gas-supply, and cam F^3, for opening the escape-valve F, substantially as herein described.

6. In gas-motor engines, the combination of the cylinder A, piston B, engine-shaft I, counter-shaft K, crank K^2, slide D, gas-slide P, cam R, escape-valve F, lever F^1, and cam F^3, all arranged and operating substantially as and for the purposes herein described.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses this 1st day of June, 1876.

NICOLAUS AUGUST OTTO.

Witnesses:

FRIEDRICH ALBERT SPIECKER,

GUSTAV KLEINJING.

(No Model.) 3 Sheets—Sheet 1.

G. MARCONI.

TRANSMITTING ELECTRICAL SIGNALS.

No. 586,193. Patented July 13, 1897.

Fig. 1.

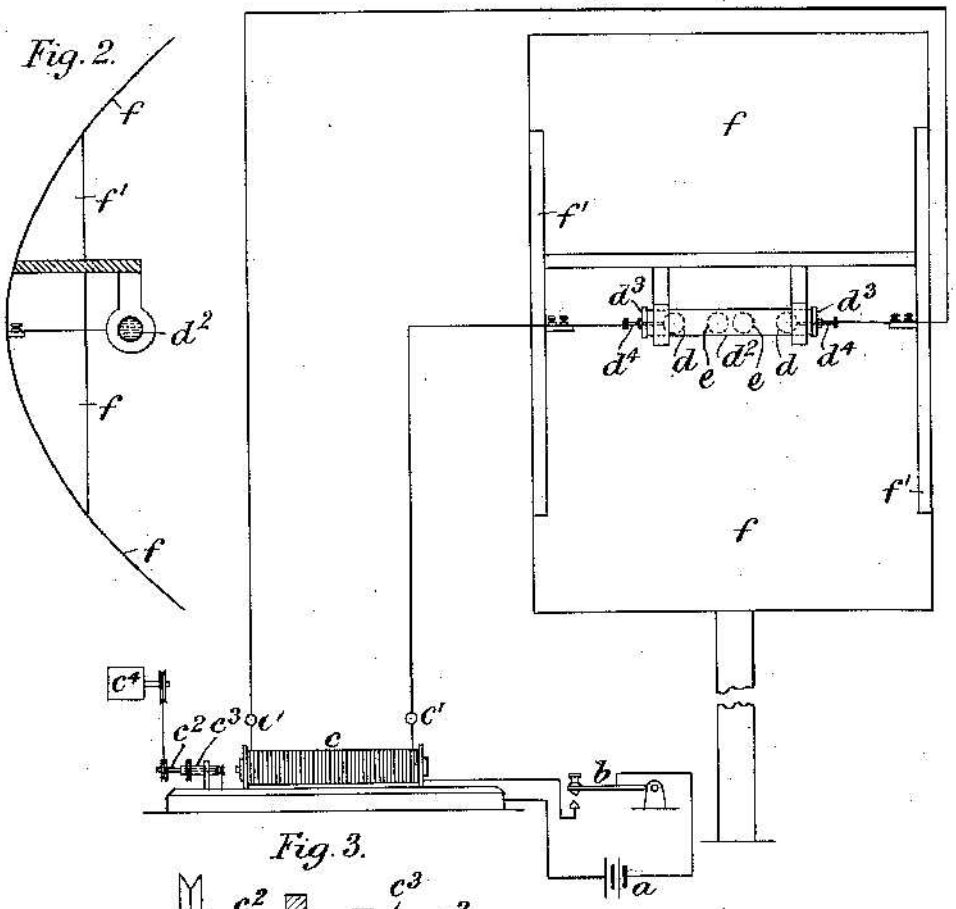


Fig. 2.

Fig. 3.

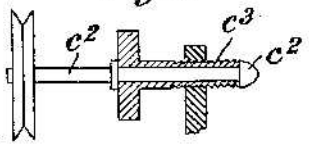
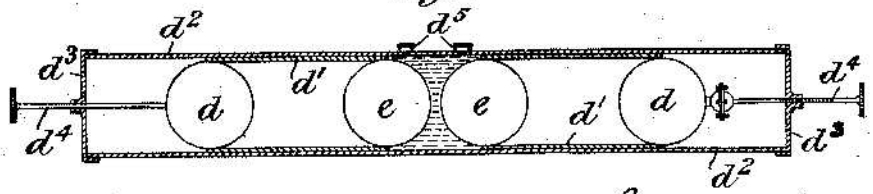


Fig. 2a.



Witnesses
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B. W. Miller.

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Inventor
By his Attorneys,
Baldwin, Davidson & Wright.

(No Model.) 3 Sheets—Sheet 2.

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TRANSMITTING ELECTRICAL SIGNALS.

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Fig. 4.

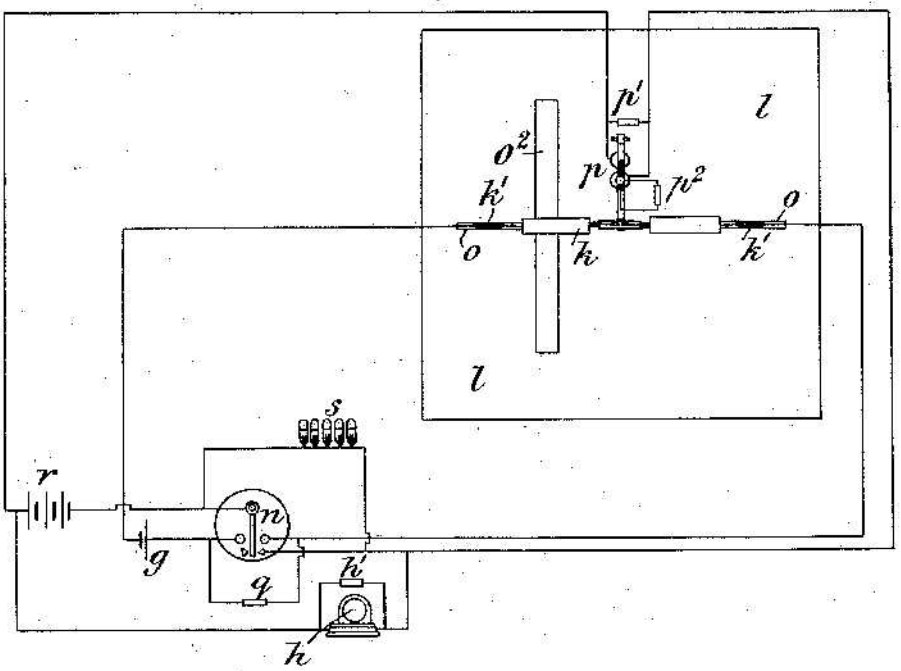

Fig. 5.

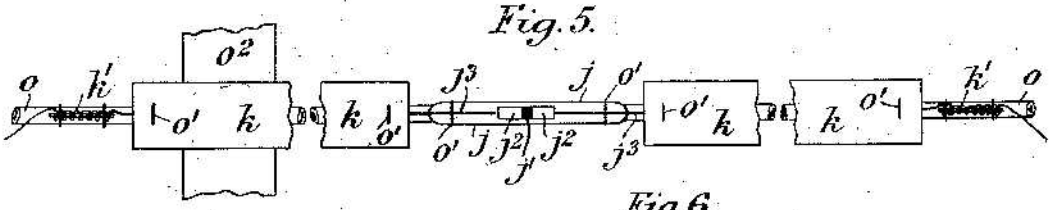

Fig. 6.

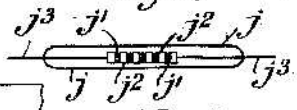

Fig. 7.

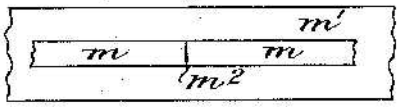

Fig. 8.

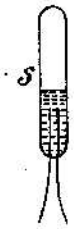

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Fig. 9.

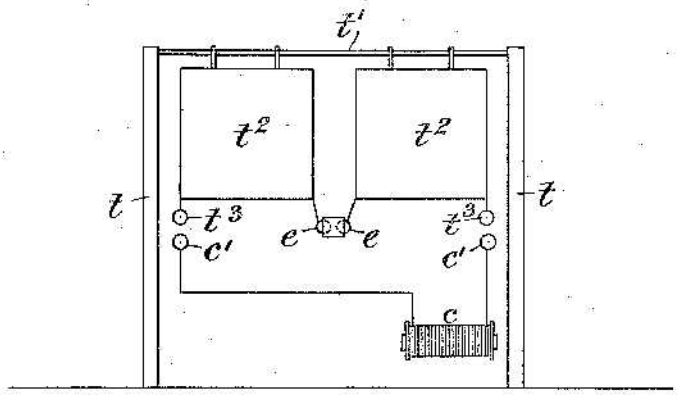


Fig. 10.

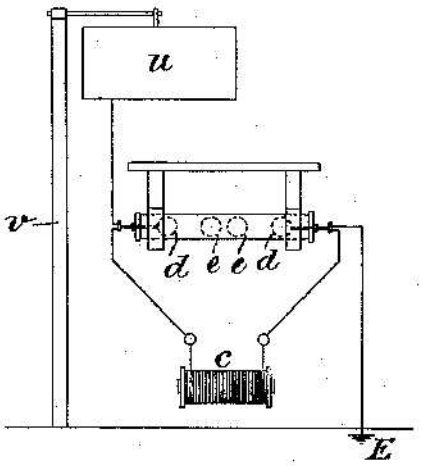
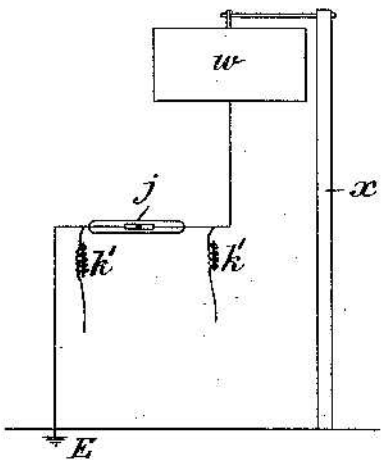


Fig. 11.



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UNITED STATES PATENT OFFICE.

GUGLIELMO MARCONI, OF LONDON, ENGLAND.

TRANSMITTING ELECTRICAL SIGNALS.

SPECIFICATION forming part of Letters Patent No. 586,193, dated July 13, 1897.

Application filed December 7, 1896. Serial No. 614,838. (No model.)

To all whom it may concern:

Be it known that I, GUGLIELMO MARCONI, student, a subject of the King of Italy, residing at 21 Burlington Road, London, in the county of Middlesex, England, have invented certain new and useful Improvements in Transmitting Electrical Impulses and Signals and in Apparatus Therefor, of which the following is a specification.

According to this invention electrical signals, actions, or manifestations are transmitted through the air, earth, or water by means of oscillations of high frequency, such as have been called the "Hertz rays" or "Hertz oscillations." Usually all line-wires are dispensed with. At the transmitting-station I employ a Ruhmkorff coil, having in its primary circuit a Morse key or other signaling instrument and at its poles appliances for producing the desired oscillations. The Ruhmkorff coil may, however, be replaced by any other source of high-tension electricity. When working with large amounts of energy, it is, however, better to keep the coil or transformer constantly working for the time during which one is transmitting, and instead of interrupting the current of the primary interrupting the discharge of the secondary. In this case the contacts of the key should be immersed in oil, as otherwise, owing to the length of the spark, the current will continue to pass after the contacts have been separated. At the receiving-station there is a local-battery circuit, containing any ordinary receiving instrument and an appliance for closing the circuit, the latter being actuated by the oscillations from the transmitting-station. When transmitting through the air and it is desired that the signal should only be sent in one direction, I place the oscillation-producer at the transmitting-station in the focus or focal line of a reflector directed to the receiving-station, and I place the circuit-closer at the receiving-station in a similar reflector directed toward the transmitting-station. When transmitting signals through the earth, I connect one end of the oscillation-producer and one end of the circuit-closer to earth and the other ends to similar plates, preferably electrically tuned with each other in the air and insulated from earth.

Figure 1 is a diagrammatic front elevation of the instruments at the transmitting-station when signaling through the air, and Fig. 2 is a vertical section of the transmitter. Fig. 2^a is a longitudinal section of the oscillator to a larger scale. Fig. 3 shows a detail on a larger scale. Fig. 4 is a diagrammatic front elevation of the instruments at the receiving-station. Fig. 5 is a full-sized view of the receiver. Fig. 6 shows a modification of the tube *j*. Fig. 7 shows the detector. Fig. 8 is a full-sized view of the liquid-resistance. Figs. 9 and 10 show modifications of the arrangements at the transmitting-station. Fig. 11 shows a modification of the arrangements at the receiving-station.

Referring now to Fig. 1, *a* is a battery, and *b* an ordinary Morse key closing the circuit through the primary of a Ruhmkorff coil *c*. The terminals *c'* of the secondary circuit of the coil are connected to two metallic balls *d d*, fixed by heat or otherwise at the ends of tubes *d' d'*, Fig. 2^a, of insulating material, such as ebonite or vulcanite. *e e* are similar balls fixed in the other ends of the tubes *d'*. The tubes *d'* fit tightly in a similar tube d^2, having covers d^3, through which pass rods d^4, connecting the balls *d* to the conductors. One (or both) of the rods d^4 is connected to the ball *d* by a ball-and-socket joint and has a screw-thread upon it working in a nut in the cover d^3. By turning the rod therefore the distance of the balls *e* apart can be adjusted. d^5 are holes in the tube d^2, through which vaseline, oil, or like material is introduced into the space between the balls *e*

The balls *d* and *e* are preferably of solid brass or copper, and the distance they should be apart depends on the quantity and electromotive force of the electricity employed, the effect increasing with the distance so long as the discharge passes freely. With a coil giving an ordinary eight-inch spark the distance between *e* and *e* should be from one twenty-fifth to one-thirtieth of an inch and the distance between *d* and *e* about one and a half inches. *f* is a cylindrical parabolic reflector made by bending a metallic sheet, preferably of brass or copper, to form and fixing it to metallic or wooden ribs *f'*. Other conditions being equal the larger the balls the greater is the distance at which it is possible to communicate. I have generally used

balls of solid brass of four inches diameter, giving oscillations of ten inches length of wave.

The reflectors applied to the receiver and transmitter ought to be preferably in length and opening the double at least of the length of wave emitted from the oscillator.

If a very powerful source of electricity giving a very long spark be employed, it is preferable to divide the spark gap between the central balls of the oscillator into several smaller gaps in series. This may be done by introducing between the big balls smaller ones, (of about half an inch diameter,) held in position by ebonite frames.

I find that the regularity and power of the discharge of an ordinary Ruhmkorff coil with a trembler-break on its primary is greatly improved by causing one of the contacts of the vibrating break to revolve rapidly. I do this by having a revoluble central core c^2, Fig. 3, in the ordinary screw c^8, which is in communication with the platinum contacts. I cause the said central core with one of the platinum contacts attached to it to revolve by connecting it to a small electric motor c^4. This motor can be worked by the same circuit that works the coil, or, if necessary, by a separate circuit. The connections are not shown in the drawings. By this means the platinums are kept smooth and any tendency to stick is removed. They last also much longer. At the receiving-station is a battery whose circuit includes an ordinary telegraphic instrument (or it may be a relay or other apparatus which it is desired to work from a distance) and a circuit-closer.

In Fig. 4, g is the battery, and h a telegraphic instrument on the derived circuit of a relay n.

The appliance I employ as a circuit-closer is shown full size at Fig. 5 and consists of a glass tube j, containing metallic powder or grains of metal j', each end of the column of powder being connected to a metallic plate k of suitable length to cause the system to resonate electrically in unison with the electrical oscillations transmitted. The glass tube may be replaced in some cases by one of gutta-percha or like material. Two short pieces of thick silver wire j^2 of the same diameter as the internal diameter of the tube j, so as to fit tightly in it, are joined to two pieces of platinum wire j^3. The tube is closed and sealed onto the platinum wires j^3 at both ends.

Many metals can be employed for producing the powder or filings j'; but I prefer to use a mixture of two or more different metals. I find hard nickel to be the best metal, and I prefer to add to the nickel filings about ten per cent. of hard-silver filings, which increase greatly the sensitiveness of the tube to electric oscillations. By increasing the proportion of silver powder or grains the sensitiveness of the tube also increases; but it is better for ordinary work not to have a tube of too great sensitiveness, as it might be influenced by atmospheric or other electricity. The sensitiveness can also be increased by adding a very small amount of mercury to the filings and mixing up until the mercury is absorbed.

The mercury must not be in such a quantity as to clot or cake the filings. An almost imperceptible globule is sufficient for a tube. Instead of mixing the mercury with the powder one can obtain the same effects by slightly amalgamating the inner surfaces of the plugs which are to be in contact with the filings. Very little mercury must be used, just sufficient to brighten the surface of the metallic plugs without showing any free globules. The size of the tube and the distance between the two metallic stops may vary under certain limits. The greater the space allowed for the powder the larger and coarser ought to be the filings or grains.

I prefer to make my sensitive tubes of the following size: The tube j is one and one-half inches long and one-tenth or one-twelfth of an inch internal diameter. The length of the stops j^2 is about one-fifth of an inch, and the distance between the stops is about one-thirtieth of an inch. I find that the smaller the space between the stops in the tube the more sensitive it proves, but the space cannot under ordinary circumstances be excessively shortened without injuring the fidelity of the transmission.

The metallic powders ought not to be fine, but rather as coarse as can be produced by a large and rough file.

All the very fine powder ought to be removed by blowing or sifting.

The powder ought not to be compressed between the stops, but rather loose and in such a condition that when the tube is tapped the powder may be seen to move.

The tube must be sealed, but a vacuum inside it is not essential, except the slight vacuum which results from having heated it while sealing it. Care must also be taken not to heat the tube too much in the center when sealing it, as it would oxidize the surfaces of the silver stops and also the powder, which would diminish its sensitiveness. I use in sealing the tubes a hydrogen and air flame. A vacuum is, however, desirable, and I have used one of about one one-thousandth of an atmosphere, obtained by a mercury-pump. It is also necessary for the powder or grains to be dry and free from grease or dirt, and the files used in producing the same ought to be frequently washed and dried and used when warm.

If the tube has been well made, it should be sensitive to the induction of an ordinary electric bell when the same is working at one to two yards or more from the tube.

In order to keep the sensitive tube j in good working order, it is desirable, but not absolutely necessary, not to allow more than one milliampere to flow through it when active. If a stronger current is necessary, several tubes may be put in derivation between the

tuned plates, but this arrangement is not quite as satisfactory as the single tube. It is necessary when using tubes of the type I have described not to insert in the circuit more than one cell of the Leclanché type, as a higher electromotive force than 1.5 volts is apt to pass a current through the tube even when no oscillations are transmitted. I can, however, construct tubes capable of working with a much higher electromotive force. Fig. 6 shows one of these tubes. In this tube instead of one space or gap filled with filings there are several spaces separated by sections of tight-fitting silver wire. A tube thus constructed, observing also the rules of construction of my tubes in general, will work satisfactorily if the electromotive force of the battery in circuit with the tube is equal to 1.2 volts multiplied by the number of gaps. With this tube also it is well not to allow a current of more than one milliampere to pass.

The tube *j* may be replaced by other forms of imperfect electrical contacts, but this is not desirable.

The plates *k* are of copper or aluminium or other metal, about half an inch or more broad, about one-fiftieth of an inch thick, and preferably of such a length as to be electrically tuned with the electric oscillations transmitted. The means I adopt for fixing the length of the plates is as follows: I stick a rectangular strip of tin-foil *m* (see Fig. 7) about twenty inches long (the length depends on the supposed length of wave that one is measuring) by means of a weak solution of gum onto a glass plate *m'*. Then by means of a very sharp penknife or point I cut across the middle of the tin-foil, leaving a mark of division m^2. If this detector is held in the proximity (four or five yards) and parallel with the axis of the oscillator in action, it will show little sparks at m^2. If the length of the pieces of tin-foil approximates to the length of wave emitted from the oscillator, the spark will take place between them at a certain distance from the transmitter, which is a maximum when they are of suitable length. By shortening or lengthening the strips, therefore, it is easy to find the length most appropriate to the length of wave emitted by the oscillator. It is desirable to try this detector in the focus or focal line of the reflector. The length so found is the proper length for the plates *k*, or rather these should be about half an inch shorter on account of the length of the sensitive tube *j*, connected between them.

l is a cylindrical parabolic reflector similar to that used at the transmitting-station.

The plates *k* may be in the form of tubes or even wires.

It is slightly advantageous for the focal distance of the reflector to be equal to one-fourth or three-fourths of the wave length of the oscillation transmitted.

When no oscillations are sent from the transmitting-station, the tube *j* does not conduct the current, and the local-battery circuit is broken, but when the powder or tube is influenced by the electrical oscillations from the transmitter it conducts and closes the circuit. I find, however, that when once started the powder in the tube continues to conduct even when the oscillations from the transmitter have ceased, but if it be shaken or tapped the circuit is broken. A tube well prepared will instantly interrupt the current passing through it at the slightest tap, provided it is inserted in a circuit in which there is little self-induction and small electromotive force, such as a single cell, and where the effects of self-induction have been removed by one of the methods which I will presently describe.

The two plates *k* communicate with the local circuit through two very small coils *k'*, which I will call "choking-coils," formed by winding a few inches of very thin and insulated copper wire around a bit of iron wire about an inch and a half long. The object of these choking-coils is to prevent the high-frequency oscillation induced across these plates by the transmitter from dissipating itself by running along the local-battery wires which might weaken its effect on the sensitive tube *j*. These choking-coils may, however, be sometimes replaced by simple thin wires. They may also be connected directly to the tube *j*. The local circuit in which the sensitive tube *j* is inserted contains a sensitive relay *n*, preferably wound to a resistance of about twelve hundred ohms. This resistance need not be necessarily that of the relay, but may be the sum of the resistance of the relay and another additional resistance. The relay ought to be one possessing small self-induction.

The plates *k*, tube *j*, and coils *k'* are fastened by means of wire stitches *o'* to a thin glass tube *o*, preferably not longer than twelve inches, firmly fixed at one end to a strong piece of timber o^2. This may be done by means of wood or ebonite grasping-screws.

I do the tapping automatically by the current started by the tube, employing a trembler *p* on the circuit of the relay *n* similar in construction to that of an electric bell, but having a shorter arm. The vibrator must be carefully adjusted. Preferably the blows should be directed slightly upward to prevent the filings from getting caked. In place of tapping the tube the powder can be disturbed by slightly moving outward and inward one or both of the stops j^2, the trembler *p* being replaced by a small electromagnet (or magnets) whose armature is connected to the stop.

I ordinarily work the telegraphic receiver *h* (or other instruments) by a derivation, as shown, from the circuit which works the trembler *p*. They can also, however, be worked in series with the trembler. When working ordinary sounders or Morse apparatus, a special adjustment of the same is sometimes needed to enable one to obtain dots and dashes. Sometimes it is necessary to work the telegraphic instruments or relays from the back-stops of the first relay, as is done in

some systems of multiple telegraphy. Such adjustments are known to telegraphic experts.

By means of a tube with multiple gaps it is possible to work the trembler and also the signaling or other apparatus direct on the circuit which contains the tube, but I prefer when possible to work with the single-gap tube and the relay, as shown. With a sensitive and well-constructed trembler it is also possible to work the trembler with the single-gap tube in series with it without the relay.

In derivation on the terminals of the relay n is placed an ordinary platinoid resistance double-wound (or wound on the "bight," as it is sometimes termed) coil q of about four times the resistance of the relay, which prevents the self-induction of the winding of the relay from affecting the sensitive tube.

The circuit actuated by the relay contains an ordinary battery r of about twelve cells and the trembler p, the resistance of the winding of which should be about one thousand ohms, and the nucleus ought preferably to be of soft iron, hollow and split lengthwise, like most electromagnets used in telegraph instruments. In series or derivation from this circuit is inserted the telegraphic or other apparatus h which one may desire to work. It is desirable that this instrument or apparatus, if on a derivation, should have a resistance equal to the resistance of the trembler p. A platinoid resistance h' of about five times the resistance of the instrument is inserted in derivation across the terminals of the instrument and connected as close to the same as possible. In derivation across the terminals of the trembler p is placed another platinoid resistance p', also of about five times the resistance of the trembler. A similar resistance p^2 is inserted in a circuit connecting the vibrating contacts of the trembler. In derivation across the terminals of the relay-circuit it is well to have a liquid resistance s, which is constituted of a series of tubes, one of which is shown full size in Fig. 8, filled with water acidulated with sulfuric acid. The number of these tubes in series across the said terminals ought to be about ten for a circuit of fifteen volts, so as to prevent, in consequence of their counter electromotive force, the current of the local battery from passing through them, but allowing the high-tension jerk of current generated at the opening of the circuit in the relay to pass smoothly across them without producing perturbing sparks at the movable contact of the relay. It is also necessary to insert a platinoid resistance in derivation on any apparatus one may be working on the local circuits. These resistances ought also to be inserted in derivation on the terminals of any resistance which may be apt to give self-induction.

I have hitherto only mentioned the use of cylindrical reflectors, but it is also possible to use ordinary concave reflectors, preferably parabolic, such as are used for projectors.

It is not essential to have a reflector at the transmitters and receivers, but in their absence the distance at which one can communicate is much smaller.

I find it convenient when transmitting across long distances to make use of the transmitter shown in Fig. 9.

$t\,t$ are two poles connected by a rope t', to which are suspended by means of insulating suspenders two metallic plates $t^2\,t^2$, preferably in the form of cylinders closed at the top, connected to the spheres e (in oil or other dielectric, as before) and to the other balls t^3 in proximity to the spheres c', in communication with the coil or transformer c. The balls t^3 are not absolutely necessary, as the plates t^2 may be made to communicate with the coil or transformer by means of thin insulated wires. The receiver I adopt with this transmitter is similar to it, except that the spheres e are replaced by the sensitive tube j and plates k, while the spheres t^3 are replaced by the choking-coils k', in communication with the local circuit. It may be observed that, other conditions being equal, the larger the plates at the transmitter and receiver and the higher they are from earth and to a certain extent the farther apart they are the greater is the distance at which correspondence is possible.

When transmitting through the earth or water, I use a transmitter as shown in Fig. 10. I connect one of the spheres d to earth E, preferably by a thick wire, and the other to a plate or conductor u, suspended on a pole v and insulated from earth; or the spheres d may be omitted and one of the spheres e be connected to earth and the other to the plate or conductor u. At the receiving-station, Fig. 11, I connect one terminal of the sensitive tube j to earth E, also by a thick wire, and the other to a plate or conductor w, preferably similar to u. The plate w may be suspended on a pole x and must be insulated from earth. The larger the plates of the receiver and transmitter and the higher from the earth the plates are suspended the greater is the distance at which it is possible to communicate. When using the last-described apparatus, it is not necessary to have the two instruments in view of each other, as it is of no consequence if they are separated by mountains or other obstacles. At the receiver it is possible to pick up the oscillations from the earth or water without having the plate w. This may be done by connecting the terminals of the sensitive tube j to two earths, preferably at a certain distance from each other and in a line with the direction from which the oscillations are coming. These connections must not be entirely conductive, but must contain a condenser of suitable capacity—say one square yard of surface. Balloons can also be used instead of plates on poles, provided they carry up a plate or are themselves made conductive by being covered with tin-foil. As the height to which they may be sent is great, the distance at which communication is possible be-

comes greatly multiplied. Kites may also be successfully employed if made conductive by means of tin-foil.

The apparatus above described is so sensitive that it is essential either that the transmitters and receivers at each station should be at a considerable distance from each other or that they should be screened from each other by stout metal plates. It is sufficient to have all the telegraphic apparatus in a metal box and any exposed part of the circuit of the receiver inclosed in metallic tubes which are in electrical communication with the box. (Of course the part of the apparatus which has to receive the radiation from the distant station must not be inclosed, but possibly screened from the local transmitter by means of metallic sheets.) When working through the earth or water, the local receiver must be switched out of circuit when the transmitter is at work, and this may also be done when working through air.

What I claim is—

1. In a receiver for electrical oscillations the combination of an imperfect electrical contact, a circuit through the contact and means actuated by the circuit for shaking the contact.

2. In a receiver for electrical oscillations the combination of an imperfect electrical contact, metallic plates connected to it, a circuit through the contact and means actuated by the circuit for shaking the contact.

3. In a receiver for electrical oscillations the combination of an imperfect electrical contact, metallic plates connected to the contact, choking-coils connected to the contact, a circuit through the coils, and contact and means actuated by the circuit for shaking the contact.

4. In a receiver for electrical oscillations the combination of a tube containing metallic powder, a circuit through the powder and means actuated by the circuit for shaking the powder.

5. In a receiver for electrical oscillations the combination of a tube containing metallic powder, metallic plates connected to the powder, a circuit through the powder and means actuated by the circuit for shaking the powder.

6. In a receiver for electrical oscillations the combination of a tube containing metallic powder, metallic plates connected to the powder, choking-coils connected to the powder, a circuit through the coils and powder and means actuated by the circuit for shaking the powder.

7. In a receiver for electrical oscillations the combination of a tube containing a mixture of metallic powders, a circuit through the powder, and means actuated by the circuit for shaking the powder.

8. In a receiver for electrical oscillations the combination of a tube containing a mixture of metallic powders, metallic plates connected to the powder, a circuit through the powder and means actuated by the circuit for shaking the powder.

9. In a receiver for electrical oscillations the combination of a tube containing a mixture of metallic powders, metallic plates connected to the powder, choking-coils connected to the powder, a circuit through the coils, and powder and means actuated by the circuit for shaking the powder.

10. In a receiver for electrical oscillations the combination of a tube containing a mixture of metallic powder and mercury, a circuit through the powder and means actuated by the circuit for shaking the powder.

11. In a receiver for electrical oscillations the combination of a tube containing a mixture of metallic powder and mercury, metallic plates connected to the powder, a circuit through the powder and means actuated by the circuit for shaking the powder.

12. In a receiver for electrical oscillations the combination of a tube containing a mixture of metallic powder and mercury, metallic plates connected to the powder, choking-coils connected to the powder, a circuit through the coils and powder and means actuated by the circuit for shaking the powder.

13. In a receiver for electrical oscillations the combination of a tube, metallic plugs in the tube, metallic powder between the plugs, a circuit through the plugs and powder and means actuated by the circuit for shaking the powder.

14. In a receiver for electrical oscillations the combination of a tube, metallic plugs in the tube, metallic powder between the plugs, metallic plates connected to them, a circuit through the plugs and powder and means actuated by the circuit for shaking the powder.

15. In a receiver for electrical oscillations the combination of a tube, metallic plugs in the tube, metallic powder between the plugs, metallic plates connected to the plugs, choking-coils connected to the plugs, a circuit through the coils and plugs and means actuated by the circuit for shaking the powder.

16. In a receiver for electrical oscillations the combination of a tube, metallic plugs in the tube, a mixture of metallic powders between the plugs, a circuit through the plugs and powder and means actuated by the circuit for shaking the powder.

17. In a receiver for electrical oscillations the combination of a tube, metallic plugs in the tube, a mixture of metallic powders between the plugs, metallic plates connected to the plugs, a circuit through the plugs and powder and means actuated by the circuit for shaking the powder.

18. In a receiver for electrical oscillations the combination of a tube, metallic plugs in the tube, a mixture of metallic powders between the plugs, metallic plates connected to the plugs, choking-coils connected to the

plugs, a circuit through the coils plugs and powder and means actuated by the circuit for shaking the powder.

19. In a receiver for electrical oscillations the combination of a tube, metallic plugs in the tube, a mixture of metallic powder and mercury between the plugs, a circuit through the plugs and powder and means actuated by the circuit for shaking the powder.

20. In a receiver for electrical oscillations the combination of a tube, metallic plugs in the tube, a mixture of metallic powder and mercury between the plugs, metallic plates connected to the plugs, a circuit through the plugs and powder and means actuated by the circuit for shaking the powder.

21. In a receiver for electrical oscillations the combination of a tube, metallic plugs in the tube, a mixture of metallic powder and mercury between the plugs, metallic plates connected to the plugs, choking-coils connected to the plugs, a circuit through the coils plugs and powder and means actuated by the circuit for shaking the powder.

22. In a receiver for electrical oscillations the combination of an imperfect electrical contact, a circuit through the contact, a relay actuated by the circuit and means actuated by the relay for shaking the contact.

23. In a receiver for electrical oscillations the combination of an imperfect electrical contact, metallic plates connected to it, a circuit through the contact, a relay actuated by the circuit and means actuated by the relay for shaking the contact.

24. In a receiver for electrical oscillations the combination of an imperfect electrical contact, metallic plates connected to the contact, choking-coils connected to the contact, a circuit through the coils and contact, a relay actuated by the circuit and means actuated by the relay for shaking the contact.

25. In a receiver for electrical oscillations the combination of a tube containing metallic powder, a circuit through the powder, a relay actuated by the circuit and means actuated by the relay for shaking the powder.

26. In a receiver for electrical oscillations the combination of a tube containing metallic powder, metallic plates connected to the powder, a circuit through the powder, a relay actuated by the circuit and means actuated by the relay for shaking the powder.

27. In a receiver for electrical oscillations the combination of a tube containing metallic powder, metallic plates connected to the powder, choking-coils connected to the powder a circuit through the coils and powder a relay actuated by the circuit and means actuated by the relay for shaking the powder.

28. In a receiver for electrical oscillations the combination of a tube containing a mixture of metallic powders, a circuit through the powder, a relay actuated by the circuit and means actuated by the relay for shaking the powder.

29. In a receiver for electrical oscillations the combination of a tube containing a mixture of metallic powders, metallic plates connected to the powder, a circuit through the powder, a relay actuated by the circuit and means actuated by the relay for shaking the powder.

30. In a receiver for electrical oscillations the combination of a tube containing a mixture of metallic powders, metallic plates connected to the powder, choking-coils connected to the powder, a circuit through the coils and powder, a relay actuated by the circuit and means actuated by the relay for shaking the powder.

31. In a receiver for electrical oscillations the combination of a tube containing a mixture of metallic powder and mercury, a circuit through the powder, a relay actuated by the circuit and means actuated by the relay for shaking the powder.

32. In a receiver for electrical oscillations the combination of a tube containing a mixture of metallic powder and mercury, metallic plates connected to the powder, a circuit through the powder, a relay actuated by the circuit and means actuated by the relay for shaking the powder.

33. In a receiver for electrical oscillations the combination of a tube containing a mixture of metallic powder and mercury, metallic plates connected to the powder, choking-coils connected to the powder, a circuit through the coils and powder, a relay actuated by the circuit and means actuated by the relay for shaking the powder.

34. In a receiver for electrical oscillations the combination of a tube, metallic plugs in the tube, metallic powder between the plugs, a circuit through the plugs and powder, a relay actuated by the circuit and means actuated by the relay for shaking the powder.

35. In a receiver for electrical oscillations the combination of a tube, metallic plugs in the tube, metallic powder between the plugs, metallic plates connected to the plugs, a circuit through the plugs and powder, a relay actuated by the circuit and means actuated by the relay for shaking the powder.

36. In a receiver for electrical oscillations the combination of a tube, metallic plugs in the tube, metallic powder between the plugs, metallic plates connected to the plugs, choking-coils connected to the plugs, a circuit through the coils, plugs and powder, a relay actuated by the circuit, and means actuated by the relay for shaking the powder.

37. In a receiver for electrical oscillations the combination of a tube, metallic plugs in the tube, a mixture of metallic powders between the plugs, a circuit through the plugs and powder, a relay actuated by the circuit, and means actuated by the relay for shaking the powder.

38. In a receiver for electrical oscillations the combination of a tube, metallic plugs in the tube, a mixture of metallic powders between the plugs, metallic plates connected to

the plugs, a circuit through the plugs and powder, a relay actuated by the circuit, and means actuated by the relay for shaking the powder.

39. In a receiver for electrical oscillations the combination of a tube, metallic plugs in the tube, a mixture of metallic powders between the plugs, metallic plates connected to the plugs, choking-coils connected to the plugs, a circuit through the coils, plugs and powder, a relay actuated by the circuit and means actuated by the relay for shaking the powder.

40. In a receiver for electrical oscillations the combination of a tube, metallic plugs in the tube, a mixture of metallic powder and mercury between the plugs, a circuit through the plugs and powder, a relay actuated by the circuit and means actuated by the relay for shaking the powder.

41. In a receiver for electrical oscillations the combination of a tube, metallic plugs in the tube, a mixture of metallic powder and mercury between the plugs, metallic plates connected to the plugs, a circuit through the plugs and powder, a relay actuated by the circuit and means actuated by the relay for shaking the powder.

42. In a receiver for electrical oscillations the combination of a tube, metallic plugs in the tube, a mixture of metallic powder and mercury between the plugs, metallic plates connected to the plugs, choking-coils connected to the plugs, a circuit through the coils, plugs and powder, a relay actuated by the circuit and means actuated by the relay for shaking the powder.

43. The combination of a spark-producer at the transmitting-station, an earth connection to one end of the spark-producer, an insulated conductor connected to the other end, an imperfect electrical contact at the receiving-station, an earth connection to one end of the contact an insulated conductor connected to the other end and a circuit through the contact.

44. The combination of a spark-producer at the transmitting-station, an earth connection to one end of the spark-producer, an insulated conductor connected to the other end, an imperfect electrical contact at the receiving-station, an earth connection to one end of the contact an insulated conductor connected to the other end, a circuit through the contact and means actuated by the circuit for shaking the contact.

45. The combination of a spark-producer at the transmitting-station, an earth connection to one end of the spark-producer, an insulated conductor connected to the other end, an imperfect electrical contact at the receiving-station, choking-coils connected to each end of the contact, an earth connection to one end of the imperfect contact an insulated conductor connected to the other end and a circuit through the coils and contact.

46. The combination of a spark-producer at the transmitting-station, an earth connection to one end of the spark-producer, an insulated conductor connected to the other end, an imperfect electrical contact at the receiving-station, choking-coils connected to each end of the contact, an earth connection to one end of the imperfect contact, an insulated conductor connected to the other end, a circuit through the coils and contact and means actuated by the circuit for shaking the contact.

47. The combination of a spark-producer at the transmitting-station, an earth connection to one end of the spark-producer, an insulated conductor connected to the other end, a tube containing metallic powder at the receiving-station, an earth connection to one end of the powder, an insulated conductor connected to the other end and a circuit through the powder.

48. The combination of a spark-producer at the transmitting-station, an earth connection to one end of the spark-producer, an insulated conductor connected to the other end, a tube containing metallic powder at the receiving-station, an earth connection to one end of the powder an insulated conductor connected to the other end, a circuit through the powder and means actuated by the circuit for shaking the powder.

49. The combination of a spark-producer at the transmitting-station, an earth connection to one end of the spark-producer, an insulated conductor connected to the other end, a tube containing metallic powder at the receiving-station, choking-coils connected to each end of the powder, an earth connection to one end of the powder, an insulated conductor connected to the other end and a circuit through the coils and powder.

50. The combination of a spark-producer at the transmitting-station, an earth connection to one end of the spark-producer, an insulated conductor connected to the other end, a tube containing metallic powder at the receiving-station, choking-coils connected to each end of the powder, an earth connection to one end of the powder, an insulated conductor connected to the other end, a circuit through the coils and powder and means actuated by the circuit for shaking the powder.

51. The combination of a spark-producer at the transmitting-station, an earth connection to one end of the spark-producer, an insulated conductor connected to the other end, a tube containing metallic powder at the receiving-station, choking-coils and earth connection through condensers connected to each end of the powder, a circuit through the coils and powder and means actuated by the circuit for shaking the powder.

52. In a receiver for electrical oscillations, the combination of an imperfect electrical contact, a circuit through the contact, an electric trembler shaking the contact, and means for preventing the self-induction of the trembler from affecting the contact.

53. A receiver for electrical oscillatory impulses having a medium whose electrical resistance is altered by the received electrical oscillations, a trembler or shaker for acting upon the variable-resistance medium to restore it to its normal condition of electrical resistance, and means for controlling such trembler to cause it to act upon the variable-resistance medium to restore it to its normal condition after each reception of such oscillatory impulses.

54. A receiver for electrical oscillatory impulses having a medium whose electrical resistance is altered by the received electrical oscillations, a trembler or shaker for acting upon the variable-resistance medium to restore it to its normal condition of electrical resistance, means controlling such trembler to cause it to act upon the variable-resistance medium to restore it to its normal condition after each reception of such oscillatory impulses, and means for rendering manifest said electrical oscillatory impulses consecutively received, whereby defined signals may be given out by the receiver.

55. The combination of a transmitter capable of producing at will of the operator electric oscillatory impulses or rays, and a receiver responsive thereto having a variable-resistance medium whose resistance is altered by such received oscillatory impulses, means controlled by the received oscillations for restoring such medium to its normal condition after each reception of such oscillations, and means for rendering manifest the received oscillations, whereby signals sent from the transmitter may be received upon the receiver.

56. The combination of a transmitter capable of producing electrical oscillations or rays at the will of the operator, and a receiver located at a distance and having a conductor tuned to respond to such oscillations, a variable-resistance medium, in circuit with the conductor, whose resistance is altered by the received oscillations, means controlled by the received oscillations for restoring the resistance medium to its normal condition after each reception of such oscillations, and means for rendering the received oscillations manifest.

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Witnesses:
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FRED C. HARIES.

Dec. 17, 1957 R. J. TAYLOR 2,816,721

ROCKET POWERED AERIAL VEHICLE

Filed Sept. 15, 1953

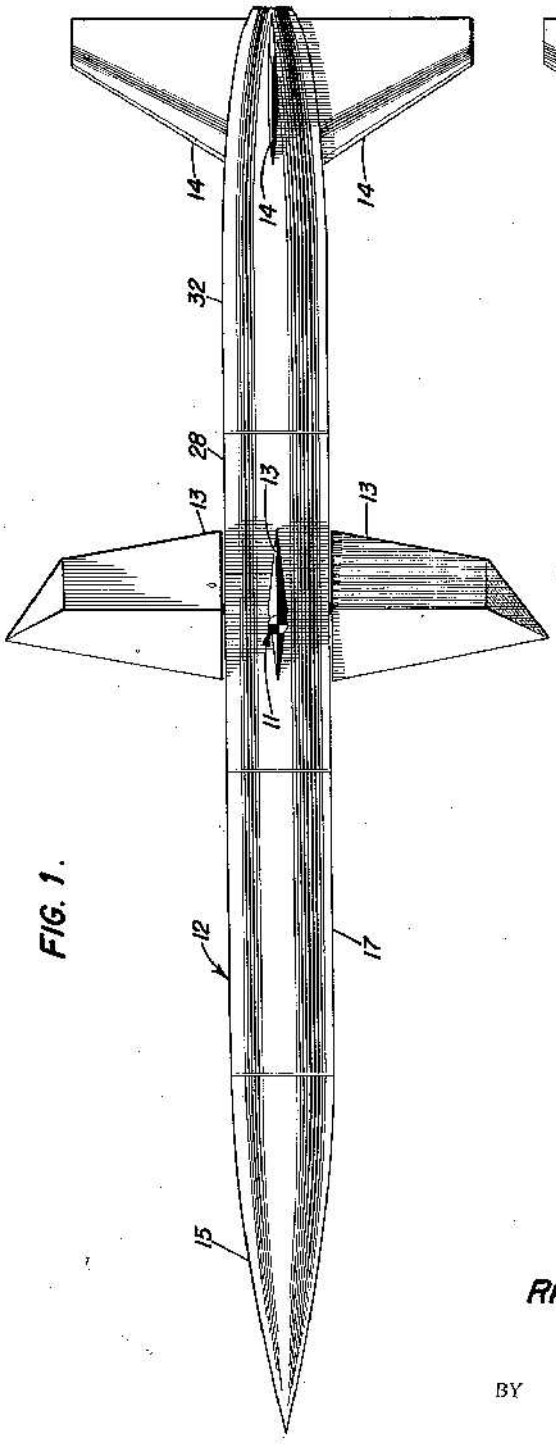

FIG. 1.

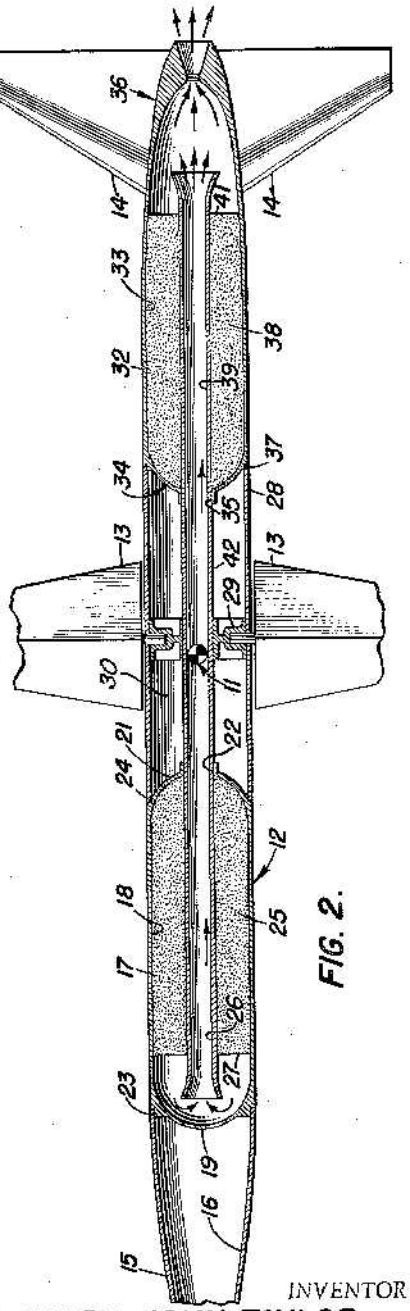

FIG. 2.

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2,816,721
Patented Dec. 17, 1957

2,816,721

ROCKET POWERED AERIAL VEHICLE

Richard John Taylor, Buffalo, N. Y., assignor to the United States of America as represented by the Secretary of the Navy

Application September 15, 1953, Serial No. 380,380

4 Claims. (Cl. 244—74)

This invention relates generally to aerial vehicles and more particularly to an improved rocket engine for an aerial vehicle.

The conventional rocket engine employs a solid propellant fuel in the form of a grain or several grains which may be designed for end burning. A grain designed for end burning is characterized by even burning to produce a constant thrust throughout the life of the grain. However, the ordinary end burning grain in being consumed causes a shift in the center of gravity of an aerial vehicle propelled by the grain. Such a shift upsets the optimum conditions for which the vehicle was designed and brings into play aerodynamic forces which affect the steering control of the vehicle.

It is customary in the construction of aerial vehicles to locate wing surfaces at the center of gravity. In general, the center of gravity is positioned in the heaviest portion of the vehicle which in most cases is that containing the propulsion system. A rocket powered vehicle, therefore, is generally constructed with wing surfaces mounted on that area of the vehicle constituting the rocket engine. A serious problem is presented, however, in attaching wings to a rocket engine because of the corrosive effects of hot combustion gases normally produced in the operation of the engine. This problem is further complicated if wing control apparatus is to be employed for varying the attitude of the wings.

It is, therefore, the principal object of this invention to provide a rocket engine having a substantially stable center of gravity.

A further object of this invention is to provide a rocket engine in which combustion gases normally produced in operation are handled in such a manner that their corrosive effect is restricted.

Further objects and attendant advantages of this invention will become evident from the following detailed description taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a side elevation of a rocket powered aerial vehicle; and

Fig. 2 is an axial section of the main body of the aerial vehicle shown in Fig. 1, particularly illustrating the rocket engine constituting the present invention.

Referring now to Fig 1, the aerial vehicle shown therein has a center of gravity 11 and includes a hollow main body 12, wings 13 mounted on said main body at the center of gravity 11 and tail fins 14 mounted on the rear end portion of the main body.

As best shown in Fig. 2, the body 12 comprises four sections. The forwardmost section includes a casing 15, in the shape of an ogive forming the nose of the body 12. A compartment 16 is defined by the casing 15 and is adapted to accommodate a warhead and/or guidance instrumentation.

The section next to the rear of the casing 15 is a cylindrical shell 17 constituting a forward combustion chamber 18. The shell 17 is constructed with a hemispherical forward end wall 19 and a hemispherical rear end wall 21 having an opening 22. The forward end wall 19 is formed with an external annular shoulder 23 for receiving the rear end of the casing 15 and for connecting said casing to the shell 17, by way of welding, riveting or by other suitable means. The rear end wall 21 is similarly formed with an external annular recess 24 for connecting the shell to the section next rearward, to be described hereinafter. A propellant grain 25, cylindrically shaped with an axial bore 26, is disposed in the chamber 18. As shown in Fig. 2, the grain 25 fills the rear and intermediate portions of the shell 17 but ends short of the forward end wall 19 in a transverse burning surface 27 confronting said forward end wall.

Immediately to the rear of the shell 17 there is positioned a cylindrical casing 28 constructed with wing sockets 29 on its intermediate portion and defining a cell 30 for the accommodation of wing control and other apparatus. The wing sockets 29 mount wings on the body 12 and may be adapted to permit wing movements induced by the wing control apparatus contained in the cell 30. The forward end of the casing 28 is received by the annular shoulder 24 in the shell 17 for attachment to said shell in any suitable manner.

The rearmost section of the body 12 comprises a second cylindrical shell 32 constituting a rearward combustion chamber 33. Thes hell 32 is constructed with a hemispherical forward end wall 34 having an opening 35, and with an exhaust nozzle 36 at its rear end. The forward end wall 34 is formed with an external shoulder 37 which receives the rear end of the cylindrical casing 28 and is attached thereto by any appropriate securing medium. A propellant grain 38 having an axial bore 39 and disposed within the shell 32 fills the forward and intermediate portions of said shell but ends short of the nozzle 36 in a flat burning surface 41 which confronts said nozzle.

In order to provide gas transfer communication between the combustion chambers 18 and 33, a tube 42, made of a heat resistant material, communicates with the forward combustion chamber 18 and extends, axially of the missile, into the rear combustion chamber 33. More specifically, the tube 42 passes through the axial bore 26 of the grain 25 and the opening 22 into the casing 28. It extends axially through the casing 28 and enters the rear combustion chamber 33 through the opening 35, whereupon it extends along the bore 39 of the grain 38 to communicate with the chamber 33.

The rocket engine of this invention, therefore, comprises the forward combustion chamber 18 containing the propellant grain 25, the rear combustion chamber 33 containing the propellant grain 38 and the gas transfer tube 42 providing communication between said combustion chambers. In operation, the grain 25 in the forward chamber 18 burns rearwardly, from the burning surface 27, and the combustion gases thereby produced are conducted through the tube 42 to the rear chamber 33. The grain 38 in the rear chamber 33 burns forwardly from the burning surface 41. The combustion gases from both combustion chambers, 18 and 33, combine and efflux through the exhaust nozzle 36, thus providing a propulsive thrust.

By dividing the propellent grain of the rocket engine in the manner described above, it is possible to safely mount the wing sockets 29 or other wing attaching means at the center-of-gravity of said engine. In addition, such an arrangement also permits the convenient location of guidance and/or wing actuating equipment proximate to the wing sockets and wings.

It can be seen that the center-of-gravity 11 of the rocket engine of this invention will remain substantially in the same position during the burning of the propellant grains 25 and 38. This feature is of utmost importance

when the engine is used as the propulsive system in an aerial vehicle.

The propulsive thrust produced by this improved rocket engine is greatly increased over a conventional rocket engine of equal cross-sectional dimensions. This will be understood from the fact that two surfaces on the propellant grains, 27 and 41, of the improved engine burn to produce a greater volume of combustion gases and a higher pressure. Thus, the combustion gases efflux through the exit nozzle with a greater momentum to produce an increased thrust, whereas the conventional rocket engine employs a propellant grain which burns from a single surface only, thereby producing a smaller volume of combustion gases at lower pressures, with the result that the thrust of the conventional rocket engine is smaller.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. In combination with an aerial vehicle having two pairs of wings arranged in a cruciform configuration and pivotally mounted on the body of said vehicle at the center of gravity thereof and two pairs of tail fins mounted on the rear end of said body of said vehicle, a rocket engine located in said vehicle body, said engine including spaced forward and rearward combustion chambers containing combustible material, said combustion chambers and combustible material being located substantially symmetrical with respect to the center of said vehicle, said combustible material of said forward combustion chamber being arranged to burn rearwardly of said vehicle and said combustible material of said rearward combustion chamber being arranged to burn forwardly of said vehicle, a rearwardly directed nozzle connected to said rearward combustion chamber, and means including a transfer tube for conducting combustion gases generated upon ignition of said combustible material from said forward combustion chamber to said rearward combustion chamber for efflux through said nozzle, whereby upon burning of said combustible material in said combustion chambers, the center of gravity of said vehicle remains substantially in the same position.

2. An arrangement as set forth in claim 1, wherein said combustion chambers are cylindrical in shape.

3. An arrangement as set forth in claim 2, wherein said combustion chambers have hemispherical end walls.

4. An arrangement as set forth in claim 1, wherein structure is provided between said combustion chambers to define an intermediate chamber for receiving guidance and control equipment, including means for attaching said two pairs of wings to said vehicle.

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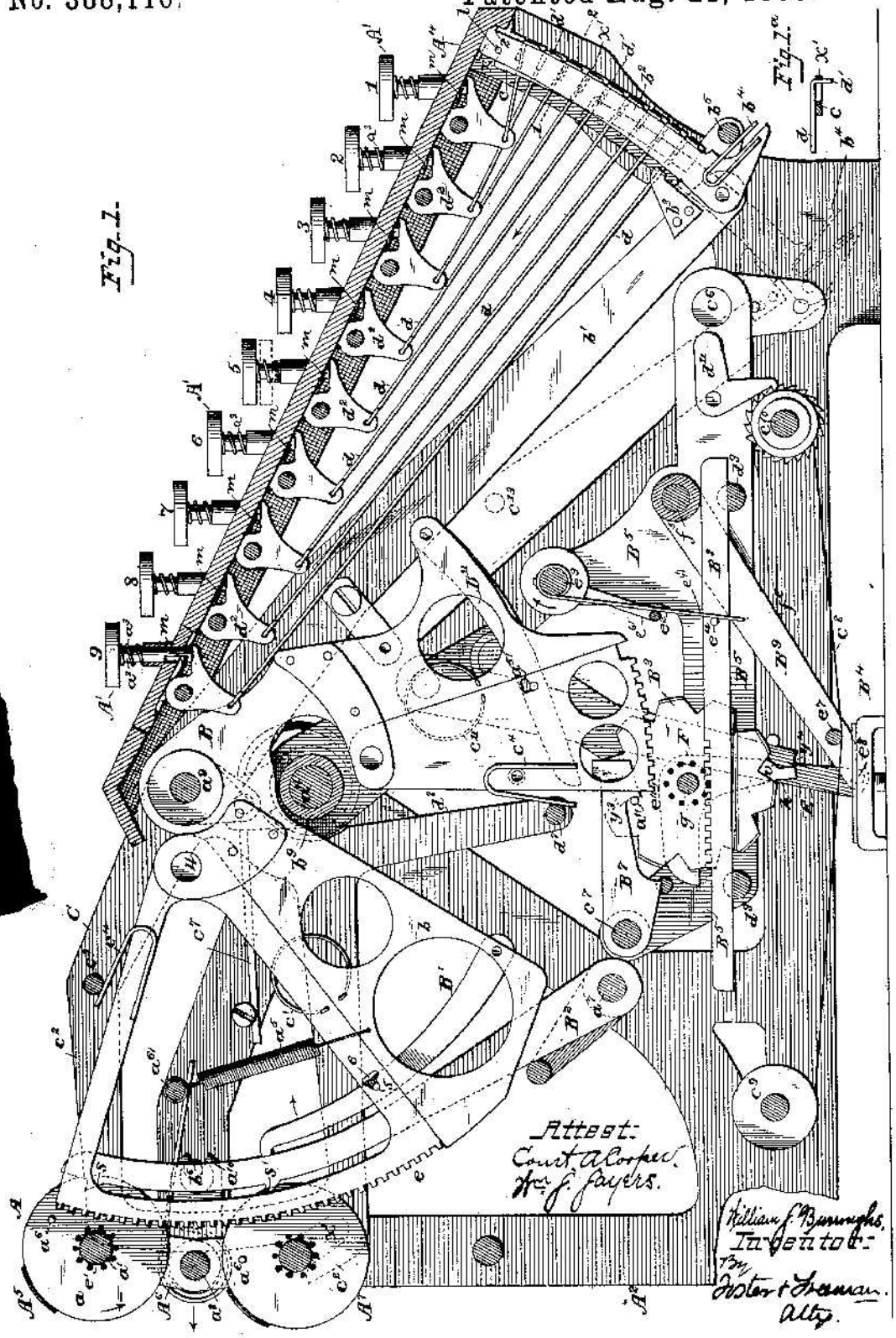
(No Model.) 7 Sheets—Sheet 1.

W. S. BURROUGHS.

CALCULATING MACHINE.

No. 388,116. Patented Aug. 21, 1888.



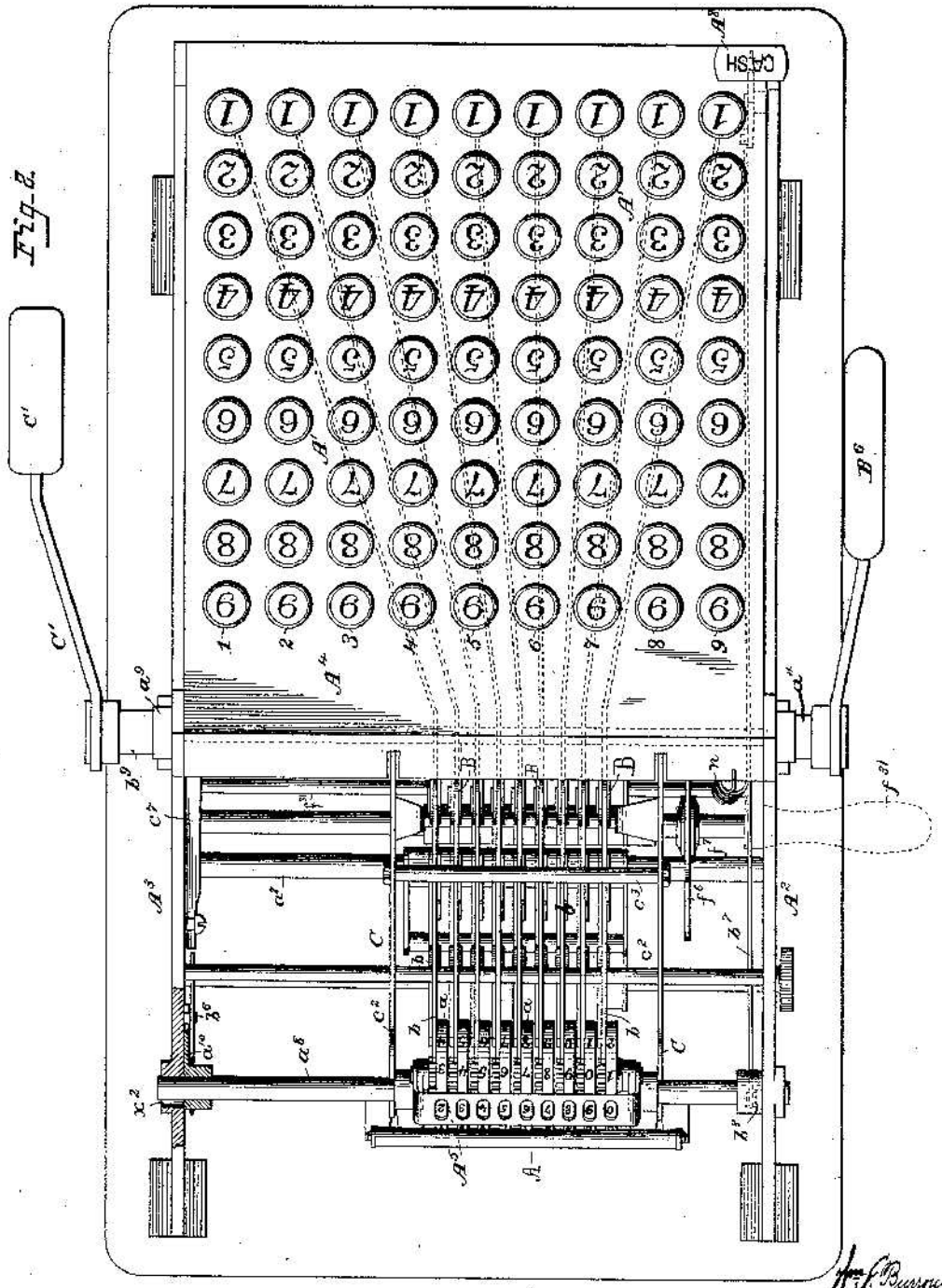
(No Model.) 7 Sheets—Sheet 2.

W. S. BURROUGHS.

CALCULATING MACHINE.

No. 388,116. Patented Aug. 21, 1888.

Fig. 2.



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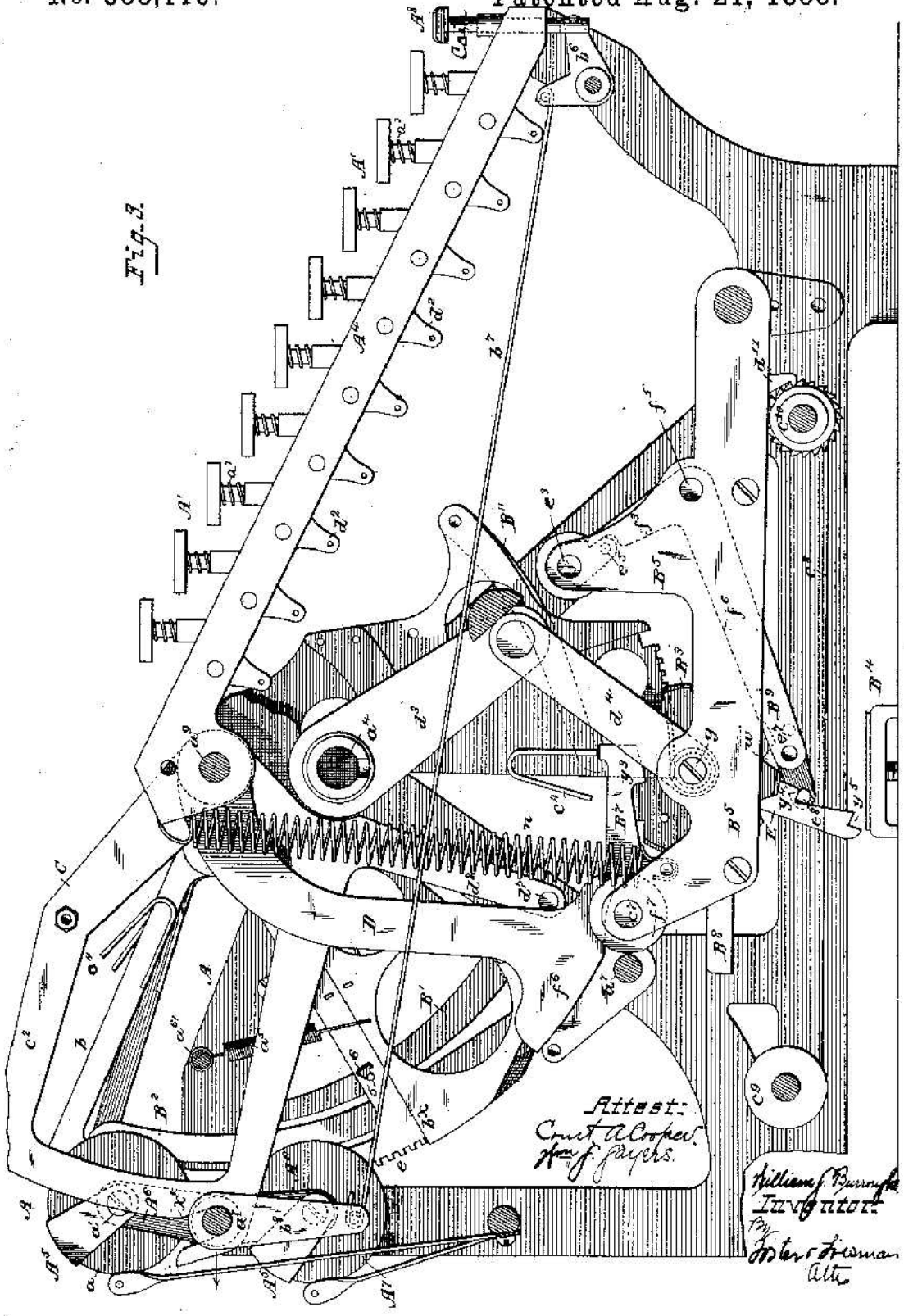
(No Model.) 7 Sheets—Sheet 3.

W. S. BURROUGHS.

CALCULATING MACHINE.

No. 388,116. Patented Aug. 21, 1888.

Fig. 3.



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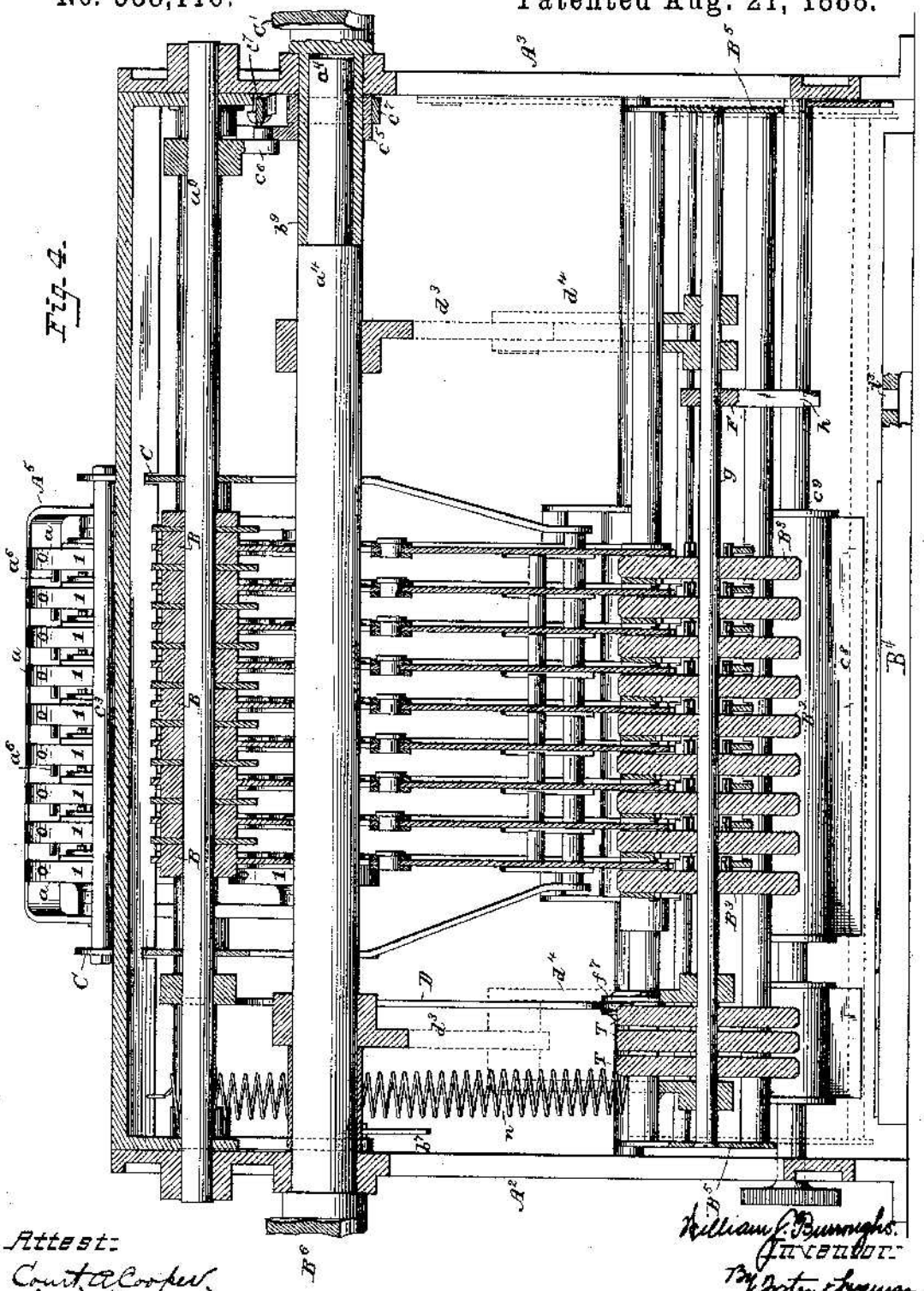

Fig. 4.

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Fig. 5.

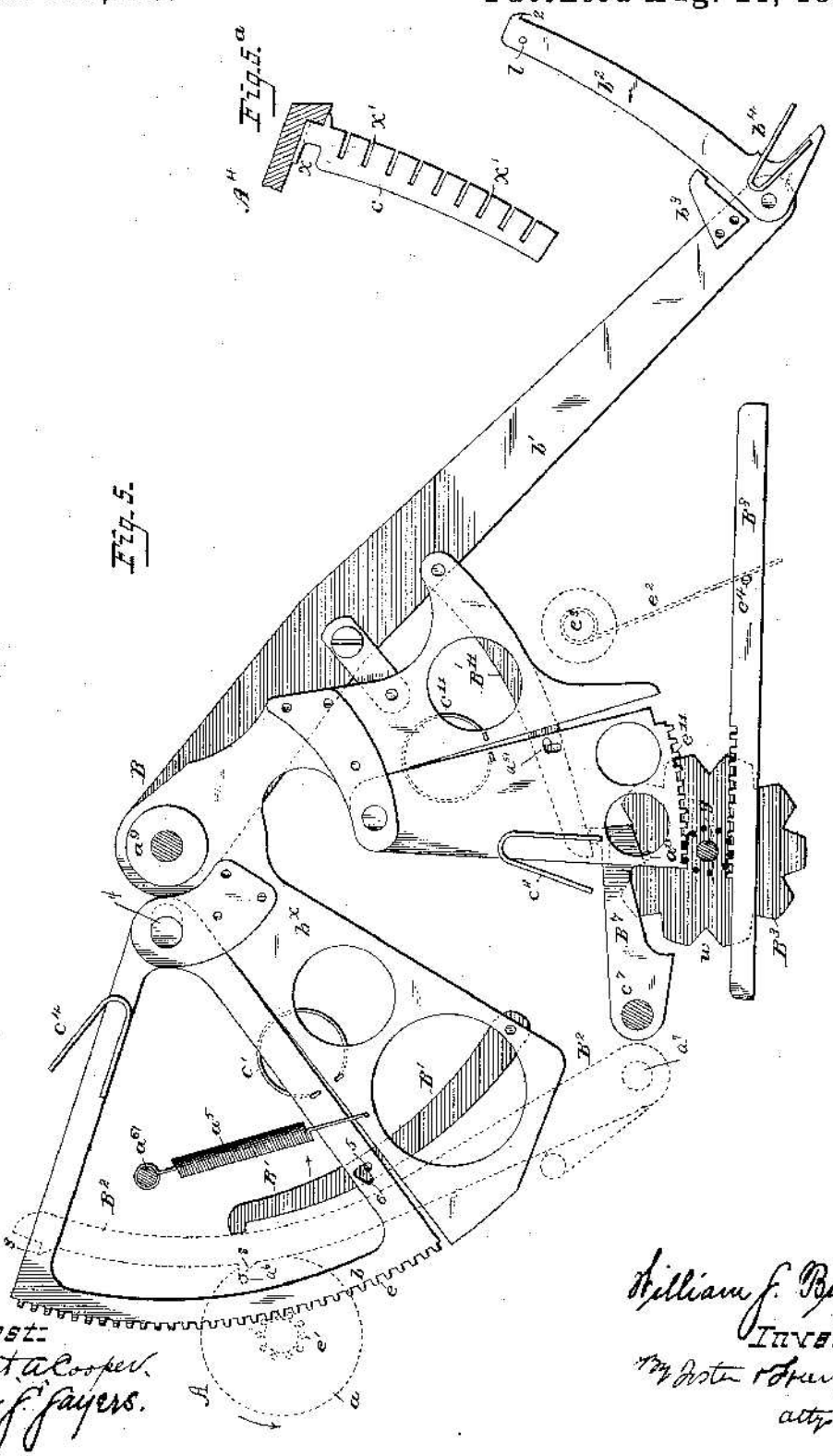

Fig. 5a.

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Fig. 7.

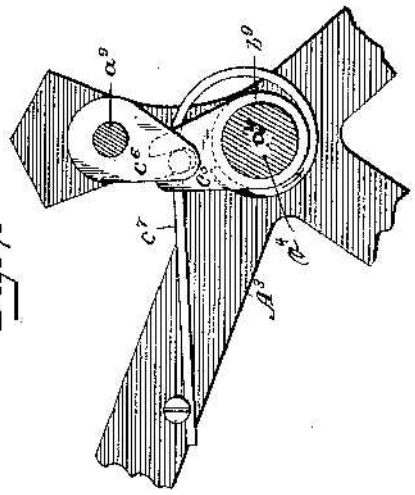

Fig. 6.

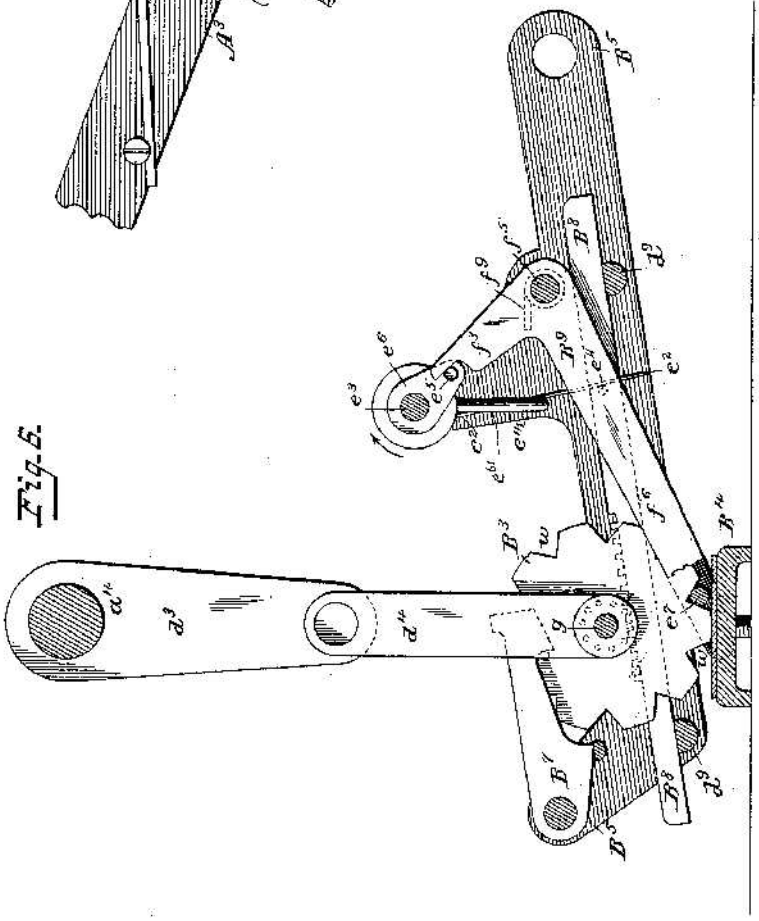

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Fig. 9.

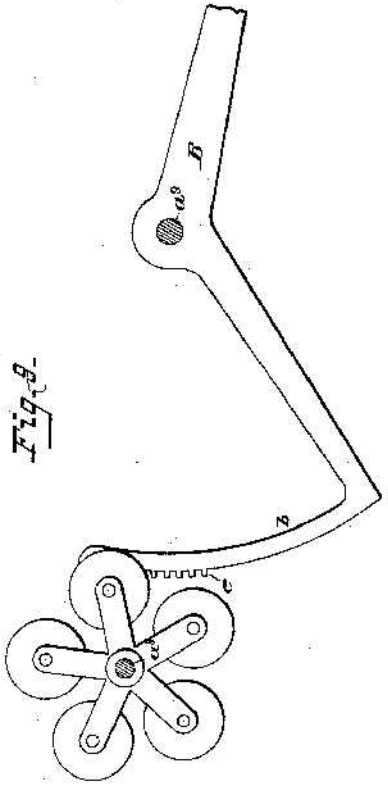


Fig. 10.

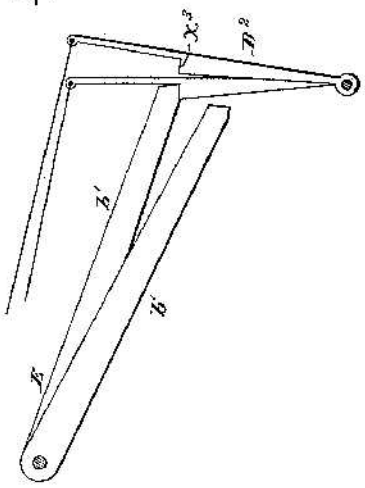
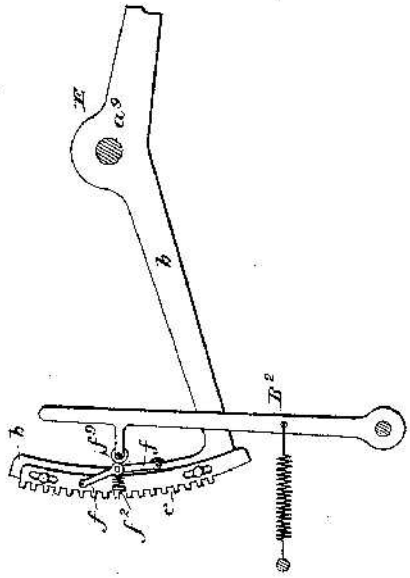


Fig. 11.



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Wm. F. Jaynes.

William S. Burroughs,
Inventor:
By Foster & Freeman
Atty.

UNITED STATES PATENT OFFICE.

WILLIAM S. BURROUGHS, OF ST. LOUIS, MISSOURI, ASSIGNOR, BY DIRECT AND MESNE ASSIGNMENTS, TO THE AMERICAN ARITHMOMETER COMPANY, OF SAME PLACE.

CALCULATING-MACHINE.

SPECIFICATION forming part of Letters Patent No. 388,116, dated August 21, 1888.

Application filed January 10, 1885. Serial No. 152,485. (No model.)

To all whom it may concern:

Be it known that I, WILLIAM S. BURROUGHS, a citizen of the United States, residing at St. Louis, in the State of Missouri, have invented certain new and useful Improvements in Mechanical Accountants, of which the following is a specification.

My invention relates to that class of apparatus used for mechanically assisting arithmetical calculations; and my invention consists in the combination, with one or more registers, of a series of independent keys and intervening connections constructed, arranged, and operating, as fully specified hereinafter, so as to indicate upon the register the sum of any series of numbers by the proper manipulation of the keys, and also so as to print or permanently record the final result.

In the drawings, Figure 1 is a longitudinal sectional elevation of an apparatus embodying my invention. Fig. 1^a is a cross-section on the line 1 2, Fig. 1. Fig. 2 is a plan view of the apparatus in part section. Fig. 3 is a longitudinal elevation in part section. Fig. 4 is a transverse sectional elevation. Fig. 5 is a detail view showing the connections between the keys and the registers, with the exception of the "regulating devices." Fig. 5^a is a detail view of part of the regulating devices. Fig. 6 is a detail view of the printing-register and its immediate connections. Fig. 7 is a detached view showing the connections between two of the shafts. Fig. 8 is a view showing a modified form of registering operating device. Fig. 9 is a view illustrating a mode of adjusting a series of registers. Fig. 10 illustrates a modification of the regulating devices.

The indicating-register A consists of a series of movable numbered pieces—as plates, disks, wheels, or segments—indicating by their position the sum added at each operation of the machine, and I therefore term them the "indicators." Each indicator is shown as consisting of a disk, a, revolving freely upon a shaft, a', and having upon its periphery a series of figures from 0 to 9; but it may be a plate or segment suitably supported and graduated in the same manner as the disk. Each indicator derives its movement from the operation of a series of nine keys, A', of any suitable construction, marked separately with a series of numbers from 1 to 9, and between the indicator and each key, and governed by the latter, intervene a series of devices, which may be of any suitable construction to transmit the motion of the key to the indicator, and regulate the adjustment of the latter, and which I include under the general terms of "connections" and "operating connections."

The registering device, the keys and connections, and other parts, hereinafter referred to, are supported in a suitable frame having side pieces, A^2 A^3, and connecting-bars, which latter also serve as supports for the intervening mechanism, and the frame supports a keyboard, A^4, provided with recessed nipples, through which slide the shanks a^2 of the keys A', a spiral spring, a^8, tending to keep each key in its elevated position, and a lip at the bottom of the key striking a detachable strip, m, which bears against a flat side of the key and prevents the turning thereof, limits its movement, and facilitates its ready detachment when necessary.

The series of keys which operate in connection with each indicator is arranged upon a line parallel to the sides of the frame, and a lever, B, supported by a transverse shaft, a^9, when released by the action of any one of a series of keys operates automatically the indicator pertaining to that series.

Each lever B consists of a segmental "head," b, and an arm, b', the heads of all the levers being parallel to each other and in close proximity, and the arms diverging from the fulcrum a^9, so that the rear end of each arm will be below the key of one of the series farthest from the head.

Teeth at the edge of each head b constitute a rack, c, which engages with a pinion, c', at the side of one of the indicator-disks, and the movement of the lever is so limited that the indicator-disk will be turned nine-tenths of a revolution at each full movement of the lever, a perforated plate or gage, A^5, serving as an index to expose or designate the figure indicating the number added.

It is necessary that the indicator be moved

as each key is depressed to an extent proportioned to the position of the key and the number indicated upon the latter, and in order to effect this without varying the movements of the keys or the power applied to operate the latter I employ devices between each series of keys and the lever operated thereby, which constitute part of the "connections" between the keys and indicator, and which I term the "regulating devices."

The arms b' may be weighted so as to normally fall to their lowest position when released; but I prefer to secure a more positive action by means of springs a^5, connected to a cross-bar, a^{11}, of the frame and to the heads of the levers, so as to lift the latter.

The regulating devices are so constructed that when a key is depressed the lever will be released, and will then fall to an extent corresponding to the position of the operating-key, which, therefore, instead of acting directly upon the lever, operates the latter intermediately through said regulating devices, so that the key may recover its position at once after being struck.

In the construction shown the regulating devices connected with each series of keys consist of a lock which holds the arm b' of the lever normally in its highest position and a movable stop operated by the key, which limits, when it is set, the descent of the arm b' of the lever.

The lock, as shown, consists of a strip, b^2, pivoted to the end of each arm b' and limited in its rear movement by stop b^3 and carrying a lug, l. Adjacent to each strip b^2 a fixed plate, c, Figs. 1 and $5^{\times}$, is secured to the key-board A' and pendent therefrom and provided with a notch, x, near its upper end, into which the lug l enters as the arm b' is brought to its highest position and the strip b^2 falls forward. This forward movement of the strip b^2 is insured by the contact of a spring projection, b^4, extending from the strip b^2, with a stationary cross-bar, b^5, supported by the sides of the frame.

In the outer edge of the plate c is a series of notches, x', corresponding in number to the keys of the series, and through each notch extends the bent end d' of a rod, d, which is connected to the lower arm of a crank-lever, d^2, one of which is pivoted to a lug under the key-board beneath each key, and has its other end or arm projecting below the end of the key. The bent ends d' of the rods d constitute the stops. When one of the keys (say, the key 5, Fig. 1) is depressed, the rod d of the lever d^2, below said key, will be drawn in the direction of its arrow, and the end d', bearing upon the edge of the strip b^2, will carry the latter inward until the pin 1 is carried out of the notch x, when the action of the spring a^5 will cause the arm b' and strip b^2 to fall until a lip, 2, at the upper end of the strip b^2 strikes the bent end d' of the rod d, which acts as a stop, limiting the further movement of the lever downward. As the inward movement of each stop end d' carries the strip b^2 inward the lip 2 of the strip will escape contact with all of the stops above the one which has been so set by the movement of the key, so that the said stop only will be struck by the lip; and as the stops, beginning at the top, are connected with the keys in the order in which the latter are numbered, the movement of the lever will be greater in proportion as the stop operated is lower down, and the movement of the indicator will be proportionately increased.

As in other registering devices, it becomes necessary when the number added exceeds the highest number upon the indicator operated to also adjust the adjacent indicator accordingly. Thus, if one of the indicators is set to display the figure 8 and the number 5 or any number greater than 1 is to be added and indicated, the said indicator must be turned until it exhibits the figure 3, while the adjacent indicator must also be turned to disclose the figure 1, the sum of the two numbers being 13, which requires the adjustment of two indicators to show it.

To effect the turning of the second indicator without operating two keys, I construct the parts which I term the "connection" between each indicator and its key, so that a portion of said connection geared with the indicator is capable of a slight movement independently of the other parts of the connection. I lock these two parts together so that ordinarily they will operate as one, and provide means whereby the movable part is unlocked and moved to turn the indicator the extent of one figure whenever the adjacent indicator is brought to a position to necessitate such movement. Thus, the head of each lever B consists of the arm or portion $b^{\times}$, connected rigidly to the arm b', and the toothed segment b, pivoted at 4 to the arm $b^{\times}$, and a spring, c', is connected to the two parts, $b\,b^{\times}$, so as to tend to separate them, and a lever, B', is pivoted to the part $b^{\times}$, and is provided with a pin, 5, which enters an L-shaped slot, 6, in the part b and holds the latter in proximity to the part $b^{\times}$ until the lever B' is swung in the direction of its arrow, Figs. 1 and 5, when the pin will enter the vertical portion of the slot and permit the portion b to rise under the action of the spring c', and thereby turn the indicator to which said portion b is geared one-tenth of a revolution in the direction of its arrow. The lever B' is moved to unlock the part b by a pin, a^6, projecting from the side of the indicator next to that to which the part b is geared, which pin, as the figure 0 is brought toward the index-plate A^3, strikes a projection, s, on a lever, B^2, pivoted to a cross-bar, a^7, and swings it so as to bear against the end of the lever B' and carry the latter with it to unlock the swinging segment, which will then rise under the action of its spring c' and turn the indicator next adjacent to that indicator whose pin acted upon the lever B^2.

All the indicators are operated by the move-

ments of the respective keys in the manner above described, and after a series of keys has been struck to register one of the numbers to be added together it becomes necessary to bring the parts to their normal positions, so as to permit any additional number to be added, inasmuch as after a lever, B, has been adjusted by the action of one key its head must be depressed before it can respond to the action of another key. Thus, if the number 72,842 is to be added, all the heads are depressed to bring the parts to an operative position, and the keys 7 2 8 4 2 in the series 5 4 3 2 1 are successively struck, thereby releasing the corresponding levers, which move to different degrees, according to the positions of the keys and the positions to which the stops d' are set, and the indicators show by the figures visible through the index-plate A^5 an increase corresponding to the sum added. If, now, the sum 234 is to be added, the heads of the levers are all again depressed to restore the parts to position, so that when the keys 2 3 4 in the series 3 2 1 are struck the corresponding levers can move each to an extent necessary to insure the required adjustment of the indicator and the exhibition of figures indicating an increase of 234.

The adjustment of the levers is effected by pressure upon the upper sides or edges of the segments b, which has the effect of moving such of the latter as have been separated from the portions $b^\times$ into contact therewith, when they will be locked in place by the arms B′ falling back and carrying the pins 5 into the horizontal portions of the slots. The combined movement will then carry down all the segments until the arms b' are all elevated to their highest positions.

As the depression of the segments while in gear with the pinions e' would turn back the indicators, I provide means for throwing the segments and pinions out of gear prior to any downward movement of the segments. One means of effecting this is shown, and consists in journaling the shaft a' in a swinging frame, A^6, pivoted upon the cross-bar a^8, and in swinging the frame back to throw the pinions and racks out of gear prior to the descent of the segments. One means of effecting this adjustment is shown, and consists of a frame, C, carried by the shaft a^9, Fig. 4, and consisting of side pieces, c^2 c^3, and a cross-bar, c^4, each side piece having near its lower edge an inclined slot, x', Figs. 1 and 3, adapted to receive the cross-bar a^8, sliding in slots in the side pieces of the main frame, when the frame C is raised, the inclined edge x^3 of the slot serving to thrust the bar a^8 back in the direction of the arrow as the said frame C begins to swing downward, which backward motion of the cross-bar a^8 will be effected before the cross-bar c^4 is brought in contact with the upper edges of the segments.

The frame C is operated by a hand-lever, C′, which is connected to operate the shaft a^9, as described hereinafter, and when the end of the lever which is toward the operator is depressed the frame C will be swung downward and will force out the cross-bar a^8, with the frame A^6 and the indicators, until the pinions e' are free from gear with the racks, and the edges of the frame will then remain in contact with the cross-bar a^8 and hold it in position, the cross-bar c^4 being then brought against the upper edges of the segments and depressing the latter. After the levers B are brought to their normal position the hand-lever C′ is released, when it will rise and the frame C will swing upward and the cross-bar a^8 will enter the slots x', and the pinions will be brought into gear with the racks as the frame C reaches the limit of its upward movement.

To permit the return movement of the cross-bar a^8, the ends thereof enter slots x^2 in the side pieces of the frame, and an arm, a^{10}, projecting from the cross-bar a^8, is slotted to receive a pin, b^6, on one of the side pieces, which prevents the turning of the cross-bar as it slides back and forth.

To prevent objectionable shocks and jars in bringing the cross-bar c^4 against the segments, I place springs c^5 upon the segments so as to be struck by the cross-bar.

It will be seen that by the construction above described each indicator is operated upon the depression of any one of the keys of a single series, and that it has the effect when turned beyond a complete revolution of moving the adjacent indicator one step; that all the keys have the same extent of movement and are operated by the same amount of pressure, but that while the movements of the keys are the same, the extent of the movement of the connections between the keys of each series and each indicator will vary according to the position of the key which is operated, with a corresponding variation in the motion of the indicator. It will be apparent that these effects may be secured by the use of keys and intermediate connections differing to some extent from those described. For instance, each series of keys may operate upon a shaft suitably geared with the corresponding indicator instead of through the medium of a rocking-lever. The register may of course be of any usual or suitable character. The indicators may be differently connected, as is common in registering devices, so that each will be moved one step as the adjacent indicator completes its entire movement, in which case the rack must be thrown out of gear with the second indicator until the latter has moved one step.

Instead of withdrawing the register from engagement with the racks the latter may be hung to pivots sliding in elongated openings, so as to be withdrawn from the register, as shown in Fig. 5, dotted lines, or the register and the rack may be kept in constant connection, each pinion having a ratchet-connection with the indicator, so as to turn the latter when the rack is raised, but to revolve independently of the indicator when the rack descends.

It will be obvious that any suitable locking mechanism may be employed for connecting the rack portion of the segment with its support, so as to permit a limited independent movement of the rack portion, and that such locking mechanism may be actuated from the indicators in a different manner from that described. Thus the segmental rack *e* may be guided to slide upon the head *b*, as shown in Fig. 8, and be moved thereon to a limited extent by straightening or bending the toggle-levers *f f*, which may be effected by bringing a roller, f^9, to bear against the same in one direction and by a spring, f^2, forcing them in the opposite direction, the roller f^9 being carried by levers operated in like manner as the levers B^2, or in any other suitable manner.

Different forms of regulating devices may be employed for determining the extent of the movement of the connections according to the key operated. Thus the keys may be connected to operate arms B^2, Fig. 10, with shoulders x^3 arranged to hold the arms *b'* of the levers B in their elevated position until the arms B^2 are swung forward.

Instead of restoring the levers B to their position by means of the cross-bar c^3 bearing upon the levers, they may be moved by a cross-bar, c^{13}, extending beneath the arms *b'*, as shown in dotted lines, Fig. 1, or in any other suitable manner.

In some kinds of calculations it is necessary to indicate the sums of different kinds of articles or money. For instance, in a bank it is sometimes necessary to ascertain the aggregate amount of a series of checks and also the amount of money represented by notes or coin and pertaining to the same transaction. In order to permit this to be done with facility, I provide two or more registering devices in connection with one set of keys and intermediate mechanism, and means whereby either register may be thrown into operative connection with the keys. Thus the second register, A^7, is hung to the same frame, A^6, that carries the first register, A, and this frame is vibrated so as to bring the pinions of either register into gear with the racks *e*. This vibration is effected by means of a key, A^8, actuating a crank-lever, b^8, connected by a rod, b^7, with an arm, b^9, upon the shaft a^8. The upper register is held in connection with the keys while the sum of the checks is being taken, and after this is done the key A^8 is depressed and the lower register will be swung into gear, and the amount of cash is registered thereon, and if additional cash or checks are then received the additional amounts may be added upon either register by swinging it into operative connection with the key and without any alteration of the other register.

Where, as in custom-houses and other places, it is necessary to indicate the value or number of a series of different articles, a series of registers may be employed to be operated from the same series of keys. One mode of arranging the registers in such case is shown in Fig. 9, which shows five registers carried by an armed frame, revolving upon or with the shaft a^8, and capable of being turned so that either register may be brought at will in operation with the connecting devices between the register and the keys.

When two registers are arranged one above the other, so that either may be brought into connection with the racks, the latter are necessarily longer than would be required if the arrangement shown in Fig. 9, or if but one registering device, was used.

When the arrangement shown in Figs. 1 to 7 is employed, the slot in the arm a^{10}, which receives the pin b^6, is widened, as shown in Fig. 1, so as to permit the swinging of the arm a^{10} required by the vibration of the shaft a^7.

As it is necessary that each indicator of the lower register shall upon the completion of its revolution move the succeeding indicator one step, as in the upper register, I effect this by extending the levers B^2 or projections *s'* thereof, so as to be struck by the pins a^6 of the lower indicators to unlock the segments in the same manner as they are unlocked by the upper indicators when the upper register is in use and with like effect.

The movement of the frame C is effected from the handle C' by connecting the latter to a sleeve, b^{11}, receiving and turning upon the shaft a^4 and carrying a slotted arm, c^5, receiving a pin upon the end of an arm, c^6, extending from the shaft a^9, and a spring, c^7, secured to the side frame, is coiled around the hub of the shaft b^9 and secured thereto at the end and serves to turn the sleeve in the direction of the arrow, Fig. 7, the sleeve being turned in a reverse direction to depress the frame C whenever the handle C' is depressed.

It is frequently desirable to secure a permanent indication of the sum shown upon the register, but this cannot always be well done without so covering the register as to prevent the figures upon the latter from being seen. In order to secure a visible representation as well as a permanent indication of the number registered, I employ, in addition to the registering devices described, recording devices, one arranged so as to be readily inspected and the other constructed and combined with means whereby to also print the numbers registered upon a strip of paper. Thus the second register, A^7, may be combined with gears throwing it into connection with the register A and with an inked ribbon and platen whereby the row of figures in line upon the lower register may be transferred to the paper, while those on the upper register are exposed. I prefer, however, instead of using the register A^7, to use an independent printing-recorder, B^3, preferably arranged beneath the shaft a^1 and above a platen, B^4, upon the base-plate of the machine. When this arrangement is employed the shaft *g* of the recorder B^3 is carried by a frame, B^5, hung to studs c^6 upon the side frames of the machine, and combined with devices whereby the said frame may be raised

to bring the recorder into connection with the devices for operating it from the keys, and lowered to bring the lower row of type or figures against the paper upon the platen.

The adjustment of the indicators or wheels of the printing-register is effected by connections precisely similar to those employed for adjusting the upper register, each lever B carrying a second head or segment with a rack, e'', which gears with the corresponding pinion of the adjacent indicator of the lower register and operates the same in the same manner as has been described in connection with the register A. In the operating device for the printing-recorder the movable section of the head or segment is provided with an L-shaped slot to receive a pin, a^{51}, upon a locking-arm, B'', operating in the same manner as the locking-levers B' and operated from the pins a'' on the indicators through the medium of levers B^7, each of which is hung to a cross-bar, c^7, on the frame, and as a pin, a'', is brought beneath its inclined lower edge the lever is raised, strikes the end of the locking-lever B'', and thereby releases the adjacent segment to permit it to swing out under the action of a spring, a'', to move the adjacent indicator one step.

The frame B^5 may be depressed to bring the printing-recorder in contact with the platen by means of the arm f^{31}, (dotted lines, Fig. 2,) extending from the frame and adapted to be operated directly by hand, the frame being raised by a spring, n, or otherwise. I prefer, however, to employ devices operating more positively, and consisting, as shown, of toggle-levers d^2 d^3, the former secured to the shaft d^1 and the latter jointed to the levers d^4 and also to the frame B^5, as shown, so that by depressing a handle or arm, B^6, on the shaft d^4 to rock the latter in one direction the frame B^5 will be carried downward and the printing-indicators will be brought against an inked ribbon, c^8, while the spring n lifts the frame, when pressure upon the arm B^6 is removed. The inked ribbon is carried by rollers c^9 c^{10}, the latter provided with a ratchet with which a pawl, d^{11}, upon the frame B^5 engages, so as to move the ribbon slightly at each movement of the frame.

As in the devices operating with the register A, it is necessary to restore the movable parts of the segments to their position after each operation upon the keys; and this I effect by means of a cross-bar, d^7, carried by arms d^8 of the frame C and brought against springs at the edges of the heads of the segments of the recorder, as the cross-bar c^3 is brought against the corresponding parts of the segments operating the register A.

It is of course necessary to throw the pinions of the register B^5 out of gear with the racks e'' before each readjustment of the levers B. This is effected at the same time that a like operation is effected with the register A by means of an arm, D, Fig. 3, connected to the shaft a^3, having a cam end, f^6, which bears upon a grooved wheel, f^7, upon the cross-bar c^7 of the frame B^5, and when the frame C is depressed the cam end of the arm forces downward the end of the frame B^5 to carry the pinions from gear with the racks.

It is generally desirable that the printing-wheels shall be restored with all the indicators at zero after any number has been registered and printed, in order that it may be in position to be properly reset to indicate any number to be subsequently registered and printed, although the register A may indicate the sum of both numbers; and to secure this result I combine with each indicator a rack-bar, B^8, sliding in bearings d^9 d^9 upon the frame B^5, and each gearing with the pinion of one of the indicators, and a spring, e^2, upon a cross-bar, e^3, is arranged to be brought to bear upon a pin or bearing, e^4, upon each rack-bar B^8, so as to throw it inward to bring the pin a'' of the adjacent indicator against a shoulder, y^5, of one of the levers B^7, when the sign "0" will be the lowermost sign upon the indicator.

When the indicators of the printing-recorder are to be operated from the keys, they should be left perfectly free to turn without resistance, and the shaft e^3, which carries the springs e^2, is therefore hung in the frame B^5, so as to swing freely, and each spring e^2 will swing forward without resistance as the rack-bar B^8 is moved forward. When the indicators are to be restored to position, the shaft e^3 is turned in the direction of its arrow, Figs. 1 and 6, so as to cause the springs e^2 to bear against the pins e^1, when each bar B^8 will be moved until the indicator connected therewith is brought to the zero position, the extent of the movement of course depending upon the extent to which the indicator has been previously turned from such position. The movement of the shaft e^3 requisite to bring the springs to bear upon the pins e^4 results from the swinging by hand of a crank-lever, B^9, pivoted upon a shaft, f^3, carried by the frame B^5, and one arm, f^4, of which lever bears upon a pin, e^5, projecting from an arm, e^6, upon the shaft e^3, the long arm f^6 of the lever extending downward and forward and in conjunction with a similar arm at the opposite side carrying a cross-bar, e^7. A spring, f^9, Fig. 6, dotted lines, coiled upon the shaft f^3, tends to raise slightly the lower end of the arm f^6, and a lug, e^8, at the end of said arm is arranged to engage with shoulders y^4 y^5 upon an arm, E, pivoted to one of the side frames of the machine and swinging freely upon its pivot. Arms e^{51}, projecting from the shaft e^3, carry a cross-bar, e^{11}, Fig. 1, upon which the springs e^2 bear, and which when carried from the springs by the rocking of the shaft e^3 in the direction of the arrow permits the springs to move independently in acting upon the rack-bars B^8. When the frame B^5 is depressed to effect the printing, the lug e^8 is carried beneath the shoulder y^5 of the lever E, and when the frame B^5 again rises the lever B^9 will be retained in its position, Fig. 1, and its arm f, bearing upon the lug e^5, will swing the shaft e^3 in the direction of its

arrow, Fig. 6, and carry the cross-bar e^{11} away from the springs e^2, which will then move inward the bars B^5 and restore the indicators to their zero positions. The parts remain in the position described until the frame B^6 is about horizontal; but as it rises higher the lever B^9 will be slightly retracted and the lug e^8 will be withdrawn from the shoulder y^6, and the lever B^9 will be lifted by the action of the spring f^{10} until the lug e^8 strikes the shoulder y^4, Fig. 3, the lever B^9 being then free from contact with the pin e^9, so that the shaft e^3 can swing freely and the springs e^2 will exert no action upon the bars B^5.

The cross-bar e^7 acts as an equalizing-bar to bring the wheels into line and hold them in place. As the printing-recorder descends upon the said cross-bar the latter passes into the notches w of the wheels B^3, and, bearing against the inclined sides of the latter, brings all the indicators into line and holds them in place, and as the register rises (the bar e^7 being held in place by the action of the lever E) the wheels pass from the bar and are then free to turn under the action of the devices set in motion by the keys.

It is desirable in many instances to prevent duplicate printing—that is, after the recorder has once been pressed upon the paper to prevent it from again being forced down to make a print until a new number has been registered. To effect this an L-shaped dog, F, Figs. 1 and 4, is hung loosely to the shaft g of the printing-recorder, so that one arm will extend over the bar d^6, while the other arm, h, is pendent and is provided with an inclined edge, v, so arranged as to be struck by the cross-bar e^7 when the latter enters the notches w.

In the platen B^4 is an opening or notch, i^6, so arranged that when the cross-bar e^7 is in the lowest notch, w, to its greatest depth, the dog F will be held in such position that its end will enter the opening i^6, and the frame B^6 can descend to such an extent as to effect the printing. When, however, the printing has been effected and the cross-bar e^7 is held by the action of the lever E in the position shown in Fig. 1, the dog F will swing to such a position that its lower end will strike the face of the platen and prevent the contact of the type with the paper if the frame is depressed. This arrangement also prevents the battering of the type, which might result if any one or more of the wheels was turned so that the face of the type would not be presented absolutely parallel to that of the platen. If one of the wheels was thus out of adjustment, the cross-bar e^7 could not travel as far as the bottoms of all of the notches w, and the dog F could not therefore be moved by the cross-bar to its full extent, and consequently would not be in position to enter the opening i^6 and would prevent the descent of the frame and the battering of the type.

I do not limit myself to the mode described of restoring the indicators to their normal positions, as other means might be adopted. For instance, they might be weighted so as to normally hang with the figure 0 lowermost, to take this position whenever the indicators are free from contact with suitable friction devices. Other means than those described may be employed for bringing the springs to bear upon the rack-bars when the indicators are to be adjusted, leaving them free at other times, and other stop-motions may be used to prevent the full descent of the printing-indicators after one impression or when any of said wheels are out of adjustment.

In some instances it is desirable to print the date upon each slip upon which the number is printed. This I effect by arranging dating-wheels T upon the shaft g, or otherwise supporting them on the frame B^5, so as to operate in connection with the other printing-wheels when the frame B^5 is depressed.

I do not here claim any of the features shown herein and also shown and claimed in my applications Serial No. 174,593, filed August 17, 1885; Serial No. 195,583, filed March 17, 1886, and Serial No. 256,566, filed November 30, 1887; nor the printing devices herein described and forming the subject-matter of my application, Serial No. 279,609, filed July 11, 1888.

I claim—

1. The combination of a series of numbered independent indicators, a series of independent keys to each indicator, connections between each of the series of keys and each indicator, said connections being arranged to insure the movement of each indicator upon the movement of any key of its series and including a series of stops to each series of keys adjustable by but independent of the keys, arranged to vary the extent of movement of the indicator according to the position of the key struck, substantially as described.

2. The combination of a series of independent indicators, a series of keys to each indicator, connections whereby each indicator is operated on the movement of any key of its series, connections whereby each indicator on completing a revolution turns the adjacent indicator of higher order one step, and means for disconnecting the indicators from the connections after each number is registered to permit the connections to assume a position to operate the indicators to register another number, substantially as described.

3. The combination of the series of independent numbered indicators and a series of independent keys having uniform movements connected with each indicator and constructed to operate two or more of the indicators simultaneously when released by the action of two or more keys, and locking and releasing devices operated by but independent of the keys for releasing and regulating the movement of the indicator-operating devices, substantially as described.

4. The combination, with the series of indicators and with a series of keys connected with

each indicator, of a series of levers each connected to turn the indicator by its movement, and locking and releasing and regulating devices arranged between each lever and its keys, whereby the lever is released and its movement regulated according to the position of the key struck, substantially as set forth.

5. The combination, with the indicators and pinions and independent keys arranged in series, of actuating-levers carrying racks engaging with the pinions and regulating devices between each lever and each series of keys, the keys capable of movement independently of said devices, substantially as specified.

6. The combination, with the keys, indicators, and intermediate operating-connections between each key and each indicator, of means, substantially as described, for moving the indicators to throw them out of gear with the said connections upon their return motion, substantially as set forth.

7. The combination, with one or more keys, a series of levers, indicators, and pinions, of devices for throwing the indicators out of connection with the levers after the indicators have been operated by the movements of the keys, substantially as set forth.

8. The combination, with the indicators and pinions and with the operating levers and racks, of appliances for throwing the pinions and racks out of gear after the movement of the indicators, for the purpose specified.

9. The combination, with the indicators, a series of keys to each indicator, and a series of levers for operating the indicators, of appliances for throwing the indicators out of gear with the operating devices when the latter are moved in one direction, substantially as specified.

10. The combination, with the keys, a series of independent rack-levers and indicators, of a frame supporting the indicators and adjustable to and from the said levers, substantially as set forth.

11. The combination, with the series of operating rack-levers, the shaft a^5, and indicators supported by said shaft a^5, of a vibrating frame provided with edges bearing against the shaft and constructed to move the latter to and from the levers, substantially as specified.

12. The combination, with the indicators, keys, and a series of levers acting upon the indicators, of a cross-bar and means for moving the bar to restore the levers to their normal positions, substantially as specified.

13. The combination, with the indicators, a series of independent operating rack-levers, and series of keys, of a cross-bar arranged to move the levers to their normal position after they have been lifted by the action of the keys, substantially as set forth.

14. The combination, with the indicators and actuating-levers and independent keys, of a frame carrying a cross-bar arranged to strike the actuating-levers, and a handle connected to operate said frame, substantially as set forth.

15. The combination, with the indicators and a series of independent rack-levers, of a frame carrying a cross-bar for moving said levers, and devices whereby to throw the indicators in and out of gear with the levers, substantially as specified.

16. The combination, with the indicators, a series of independent keys to each indicator, and a series of independent intermediate connections, of a regulating device between the said connections and the keys, constructed to insure and determine the movement of the connections, substantially as set forth.

17. The combination, with the indicators and a series of independent keys to each indicator, of a separate connection for moving each indicator, and a lock connected to be operated by each key of the series, whereby each connection is held in its operative position, substantially as set forth.

18. The combination, with the series of keys, indicators, and intermediate connections, of a lock for securing each connection, and connections between each key and the lock, whereby said lock is operated by each key of the series, substantially as specified.

19. The combination, with the series of independent indicators, a series of keys to each indicator, and an operating-lever to each series of keys, of a locking-plate and connections between each key and said plate, substantially as set forth.

20. The combination, with the indicators, keys, operating-connections, and locks, of stops, each connected to be operated by one of the keys and arranged to limit the movement of the operating-connections according to the key depressed, substantially as specified.

21. The combination, with the indicators, keys, and operating-connections, of a series of stops for limiting the movements of said connections, each connected to and movable by one of the keys, substantially as set forth.

22. The combination, with the operating-lever and a series of keys, of a corresponding series of stops arranged to limit the movements of the lever, and connections between each key and one of the stops, substantially as specified.

23. The combination of the operating-lever carrying an arm provided with a lip, 2, a series of stops and connections between the stops and keys, whereby any one of the stops may be thrown into the path of the lip, substantially as specified.

24. The combination, with the operating-lever and a series of keys, of a lock for securing the lever in its elevated position, a series of stops for limiting the downward movements of the lever, and connections between each key and the lock and one of the stops, substantially as specified.

25. The combination of a frame having a

stationary shoulder, the operating-lever, keys, notched bar, stops connected to be operated by the keys, and a strip, b^2, pivoted to the lever, constructed to engage with said stationary shoulder on the frame, and provided with a lip, 2, arranged to engage with the stops, substantially as specified.

26. The combination, with each indicator and a series of keys to each indicator, of a series of independent intermediate connections, a spring for operating each connection to a limited extent independently of the key, a detent, and means for releasing the latter to permit the connection on one indicator to move independently of the key and operate its indicator when the adjacent indicator completes its revolution, substantially as specified.

27. The combination, with a series of indicators, a series of keys, and connections, of means for operating the latter upon the movement of any key or keys, the said connections being provided with parts capable of a limited movement independent of the other parts, with locking devices, and with means for releasing the latter as each indicator completes a revolution, substantially as set forth.

28. The combination, with a series of indicators, of a corresponding series of actuating devices, and connections whereby the actuating device of one indicator is moved one step, whether in motion or at rest, as the adjacent indicator completes its movement, substantially as set forth.

29. The combination, with the series of indicators and series of keys and series of independent actuating-connections between the keys and indicators, of means, substantially as described, for turning each indicator one step independently of the key action as the next lower indicator completes a revolution, substantially as described.

30. The combination, with the indicators and keys, of actuating-levers constructed to move the indicators under the action of the keys, and each lever consisting of two parts, one having a limited movement independent of the other under the action of a spring, a lock for holding the two parts in connection, and connections between the indicators and locks, whereby each movable portion is released to automatically actuate the adjacent indicator as the next indicator completes its revolution, substantially as set forth.

31. The combination, with the indicating-disks and keys, of levers, each provided with a part geared with one of the indicators and capable of a limited movement to turn the latter, with a locking-lever, and connections between the latter and the adjacent indicator, substantially as and for the purpose set forth.

32. The combination, with the indicators, of operating-levers in two parts, and locking-levers B' and B^2, substantially as specified.

33. The combination, with a series of indicators, keys, and intermediate connections, of one or more additional series of indicators, and means for throwing either series into connection with the operating devices, substantially as set forth.

34. The combination of a series of indicators, a series of keys to each indicator, and connections whereby each indicator may be set by the action of any key of one series, and a device for restoring the connections to their normal positions at the will of the operator, substantially as set forth.

35. The combination, with the series of keys, of two or more registering devices, each consisting of a series of numbered indicators, and series of intermediate independent operating-connections, and means for turning the registering devices to bring either one of the same into connection with the operating devices, substantially as set forth.

36. The combination of a series of indicators, and operating-keys and connections for moving said indicators, and operating appliances independent of the keys and indicators, whereby each indicator is moved one step by said appliances independently of the keys as the adjacent indicator completes its revolution, and devices operated by the indicators for throwing said appliances into action as each indicator completes its revolution, substantially as described.

37. The combination, with two or more series of keys, of a series of printing indicators and independent connections, whereby each indicator is controlled by each key of one of the series, and means for throwing the indicators out of gear with the connections, substantially as set forth.

38. The combination, with the series of keys and registering device operated therefrom, of an independent printing-recorder, and connections whereby the latter is moved from the same keys and to the same extent as the said registering device, and means for throwing each register out of gear with the connections, substantially as described.

39. The combination, with the series of disks provided with lateral pins, of levers B, racks hung to said levers, and locking-levers B', and springs c', substantially as described.

40. The combination of the disks provided with pins a^6, levers carrying racks pivoted thereto, springs c', locking-levers B', and levers B^2, substantially as described.

41. The combination, with the register and the recorder, of levers each carrying two series of racks capable of independent movement, one gearing with the register and the other with the recorder, and rack-operating devices, substantially as described.

42. The combination, with the levers B, carrying racks pivoted thereto, and locking-levers B', of two adjustable registers, and levers B^2, constructed to operate with the disks of each register, substantially as described.

43. The combination of the keys, indicating-register, intermediate connections, and printing-recorder, frame B^5, carrying the same,

and toggle-levers d^3 d^4, substantially as described.

44. The combination, with the independent keys arranged in series, and indicators and connections, of levers d^2, slotted plate c, and rods d, connected to the levers and having terminal stops, substantially as described.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

W. S. BURROUGHS.

Witnesses:
F. L. FREEMAN,
CHARLES E. FOSTER.

(No Model.)

W. L. JUDSON.

CLASP LOCKER OR UNLOCKER FOR SHOES.

No. 504,038. Patented Aug. 29, 1893.

Fig. 1.

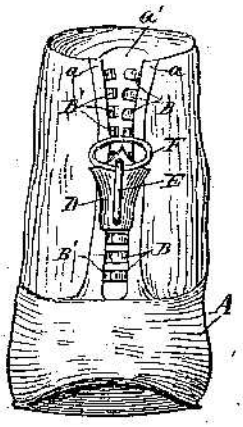


Fig. 2.

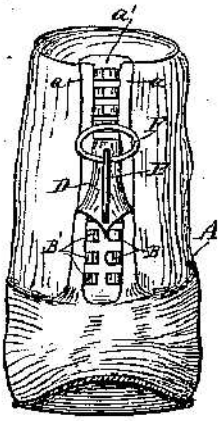


Fig. 6.

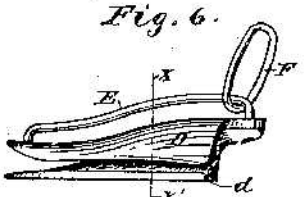


Fig. 8

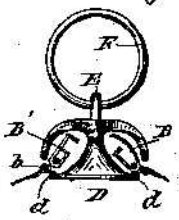


Fig. 9.

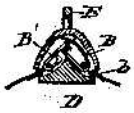


Fig. 10.

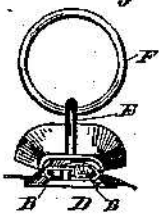


Fig. 7.

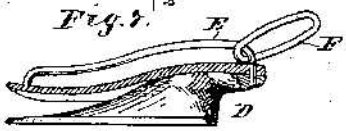


Fig. 5.

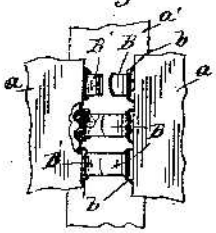
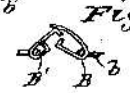


Fig. 3.

Fig. 4.



Witnesses.
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E. F. Elmore.

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Whitcomb L. Judson
By his Attorney.
Jas. F. Williamson

UNITED STATES PATENT OFFICE.

WHITCOMB L. JUDSON, OF CHICAGO, ILLINOIS.

CLASP LOCKER OR UNLOCKER FOR SHOES.

SPECIFICATION forming part of Letters Patent No. 504,038, dated August 29, 1893.

Application filed November 7, 1891. Renewed February 13, 1893. Serial No. 462,923. (No model.)

To all whom it may concern:

Be it known that I, WHITCOMB L. JUDSON, a citizen of the United States, residing at Chicago, in the county of Cook and State of Illinois, have invented certain new and useful Improvements in Clasp Lockers or Unlockers for Shoes, &c.; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

My invention relates to clasp lockers or unlockers for automatically engaging or disengaging an entire series of clasps by a single continuous movement.

The invention was especially designed, for use as a shoe-fastener; but is capable of general application wherever clasps consisting of interlocking parts may be applied, as for example, to mail-bags, belts, and the closing of seams uniting flexible bodies. To these ends, the clasps are made with interlocking parts, which when in position, can only engage with each other when at an angle to the line of strain. The clasps have underreaching and overlapping projections or lips at their forward ends, which prevent the engagement or disengagement of the hook-portions of the clasps, except when thrown upward, so that the parts stand at an angle to each other of about ninety degrees. These clasps or fasteners, when in position on the flaps of a shoe or other adjacent parts which are to be united, may be engaged one at a time in succession, by bringing the two parts of the clasp into their proper angular relation to each other, by hand. But this is a tedious operation; and makes it difficult to draw the adjacent parts together, under the proper strain. I therefore provide a hand device, consisting of a movable guide, having cam-ways for permitting the passage of the clasps, by the movement of the guide from one end to the other of the series; and the cam-ways are so shaped and related that by the passage of the guide in one direction, the clasps will be drawn together and engaged, while by the passage of the guide in the other direction, the clasps will be disengaged and separated. In other words, one end of the guide has two channels or grooves, for receiving the parts of the fasteners when open or disengaged, and this may be called the forward end of the guide. The other or back end of the guide has a single channel or cam-way, into which the two channels from the forward end converge over an angular center ridge or instep. By moving the guide, so that the separate parts of the clasp enter the respective channels or cam-ways at the front of the guide the entire series of clasps will be delivered from the other or rear end of the guide properly engaged together. If the clasps be engaged and the united set be introduced at the rear end of the guide, and the guide moved over the same, the clasps will be delivered, disengaged from each other, at the forward end of the guide.

The invention, as applied to fasten shoes, is illustrated in the accompanying drawings, wherein, like letters referring to like parts throughout, Figure 1 is a front view of a shoe embodying my invention, showing the guide as applied to close the fastenings. Fig. 2 is a similar view, showing the guide, as applied to open the fastenings. Fig. 3 is an end view of one of the clasps detached, shown as in the locked position of the parts. Fig. 4 is a similar view, showing the angle which the parts of the clasps must assume, to lock or unlock. Fig. 5 is a plan, showing several clasps in position, on portions of the flaps of a shoe. Fig. 6 is a side elevation of the guide, the right hand end of the figure, being the front end of the guide. Fig. 7 is a longitudinal section of the guide. Fig. 8 is a front end view of the same, showing the entering position or delivering position of the unlocked clasps. Fig. 9 is a vertical cross-section on the line X X of Fig. 6, showing the clasps at their engaging or disengaging position, at the top of the ridge. Fig. 10 is a rear end view of the guide, showing the entering or delivering position of the clasps when engaged.

A is the body of the shoe, and *a a* are the flaps of the same. *a'* is the tongue underlying the flaps.

B B' are the two parts of the clasp, constructed with hook-portions and underreaching and overlapping parts, as before stated. The clasps are attached to the flaps of the

shoe in any suitable way, shown as by wires *b* in Fig. 5, and as by lacing-strings C, in Fig. 11.

D is the guide. The base-piece of the guide is flat on its under surface, and has on its margin upturned lips *d*. The top-plate of the guide is concave or bell-shaped, and the connecting-body or center-piece uniting the two plates is angular in cross section, as before stated, and extends from the forward end of the guide to a point near the center of the same, and serving to divide the space between the base and top pieces into two channels or camways at the front end of the guide, which terminate as before stated, in the common channel or camway, at the back of the guide. A bail E is fixed to the top piece of the guide and carries a ring F, which serves as a finger-pull to operate the guide. In virtue of the bail, the ring or finger-pull may be shifted, so that the strain may be applied near the forward end of the guide, for moving the guide forward, and near the rear end of the guide, when moving the same backward.

The operation of this device has already been described.

The clasps may be easily and cheaply made of any suitable metal, and may be finished in any desired manner, so as to give an ornamental appearance. They may be very small in size and when properly applied to a shoe, will give the same a neat appearance and be comfortable to the wearer. It should be noted that the clasps are placed sufficiently close together on the flaps of the shoe, so that they cannot be disengaged by an endwise movement of the same.

The guide or hand-device may be made relatively small, as compared with the drawings, so that it may be readily inserted at the lower end of the series of fasteners, working on the tongue of the shoe, as a base or trackway. It should be noted that the guide acts not only to engage the clasps in its forward motion, but serves also to draw the flaps together, and the parts of the shoe tightly about the foot.

The practicability of the invention herein described has been demonstrated by actual usage of the same.

It will be noted, that in the construction shown in Fig. 11, the shoe is provided with top or overlapping flaps *c*, for concealing the fasteners from view.

What I claim, and desire to secure by Letters Patent of the United States, is as follows:

1. A device for engaging and disengaging a series of two-part clasps upon a shoe or other article, consisting of a guide-block, having two guide-ways, which are separated at one end thereof, and converge into a single guide-way, at the other end thereof, said guideways being adapted to engage and carry the interlocking parts of the clasps into or out of engagement with each other, as the block is moved forward or backward over the same, substantially as described.

2. A device for engaging and disengaging a series of two-part clasps, upon a shoe or other article, the interlocking members of which are engageable or disengageable by an angular movement of the same, the said device consisting of a guide-block having a pair of camways or guide-channels, in angular relation to each other at one end of the block, and converging and blending into a common cam-channel or guideway at the opposite end of the block, substantially as described.

3. A hand-device, for engaging or disengaging a series of two-part clasps, upon a shoe or other article, by a single continuous movement, the said device consisting of a movable guide-block having a pair of diverging camways or guide-channels, at one end of the block, which converge and blend into a single camway or guide-channel at the other end of the block, over an angular surface, located at the junction of the said ways, and extended outward on an incline toward the end of the single camway, substantially as and for the purpose set forth.

4. A device for engaging and disengaging a series of clasps upon a shoe or other article, the interlocking parts of which engage or disengage by an angular movement of the same, the said device consisting of a guide-block, having two bell-mouthed guideways in angular relation to each other, on opposite sides of the block, at one end thereof, and converging and blending over an angular surface into a single bell-mouthed guideway at the other end of the block, substantially as described.

5. A hand device for locking or unlocking a series of two-part clasps or similar interlocking parts, which engage or disengage by an angular movement, the said device consisting of a movable guide-block provided with a pair of divergent camways or guide-channels, at one end of the block with bell mouths at an angle to each other in the vertical plane, the said channel converging over an angular surface at the junction of the ways into a single camway or guide channel at the other end of the block having a bell mouth in the horizontal plane, whereby, under a single continuous movement of the hand device, the clasps may be drawn together and engaged or be disengaged and separated at will.

6. A device for engaging and disengaging a series of two-part clasps upon a shoe or other article, the same consisting of a block having two guideways which are separated at one end thereof and converge into a single guideway at the other end and a shifting finger-pull connected with the block and arranged to slide to either end for applying power to pull the block in either direction, substantially as and for the purpose set forth.

7. A device for engaging and disengaging a series of two-part clasps upon a shoe or other article, the same consisting of a block having two guideways which are separated

at one end thereof and converge into a single guideway at the other end, said block being provided with a staple extending from end to end thereof and a ring upon the staple constituting a shifting finger-pull to draw the block in either direction, substantially as described.

In testimony whereof I affix my signature in presence of two witnesses.

WHITCOMB L. JUDSON.

Witnesses:
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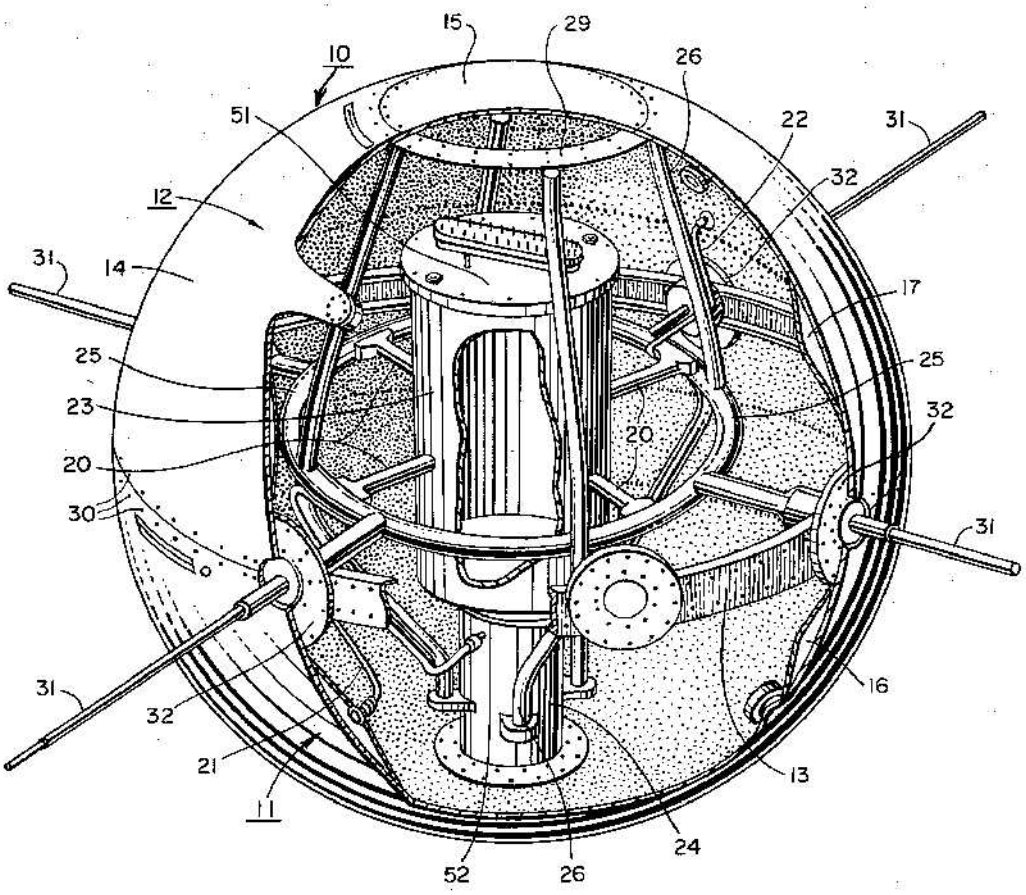
May 20, 1958 R. C. BAUMANN 2,835,548

SATELLITE STRUCTURE

Filed Aug. 1, 1957 3 Sheets-Sheet 1

FIG. 1



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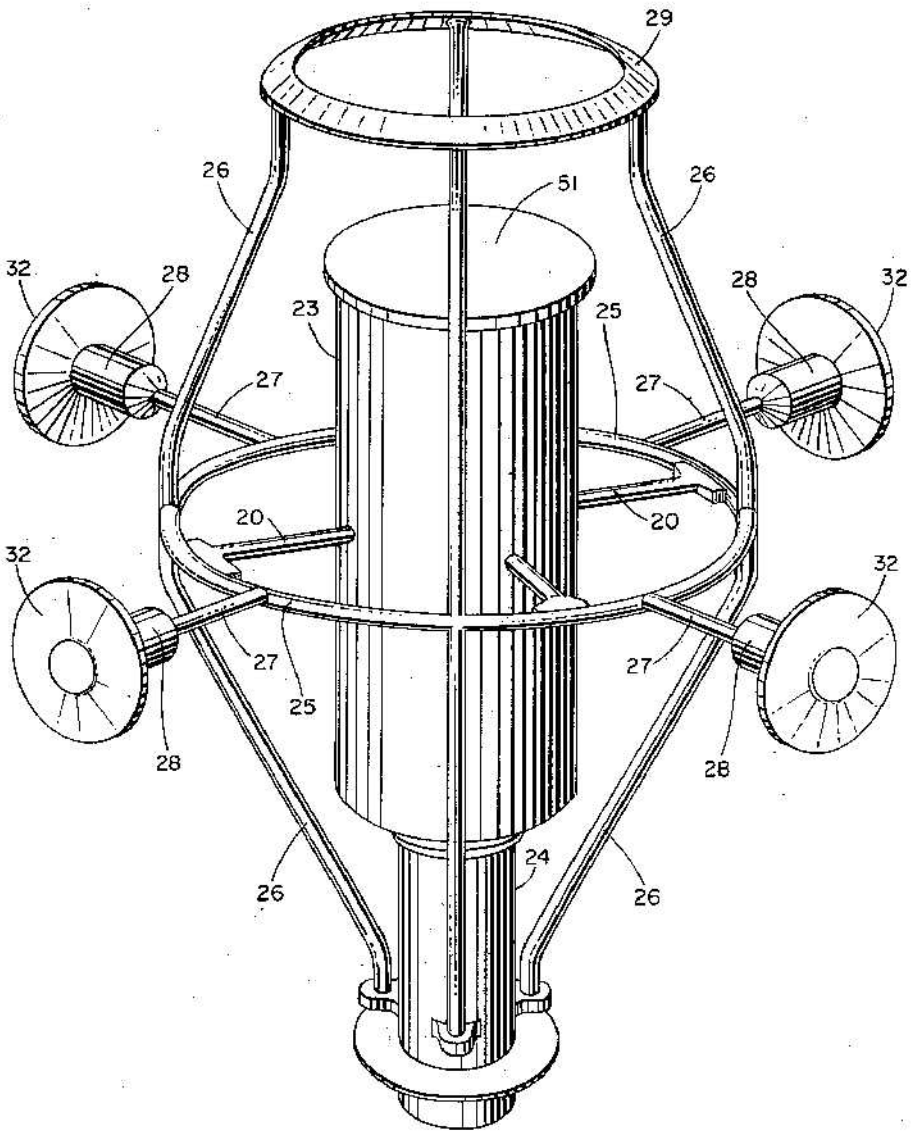
SATELLITE STRUCTURE

Filed Aug. 1, 1957 3 Sheets-Sheet 2

FIG. 2



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SATELLITE STRUCTURE

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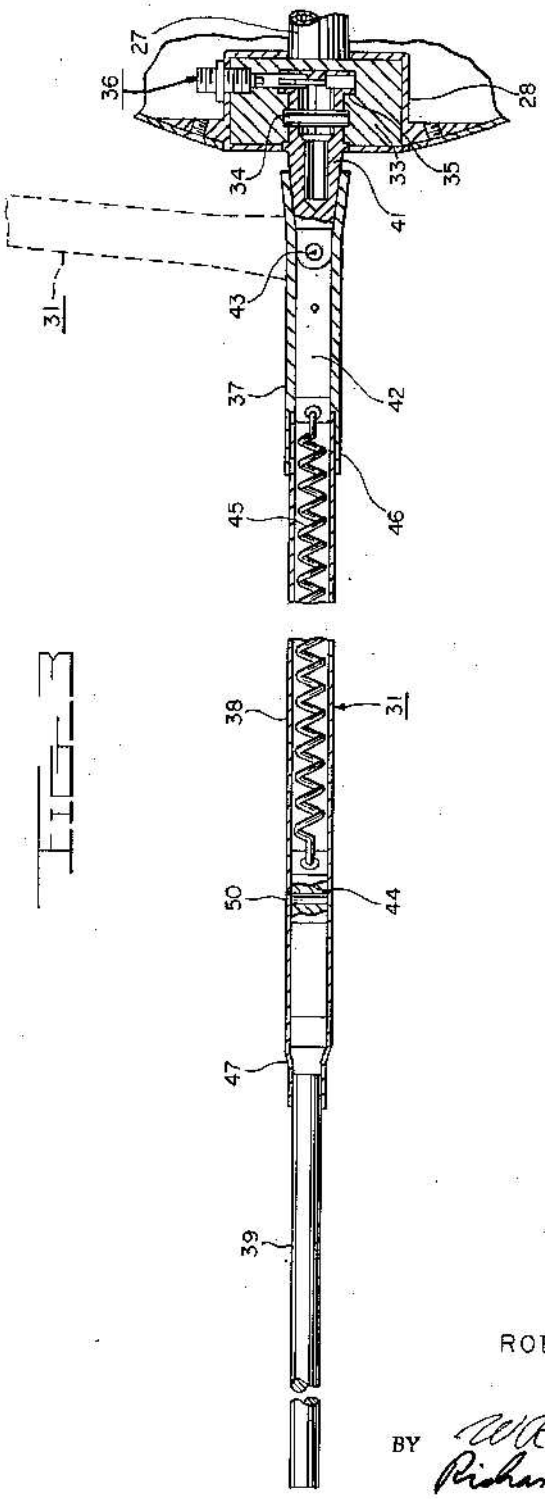

FIG. 3

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United States Patent Office

2,835,548

Patented May 20, 1958

2,835,548

SATELLITE STRUCTURE

Robert C. Baumann, Alexandria, Va., assignor to the United States of America as represented by the Secretary of the Navy

Application August 1, 1957, Serial No. 675,787

9 Claims. (Cl. 312—352)

(Granted under Title 35, U. S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

The present invention relates to the design of earth satellites and more particularly to the outer shell structure of the satellite and the supporting members therein which carry the instruments.

Heretofore scientific explorations of the upper atmosphere in order to obtain a better understanding of the physical phenomena in these regions has been carried out by the use of gas filled balloons and by rockets carrying specific instruments. These explorations have been limited to certain areas of the upper atmosphere and to short periods of time for taking the desired data.

Earth satellites made according to the present invention can be fired into the upper atmosphere to encircle the earth and to obtain data throughout the whole area about the earth. Observations can be made of electromagnetic radiation from the sun which does not penetrate the earth's atmosphere, and to study incoming radiations and relate them to the affected regions of the atmosphere such as ozonosphere and the ionosphere. The satellite will further provide new and unprecedented opportunities for scientific measurements of the upper atmosphere and will increase the observable time for taking measurements and provide a more widespread test area. Also more intelligent information about the size and shape of the earth can be obtained by such a satellite.

It is therefore an object of the present invention to provide a satellite structure which can be fired into the upper atmosphere and remain for relatively long periods of time.

Another object is to provide a structure which is adapted to carry instruments into the upper atmosphere for upper atmosphere observation.

Yet another object is to provide a structure which can be easily assembled and disassembled.

Other and more specific objects of this invention will become apparent upon a careful consideration of the following detailed description when taken with the accompanying drawings, in which:

Fig. 1 is a plan view of the satellite which is cut away to illustrate the inner structure;

Fig. 2 is a side elevation view of the inner structure of the satellite;

Fig. 3 is a sectional view of the antenna which illustrates the mechanism which operates the antenna to permit folding.

The present invention provides a spherical shell within which a supporting structure aids in maintaining the shape of the spherical shell and also provides easy access to the innermost part for securing and assembling the instruments. The inner structure has antennas connected thereto which are adapted to extend outwardly along the equator to provide the necessary function of sending and receiving signals.

Referring now to the drawings wherein like reference characters represent like parts throughout, the satellite

structure **10**, as illustrated, comprises a housing which has a lower hemispherical section **11** and an upper hemispherical section **12** which are fastened at the equator to a channeled structure **13**, by rivets and/or screws as appropriate. The upper hemispherical section **12** is formed in two parts **14**, **15** wherein the uppermost part **15** permits limited access to the inside thereof for adjusting the instruments and final assembly thereof. The housing is formed of magnesium or any other suitable material which will withstand the pressures and temperatures of the atmosphere within which the satellite structure travels, and in addition the rigorous vibration, acceleration and aerodynamic heating incurred during the ascending trajectory.

The lower and upper hemispherical housing sections are girdled on the inner surface respectively by pressure zones **16** and **17** formed by an annular band of metal similar to the housing and welded thereto. The band is somewhat rounded and so formed so as to afford equal strength to withstand pressures both internally and externally. The pressure zones have pressure lines **21** and **22** which extend therefrom and connect with a pressure gauge (not shown) in the inner structure. The pressure zones are adapted to withstand both positive and negative (vacuum) pressures. The zones are filled with unequal pressures for the purpose of determining if puncture occurs during the ascending trajectory and further to determine which of the hemispherical sections has been punctured in the event the shell is punctured during flight.

The housing has an inner supporting structure which comprises an inner cylindrical chamber **23** secured at the bottom by a low thermal conductivity support **52** of "Kel–F" or other suitable material, to a main support column **24** which is connected at the bottom to the inner surface of the lower hemispherical surface. Concentric with the cylindrical chamber is a tubular ring **25** which is connected to the chamber by four tubular rods **20** made of "Kel–F" or other suitable material with low thermal conductivity, said rods extending therefrom along equally spaced radii at the equator of the spherical shell. The tubular ring is supported vertically by four bow shaped tubular members **26** spaced 90 degrees apart with respect to a plane through the equator of the spherical shell. The bottom ends of members **26** are secured to the main support **24** by welding or any other suitable manner and the upper ends are likewise secured to an annular member **29** to which sections **14** and **15** of the upper hemispherical section are secured. The main support **24** is also designed to receive the satellite separation mechanism. Extending radially from the concentric ring **25** along radii in the equatorial plane are four tubular rods **27** spaced 90° apart and 45° with respect to members **26**. Each of the rods terminate in an enlarged cylindrical tubular portion **28** which supports an antenna **31** and a flanged portion **32** on the end thereof that aids in supporting the shell structure at the equator. As can be seen by illustration in Fig. 1, the shell structure is also supported at the north and south poles by the supporting frame structure.

The flanged portion **32** is curved to fit along the inner surface of the shell structure which is secured thereto by suitable screws **30** or any other suitable means and the cylindrical end portion of the antenna supporting structure in adapted to receive the end of the antenna and an insulating member **33** by which the antennas are secured to the tubular end portions. The insulating members may be made of Teflon or any other suitable material which is cylindrical in shape and has a diameter such that it fits tightly into the cylindrical end piece. The insulating member is formed in two pieces and adapted to fit about the end of the antennas which is held thereto by a pin **34** and a rib **35** on the end of the antenna. A connector **36** makes contact with the antenna to provide connecting

means through which signals may be sent or received and also to provide means for holding the insulating member and antennas in the cylindrical end piece 28.

The antennas are designed such that they may be folded at an acute angle with respect to the antenna support rods 27. The antennas are made in three sections 37, 38 and 39 of aluminum tubing having a wall thickness of 0.024 inch. The tubes provide a means by which suitable mechanism may be installed to permit folding and subsequent automatic return to a locked unfolded position as shown in Fig. 3. The mechanism includes a short stub end 41 which is secured to the cylindrical end pieces 28 by insulating member 33 and connector 36, and tapered on the other end to be received by a tapered end of antenna section 37. The stub end 41 is secured to an elongated cylindrical member 42 which is adapted to be inserted for free movement into the antenna end section 37 and pivotably connected to stub end 41 at 43. A fixed member 44 is secured in the outer end of section 38 by rivet 50 and a spring 45 is connected thereto and to the cylindrical member 42. The inner end of antenna section 38 is connected to the outer end of section 37 at 46 adjacent to cylindrical member 41 and the inner end of section 39 is secured at 47 to the outer end of antenna section 38 adjacent to the fixed member 44.

In order to position the antenna in its folded position, the antenna is pulled away from the spherical section until the inner tapered end of section 37 clears the pivot 43 which permits folding. During launching of the satellite the antennas will be in a folded position shown by dotted lines in Fig. 3 and resting upon suitable stops on the nose cone section, not shown, and upon release of the nose section, the spring 45 will pull the antennas into normal flight position as shown in Figs. 1 and 3. Such an arrangement affords protection for the antennas during the critical stages of launch as well as enabling the use of a relatively long antenna without modification to the launching vehicle.

In addition to the antennas equally spaced about the equator there are suitably spaced four microphones, a Lyman Alpha solar cell and a Lyman Alpha ion chamber. Further there are various gages and connections thereto from the shell structure such as erosion gages, temperature gages, pressure gages and any other attachment for suitable equipment.

The cylindrical chamber 23 is adapted for use as the power supply storage and for securing various instruments therein. These instruments do not constitute a part of the present invention, therefore, further discussion is not seen to be necessary. However, the top cover 51 for the cylindrical chamber provides the connections for most of the instruments in the chamber and is therefore designed to secure the connectors therein.

The internal structure, the internal cylindrical chamber and shell assembly are electro-plated with zinc, copper, silver and a coating of 0.00005 inch of gold to facilitate handling, reduce corrosion, and for thermal considerations. The outer surface of the magnesium sphere is further coated evaporatively with a silicon monoxide coating which has several underlying coatings of other metal substances as follows: a layer of chromium, a layer of silicon monoxide, and a layer of aluminum. The final silicon monoxide coating gives the desired thermal emissivity. These coatings are for the purpose of regulating, to some degree, the mean orbital temperature of the housing by setting the ratio between absorptivity and emissivity.

The above structure has been described for a satellite structure to be used in actual flights in the upper atmosphere. However, it is to be understood that applicant is not to be limited to the materials from which the structure is made since it is obvious that similar structures can be made of other materials. The materials from which the satellite structure is made will depend on the particular use to which it will be applied, that is, similar structures can be used for giving lectures, group discussions or even as a toy and will not require the particular materials for the structure as required for upper atmosphere flights.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. A satellite which comprises a thin shell spherical structure and an inner support structure, said inner support structure comprising a support column, a plurality of bow-shaped members and a first ring, all positioned concentrically about an axis through said spherical structure, said bow-shaped members being secured at one end to said support column and at the other end to said first ring, said support column and said first ring being secured to the inner surface of said spherical structure, a second ring secured to said bow-shaped members at the equator of said spherical structure and a plurality of radially extending members secured to said second ring and to the inner surface of said spherical structure at the equator.

2. A satellite as claimed in claim 1 wherein the ends of said plurality of radially extending members secured to said ring and to the inner surface of said spherical structure are adapted for mounting antennas that extend outwardly from said spherical structure, said antennas being adapted for pivotable movement for angularly positioning said antennas with respect to said mounting structure.

3. A satellite structure comprising an outer spherical structure and a supporting structure within said spherical structure, said supporting structure being formed of a plurality of bow-shaped members assembled about an axis of said spherical structure and secured respectively at opposite ends to a cylindrical chamber and a concentric ring each of which are secured to the inner surface of said spherical structure, and a ring secured to said bow-shaped members at points on a plane perpendicular to the axis about which said spherical structure is secured.

4. A satellite structure which comprises a thin shell spherical structure and a supporting structure within said spherical structure, said supporting structure comprising a plurality of bow-shaped members, a support column and a first ring, all assembled concentrically about an axis through said spherical structure perpendicular to a plane through the spherical section at the equator, said bow-shaped members being equally spaced and secured at one end to said support column and secured at the opposite end to said first ring, a second ring structure secured to said bow-shaped members along the plane at the equator, radially extending support members secured to said second ring structure about said bow-shaped members and to said support column, and other radially extending support members secured to said second ring structure about said bow-shaped members and to the inner surface of said spherical structure at the equator.

5. A satellite structure as claimed in claim 4 in which at least four bow-shaped members form a part of said supporting structure.

6. A satellite structure as claimed in claim 4 in which said spherical structure is formed by a plurality of sections.

7. A satellite structure as claimed in claim 4 in which said spherical structure is formed by one section from the equator and below and by two sections from the equator and above said equator, two of said sections being adapted to be secured at the equator to circularly extending channel sections and said two sections above said equator being adapted to be secured to said concentric ring of said supporting structure.

8. A satellite structure which comprises a thin shell three sectioned spherical structure and a supporting structure within said spherical structure, said supporting

structure comprising at least four bow-shaped members, a support column and a first ring all assembled concentrically about an axis through said spherical structure perpendicular to a plane through the spherical structure at the equator, said bow-shaped members being equally spaced and secured at one end to said support column and secured at the opposite end to said first ring, said support column being secured to the inner surface of said spherical structure, a second ring structure secured to said bow-shaped members on a plane through the equator of said spherical structure, radially extending support members secured to said ring structure and to said support column on said plane, other radially extending support members secured to said ring structure at one end and having a flanged end at the other end adapted to be secured to the inner surface of said spherical surface at the equator thereof, said flanged end of said other radially extending support members being

adapted to support antennas on the outer surface of said spherical structure.

9. A satellite structure as claimed in claim 8 wherein one of said sections forms a part of the shell structure from the equator and below and the other two sections form the surface above said equator, the section below the equator and one of the sections above the equator being adapted to be connected to circularly extending channel sections at the equator and the two sections above the equator being adapted to be connected to said first ring of said support structure.

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Sheet 1. 2 Sheets.

Sholes, Glidden & Soule.

Type Writing Mach.

No. 79,265. Patented Jun. 23, 1868

Fig. 1.

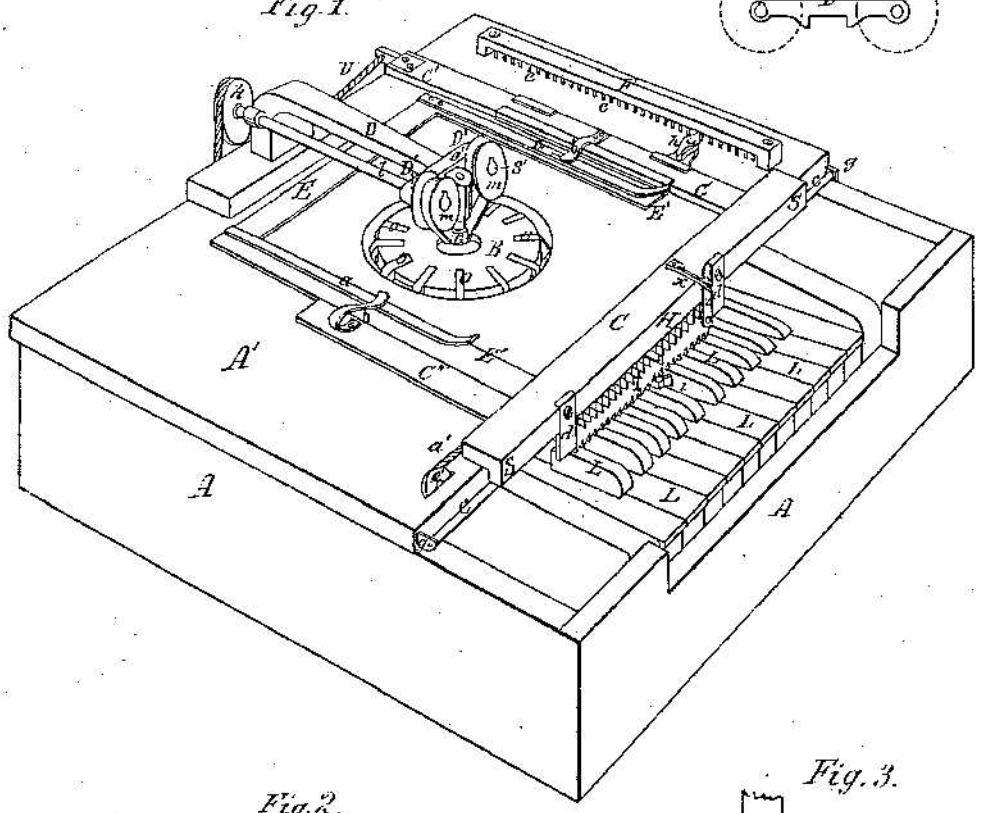


Fig. 9.

Fig. 2.

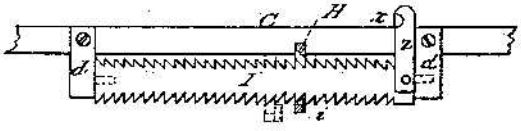
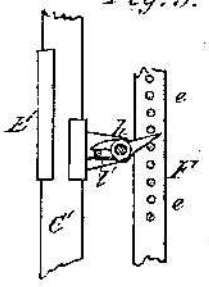


Fig. 3.



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Sheet 2. 2 Sheets.

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Type Writing Mach.

No. 79,265. Patented Jun. 23, 1868.

Fig. 4.

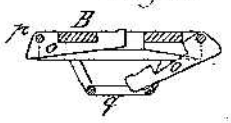


Fig. 5.

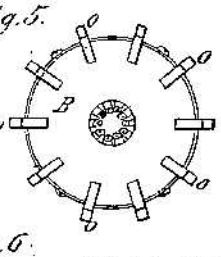


Fig. 6.

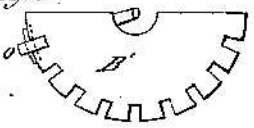


Fig. 7.

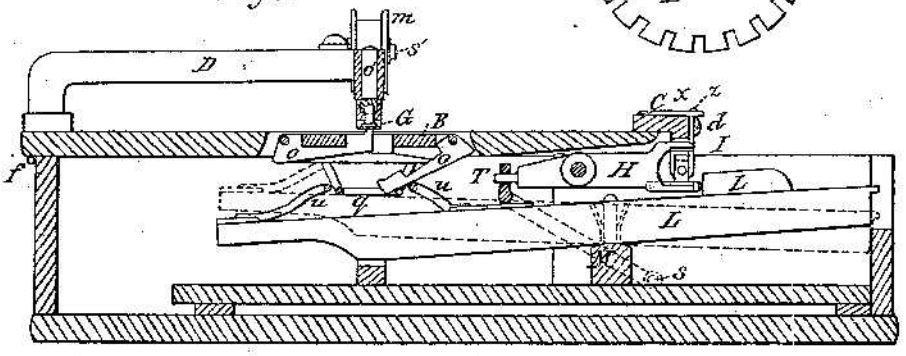
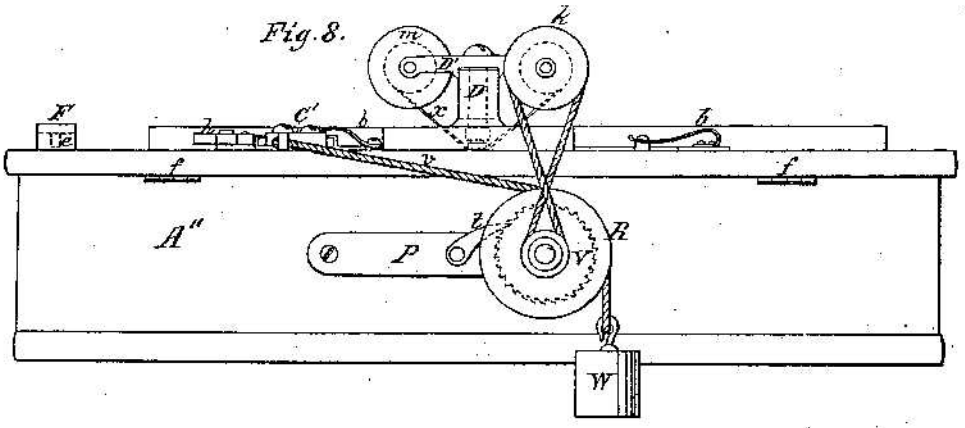


Fig. 8.



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UNITED STATES PATENT OFFICE.

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IMPROVEMENT IN TYPE-WRITING MACHINES.

Specification forming part of Letters Patent No. **79,265**, dated June 23, 1868.

To all whom it may concern:

Be it known that we, C. LATHAM SHOLES, CARLOS GLIDDEN, and SAMUEL W. SOULE, of the city of Milwaukee, and county of Milwaukee, and State of Wisconsin, have invented new and useful Improvements in Type-Writing Machines; and we do hereby declare that the following is a full, clear, and exact description of the invention, which will enable those skilled in the art to make and use the same, reference being had to the accompanying drawings, forming part of this specification, in which—

Figure 1 is a perspective view of the machine; Figs. 2, 3, 4, 5, 6, and 9, views of detached parts thereof; Fig. 7, a view of a longitudinal vertical section thereof, and Fig. 8 a view of the rear elevation of the same.

This invention is of improvements to an invention of a type-writing machine, an application for a patent for which we filed October 11, 1867. Its features are a better way of working the type-bars, of holding the paper on the carriage, of moving and regulating the movement of the carriage, of holding, applying, and moving the inking-ribbon, a self-adjusting platen, and a rest or cushion for the type-bars to follow.

Make a case A, about two feet square, four to six inches deep, or of any requisite dimensions, of material and finish to one's taste, with the lid or cover A′ hinged to the back board A^2 by hinges *f*, as shown in Figs. 7 and 8. In the cover cut a circle, as shown in Fig. 7. Make a circular annular disk B, of any hard tough material (we use and prefer brass) four to five inches in diameter, or any required size, with a circle or hole in the center, one to one and a half or more inches in diameter, with the outer edge or periphery one-half to three-fourths of an inch or more thick, and the inner edge or circumference of the central circle two-eighths to three-eighths of an inch or more thick, with the top side planed level and smooth and the bottom side beveled, if preferred, from the outer to the inner edge with as many radial slots or grooves as types to be used cut in the bottom side from the central circle to the periphery, and deep to within an eighth of an inch of the top, less or more, with slots in the outer edge or periphery one-half to three-fourths of an inch or more deep toward the central circle to meet and fit exactly the radial grooves, and with a groove for pivot-wire cut in and circumscribing the periphery, as shown in Figs. 1 and 5.

Of any suitable material (we use and prefer steel) make as many type bars or hammers *o* as types to be used or slots in the disk. Pivot the outer ends of the type-bars in the slots in the outer edge by a wire laid in the groove in the periphery circumscribing the disk. On the upper sides of the inner ends of the type-bars cut in relief the types to be used. Make all the type-bars of the exact length of the radius of the circle of the disk, so each type on the inner ends, when thrown up into the radial grooves, will strike against the central point. (See Figs. 1, 5, and 7.) Fasten the disk thus combined with the type-bars in the circle in the cover of the case, as shown in Figs. 1 and 7, by any convenient means not interfering with the working of the type-bars. (We set it on wire posts fastened to the bottom of the case.) In the case, on a suitable frame, put a key-board similar to the key-board of a piano, having as many keys L, plus one, as types to be used, as shown in Fig. 1, each key reaching from the front in under or opposite the type-bars and pivoted to or vibrating on the fulcrum or beam M, as shown in Fig. 7. On the inner end of each key, excepting the space-key, fasten a finger *a*, made in any convenient way, (we use a stiff wire,) or bend the inner ends of the keys so the fingers will be part of the keys to reach the corresponding type-bar, so that when the front end of the key is pressed down it will strike and throw the type-bar up into its radial groove and its type-end against the central point, as shown in Fig. 7. The ends of the fingers will thus be in a circle corresponding to the circle of the disk and type-bars. Within and below the circle of the fingers and type-bars set a cushion or rest *q*, of any material for the type-bars to fall back and rest on after having been thrown up against the central point, as shown in Fig. 7. Over the central point of the inner circle of the disk suspend a solid anvil or post O′ in any firm manner, as by the arm D, fastened to the edge of the case and reaching out to the anvil, as shown in Figs. 1 and 7. In the bottom of the

anvil make a spherical cavity or bowl. Make a platen G of any hard smooth substance (we use metal) with the bottom or face finished smooth and level, and with the top spherical to fit the bowl in the bottom of the anvil. Fit and attach the spherical end of the platen in and to the bowl of the anvil, thus making of the connection a universal joint, and making the platen self-adjustable. (See Figs. 1 and 7.) Hang the platen as near the plane of the surface of the cover of the case as will just admit the paper to be written on and the carbonized paper or inking-ribbon to pass easily under the platen and over the disk and case. This adjustable platen insures the types meeting the paper evenly and squarely, and giving a full and fair impression thereof when thrown against the paper.

Make an open frame C, C′, and C² with the bars C′ and C² as arms to the main bar C, as shown in Fig. 1, the arms projecting at a right angle to the main bar. Extend the arm C′ so that when the main bar C is laid flush and even with the front edge of the main part of the cover of the case it will reach entirely across to the back of the case and project so that the cord *v* may be attached to the open end, as shown in Fig. 1. To the front edge of the bar C attach a cleat S, to jut down against the edge of the cover of the case, as shown in Fig. 1. On the front edge of the top of the cover lay a rail, and on the under side of the bar C at each end, in the corner next to the cleat S, pivot a small flange-wheel to roll on the rail and enable the frame to move easily from right to left and back, or attach the ears *g* to the edge of the cover or table, as shown in Fig. 1, (two, next the keys, not being seen in the drawings, because of the cleat S,) and under the cleat S fasten two rings to serve as guides. To the ears *g* attach rods *c*, extending from the ears seen in Fig. 1 to the ears unseen next the keys and through the guides. This will enable the frame to slide easily from right to left and back, and be a guide to keep it always in place. To and within the frame C, C′, and C² attach another open frame E, E′, and E², as shown in Fig. 1, with the bar E opposite and parallel to the bar C, and the bars E′ and E² parallel with the bars C′ and C². To the bars C′ and C² attach springs *b* on a line through the center of the platen, parallel to the bar C, to press down on the bars E′ and E². Arrange the frame E, E′, and E² to slide to and from the bar C, the bars E′ and E² along the bars C′ and C², either by slots or grooves in the inner edges of the bars C′ and C², and tongues on the outer edges of the bars E′ and E² to fit and work therein, or by clasps on the bars E′ and E², reaching over and around the bars C′ and C², and fitted so as to slide readily or by any other obvious device. At the ends of the bars E′ and E², where they join the bar E, fasten two limber, thin, flat wire springs *a*, as long as the bars E′ and E², so that in sliding the frame E, E′, and E² to and from the bar C the springs *a* will be pressed close to the bars E′ and E² at every point in their length as they pass down and under the springs *b*, attached to the bars C′ and C². Rabbet the bars E, E′, and E² at their inner edges, so they may be as thin as practicable, and form a chase or bed for the paper to lie in. This combination of devices forms a simple and practicable paper-carriage, the larger and primary frame C, C′, and C², movable to and from in one direction—say east and west—carrying the smaller and secondary frame E, E′, and E² with it, and the latter frame movable in the transverse direction to and from north and south, while the former is stationary, thus furnishing a movement in one direction for a line of words and in the opposite direction for a series of lines.

On the edge of the cover of the case at the right of the paper-carriage attach the bar F, laid on stops or shoulders, so that the under side of the bar will be one-half inch or more above the table or cover of the case. In this bar set a series of pins *e*, running down into the table, so as to be fast and firm at regular and equal distances apart, the distance desired for the space (including the line) from one line of writing to another, as shown in Fig. 1. From the right-hand edge of the bar E′ of the paper-carriage project a lip out under the bar C′ or from the clasp attached to E′ and around C′, and on this lip pivot a pawl *h*, with a sharp incline on the side toward the front of the case running to a point, so arranged with a stop that it cannot be turned on the pivot in the direction of the back of the case, but readily turned in the opposite direction and held in position by a yielding-spring *l*, all as shown in Figs. 1 and 3. By moving the carriage to the right side of the case the point of the pawl *h* will just pass a pin *e* on the side from the front of the case. The incline of the pawl on the side next the pin being equal to the distance from one pin to another, and the pawl not being turnable on its pivot in the direction from the front to the back of the case, the frame E, E′, and E², with the paper, when on it, necessarily will be moved the proper distance from one line of writing to another.

Attach to the right-hand corner of the carriage-frame a cord *a′* and run it lengthwise of the bar under the bar C in a groove in the bar or table for that purpose, or it may be close to and inside of the bar, over a pulley *e′*, fitted in and below the top surface of the table, as shown in Fig. 1, and fasten to the other end of it a weight under the case, but unseen in the drawings. To the other end of the bar C′ fasten a cord *v*, and run it down over a large pulley R on the back side of the case A², and to the other end of the cord hang the weight W, as shown in Fig. 8. These cords *v* and *a′*, attached one to each corner of the carriage on one side, running over the pulleys R and *e′* and fastened to the weight W and the weight W′ (unseen in the draw-

ings) are the force and means of moving the carriage and paper while writing.

Under the table or cover of the case, behind the beam or fulcrum M, between the fulcrum and the disk a suitable distance, on and across all the keys, lay a bar T, with the ends bent at a right angle and extended and pivoted to the frame below and in front of the fulcrum, as shown at *s*, Fig. 7, so that when the front ends of the keys are pressed down the rear ends will strike against and raise the bar an extent in proportion to the distance from the fulcrum. Connect a lever H to the middle of the bar T, midway of the key-board, extending directly over and parallel with and between the middle keys, and pivoted in the middle on a suitable support, as shown in Fig. 7. Bifurcate the front end of this lever and make the right-side faces of the forks perpendicular and the left-side faces inclined, the upper one to the left upward and the under one to the left downward, with the under edge of the upper fork and the upper edge of the under fork sharp like saw-teeth, as shown in Figs. 1 and 2, particularly in Fig. 2. Fasten to the bar C of the carriage-frame two holders or arms *d*, extending down through the cleat S, or fasten them directly to the cleat, and pivot in their lower ends the ends of the ratchet-bar I, as shown in Figs. 1 and 2. Serrate the bar I on both sides with notches like saw-teeth, as shown in Figs. 1 and 2. Make these notches, teeth, or cogs regular and equidistant apart, the exact distance required for a letter in writing or printing on the paper. Make the left side of the faces of the teeth or cogs perpendicular, both above and below, and the right-side faces inclined exactly alike, but the reverse of the teeth or cogs of the inner edges of the forks of the lever H, so that of the lever H, with its forks embracing the ratchet-bar I, in moving up and down first one and then the other forks will strike and fit into the notches of the bar I, as shown in Figs. 1 and 2. Make the forks of the lever H so far asunder as just to allow the ratchet I in its widest way to pass between. At the right side, considered from the front of the under fork of the lever H, attach a thin yielding spring *i*, as shown in Figs. 1 and 2. Make the upper and sharp edge of the under fork stand a hair-breadth or slight distance to the right of the under and sharp edge of the upper fork, and then, as the weights W and W′, attached to the cords *v* and *a′*, over the pulleys R and *e′*, as shown in Figs. 1 and 8, (excepting that the weigh' W′ is unseen in the drawings,) are constantly pulling at the carriage to draw it from the right to the left of the table or case. When the upper fork is thrown up out of an upper notch in the ratchet, the carriage will move to the left till the left-side perpendicular face of the tooth or cog next to the right and below meets and strikes against the right-side perpendicular face of the under fork, and the carriage is thereby stopped. Fix the thin yielding spring *i* so that when the upper fork is pressed down into an upper notch of the ratchet I the spring will fly back against and up into the next tooth and notch to the right below. The office of this yielding spring is to assist the under fork to catch every under tooth and not let one slip by. As the ratchet is moved along by the carriage till the face of the tooth to the right below strikes and stops against the spring and under fork, the left perpendicular face of the tooth directly above is moved to and directly in line up and down into a hair-breadth with the perpendicular face of the fork above, so that when the front end or forks of the lever are moved or pressed down and the under fork lets go its hold of an under tooth the upper fork falls into the notch and against the tooth directly above and prevents the ratchet from moving; but when the forks are thrown up and the upper fork lets go its hold of the tooth above the ratchet moves to the left the space of one notch till the next tooth to the right below, with the yielding spring in the notch at its perpendicular face, strikes against the perpendicular face of the under fork. In this way the ratchet and carriage are held firmly still, while the front or bifurcated end of the lever H is thrown and held down, but moves to the left one notch, a regular, exact, and equal distance every time the bifurcated end of the lever is thrown up, and as striking down the front end of each key, as at L in Fig. 1, raises the bar T laid across the key at the rear of the fulcrum M, and raises the rear end of the lever H, attached to the bar T, it therefore necessarily throws down the bifurcated or front end of the lever, and as the key rises to its place of rest again all these movements are reversed and necessarily throw up again the front end of the lever. Thus the working of the keys L, in combination with the weights W and W′, (the latter unseen,) the cords *v* and *a′* the pulleys R and *e′*, the bar T, the lever H, the ratchet I, and the carriage inevitably moves the paper a regular, uniform, and exact distance—any distance desired for a type or letter every time a key is struck—and the paper is moved while the type-bar is falling to the cushion, and stopped and held firmly stationary while the type is struck against it and the platen.

On the end of the ratchet I, to the right, attach the lever *z*, to turn it down flatwise when desired, as shown in Figs. 1 and 2. To the bar C of the carriage attach a yielding spring *x* to hold the lever and ratchet in perpendicular position, while the carriage is moving from right to left, as shown in Figs. 1 and 2. Turn the lever *z* forward and down, and therewith the ratchet, to a horizontal position, and the ratchet and carriage can be moved from left to right, the ratchet through and between the embracing-forks of the lever H readily and without obstruction. This can be done by the hand or by any obvious device by a foot-treadle, thus completing the

means for the right and left movement of the carriage and paper.

On the front end of the arm D, just behind the anvil, put a cross-beam D′, as shown in Figs. 1, 8, and 9. In the end of the cross-beam, at the right, put a gudgeon s', and through the end at the left run a shaft l, and through a box at the left side of the back end of the arm D, as shown in Figs. 1 and 8, make two ribbon-spools m, of any adequate size, with holes in their centers, to slip on and revolve on the gudgeon s', as shown in Figs. 1, 8, and 9. At the circumference of the holes in the spools m in the inner edge of each spool, through from side to side, cut a slot to fit on a key or cog or spur on the front end of the shaft l forward of the cross-beam D′, so that whichever spool is put on the shaft will be fast thereto and cannot revolve thereon. On the hind end of the shaft l fasten a pulley k, as shown in Figs. 1 and 8. Make the pulleys R and k, as shown in Fig. 8, cone pulleys—that is, make each R and k a series of pulleys, decreasing in size in regular conical order. Pivot the pulley R on a bar P, and pivot the bar P to the back side of the case A^2, so that the pulley may rise and fall freely, as shown in Fig. 8. Attach a ratchet-wheel V, with a pawl t, pivoted to the bar P, as shown in Fig. 8, to follow and fall into the notches of the ratchet-wheel to prevent the wheel turning toward the bar F, as seen in Fig. 8, or from left to right, considered from the front. Connect the pulleys R and k with a cord or band v', as shown in Fig. 8. The pulley R, pivoted to the loose-pivoted bar P, with the weight W pulling down on the pulley, will always keep the band v' tight, so that it will not slip in working. Upon the spool m on the gudgeon s' wind the inking-ribbon, and run one end under the platen G and attach it to the spool m on the shaft l, as shown in Fig. 1. Then, as striking each key L permits the weight W, by means of the cord v over the pulley R, to pull or move the carriage the space of one notch of the ratchet-bar I, it will necessarily roll the pulley R a corresponding distance, and, as the pulleys R and k are connected by the band v', and the pulley k and the left spool m, considered from the front, both being fast to the shaft l, rolling the pulley R necessarily will roll the spools m and draw the ribbon from the loose spool on the gudgeon s' under the platen G and onto the spool attached to the shaft l, and thus give a fresh place of the inking-ribbon every time for every type to strike against, and by means of the series of conical pulleys at R and k the feed of the inking-ribbon can be regulated as may be desired.

Thus made, the type-writer is the simplest, most perfectly adapted to its work—the writing of ordinary communications with types instead of a pen—and in every way the best of all machines yet designed for the purpose, particularly as to the cost of making the machine and the neatness and labor-saving quality of its work.

Fig. 6 of the drawings represents a crescent or the segment comprising half a disk. By making the circumference large enough to receive the requisite number of radial grooves the crescent may be substituted for the disk, or, in other words, the segment comprising one-half for the whole disk.

What we claim as new and useful in our invention, and desire to secure by patent, is—

1. The key-levers L, vibrating on the fulcrum M, with the inner ends or fingers u reaching under the type-bars, so that the keys will act directly on the types, substantially as and for the purpose described.

2. The spacer or ratchet I, combined with the bifurcated lever H, connected with the bar T, pivoted at s and resting on and across the arms of the keys L behind the fulcrum M, so that striking the faces of the keys will work the teeth of the forks of the lever up and down and into the notches of the spaces and give a certain uniform and regular space movement to the paper-carriage in line of the types, when made substantially as described.

3. The pins e, fastened to the table A′, combined with the pawl h and the spring l' to give the paper-carriage a certain and regular cross-line movement at a right angle to the space movement from line to line, when made substantially as described.

4. The clasps or springs b, attached to the bars C and C′ on a line through the middle of the platen G, combined with the springs a, attached to the bar E to hold the paper to the carriage and press it down smooth and tight in passing under the platen, when made substantially as described.

5. The spools m, combined with the gudgeon s', the shaft l, the pulleys k and R, the band v', the cord v, the weight W, the ratchet-wheel V, the pawl t, and the bar P, pivoted to the back of the case A^2 to feed a fresh part of the inking-ribbon under the platen to each type successively, when made substantially as described.

This specification signed this 1st day of May, A. D. 1868.

C. LATHAM SHOLES.
CARLOS GLIDDEN.
SAMUEL W. SOULE.

Witnesses:
G. E. WEISS,
F. J. CROSBY.

March 8, 1932. I. SIKORSKY 1,848,389

AIRCRAFT, ESPECIALLY AIRCRAFT OF THE DIRECT LIFT AMPHIBIAN TYPE AND MEANS OF CONSTRUCTING AND OPERATING THE SAME

Original Filed Feb. 14, 1929 8 Sheets-Sheet 1

Fig. 1.

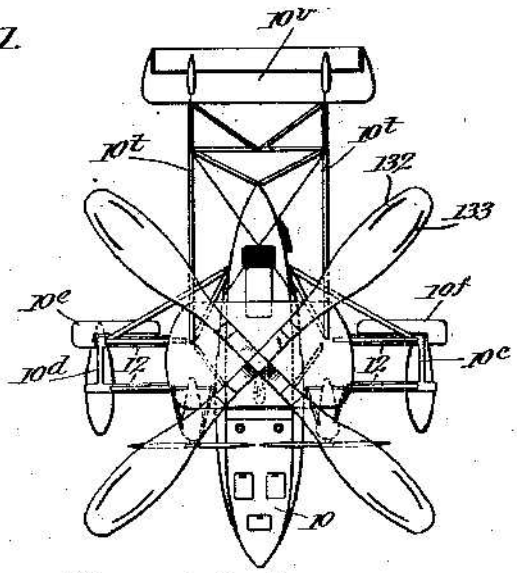
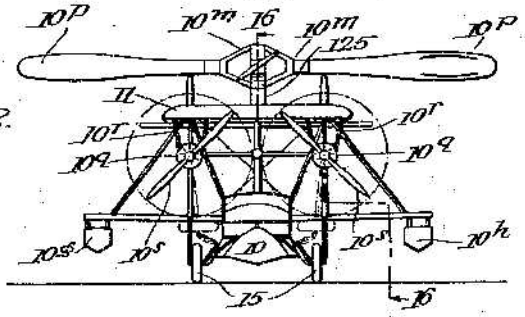


Fig. 2.



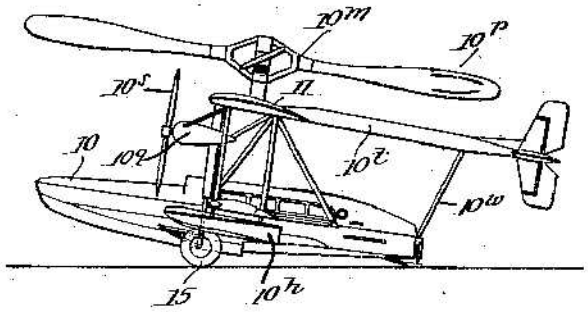


Fig. 3.

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Original Filed Feb. 14, 1929 8 Sheets-Sheet 2

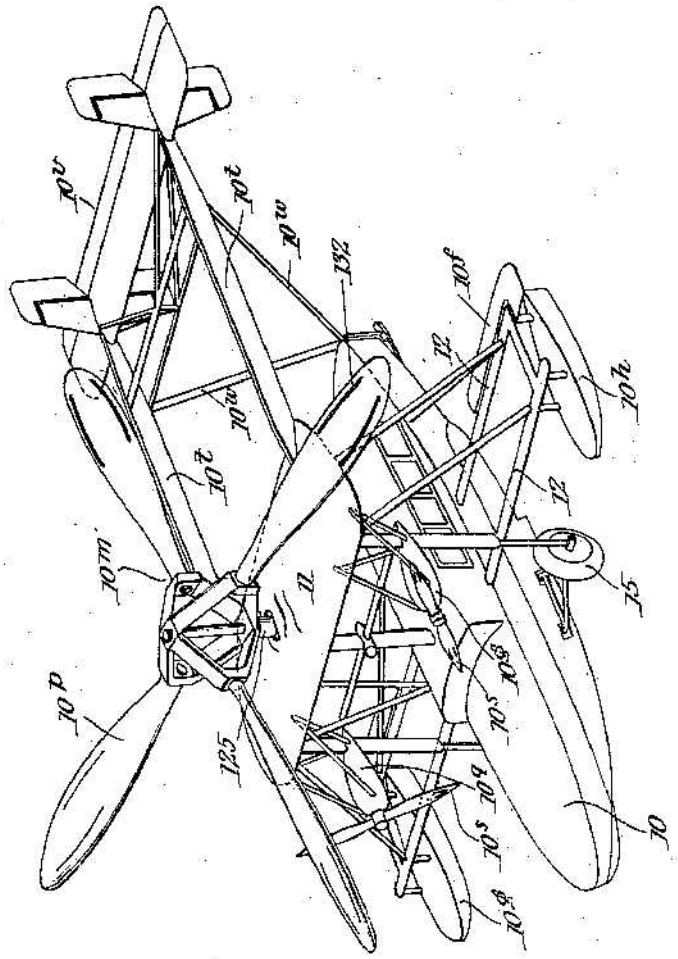

Fig. 4.

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AIRCRAFT, ESPECIALLY AIRCRAFT OF THE DIRECT LIFT AMPHIBIAN TYPE AND MEANS OF CONSTRUCTING AND OPERATING THE SAME

Original Filed Feb. 14, 1929 8 Sheets-Sheet 3

Fig. 5.

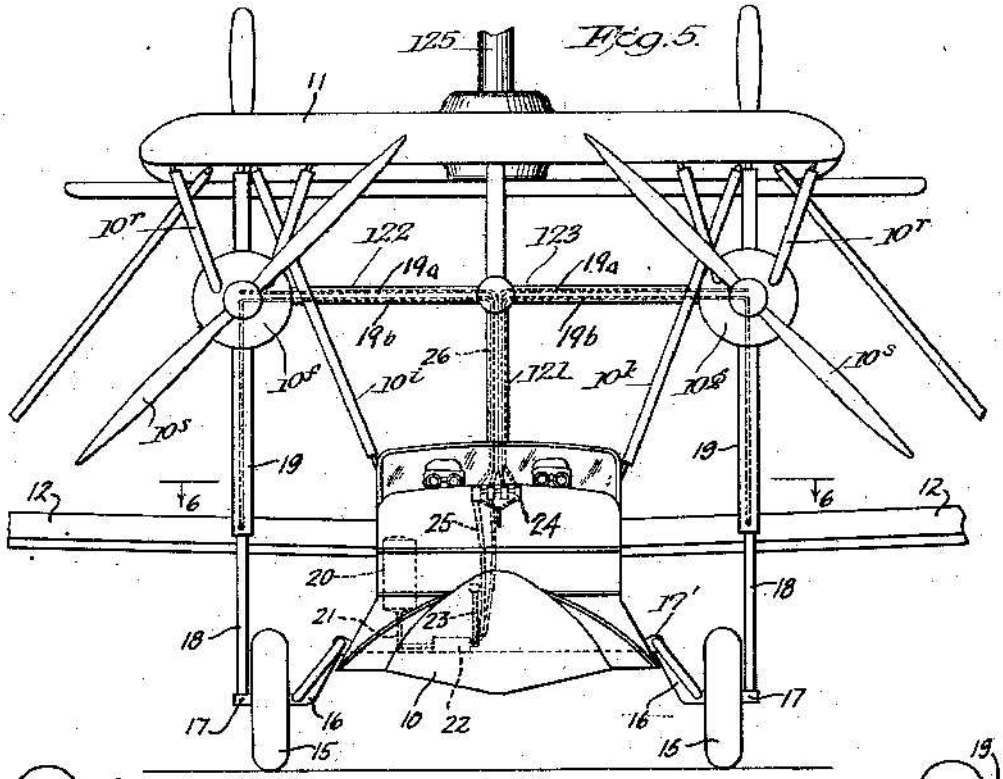
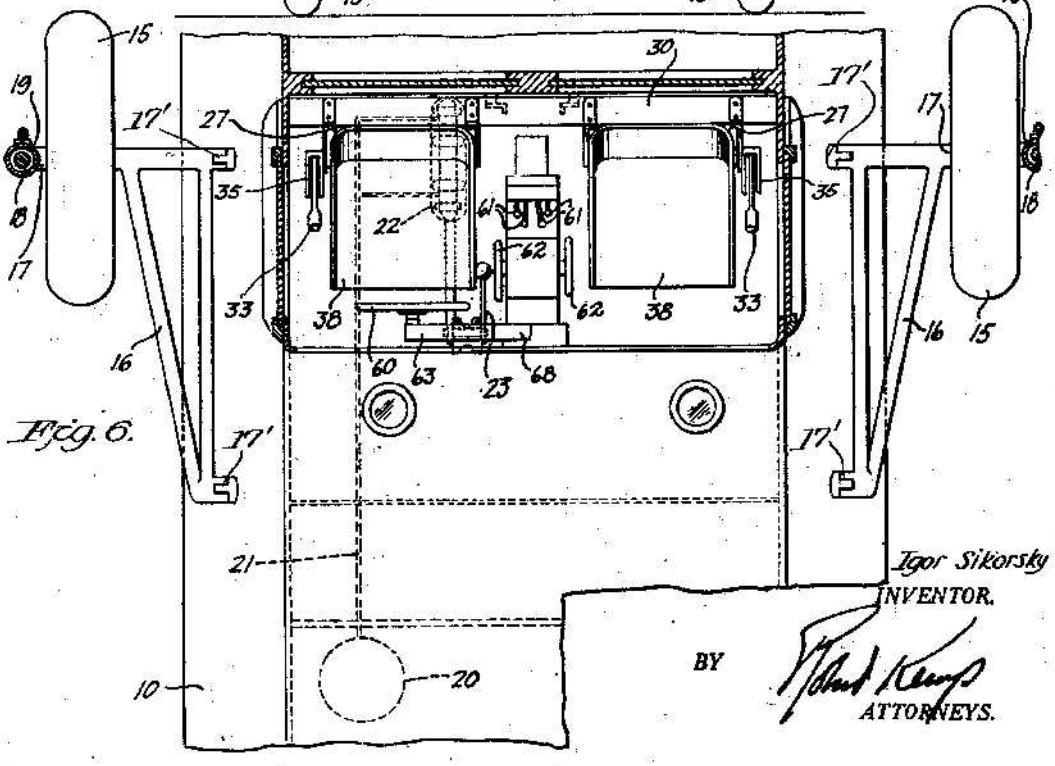


Fig. 6.



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AIRCRAFT, ESPECIALLY AIRCRAFT OF THE DIRECT LIFT AMPHIBIAN TYPE AND MEANS OF CONSTRUCTING AND OPERATING THE SAME

Original Filed Feb. 14, 1929 8 Sheets-Sheet 4

Fig. 7.

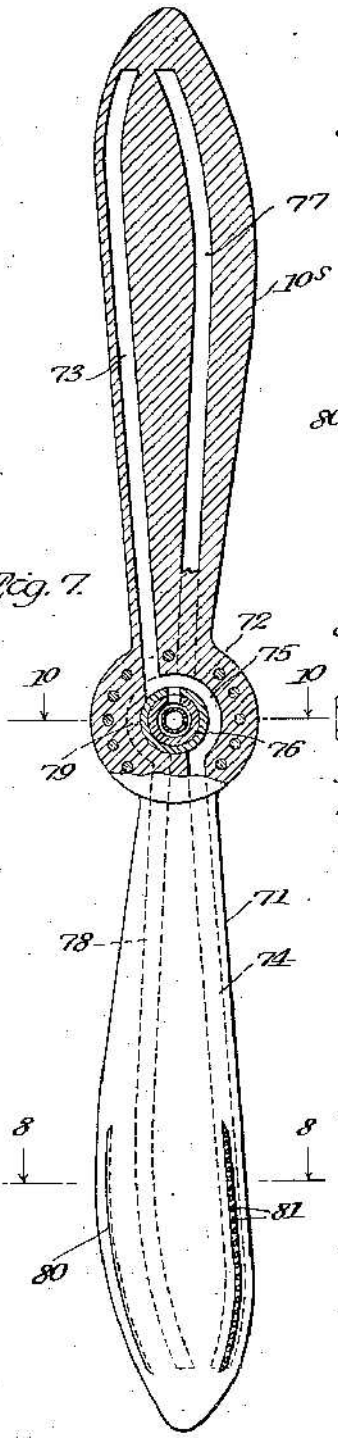


Fig. 8.

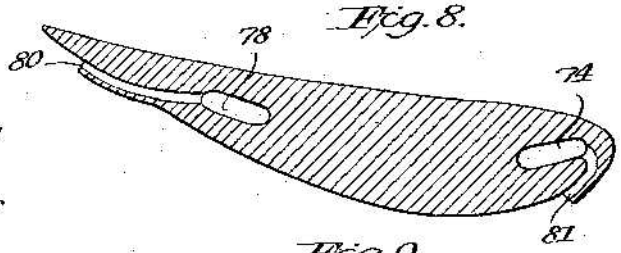


Fig. 9.

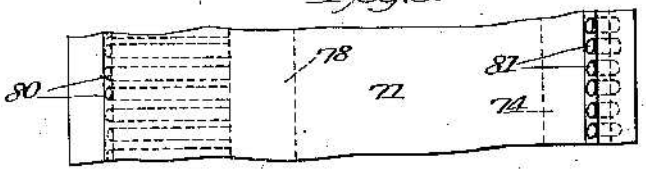


Fig. 10.

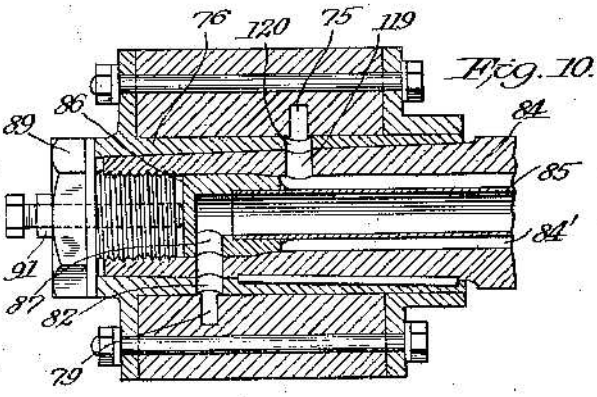
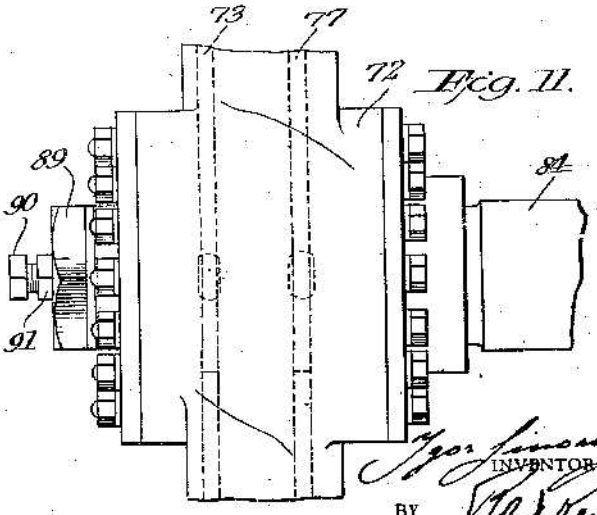


Fig. 11.



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AIRCRAFT, ESPECIALLY AIRCRAFT OF THE DIRECT LIFT AMPHIBIAN TYPE AND MEANS OF CONSTRUCTING AND OPERATING THE SAME

Original Filed Feb. 14, 1929 8 Sheets-Sheet 5

Fig. 12.

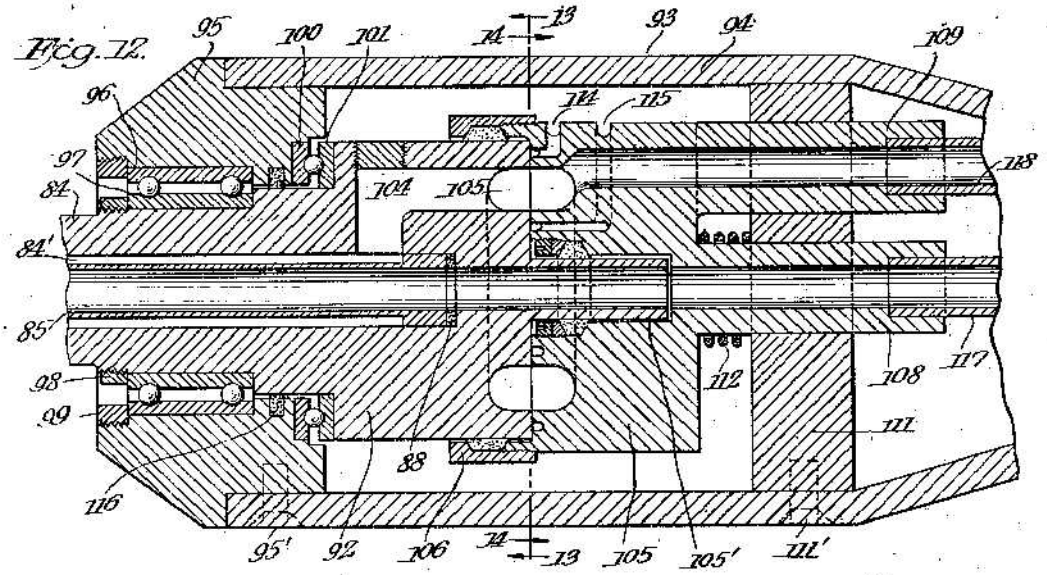

Fig. 15.

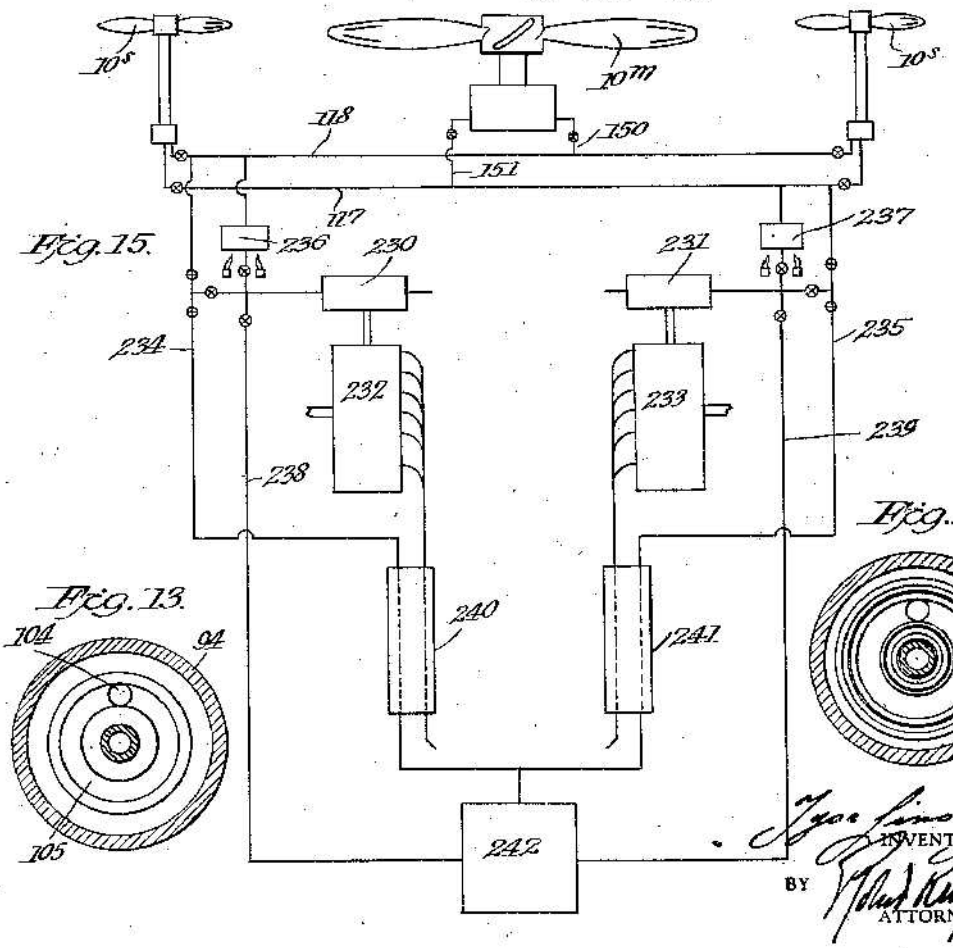

Fig. 13.

Fig. 14.

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AIRCRAFT, ESPECIALLY AIRCRAFT OF THE DIRECT LIFT AMPHIBIAN TYPE AND MEANS OF CONSTRUCTING AND OPERATING THE SAME

Original Filed Feb. 14, 1929 8 Sheets-Sheet 6

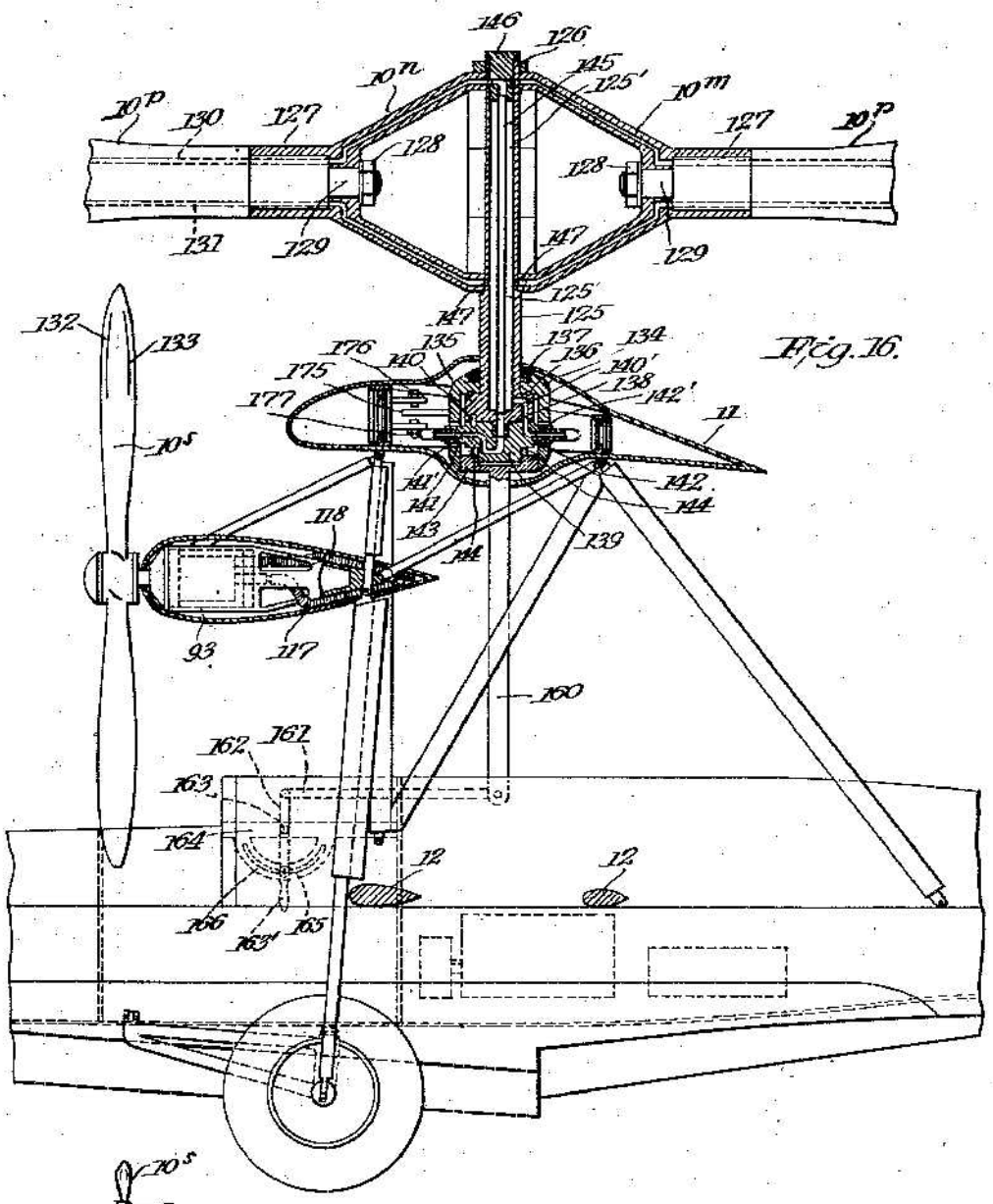

Fig. 16.

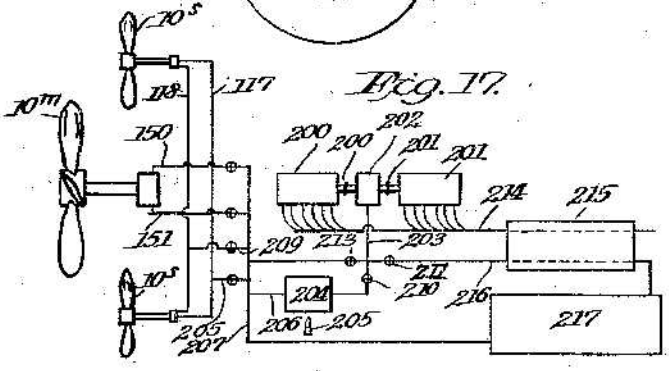

Fig. 17.

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AIRCRAFT, ESPECIALLY AIRCRAFT OF THE DIRECT LIFT AMPHIBIAN TYPE AND MEANS OF CONSTRUCTING AND OPERATING THE SAME

Original Filed Feb. 14, 1929 8 Sheets-Sheet 7

Fig. 18.

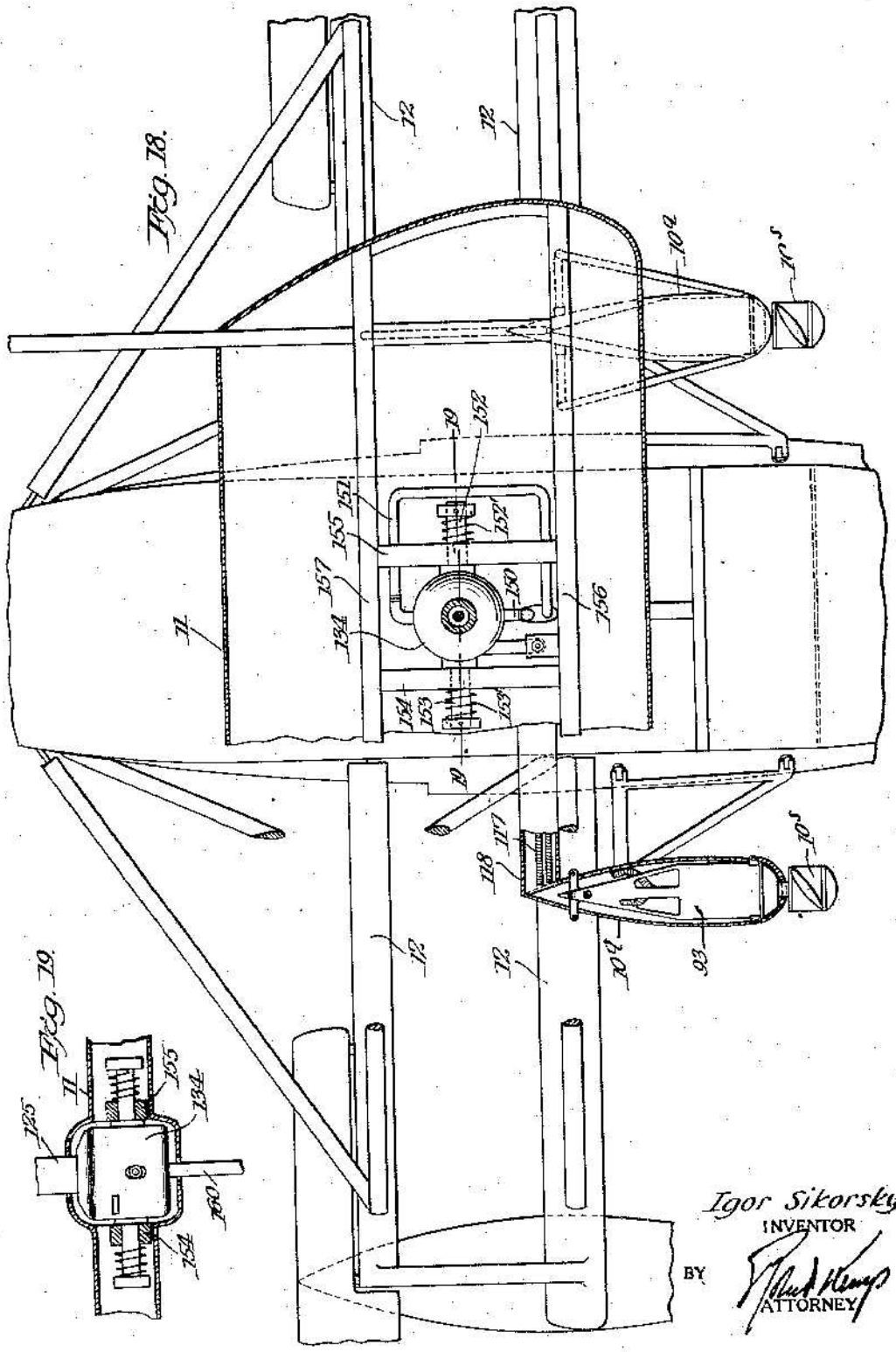

Fig. 19.

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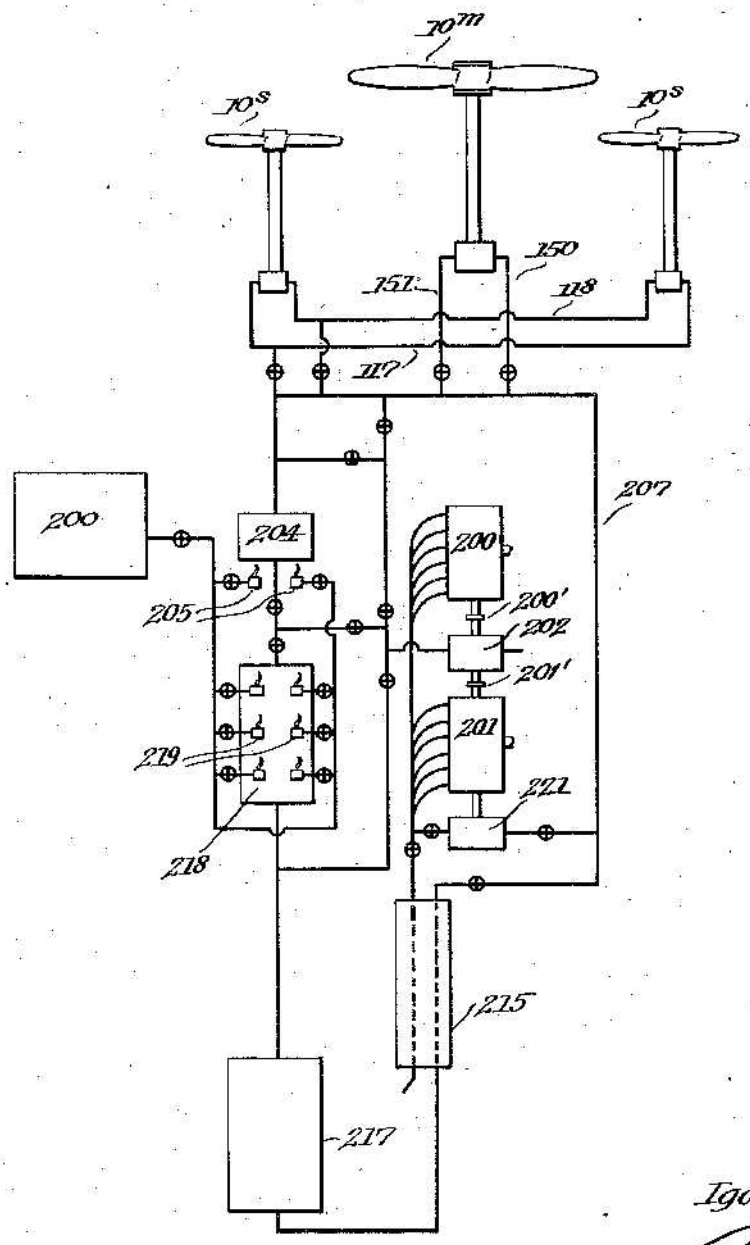
AIRCRAFT, ESPECIALLY AIRCRAFT OF THE DIRECT LIFT AMPHIBIAN TYPE AND MEANS OF CONSTRUCTING AND OPERATING THE SAME

Original Filed Feb. 14, 1929 8 Sheets-Sheet 8

Fig. 20.



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Patented Mar. 8, 1932 1,848,389

UNITED STATES PATENT OFFICE

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AIRCRAFT, ESPECIALLY AIRCRAFT OF THE DIRECT LIFT AMPHIBIAN TYPE AND MEANS OF CONSTRUCTING AND OPERATING THE SAME

Application filed February 14, 1929, Serial No. 339,784. Renewed May 20, 1931.

The present invention relates broadly to aircraft and more particularly to aircraft of the direct lift type.

It concerns a new method of constructing and operating direct lift aircraft in a manner to insure increased safety, maneuverability, comfort and reliability during taking off, flying and alighting operations.

It further contemplates aircraft provided with direct lift driving means which are driven by air or other gases issuing from reaction jets in said driving means.

It also has to do with the position, form and arrangement of the various parts of direct lift aircraft structures, as well as the form, arrangement, relative position, interrelation and details of fixed, movable and adjustable fixtures contained in or forming a part of direct lift aerial vehicles, the relation of said fixtures to each other as well as their relation to other structural elements in said aerial vehicles.

The invention further pertains especially to various combinations of any or all of said above improvements, their application to, or their use on, in, or in connection with individual heavier-than-air aircraft units of the multimotor, land-water-air type, capable of navigating with equal facility on land, water or in the air.

Where the term "aircraft" is used in the present application it includes any form of aerial vehicle capable of navigating through the air. The invention has application to aircraft of the heavier-than-air, lighter-than-air or combination type.

The term, "heavier-than-air aircraft unit of the multimotor, land-water-air type" designates a form of aircraft sometimes known as a "multimotor amphibian."

In one of its aspects the invention has to do specifically with an amplibian provided with a direct lift propeller and a plurality of horizontally acting propellers, all of the propellers being reaction-driven, that is, being rotatable under the reactive force of a fluid medium under pressure discharged through orifices in their blades toward the following edges.

As another feature of the invention an aerofoil of relatively short span is interposed between the direct lift propeller and the horizontally acting propellers. Further, the body of the amphibian supports laterally extending outriggers to which are hinged ailerons and at whose lower sides floats are secured.

The inherent structural characteristics of multimotor amphibians are such as to give rise to large parasitic drag. Consequently, the present invention has particular reference to this type of machine, since by the substitution of small transfer boxes for fluid under pressure in place of the usual engine nacelles, the resistance is greatly reduced with proportionate benefit to the flying characteristics of the machine.

As has been indicated above, in the preferred embodiment of my invention, a single direct lift propeller of large blade area is employed and a plurality of horizontally acting propellers are arranged in symmetrically horizontally spaced relation to the direct lift propeller. Thus by appropriate throttling of the horizontally acting propellers, the torque of the direct lift propeller may be effectively compensated.

The blades of the propellers are provided with orifices adjacent their trailing edges and with orifices adjacent their leading edges discharging toward the trailing edges across their negative or depression sides. The fluid under pressure discharged through the first mentioned orifices imparts rotation to the propellers in which effect the pressure medium discharged through the other set of orifices participates, although this latter is of greater importance as performing a lifting function.

The medium used may be air or air mixed with other gases such as the exhaust gases of internal combustion engines used to drive the air pump. However, I do not limit myself with respect to the nature of the fluid medium which may be any such as may be convenient and practicable.

According to one phase of the invention, the air which is to be supplied to the reaction propellers is first of all mechanically placed under pressure by means of a positive

action air pump or blower, and during its subsequent passage to the propellers, is expanded by application of heat thereto with consequent increase in work capacity. The heating of the air may be accomplished in a number of different ways which will be hereinafter described.

In addition to the mechanical advantages obtained by thus expanding the air, the discharged air serves the purpose of preventing, to a large extent, the formation of ice on the aircraft members.

An embodiment of the invention will be described in detail with reference to the accompanying drawings in which:

Fig. 1 is a plan view of an amphibian constructed in accordance with the present invention.

Fig. 2 is a front elevation of the amphibian.

Fig. 3 is a side elevation of the amphibian.

Fig. 4 is an isometric perspective of the amphibian.

Fig. 5 is an enlarged view in front elevation of the central portion of the amphibian.

Fig. 6 is a section on the line 6—6 of Fig. 3.

Fig. 7 is an elevation of a propeller back, partly in section.

Fig. 8 is a section on line 8—8 of Fig. 7.

Fig. 9 is an enlarged elevation of a portion of the propeller shown in Fig. 7.

Fig. 10 is a section on line 10—10 of Fig. 7.

Fig. 11 is a side elevation of the propeller boss.

Fig. 12 is a longitudinal section through a transfer box for the fluid pressure medium.

Fig 13 is a partial section along line 13—13 of Fig. 12.

Fig. 14 is a partial section along line 14—14 of Fig. 12.

Fig. 15 is a diagram showing one form of arrangement of the units comprising the propulsion system.

Fig. 16 is a section on line 16—16 of Fig. 2.

Fig. 17 is a diagram showing another arrangement of the units comprising the propulsion system.

Fig. 18 is a plan view of a portion of the amphibian with parts in section.

Fig. 19 is a section on line 19—19 of Fig. 18, and

Fig. 20 is a diagram showing a modified arrangement of units comprising the propulsion system.

Referring first to Figs. 1 to 4, 10 designates the body-boat of an amphibian, while 12 designates streamline outriggers, springing laterally from the body-boat and joined together at their outer ends by means of members 10*c* and 10*d*. The rear outriggers have hinged thereto ailerons 10*e* and 10*f*, while floats 10*g* and 10*h* are secured beneath the outer ends of the outriggers. An aerofoil 11 of relatively short span is disposed above the body-boat and interconnected therewith as by struts 10*i*, 10*k* etc.

A shaft 125, normally lying in a vertical line passing through the center of gravity of the machine, supports a direct lift propeller 10*m* here shown as comprising an open framework boss 10*n* and blades 10*p*. Streamline housings 10*q* supported from suspension members 10*r* secured to the lower surface of plane 11 adjacent its ends, encase transfer boxes for the fluid pressure medium, which boxes in turn support shafts on which propellers 10*s* are mounted. Outriggers 10*t* spring rearwardly from plane 11 and support empennage assembly 10*v* at their outer ends. The outriggers 10*t* have a direct connection with the rear end of body-boat 10 through struts 10*w*.

Landing wheels 15, Figs. 2 to 6, may be moved from the operative position shown to an inoperative position in which they lie in horizontal planes immediately below outriggers 12.

Referring particularly to Figs. 5 and 6, it will be seen that the wheel axles 17 are supported on brackets 16 pivotally connected to the body 10 at points 17′ for movement about normally substantially horizontal axes. The outer ends of wheels 17 are pivotally connected to rods 18 guided in tubular members 19 which are in turn pivoted at their upper ends to the frame structure. Rods 18 are provided interiorly of tubular members 19 with piston heads which are adapted to be suitably influenced to move the wheels from operative to inoperative position.

According to the illustrated arrangement, hydraulic pressure is employed for this motive function, the particular fluid medium preferably being oil, glycerine or the like. A supply of the pressure medium is contained in a tank 20 and a conduit 21 leads from the tank to a pressure generating device 22 which is controlled by means of a lever 23. The lines to and from pressure generator 22 are indicated at 25 and lead to a distributor 24 disposed within convenient reach of the pilot in the pilots' compartment 30. Distributor 24 is connected to tubular members 19 by means of pipes 19*a* and 19*b*, the former debouching into the tubular members above the upper limit of travel of the piston heads associated with rods 18, and the latter debouching into said members below the lower limit of travel of the piston heads. Distributor 24 is suitably provided with valves so that fluid may be supplied at will to one or both of conduits 19*a* or to one or both of conduits 19*b* so that the wheels 15 may be correspondingly raised or lowered.

The fluid medium, in addition to acting as an operating agent, has the function of serving as cushioning means when the machine is landed on its wheels.

It will be noted that the pilots' compart-

ment 30 is provided with two chairs 38 placed side by side. Since the arrangement of this compartment and the control devices therein have been particularly described and claimed in my above named applications, it will suffice here to state that the reference numerals 61 indicate the engine control levers, 33 indicates levers cooperating with segments 35 to adjust the seats to various heights and retain them in adjusted position, 62 indicates the stabilizer controls and 60 indicates the aileron control member which has a pivoted extension 63 so supported that it may be swung to bring wheel 60 in front of either chair 38.

In Fig. 7 a propeller 10*s* is shown comprising blades 70 and 71 and boss 72. The leading edge of each blade is provided with a longitudinal passage 73 and 74 respectively, these being joined by an arcuate recess 75 surrounding the propeller hub 76. Each blade has also a longitudinally extending passage 77 and 78 respectively adjacent the following edge, these passages being connected by an arcuate recess 79 similar to 75. For a distance adjacent the blade tips, discharge orifices 80 and 81 are formed, which communicate with passages 78 and 74 respectively. As particularly shown in Fig. 8, the propeller back is stepped downwardly toward its following edge, there being two steps determining respectively the position of orifices 81 and 80. Referring to Fig. 10, hub 76 is provided with an aperture 82 communicating with recess 79. Aperture 82 likewise registers with an aperture 83 formed in the wall of a hollow shaft 84 (see also Fig. 12) to the end of which the propeller hub is keyed. A tube 85, Figs. 10 and 12, is supported concentrically of the bore 84′ of shaft 84 and is closed at its front end, Fig. 10, by means of a cap 86 having an aperture 87 in register with aperture 83. The rear end of tube 85, Fig. 12 is provided with a circumferential flange for the purpose of maintaining the tube in concentric relation to bore 84′, the rear end of tube 85 seating against washer 88. The propeller hub is secured to the end of shaft 84 by means of a cap screw 89 cooperating with threads formed in the end of bore 84′. Cap screw 89 is provided with a threaded axial bore in which engages cap screw 90 which abuts with its inner end cap 86 to hold the latter and tube 85 in proper position. A nut 91 serves to lock cap screw 90 in adjusted position.

The end of shaft 84, remote from the propeller, is provided with an expanded head 92 extending within transfer box 93, Fig. 12. Transfer box 93 comprises a hollow cylindrical member 94 supporting at its end adjacent the propeller a ring 95 which latter and shaft 84 are appropriately shouldered to receive the members 96 and 97 of a ball bearing assembly constituting a journal bearing for the propeller shaft, members 96 and 97 being respectively held in position by means of rings 98 and 99.

The adjacent vertical faces of ring 95 and head 92 support members 100 and 101 of a ball bearing assembly which constitutes the thrust bearing. Ring 95 is rigidly secured to casing 94 by means of screws such as shown at 95′.

The rear face of head 92 is provided with an annular recess 105 concentric with bore 84′. This recess communicates by means of an angular passage 104 with bore 84′ forward of the flanged head of tube 85. A fitting 105 has a face adapted to contact with the rear face of head 92, this member being provided with a circumferential flange circumscribing the rear margin of head 92 and cooperating with ring 106 to form a packing gland. Member 105 is provided with a bore 105′ into which a central tubular extension 102 of head 92 projects and a packing gland 106′ is provided to effect a tight fit between the extension and bore 105′. Member 105 is provided with a rearward tubular extension 108 concentric with bore 105′ and also with an eccentric rearward extension 109 provided with a bore which communicates with an annular recess 110 registering with recess 103. Extensions 108 and 109 pass through closely fitting apertures in a wall 111 secured within casing 94 by means of screws such as shown at 111′, the casing tapering off rearward of wall 111. Rotation of fitting 105 about extension 108 is prevented by the eccentric extension 109, although axial movement of the fitting relative to wall 111 is permitted. A spring 112 yieldingly urges fitting 105 against head 92.

In practice, the interior of the casing will be filled with oil, the contacting faces of members 92 and 105 receiving lubricants through ducts 114 and 115. The escape of the oil from the forward end of the casing is prevented by a gasket 116. The fluid medium under pressure is supplied to the hollow stem 108 through a preferably flexible tube 117 which leads from air air pump preferably disposed in the body-boat. The air thus supplied passes through head 92, tube 85, apertures 87, 83, 82, recess 79 and passages 77 and 78 to discharge orifices 80. Air conducted to tubular extension 109 through pipe 118 flows into the registering annular recesses 110 and 103, passage 104, bore 84′, an aperture 119 in shaft 84, an aperture 120 in hub 76, recess 75 and passages 73 and 74 to discharge orifices 80.

The transfer boxes 93, as has been mentioned above, are disposed in streamline housings 10*q* and rigidly secured in position through struts 10*r*. Pipes 117 and 118 (see also Figs. 16 and 18) are preferably led to the transfer boxes through the streamline conduits 121, 122 and 123, Fig. 5, which likewise house tubes 19*a* and 19*b*. All conduits,

connections and other passages arranged to lead air to horizontal left side propeller 10*s* are also duplicated preferably in a symmetrical fashion for the same purpose of supplying air to right side propeller 10*s*.

The direct lift propeller 10*m* will now be described with particular reference to Figs. 1 to 4, 16, 18 and 19.

Referring particularly to Fig. 16, it will be seen that the propeller boss 10*n* consists of crossed loop-shaped members mounted at their crossed portions on a hollow vertical shaft 125. The lower members of the loops bear against a shoulder 125′, while a nut 126 secures them in position on the shaft. Blades 10*p* are secured in ferrules 127 integral with the loops and extending radially relatively to shaft 125. The propeller blades are secured in position by means of nuts 128 screwed to their stems 129. It will be seen that each blade is supported at an apex of a substantially triangular frame, the opposite triangular frames forming an integral frame of symmetrical substantially rhomboidal shape, these closed frames having major and minor axes, the propeller blades being in alignment with the major axis, while the frame is supported for rotation about its minor axis. The described arrangement gives a particularly rigid construction in that the boss has a large axial extent and supports the blades at a considerable distance from its rotational axis.

As shown in Fig. 16, the frame members of the boss are hollow and communicate with longitudinally extending passages 130 and 131 formed in the blades. Passage 130 communicates with orifices 132 in the leading edge of the blades, while passages 131 communicate with orifices 133 in the trailing edges in the same manner as has been described in connection with propeller 10*s*.

The lower end of shaft 125 is disposed in a transfer box 134 which is supported in aerofoil 11, the latter having a central vertically expanded portion for the accommodation of the box. Shaft 125 has an expanded head 135 interiorly of the transfer box and forms a thrust member cooperating with the latter through balls 136. A ball bearing journal support is indicated at 137. The lower face of head 135 is provided with an extension 138 which mates with a recess formed in the face of a fitting 139, the extension and recess being concentric with bore 125′ of shaft 125. The contacting faces of head 135 and member 139 are provided with registering annular recesses concentric with extension 138 and forming together a tubular duct 140. At diametrically opposite points member 139 is provided with arms 141 and 142 which extend through slots formed in the side walls of box 134, these slots extending in the axial direction of shaft 125. The engagement of extensions 141 and 142 with the walls of the slots prevents rotation of member 139 relative to box 134, although axial movement is permitted. The lower end of the box is closed by means of a cap 143 and between the latter and member 35 are interposed compression springs 144 which yieldingly urge member 139 against head 135.

Extension 141 has formed therein a passage 141′ which through extension 138, a tube 145 and passages in a block 146 in register with the passages formed in the upper frame members, communicates with blade passages 130. Extension 142 has a passage 142′ communicating with chamber 140 and thence through a passage 140′ with bore 125′. Bore 125′ communicates by means of apertures 147 with the passages of the lower frame members of boss 10*n* and thence with the blade passages 131. Extensions 141 and 142 are connected by means of flexible tubing 150 and 151 with the blower, tubes 150 and 151 being passed downwardly to the blower through the streamline conduit 121.

Box 134, Fig. 18, is provided on diametrically opposite sides with trunnions 152 and 153 supported in members 154 and 155 which are mounted between the front and rear spars 156 and 157 of aerofoil 11. Oppositely acting torsion springs 152′ and 153′ tend to maintain shaft 125 in a constant position relative to members 154 and 155, this position being vertical when the machine is in operation.

Extending downwardly from cap 143, Fig. 16, is a rod 160 which at its lower end is connected by means of a link 161 to a lever 162 pivotally mounted at 163 to a frame 164 disposed in the pilots' compartment. Lever 162 is provided with a handle 163 within easy reach of the pilot and may be locked in adjusted position by means of a threaded stud and nut 165 which cooperate with a slotted segment 166. Movement of handle 163 causes a corresponding movement of box 134 about its trunnions and consequently a tilting movement of shaft 125 in a fore and aft direction. It will be noted that the covering of aerofoil 11 is provided with top and bottom slots to permit free movement of shaft 125 and rod 160.

According to the described arrangement, shaft 125 may be adjusted from a vertical position in which propeller 10*m* exerts a purely vertical force, to a forwardly tilted position in which a forwardly acting resultant is obtained. The tilting movement of box 134 is limited by means of an arm 175 fixed thereto and cooperating with adjustable abutments 176 and 177.

In Fig. 17, I have shown a layout of one form of an entire propulsion system. In this figure numerals 200 and 201 denote internal combustion engines operating a positive action pump or blower 202 through the intermediary of clutches 200′ and 201′. A line 203 connects the outlet of the blower with a chamber 204 adapted to be heated by means

of a burner 205. Chamber 204 communicates by means of a line 206 with a line 207 from which branches 208 and 209 lead respectively to lines 117 and 118, which feed the horizontally acting propellers 10*s*. Branches 150 and 151 feed the direct lift propeller 10*m*.

By closing valves 210 and 211, the air may be passed directly through line 212, valve 213 being open, to line 207. The exhaust of both engines is led into a line 214 which passes through a heat exchanger 215 through which likewise passes a line 216, which through an air expansion chamber or reservoir 217 is in communication with line 207. By opening valve 211 and closing valves 210 and 213, air from the blower may be passed through the heat exchanger, the reservoir and line 207 to the propellers.

Thus, it will be seen that blower 202 may be operated by one or the other of motors 200 or 201 or by both of them and that the air therefrom may be led directly to line 207 and thence to the propellers, or may be warmed by passage through chamber 204, or may be warmed by passage through chamber 215 and then led to the propellers.

The layout according to Fig. 20 is generally similar to that of Fig. 17, although according to this figure, the air may be passed additionally through a chamber 218 in direct contact with burners 219, both the latter and burners 205 being supplied with fuel from a tank 220. Further, according to this showing, the exhaust may be by-passed through a blower 221 into line 207. It is obvious that various combinations are possible through the proper manipulation of the illustrated valves and it is not believed that further description is necessary.

According to Fig. 15, two blowers 230 and 231 are provided, each being driven by an independent internal combustion engine 232 and 233. Blowers 230 and 231 may discharge directly into lines 234 and 235 and thence to lines 117, 118, 150 and 151 to supply the propellers. By suitable manipulation of the valves, however, the blowers may be connected directly through heated chambers 236 and 237, to lines 117 and 118. By a further manipulation of the valves, the air from the blowers may be diverted into lines 238 and 239 to reservoir 242 and thence through heat exchangers 240 and 241 to lines 234 and 235. According to this arrangement, one blower alone may supply line 117 and the other line 118, or one blower alone may supply both lines.

While I have described my invention with some particularity, it is to be understood that I do not intend to restrict myself except as determined in the following claims.

I claim:

1. In an aircraft, a direct lift reaction driven propeller, a rotatable vertical shaft on which the propeller is mounted, an aerofoil beneath said propeller and a transfer box for a fluid medium under pressure and including bearing means for said shaft disposed in said aerofoil.

2. In an aircraft, a direct lift reaction driven propeller, a rotatable vertical shaft on which the propeller is mounted, an aerofoil beneath said propeller, a transfer box for fluid medium under pressure and including bearing means for said shaft disposed in said aerofoil, and mounting means for said box to enable it to tilt to move the shaft relative to said aerofoil out of its normal vertical position.

3. In an aircraft, a direct lift reaction driven propeller, a rotatable vertical shaft on which the propeller is mounted, an aerofoil beneath said propeller, a transfer box for fluid medium under pressure and including bearing means for said shaft disposed in said aerofoil, and mounting means for said box to enable it to tilt to move the shaft relative to said aerofoil out of its normal vertical position in a fore and aft direction.

4. In an aircraft, a direct lift reaction driven propeller, a rotatable vertical shaft on which the propeller is mounted, an aerofoil beneath said propeller, a transfer box for fluid medium under pressure and including bearing means for said shaft disposed in said aerofoil, trunnions supporting said box for tilting relative to said aerofoil in a fore and aft direction, and means operable to tilt said box.

5. In an aircraft, a reaction driven direct lift propeller comprising an open framework boss and hollow blades secured thereto, said framework comprising hollow members adapted to conduct a fluid medium under pressure to said hollow blades.

6. In an aircraft, a direct lift propeller comprising a boss in the form of a plurality of crossed loop-like frames, a shaft supporting said frames at their crossed portions, and blades extending radially relative to said shaft and secured to said frame.

7. In an aircraft, a body, an outrigger extending laterally from each side of the body, an aileron hinged to each outrigger, an aerofoil of relatively short span above the body and secured thereto and to the outriggers, a rearwardly extending outrigger springing from said aerofoil and supporting an empennage assembly, a direct lift propeller above the aerofoil, and a horizontally-acting propeller intermediate the aerofoil and body.

8. In an aircraft, a body, an outrigger extending laterally from each side of the body, an aileron hinged to each outrigger, an aerofoil of relatively short span above the body and secured thereto and to the outriggers, a rearwardly extending outrigger springing from said aerofoil and supporting an empennage assembly, a direct lift propeller above the aerofoil, and a plurality of longitudinally

spaced horizontally-acting propellers intermediate the aerofoil and body and symmetrically disposed relative to the direct lift propeller.

9. In an amphibian, a body, an outrigger extending laterally from each side of the body, an aileron hinged to each outrigger, a float secured to each outrigger, an aerofoil of relatively short span above the body and secured thereto and to the outriggers, a rearwardly extending outrigger springing from said aerofoil and supporting an empennage assembly, a direct lift propeller above the aerofoil, and a horizontally-acting propeller intermediate the aerofoil and body.

10. In an amphibian, a body, an outrigger extending laterally from each side of the body, an aileron hinged to each outrigger, a float secured to each outrigger, an aerofoil of relatively short span above the body and secured thereto and to the outriggers, a rearwardly extending outrigger springing from said aerofoil and supporting an empennage assembly, a direct lift propeller above the aerofoil, and a plurality of horizontally spaced horizontally-acting propellers intermediate the aerofoil and body and symmetrically disposed relative to the direct lift propeller.

11. In an aircraft, a direct lift propeller comprising a blade provided with reaction jets adjacent its following edge and jets adjacent its leading edge discharging over the top of the blade toward its following edge, said blade having separate passages therein leading to the respective jets, a substantially triangular frame element supporting said blade at an apex, the legs of said frame adjacent said apex being hollow and communicating respectively with said passages.

12. In an aircraft, a reaction-driven propeller, a blower, a plurality of internal combustion engines adapted to drive said blower either singly or in conjunction, a common conduit for the exhaust of said engines, and an airline connecting said blower and propeller and passing in heat-exchanging relation with said conduit.

13. In an aircraft, a reaction-driven propeller, a motor-driven air blower, an externally heated chamber and an internally heated chamber, and means to connect said blower and propeller through either of said chambers or through both of said chambers in either order.

14. In an aircraft, a reaction driven propeller, a blower, an internal combustion engine driving said blower, an externally heated chamber and an internally heated chamber, and means to connect said blower and propeller through either of said chambers or through both of said chambers in either order and in heat-exchanging relation with the engine exhaust.

15. In an aircraft, a reaction-driven propeller, a blower, a plurality of internal combustion engines adapted to drive said blower either singly or in conjunction, a common conduit for the exhaust of said engines, an airline connecting said blower and propeller, a second blower driven by one of said engines and having an inlet connectible with said conduit, the outlet of said second blower being connectible with said line whereby the exhaust gases may be injected into the latter.

Signed at College Point, Long Island, in the county of Queens and State of New York this 21st day of December, A. D. 1928.

IGOR SIKORSKY.

Nov. 14, 1972 M. A. FAGET 3,702,688

SPACE SHUTTLE VEHICLE AND SYSTEM

Filed Jan. 4, 1971 6 Sheets-Sheet 1

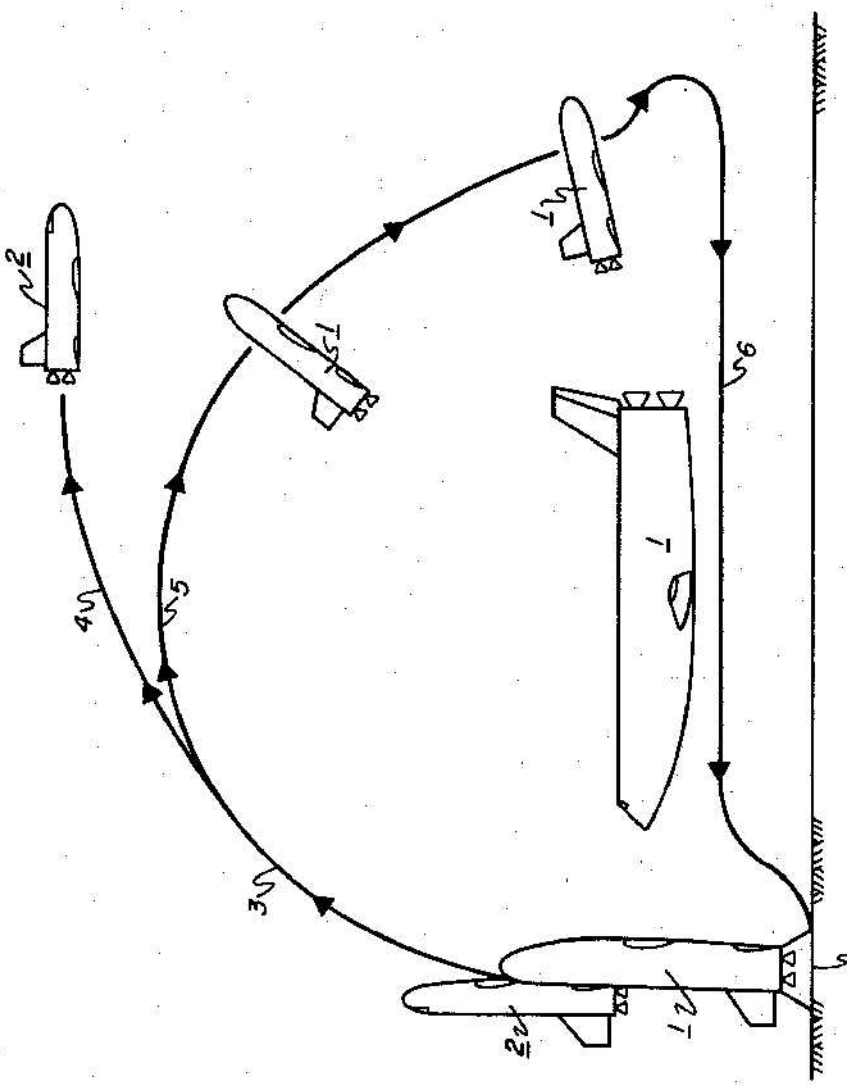

Fig. 1

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SPACE SHUTTLE VEHICLE AND SYSTEM

Filed Jan. 4, 1971 6 Sheets-Sheet 2

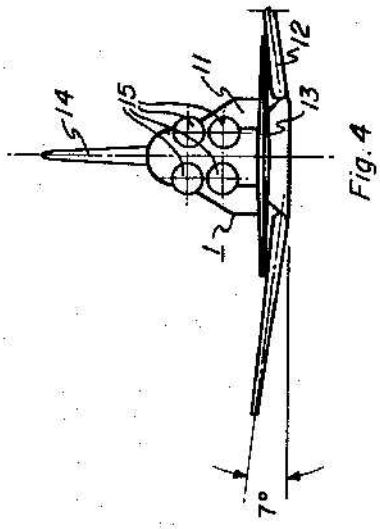

Fig. 4

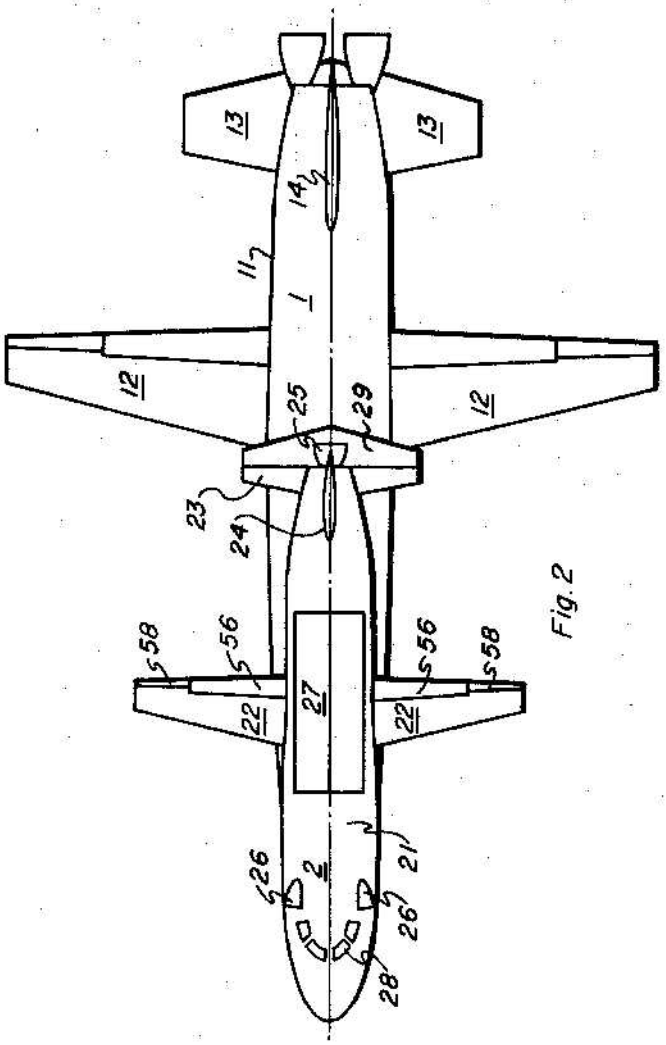

Fig. 2

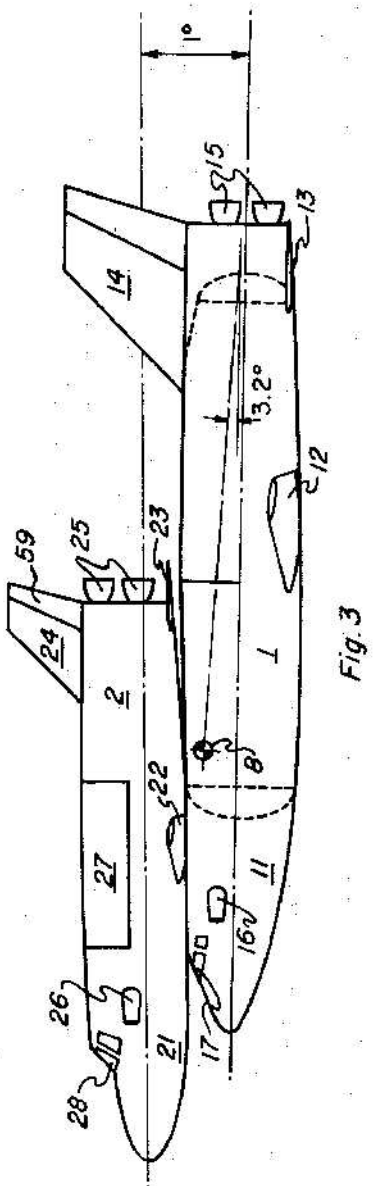

Fig. 3

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SPACE SHUTTLE VEHICLE AND SYSTEM

Filed Jan. 4, 1971 6 Sheets-Sheet 3

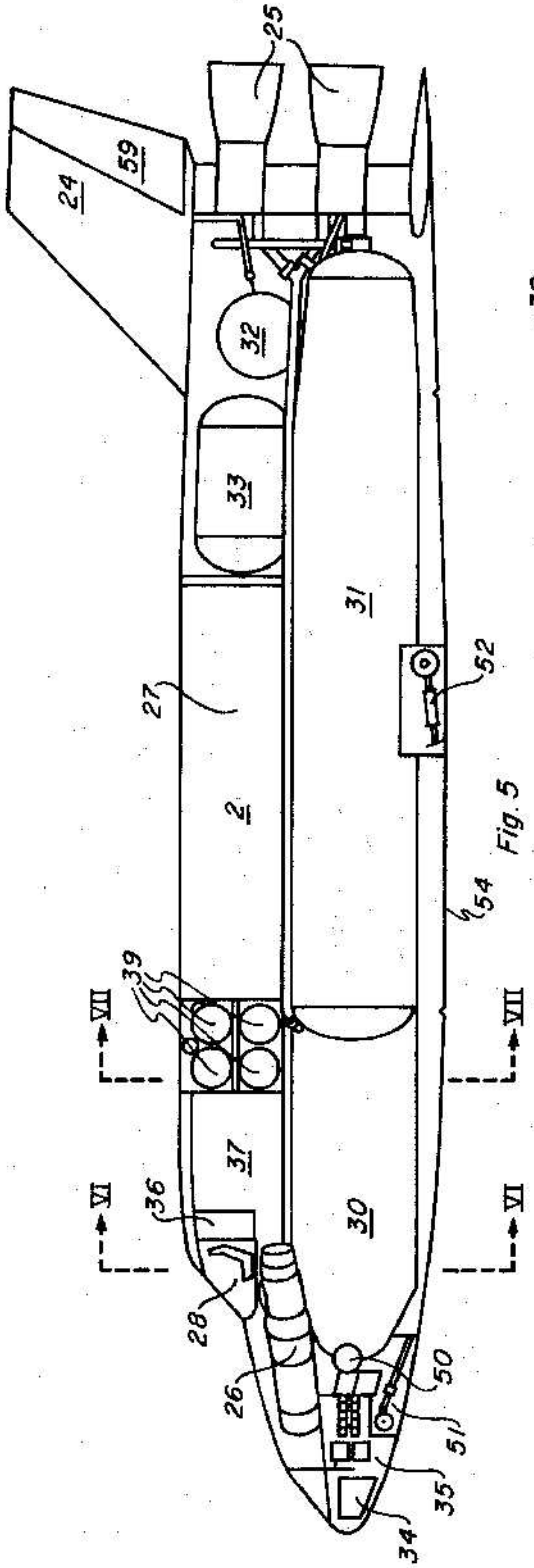

Fig. 5

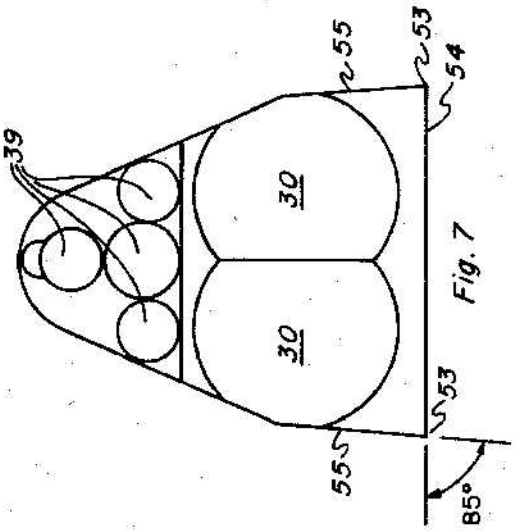

Fig. 7

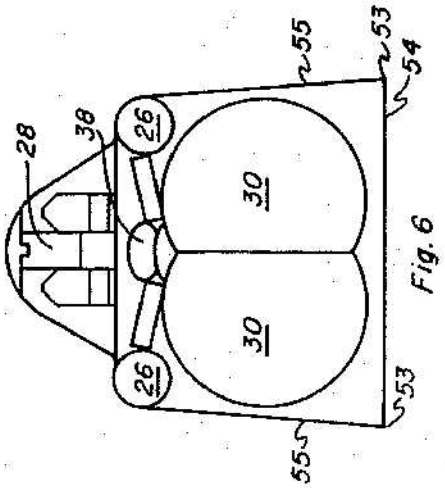

Fig. 6

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SPACE SHUTTLE VEHICLE AND SYSTEM

Filed Jan. 4, 1971 6 Sheets-Sheet 4

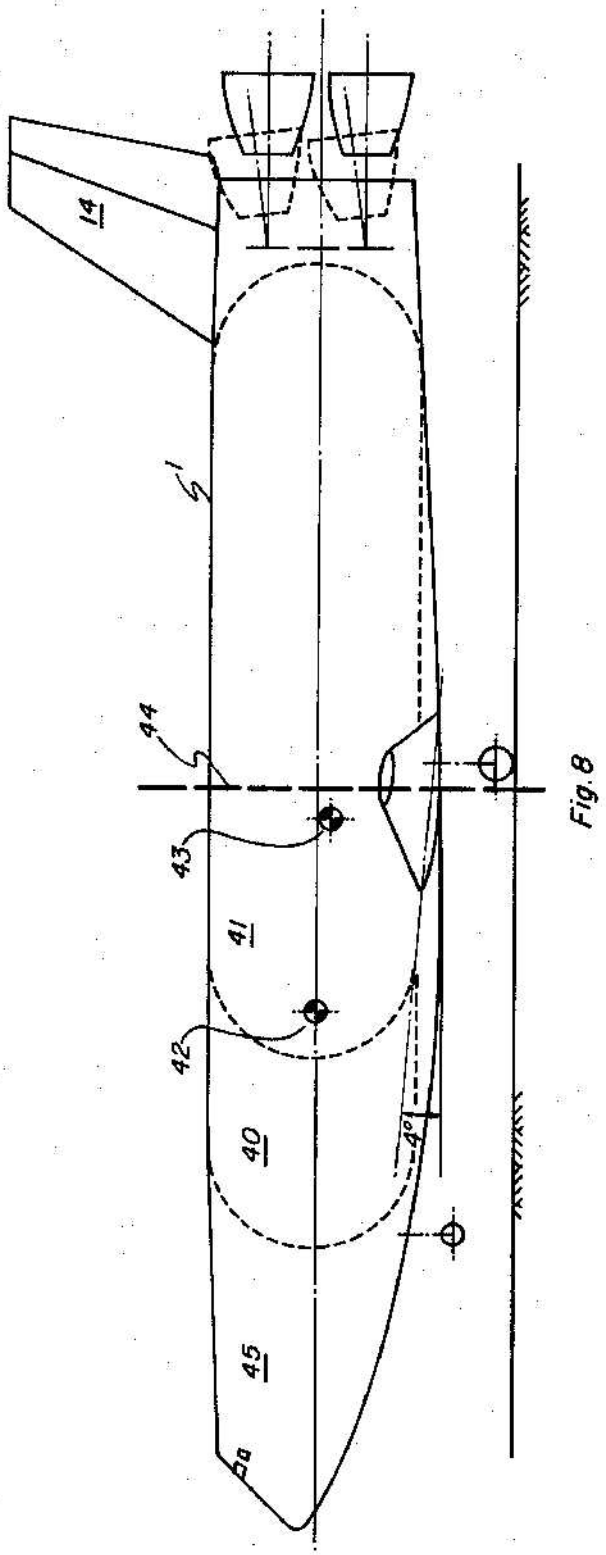

Fig. 8

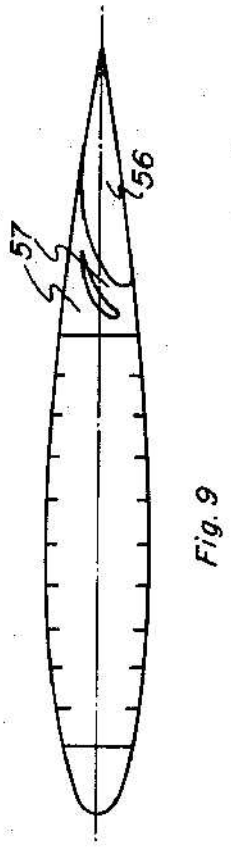

Fig. 9

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SPACE SHUTTLE VEHICLE AND SYSTEM

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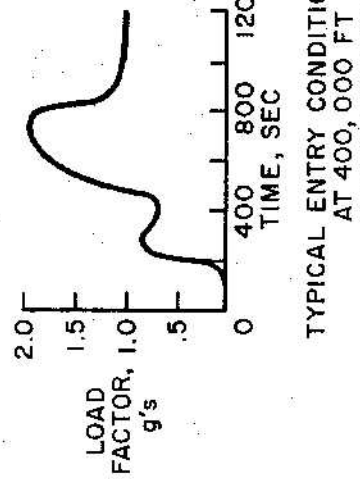

TYPICAL ENTRY CONDITIONS
AT 400,000 FT
V_I = 25,980 FPS

Fig. 11

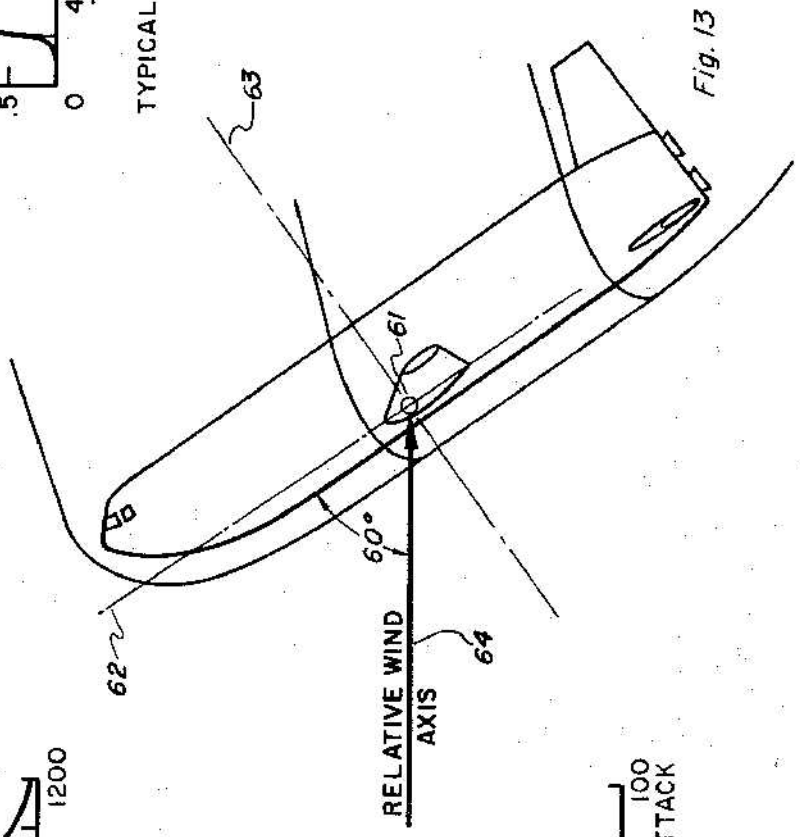

Fig. 13

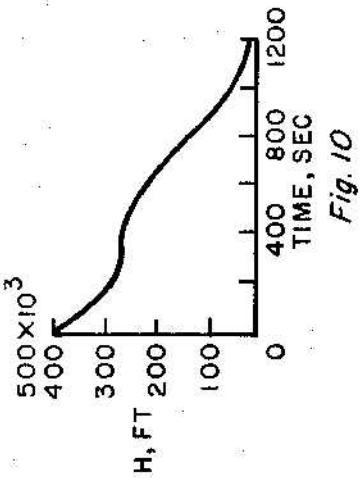

Fig. 10

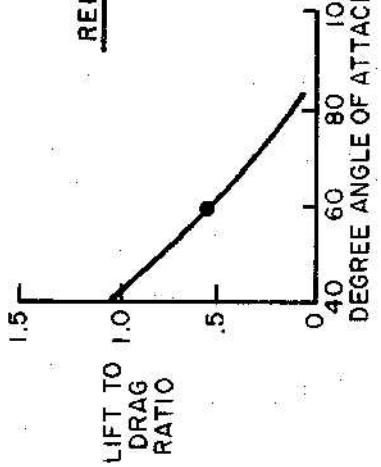

Fig. 12

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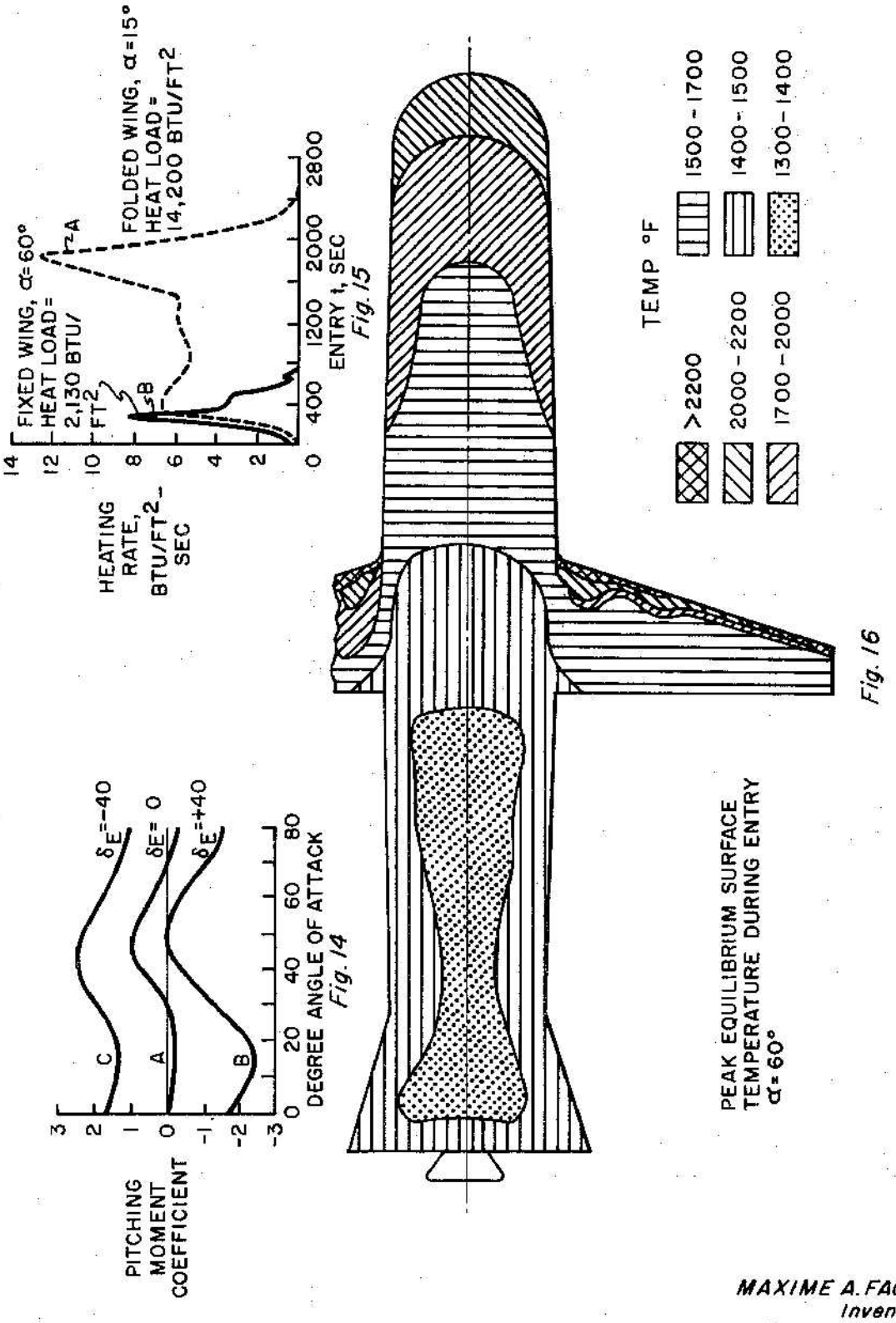
SPACE SHUTTLE VEHICLE AND SYSTEM

Filed Jan. 4, 1971 6 Sheets-Sheet 6



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United States Patent Office 3,702,688
Patented Nov. 14, 1972

3,702,688

SPACE SHUTTLE VEHICLE AND SYSTEM

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Filed Jan. 4, 1971, Ser. No. 103,551
Int. Cl. B64c 37/02
U.S. Cl. 244—155 17 Claims

ABSTRACT OF THE DISCLOSURE

A space shuttle system comprising two reusable stages, joined "piggyback" fashion for lift-off, each stage being a manual attitude controlled vehicle having fixed, aerodynamic support and control surfaces for horizontal atmospheric flight and conventional, near stall, aircraft landings. The fuselage bottom surface of each stage is transversely relatively flat and longitudinally cambered to provide dynamic lift at hypersonic atmosphere re-entry velocities and high angles of attack. Newtonian fluid flow states over bottom surfaces and the dispersion of flow stagnation regions over large areas hold vehicle surface temperatures during re-entry to tolerable levels. Other aerodynamic criteria are balanced so that each stage will have stable flight characteristics at both high and low attack angle attitudes during both the re-entry and the subsonic atmospheric flight phases.

ORIGIN OF THE INVENTION

The invention described herein was made by an employee of the United States Government and may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

BACKGROUND OF THE INVENTION

(1) Field of the invention

The present invention relates to aerospace vehicles suitable for carrying substantial payloads beyond the earth's atmosphere and for return therefrom.

Also disclosed is a technique of combining at least two reusable aero-space vehicles of the type described for the launch of large payloads to earth orbital altitudes and beyond.

Moreover, the present invention contemplates a logistical support method for constructing and sustaining artificial satellites in orbit.

(2) Description of the prior art

Historically, rocket propelled vehicles have been, for the most part, unmanned ballistic devices. Flight path control has been largely limited to the ascent trajectory; the sensory function of control being performed by pre-programmed, automatic, inertial guidance systems. So long as the exclusive purpose of a rocket shot was to occasionally deliver an inanimate and expendable article to the outer reaches of the atmosphere or the depths of space, such one-way transit was satisfactory and practicable.

With the advent of human activity in space, however, it became necessary to devise reliable return devices and techniques. Such techniques include that of U.S. Pat. No. 3,093,346 to M. A. Faget et al., which discloses a space capsule for human occupancy of the type used in the manned ventures beyond the earth's atmosphere to date. Although vehicles of the Faget et al. type have proven most satisfactory for early space missions of limited scope, such craft have relatively little lateral maneuverability after re-entry into the atmosphere and are incapable of controlled, horizontal landing. Accordingly, precise landing points are impossible to predetermine and parachutes are necessary for the final few hundred feet of descent.

The next generation of space activity will be focused on the construction and support of large manned satellites or interplanetary vehicles. Since the present and foreseeable future states of the space vehicle propulsion art are restricted by practical payload limits and costs, multiple freight and passenger sorties are therefore necessary. Accordingly, the past practice of a large inventory of single mission, expendable vehicles in various sizes, is a luxury that can no longer be tolerated. Specifically, it is necessary to reduce both payload costs and increase operational flexibility.

To achieve this end, it is necessary to develop vehicles having operational efficiencies equally high in both space and atmospheric phases. Such vehicles must be capable of carrying large payloads to orbital altitudes; non-destructively surviving re-entry stresses; sufficient aerodynamic flight characteristics (including stability and control) to land at a predetermined point without external assistance; and minimum service, fueling, and preparation down-time antecedent to re-deployment.

Among the concepts suggested by the prior patent art and other literature are the disclosures of: Phillips, U.S. Pat. No. 3,104,079, a fixed delta wing vehicle having stowable auxiliary lifting surfaces and elevons; Kehlet et al., U.S. Pat. No. 3,090,580, a lenticular vehicle having stowable aerodynamic control surfaces; and Eggers et al., U.S. Pat. No. 3,276,722, a "lifting body" vehicle. Common limitations of these vehicles, however, are development and operational costs and the fact that they are not suitable for first stage booster service.

Another prior art concept is that of U.S. Pat. No. 3,369,771 to Walley et al., which is directed to a particular recoverable booster design and system of multiple stage deployment. The Walley et al. invention includes a delta winged booster vehicle having a lifting body fuselage that may be used in one of several launch modes as either a booster or orbiter craft. Although the mission objective of Walley et al. is similar to that of the present disclosure, the distinctions between respective vehicles are of a substantial and primary nature for reasons to subsequently be made more apparent.

SUMMARY OF THE INVENTION

The present invention describes primary vehicle design and operational parameters of a reusable shuttle system for transport of passengers and cargo from the earth's surface to orbit and return. Such spacecraft parameters specify a conventionally appearing aircraft having fixed wing panels and empennage secured in fixed position to a voluminous fuselage. Total area of the vehicle bottom profile is substantially equally divided between the fuselage and the wing-empennage group. Particularly distinctive from the prior art is the fuselage bottom geometry. For reasons of stability and surface heat distribution, the fuselage bottom is relatively transversely flat, forming relatively small radius chines at the juncture with the side panels. Moreover, the interior angle formed between the mean planes of said bottom and side panels is less than 90°.

A unique aerodynamic characteristic of the fixed geometry vehicle disclosed herein is that the stabilizing forces about the three stability axes remain relatively constant throughout the re-entry regime from high hypersonic, high angle of attack to low subsonic, low angle of attack without anomalous moments and interactions in the middle Mach numbers and transonic flight regions. Such moment anomalies and instability interactions are common to all winged and lifting body vehicles previously

proposed as re-entry configurations. This characteristic is exploited by the subject vehicle to provide simple, straightforward control—one control means for re-entry and one for subsonic flight.

Contributing criteria to the aforedescribed characteristic are that the subject vehicle have both high and low angle of attack trim stability in both hypersonic and subsonic flight phases and sufficient pitch control to drive the vehicle from one stable attitude to the other. More particularly, as determined about the vehicle axes, the present invention provides for positive static roll, pitch, and yaw stability throughout the operational velocity regime. As resolved about the re-entry trajectory axis, however, i.e., an axis parallel with the relative wind, the subject vehicle has neutral static yaw stability.

Longitudinally, the fuselage bottom is ski-shaped. At the high attack angle trim point, where the wings and empennage are fully stalled, lift per unit area of fuselage is substantially equal to that of the wing-empennage group.

When used as a space transport system, two vehicles having the foregoing characteristics are joined together as first and second stages. More appropriately, the larger, first stage vehicle will hereafter be identified as the booster and the smaller, second stage vehicle as the orbiter, either of which may be characterized as a "shuttle vehicle." Relative assembly of the two vehicles for launching is to secure the orbiter bottom to the booster top, well forward of the booster pitch axis. Such disposition provides straightforward staging with good provisions for launch-load transmission between stages.

Initial ascent of the compound vehicle from an earth base is from the vertical launch position. Ascent power is provided by rocket engines positioned in the booster fuselage extreme aft end. For a launch weight of approximately 2.5 million lbs. and 25,000 lbs. orbit payload weight, staging should occur at approximately 10,000 f.p.s. While the orbiter vehicle continues under independent rocket power, the booster re-enters the atmosphere, decelerates to subsonic velocity, and makes a transitional maneuver into subsonic flight. It then either glides or cruises under turbojet power, back to land at the launch site.

The orbiter ascent trajectory delivers the loaded vehicle to the altitude and velocity vector definitive of the desired orbit where the primary engines are extinguished. While in orbit, the orbiter payload is removed. If a previously orbiting payload is to be returned to earth, said returning payload is positioned within the orbiter bay or appropriately attached to the orbiter top side. Retro engines are momentarily started to decelerate the vehicle to an acceptable re-entry velocity. Re-entry, transition and return flight of the orbiter is similar to that of the booster.

In this manner, many payload types such as satellites or sub-components of large structures such as permanent space stations or interplanetary vehicles may be placed in orbit by repeated sorties of the same shuttle vehicles. Of paramount significance is the fact that no structural portion of the delivery system is expended or abandoned. Moreover, substantial savings over prior systems may be gained in the developmental phase of the present invention by virtue of the fact that subsonic flight tests may be initiated from conventional airport takeoffs. Expendable prototypes for high altitude, vertical launch tests are eliminated. It is entirely possible that an original prototype may evolve into an operational "line" item.

BRIEF DESCRIPTION OF THE DRAWINGS

Relative to the drawings wherein like reference characters designate like or corresponding parts throughout the several views;

FIG. 1 is a schematic representation of the invention vehicles and method of deployment;

FIG. 2 is a plan view of the booster and orbiter vehicles combined in ascent configuration;

FIG. 3 is a side elevation view of the booster and orbiter vehicles combined in ascent configuration;

FIG. 4 is an aft end elevation of the booster vehicle;

FIG. 5 is a schematic cross-sectional side elevation of the orbiter vehicle;

FIG. 6 is a schematic cross-sectional end elevation of the orbiter vehicle taken from plane VI—VI of FIG. 5;

FIG. 7 is a schematic cross-sectional end elevation of the orbiter vehicle taken from plane VII—VII of FIG. 5;

FIG. 8 is a schematic cross-sectional side elevation of the booster vehicle;

FIG. 9 is a cross-sectional end elevation of a typical shuttle vehicle wing;

FIG. 10 is a graph representing the locus of altitude-time coordinates during a typical atmospheric re-entry of a shuttle vehicle;

FIG. 11 is a graph representing the locus of deceleration force-time coordinates during a typical atmospheric re-entry of a shuttle vehicle;

FIG. 12 is a graph representing the locus of lift/drag-attack angle coordinates of a typical shuttle vehicle;

FIG. 13 is a schematic representation of a shuttle vehicle in the initial atmospheric entry phase depicting pitch attitude and fluid flow pattern;

FIG. 14 is a graph representing the locus of pitching moment coefficient-attack angle coordinates respective to three positions of the vertical stabilizer;

FIG. 15 is a graph representing the locus of shuttle vehicle surface heating rate-time coordinates during a typical atmospheric re-entry of two shuttle vehicle designs having different L/D characteristics; and

FIG. 16 is a schematic bottom plan of a shuttle vehicle depicting the re-entry heat distribution.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Due to mission objectives of the next generation of manned space activity, the present invention comprehends the logistical transport and support system shown in FIG. 1 wherein a second stage or orbiter vehicle **2** is secured piggyback fashion to a first stage or booster vehicle **1** for launch from a vertical position.

Numerical criteria of the system described herein are predicated on the following booster and orbiter specifications. It should be understood, however, that the following specifications are neither limiting or exclusive but merely representative of a possible combination and are stated only as an example.

	Orbiter	Booster
	Weight × 1000 lb.	
Launch weight	360.0	1,132.0
Weight at insertion/burnout	97.2	180.0
Payload	12.5	----
Combined liftoff weight	1,492.0	----
Main engine thrust	468.0	1,940.0
Crew	2	2
Passengers	10	----
Payload volume, ft.^{3}	2,000	----

The ascent trajectory **3** of the composite vehicle carries the orbiter **2** to a selected staging velocity. Since the booster engines provide all thrust from lift-off to staging, both vehicles being functionally independent, all fuel consumption up to the staging point is from the booster **1** tankage.

When staging occurs, the orbiter **2** is thrust free and clear of the booster **1** whereupon the orbiter main engines are started. Thereafter, the orbiter **2** is propelled along the orbit injection trajectory **4**.

After separation from the orbiter **2**, the main engines of the booster **1** are extinguished thereby allowing the earth gravitational field to pull the booster **1** back into the atmosphere along the re-entry path **5**. Re-entry attitude of approximately 60° angle to the relative wind is sustained throughout entry at the end of which the angle of attack is reduced to about 20°, the normal subsonic flight attitude.

After the booster is returned to normal subsonic flight attitude, air breathing auxiliary engines are started to sustain altitude with aerodynamic lift for the base return flight **6**.

Final recovery at base **7** is a conventional, near stall, wheel landing.

Since the booster **1** is designed, as hereafter explained, to suffer no structural degradation due to the preceding sub-orbital flight and re-entry, only minimum maintenance is necessary for deployment in addition to vertical erection, loading, fueling, and replenishment of crew life-support consumables.

The orbiter **2**, being the payload carrying vehicle of the system, delivers same to the desired station for removal from a payload bay. Thereafter, retro engines, not shown, are briefly started to reduce the orbiter velocity below a critical orbit velocity so that re-entry and return to base **7** in the same manner as booster **1** may be effected.

Relative to the booster and orbiter vehicle characteristics and construction details, reference is first made to FIGS. 1–3. Booster **1** comprises a fuselage **11**, fixed positioned wings **12**, horizontal stabilizer **13**, vertical stabilizer **14**, primary propulsion rocket engines **15**, and auxiliary propulsion turbojet engines **16**.

The orbiter **2**, in many respects, is a smaller version of the booster vehicle having fuselage **21**, fixed wings **22**, horizontal stabilizer **23**, vertical stabilizer **24**, primary propulsion engines **25**, and auxiliary engines **26**. In addition, orbiter **2** is provided with a top opening, large volume, payload receiving bay **27**.

Both booster and orbiter vehicles may be manually controlled and provided with crew compartments **17** and **28** respectively.

Some internal details of booster **1** are illustrated by dashed lines in FIG. 8 where the main engine propellant tanks **40** and **41** are shown to occupy most of the internal fuselage volume. Appreciable weight savings may be gained by integrating the tank and primary vehicle structure where possible. For a liquid oxygen-hydrogen propellant system, the greater density component, oxygen, would be stored in the forward tank **40** with the lighter propellant, hydrogen, in the aft tank **41**. This arrangement allows aerodynamic stability of the vehicle during the boost flight phase. When all tanks are full, the resultant vehicle center of gravity will be positioned ahead of the center of pressure located in the proximity of plane **44**.

It should be recalled that "center of pressure" is a theoretical aerodynamic concept wherein all aerodynamic forces acting upon a vehicle may be resolved about a point as a resultant lift and drag vector and without resultant aerodynamic moment.

In the booster fuselage section **45** forward of the oxygen tanks **40** is disposed the crew compartment **17**, navigational equipment, auxiliary propulsion engines **16**, jet fuel, and fuel for attitude control engines. The attitude control engines (not shown) are small, low thrust reaction engines located in the tips of opposite wing panels and the fore and aft ends of the fuselage **11** for controlling the vehicle flight attitude during re-entry when mechanical surface controls are ineffective.

The orbiter vehicle **2**, having a more complex interior, is shown with greater detail by FIGS. 5–7. As in the booster, oxygen tanks **30** are located ahead of the center of pressure with the hydrogen tanks **31** occupying the lower aft volume of the fuselage. Propellants from tanks **30** and **31** fuel the main engines **25** during the orbit insertion trajectory **4** (FIG. 1). For on-orbit and interorbit propulsion, additional fuel is stored in tanks **32** and **33** which are high efficiency cryogenic storage vessels suitable for maintaining oxygen and hydrogen in the low temperature liquid state for long time periods.

In the nose of the orbiter fuselage **21**, ample space is provided for guidance and control equipment **34** and electric power supply equipment **35**. The space **36** immediately

aft of the crew compartment **28** is convenient for tracking, telemetry, and communication equipment. Passenger space may be provided at **37** thereby limiting the environmentally controlled volume to the composite of spaces **28**, **36**, and **37**. Environmental control equipment **38** may be conveniently positioned beneath the crew compartment **28**.

Between the passenger space **37** and payload bay **27**, auxiliary tankage **39** for attitude control engine propellants and the environmental control system may be secured with additional auxiliary tankage positioned in the region **50**.

Current designs of the present system contemplate positioning air-breathing, auxiliary propulsion, turbine engines **26** in the fuselage nose section as illustrated, but an attractive alternative is to place the engines **26** on the upper or "shaded" face of wings **22** in protective nacelles. Other embodiments of the present invention omit the air-breathing engines entirely and rely upon the gliding cross-range of the vehicle throughout the subsonic return flight **6**. This glider version of the invention accepts certain risks of loss, however, due to the fact that landings must be executed successfully in the first approach, no go-around capacity being available. Glider and sailplane experience have proven such risks to be entirely reasonable and acceptable, though.

Since the capacity for horizontal landings on conventional airport runways is a primary objective of the present shuttle system, retractable landing gear and wells therefor are provided in the fuselage structure at **51** and **52**.

The following structural and aerodynamic design parameters are relevant to both vehicles of the invention. To reduce descriptive redundancy therefore, further references will be limited to the orbiter **2**.

Aerodynamically, the factors of positive and neutral static stability is the initial tendency of a body to return to an equilibrium attitude following a disturbance. Representative of positive static stability is a spherical mass disposed within a bowl of spherical radius greater than that of the mass. Equilibrium position for the mass in a gravity environment is at rest in the bottom of the bowl. An external force disturbance to displace the mass from said equilibrium position is resisted by gravitational forces.

Neutral static stability may be defined as the tendency of a body to remain in equilibrium in a new position following a disturbance from an initial equilibrium position. This quality is represented by a spherical mass placed on a level surface in a gravity environment. The sphere will remain in any position on the surface to which it is displaced.

About the vehicle pitch axis, in the low or 20° angle of attack attitude, positive static stability is conventionally achieved by a discretely arranged relation between the vehicle center of gravity and the center of pressure as dictated by longitudinal positionment of the wing. Decalage between the wing and horizontal stabilizer provides an inherently correct stabilizing moment tending to restore the vehicle to the low angle of attack equilibrium attitude.

At the high (60°) re-entry attack angle attitude, the present vehicle represents a substantial departure from the prior art to achieve positive static pitch stability. In the first place, most of the bottom profile surface area—fuselage, wing and empennage—is arranged to "feel" substantially uniform pressure from the relative wind of re-entry. Accordingly, the vehicle fuselage **2** (FIG. 5) is constructed almost transversely flat along the bottom **54**. Since, as stated previously, the total bottom wetted area of the wing-empennage group is substantially equal to that of the fuselage, it therefore follows that lift per unit bottom wetted area is substantially equally distributed thereover.

As a note of departure, concerning operational angles of attack, it should be understood that 60° is merely a

convenient optimum for the high angle attitude. A more accurate, but elusively variable, definition of high attack angle for present purposes would be that pitch attitude at which the wings **22** are aerodynamically stalled. For the particular wing **22** described herein, stalling may occur at pitch attitudes exceeding 40° angle of attack.

Conversely, a low angle of attack is defined as a pitch attitude of less than 40° angle of attack or an operational condition whereat fluid flow over the wings **22** generates aerodynamic lift.

In view of such distinct fluid flow patterns respective to the two positions of pitch equilibrium, it is also important to point out the nature of lift relevant to said pitch attitudes. For this purpose, it is convenient to relate the functional distinctions between impulse and reaction turbine motors. The first absorbs the impact of the energizing fluid whereas the latter is driven by the reaction from an expanding, hence, accelerating fluid mass. Relating the above to this description, lift forces on the vehicle due to fluid impact at the high angle of pitch attitude will be characterized as dynamic lift whereas lift due to fluid acceleration will be characterized as aerodynamic lift.

Returning to the explanation of positive static pitch stability, it may now be seen that more static stability in the high angle attitude is a function of uniform pressure movement distribution about the pitch axis (shown as a circle **61** in FIG. **13** and extending perpendicular to roll axis **62** and yaw axis **63**). This kind of stability is inherent with a flat plate of symmetric profile. Without additional control devices, however, such stability is statically negative. Imposition of any disturbing force will elicit an accelerating departure from the equilibrium position. For this reason, the present vehicle design provides a longitudinal curve to the bottom of the fuselage, at least at either extremity thereof. Other portions of the bottom of the fuselage may be substantially longitudinally flat, or may also have a gentle curvature. In the preferred embodiment, the curvature is greatest at the bow section, then substantially flat until the extreme aft section which exhibits a curve lesser than that of the bow. This design feature can best be seen in FIGS. 3, 5, and 13. The effect of this curve is to alter the local angle of attack to the relative wind along said curved portion at a rate differential to that of the remaining vehicle bottom area. Accordingly, the coefficient of presure, a function of local angle of attack, is altered to provide restoring forces effective to return the vehicle to the equilibrium position. In other words, if the vehicle pitch attitude departs in the nose up direction, the coefficient of pressure on the flat bottom surfaces aft of the pitch axis increases at a greater rate than the cumulative result of those along the more greatly curved bow. Hence, a relative force increase is imposed on the aft side of the pitch axis **61** to cause a counteracting moment thereby driving the vehicle pitch attitude back to the equilibrium position.

Pitch departures in the nose down direction produce the opposite result to increase relative moment forces on the bow side of the pitch axis **61**.

In summary, therefore, the curved bow of the present invention provides pitch angle restoring forces for positive pitch stability in the high angle operational mode with fixed structure and with no expenditure of control power.

The rate of curvature effects the rate of restoration, a function of dynamic stability, and should be analyzed in the context of other pitch motion damping forces.

Positive static roll stability relative to the vehicle axis **62** is more conventionally achieved by a dihedral relationship between the wing panels **22** and the fuselage **21**. The 7° dihedral shown in FIG. 4 with respect to booster **1** is deemed adequate for both, re-entry and subsonic flight conditions. A dihedral angle to the horizontal stabilizer **23** will further contribute to positive static stability.

Conventional design practice is also exploited for positive static yaw stability about axis **63** in the low angle flight mode. Accordingly, the present design provides for an extreme aft mounted vertical stabilizer **24** and sweep to the wing leading edge.

The significance of positive static yaw stability, as resolved about the vehicle axis **63** in the high angle flight mode is nominal due to the near alignment of said vehicle yaw axis with the relative wind of re-entry. An angular displacement about the vehicle yaw axis **63** necessarily induces a roll disturbance in reference to the relative wind **64**. There is, therefore, no need for a restoring force to return the vehicle attitude to an equilibrium position relative to a fixed yaw axis **63** reference. Since the vehicle has positive static stability about the vehicle roll axis, such vehicle axis related yaw merely induces a corrective roll to reposition said vehicle yaw axis.

As determined about an axis of reference **64** parallel with the relative wind, however, the present vehicle may be considered neutral in static yaw stability. This is to say that the vehicle will stabilize in any angular position of a plane including both the relative wind axis **64** and the vehicle roll axis **62** as said plane revolves about said relative wind axis **64**. This may be better understood by envisioning the vehicle roll axis **62** as a straight line surface element of a regular cone revolved about the relative wind axis **64**. By such analogy, the vehicle will remain in equilibrium at any position on the cone where all three axes; roll **62**, yaw **63**, and relative wind **64**; lie in the same plane.

An interesting consequence of the foregoing is that relative to an earth gravitational reference, the vehicle may stabilize in an upside down re-entry attitude as well as right side up.

Width of the fuselage nose bottom **54** also contributes to neutral static yaw stability by attenuating or preventing destabilizing moments caused by fluctuating fluid flow fields and resultant side forces on the nose.

Selective attitude control of the present vehicle in the high angle flight mode is accomplished conventionally by small reaction engines (not shown) disposed in the wing tips and fuselage ends. Due to the inherent stability of the present vehicle, however, power and fuel reserve for such attitude control engines is substantially reduced from that required for comparable prior art designs.

Adjustable area structural panels such as flaps and elevons are not only ineffective in the early re-entry phases but use thereof in the high-heating re-entry phase would raise substantial thermodynamic difficulties.

As a special note of high angle attitude control, due to the strong interrelationship of roll stability and the relative wind axis **64** vehicle flight path may be selectively altered by sustaining an induced roll moment long enough to re-establish stable fluid flow against the new directional face of the bottom surface area.

In the low angle flight mode, ailerons **58** (FIG. 2), elevator **29**, rudder **59** (FIG. 3) are the devices of selective attitude control. As to the elevator **29** in particular, sufficient area and deflection must be provided to drive the vehicle pitch attitude from the re-entry positive static equilibrium position of approximately 60° to a positive static equilibrium pitch attitude of approximately 20° for subsonic flight. Representative design parameters are illustrated by FIG. 14 where the two positions of static pitch stability are shown by curve A which corresponds a zero pitching moment coefficient with a zero elevator deflection angle at attack angles of 30° and 70° respectively. Reasonably symmetric responses are derived from the elevator **29** at deflection angles of 40° down (curve B) and 40° up (curve C) respectively, for smooth handling characteristics and firm response rates throughout the subsonic flight region.

Other design relationships between fuselage, wing and empennage of the present vehicle are consistent with conventional aircraft design practice and are selected for proven superior flying qualities at subsonic velocities and in approach and landing maneuvers.

For example, the airfoil section of wing 22 may be selected almost exclusively on the basis of optimization for subsonic cruise and landing. An NACA 0012–64 airfoil provided with low speed lift augmenting devices such as flaps 56 and slots 57 is shown in FIG. 9. The 40° angle of incidence for the wing shown in FIG. 8 is also conventional practice.

The straight wing shown in FIG. 2, is clearly the lightest planform for these requisite purposes but a delta planform offers other advantages.

Two functions of the broad, flat fuselage bottom 54 have been recited, i.e., positive pitch and neutral yaw static stabilities. At least two more flat bottom functions are to be added, i.e., re-entry rate control and heat management.

A body having the general physical characteristics of a space vehicle, entering earth bound atmosphere at a velocity of approximately 26,000 f.p.s., encounters sufficient atmospheric density at approximately 400,000 ft. altitude to start hypersonic heating. Vehicles having a Lift/Drag ratio (L/D) of 1.5 entering the atmosphere at said velocity and at a 15° angle of attack, generate a heating rate profile as is illustrated by dotted line curve A of FIG. 15. At this rate, temperatures on the surface of a folded wing, lifting body vehicle may reach as high as 3900° F. Such temperatures are beyond the present art state for load-carrying structural members and can be tolerated only by the use of ablative heat shields which not only impose weight penalties against the total lift-off payload but require replacement after each use. Moreover, vehicles with high L/D ratios, e.g., 1.5, must sustain high heating rates for much longer time periods thereby compounding weight penalties due to the insulation required to maintain the primary interior structure temperatures within the useful range of material strength as the re-entering vehicle literally soaks in the blast furnace environment.

The large, uniformly loaded bottom surface area of the present invention enables the designer to capitalize on the advantages of a much lower L/D ratio, e.g., 0.5, and thereby avoid the above problems of a higher L/D ratio. By selecting vehicle design parameters so as to yield as L/D-attack angle relationship as represented by FIG. 12, a 60° re-entry angle of attack will produce the desired results. Not only is the re-entry heating profile substantially reduced in intensity and duration as shown by curve B of FIG. 15, but the re-entry deceleration profile is held well within the tolerable limits of most healthy persons as shown by FIG. 11. The slope of the FIG. 10 curve represents the altitude rate of descent.

It should be pointed out, however, that the thermal advantages of a low L/D ratio are not purchased without consideration. In this case, the price paid is that of operating range. The vehicle to which FIG. 15, curve A, relates, having an L/D=1.5 for a re-entry angle of attack of 15° will have an operational cross-range of 2000 N.M. The present invention, having an L/D=0.5 and a re-entry angle of attack of 60°, follows the much shorter re-entry duration as depicted by curve B which allows an operational cross-range of only 200 N.M. However, such a sacrifice is not considered controlling in most circumstances since even 200 N.M. is adequate to reach a suitable airport for landing.

In determining the L/D ratio for the re-entry flight phase, it should be recalled that at the 60° pitch attitude, the wing 22 is substantially if not completely stalled. Therefore, total vehicular lift in this attitude is attributable exclusively to the dynamic pressure against the bottom wetted surfaces of the fuselage, wing and empennage. Not until the vehicle descends to approximately 40,000 ft. and 300 f.p.s. velocity is the elevator 29 deflected down 30° (FIG. 14, curve C) to rotate the vehicle into a low angle of attack flight for generation of aerodynamic lift by fluid flow over the wing.

The 60° re-entry angle of attack has another desirable product in addition to consistency with an advantageous L/D ratio. That pitch attitude in correlation with the flat bottom profile is also responsible for widely distributed flow stagnation regions over the vehicle bottom wetted area. Large areas of flow stagnation in relation to the total wetted area is a manifestation of Newtonian (laminar) free stream flow states across said bottom wetted surface.

The mechanics of restricting fluid flow across the bottom area to the laminar flow states include the generation of one or more shock stable waves of maximum magnitude preceding the vehicle throughout the hypersonic flight phase. Since the propagation of shock waves consumes large quantities of energy, it is possible by the aforedescribed configuration to dissipate a large percentage of the altitude and velocity energy potential of the present vehicle by such device. Those skilled in the art will appreciate the practical advantage of converting this energy to heat along the wave front at a discrete distance ahead of the vehicle structure per se.

Consistent with the laws of gas dynamics and conservation of energy, diffusion of atmospheric gas past the shock wave front converts a determinable percentage of the gas total energy from the dynamic state to the static state. In this respect, the shock wave phenomena functions as a compressor to convert the compressible medium from high relative velocity, low temperature and low static pressure to a condition of low relative velocity, high temperature and high static pressure. Unlike a compressor, however, total energy of the medium before and after passing the shock wave front is substantially unchanged. It is the post wave front high temperature consequence of these physical laws that cause re-entry vehicle designers greatest concern.

The present re-entry vehicle attack profile is designed to propagate one or more shock waves, the last of which sustains a relatively stable position at a discrete distance removed from the vehicle surface. Moreover, subsequent to diffusion past said last wave front, the flow velocity of the atmospheric gas should be reduced to near sonic or less. In this velocity region, gas flow states may be limited to the Newtonian (laminar) condition thereby minimizing heat transfer from the hot, post shock wave atmospheric gas as it flows over the vehicle bottom surface. There being little mixing of flow streams across the vehicle surface, the vehicle structure need only absorb that heat of the boundary layer wetting the vehicle surface which in turn, constitutes an effective insulating layer to inhibit heat transfer from flow streams more remote from the wetted surface. The substantially flat transverse profile of the fuselage bottom minimizes the distance traversed by such insulating flow streams from the inner or centered stagnation region laterally to the sharp chines 53 which cause the flow to thereafter separate from the vehicle surface. Accordingly, less opportunity is given the flow stream to accelerate to turbulent or mixing flow velocities thereby supporting the critical necessity of maintaining a laminar condition until the gas is completely separated from all vehicle surfaces. Of course, all heat energy released by the shock wave and not transferred back to the vehicle structure is left behind the vehicle to diffuse into the general atmosphere.

Results of the foregoing physics, as applied to the present vehicle, are illustrated by FIG. 16. Leading edges of aerodynamic surfaces having small radii of curvature are outside the stagnation regions where most of the heat transfer to the vehicle structure occurs. Therefore, no unreasonable heat concentration problems are presented. Under these circumstances, the maximum expected temperature is about 2400° F. along the wing root leading edge. Structural materials are presently available to accommodate this temperature without appreciable degradation of strength.

The 5° angle of relief (FIG. 7) at the sharp planar intersection of fuselage sides 55 with bottom 54 "shades" the vehicle side and top skin structure by causing fluid flow from the stagnation region to "peel" off sharply and cleanly, as explained previously. At the same time, the relatively small radius of the "hard chines" 53 minimizes the effect of side forces on the vehicle nose due to minor deviations in vehicle alignment with the flight path to cause destabilizing moments about the yaw axis 63.

Considering both, booster 1 and orbiter 2, as a single vehicular unit as illustrated by FIGS. 2 and 3, it is important that the unit be aerodynamically stable throughout the boost trajectory 3 (FIG. 1). Accordingly, the unit center of gravity 8 must be positioned ahead of the unit center of pressure, a theoretical function of lift, drag, and angle of attack. By attaching the orbiter 2 to the booster 1 topside well forward of the booster center of mass with a 1° centerline convergence angle, the resultant unit c.g. will fall along a 3.2° intersection line with the booster center line at the engine 15 thrust center. An engine gimbal envelope of only a few degrees is necessary to maintain thrust vector alignment with the unit c.g. 8.

This "piggyback" arrangement provides a number of other features not available in a tandem or side-by-side shuttle configuration. The interconnecting structure necessary for securing the two vehicles together may be compact and contained within the aerodynamic shape of respective vehicles. Separation requirements to preclude booster 1 damage prior to firing the orbiter 2 engines 25, are less stringent. Large dimension payload pods may be attached to the orbiter with minimum geometrical interference with the booster, a capacity also having re-entry advantages by protecting a recovery load from severe re-entry heating.

It should be understood that the drawings and specification set forth hereinabove present a detailed disclosure only of a preferred embodiment of the invention and that therefore the invention is not to be limited by the specific form disclosed.

What is claimed is:

1. An aircraft having fuselage and wing means:
   - said fuselage having a longitudinally cambered, continuous bottom along the full length thereof, said bottom being substantially flat in the transverse direction whereby substantial impact lifting forces are generated against said bottom at flight angles of attack at and exceeding full stall;
   - said wing means providing aerodynamic lifting forces at flight angles of attack of less than full stall and impact lifting forces at flight angles of attack at and exceeding full stall;
   - the impact lifting force per unit area of said bottom at said flight angles of attack at and exceeding full stall substantially equaling the impact lifting force per unit area of said wing.

2. An aircraft as described in claim 1 wherein sides of said fuselage join said bottom at small angles of relief.

3. An orbital payload delivery system comprising:
   - first and second vehicles, each having aerodynamic wings, attitude control surfaces, and fuselage; the bottom of said fuselage being longitudinally cambered and substantially transversely flat, the area of said fuselage bottom being substantially equal to the bottom area of said wings and control surfaces, collectively;
   - said second vehicle having a payload receiving bay and removable cover therefor on the top side of said fuselage;
   - said first and second vehicles adapted for releasable interconnection, the bottom of said second vehicle being secured to the top of said first vehicle for vertical ascent from a static base; and
   - the gravity center of an interconnected unit comprising said first and second vehicles disposed ahead of the center of pressure of said unit.

4. The orbital payload delivery system of claim 3 wherein said unit gravity center lies along the thrust center of first vehicle primary propulsion engines.

5. The orbital payload delivery system of claim 3 wherein said second vehicle fuselage is adapted for releasable interconnection with a payload to the external topside thereof, said payload being protected by said fuselage from environmental extremes during atmospheric re-entry.

6. An aircraft having a fuselage and aerodynamic wings and control surfaces;
   - the bottom of said fuselage being substantially transversely flat with full stall pitch stabilizing means comprising fixed structure of cambered profile;
   - large area fluid flow stagnation regions formed on said fuselage, wing and control surface bottoms at flight angles of attack at and in excess of full stall;
   - relatively small linear distances between the peripheral boundaries of said stagnation regions and the peripheral boundaries of said bottom surface areas; and
   - substantially laminar fluid flow states prevailing adjacent said bottom surfaces between said stagnation regions and said bottom area pheripheral boundaries.

7. An aircraft as described in claim 6 wherein the sides of said fuselage are relatively convergent from said bottom and fluid flow separates from said fuselage, wing and control surfaces at said bottom area peripheries under said full stall attack angle flight conditions.

8. A reaction propulsion aerospace vehicle having:
   - fixed position aerodynamic lifting and control surfaces;
   - two positively statically stable trim attitudes at subsonic velocities, one stable trim attitude at an angle of attack exceeding 40 degrees and the other at an angle of less than 40 degrees; and
   - sufficient pitching moment control means to selectively drive said vehicle pitch attitude between said two stable trim attitudes.

9. An aerospace vehicle as described in claim 8 wherein said vehicle is positively statically stable about pitch and roll fuselage reference axes and neutrally statically stable about a yaw axis coinciding with a relative wind axis in flight at said attack angle in excess of 40 degrees.

10. An aerospace vehicle as described in claim 9 wherein said vehicle is positively statically stable about a vehicle reference yaw axis in flight at said attack angle of less than 40 degrees.

11. A method of recovering a vehicle having fixed aerodynamic support and control surfaces from high altitudes and hypersonic velocities comprising:
   - regulating the flight attitude of said vehicle throughout the hypersonic velocity region to attack the relative wind with a substantially maximum area profile;
   - providing positive static pitch stability throughout said hypersonic velocity region by relating the lifting force from said relative wind to the angle of incidence of said vehicle over one portion thereof at a rate different from the remaining portion;
   - generating a shock wave between the undisturbed atmospheric fluid and said attack area profile at a discrete distance ahead of said vehicle;
   - conducting fluid flow behind said shock wave over said attack area surface at laminar flow states throughout said hypersonic velocity region;
   - regulating the flight attitude of said vehicle throughout the subsonic velocity region to attack the relative wind with a substantially minimum profile;
   - generating aerodynamic lift from said fixed aerodynamic support and control surfaces throughout said subsonic velocity region; and
   - horizontally landing said vehicle in a substantially stall attitude.

12. A high attitude vehicle recovery method as described in claim 11 additionally comprising:
   - substantially separating said fluid from said attack area surface at the peripheral boundary thereof throughout said hypersonic velocity region.

13. An aircraft having fuselage means fixed position wings and attitude control surfaces:

said fuselage having roll and pitch and first yaw axes relative thereto;

a second yaw axis parallel with the relative wind against said aircraft in flight and substantially intersecting the vehicle center of gravity; and

said aircraft being positively statically stable about said roll and pitch axes and neutrally statically stable about said second yaw axis in flight at full stall attack angle attitudes.

14. An aircraft as described in claim 13 also being positively statically stable about said first yaw axes in flight at angles of attack less than full stall.

15. An aircraft having fuselage and wing means:

the bottom of said fuselage being substantially flat over a first portion thereof, both longitudinally and transversely, whereby substantially uniform impact lifting pressures are imposed against said first portion of the bottom in full stall flight attitudes; and

said fuselage bottom having rigid structural means over a second portion thereof for effecting positive static pitch stability restoring moments on said aircraft in said full stall flight attitudes.

16. An aircraft as described in claim 15 also having

means for positive static roll stability about a longitudinal fuselage axis and neutral static yaw stability about an axis parallel with the relative wind and substantially intersecting the aircraft center of gravity in said full stall flight attitudes.

17. An aircraft as described by claim 15 wherein said rigid structural means comprises longitudinally cambered surface means disposed along the leading end of said fuselage bottom.

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U.S. Cl. X.R.

244—2, 36, 90

2 Sheets—Sheet 1.

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TELEGRAPHY.

No. 174,465. Patented March 7, 1876.

Fig. 1

Fig. 2.

Fig. 3.

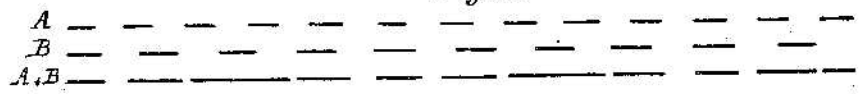


Fig. 4.

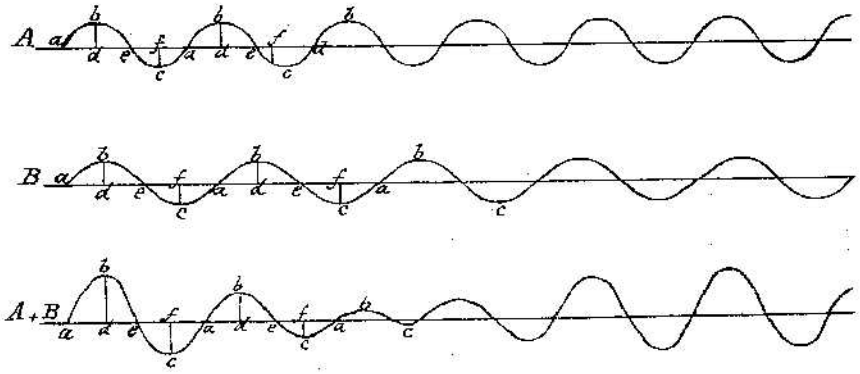
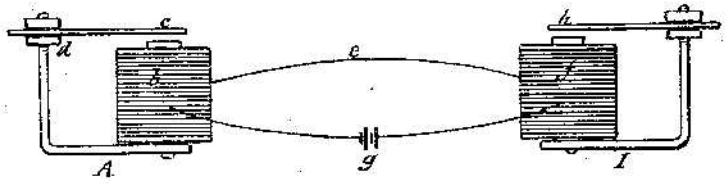


Fig. 5.



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2 Sheets—Sheet 2.

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TELEGRAPHY.

No. 174,465. Patented March 7, 1876.

Fig 6.

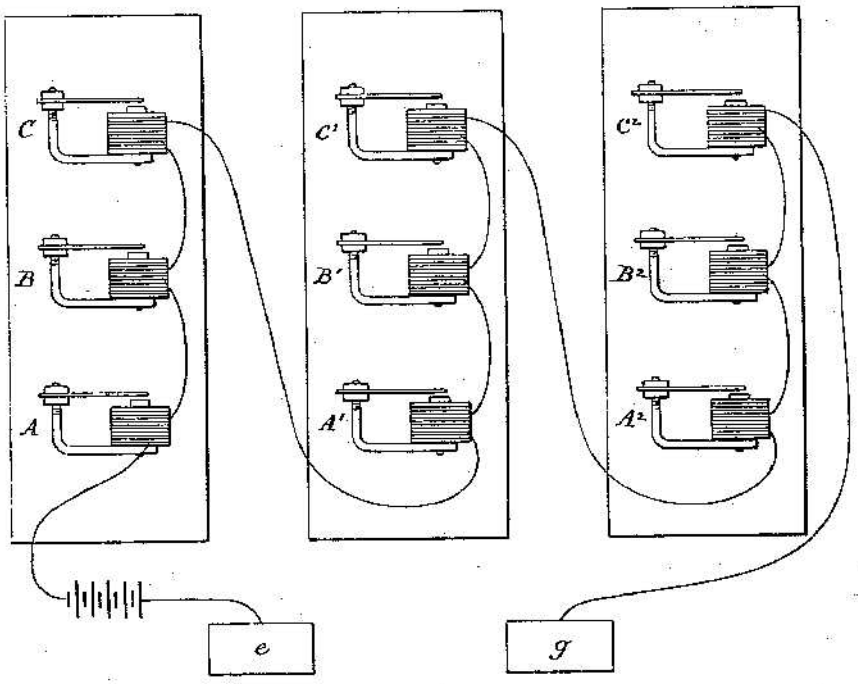
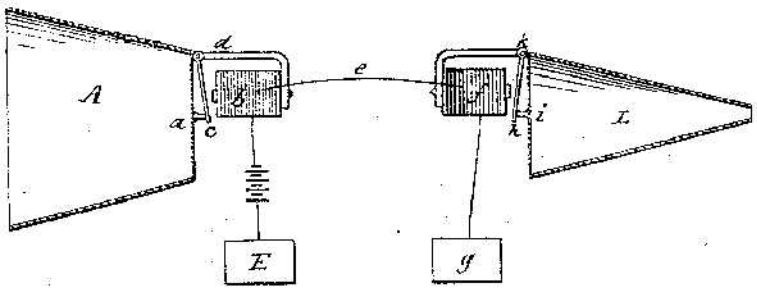


Fig. 7



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UNITED STATES PATENT OFFICE.

ALEXANDER GRAHAM BELL, OF SALEM, MASSACHUSETTS.

IMPROVEMENT IN TELEGRAPHY.

Specification forming part of Letters Patent No. **174,465**, dated March 7, 1876; application filed February 14, 1876.

To all whom it may concern:

Be it known that I, ALEXANDER GRAHAM BELL, of Salem, Massachusetts, have invented certain new and useful Improvements in Telegraphy, of which the following is a specification:

In Letters Patent granted to me April 6, 1875, No. 161,739, I have described a method of, and apparatus for, transmitting two or more telegraphic signals simultaneously along a single wire by the employment of transmitting-instruments, each of which occasions a succession of electrical impulses differing in rate from the others; and of receiving-instruments, each tuned to a pitch at which it will be put in vibration to produce its fundamental note by one only of the transmitting-instruments; and of vibratory circuit-breakers operating to convert the vibratory movement of the receiving-instrument into a permanent make or break (as the case may be) of a local circuit, in which is placed, a Morse sounder, register, or other telegraphic apparatus. I have also therein described a form of autograph-telegraph based upon the action of the above-mentioned instruments.

In illustration of my method of multiple telegraphy I have shown in the patent aforesaid, as one form of transmitting-instrument, an electro-magnet having a steel-spring armature, which is kept in vibration by the action of a local battery. This armature in vibrating makes and breaks the main circuit, producing an intermittent current upon the line-wire. I have found, however, that upon this plan the limit to the number of signals that can be sent simultaneously over the same wire is very speedily reached; for, when a number of transmitting-instruments, having different rates of vibration, are simultaneously making and breaking the same circuit, the effect upon the main line is practically equivalent to one continuous current.

In a pending application for Letters Patent, filed in the United States Patent Office February 25, 1875, I have described two ways of producing the intermittent current—the one by actual make and break of contact, the other by alternately increasing and diminishing the intensity of the current without actually breaking the circuit. The current produced by the latter method I shall term, for distinction sake, a pulsatory current.

My present invention consists in the employment of a vibratory or undulatory current of electricity in contradistinction to a merely intermittent or pulsatory current, and of a method of, and apparatus for, producing electrical undulations upon the line-wire.

The distinction between an undulatory and a pulsatory current will be understood by considering that electrical pulsations are caused by sudden or instantaneous changes of intensity, and that electrical undulations result from gradual changes of intensity exactly analogous to the changes in the density of air occasioned by simple pendulous vibrations. The electrical movement, like the aerial motion, can be represented by a sinusoidal curve or by the resultant of several sinusoidal curves.

Intermittent or pulsatory and undulatory currents may be of two kinds, accordingly as the successive impulses have all the same polarity or are alternately positive and negative.

The advantages I claim to derive from the use of an undulatory current in place of a merely intermittent one are, first, that a very much larger number of signals can be transmitted simultaneously on the same circuit; second, that a closed circuit and single main battery may be used; third, that communication in both directions is established without the necessity of special induction-coils; fourth, that cable dispatches may be transmitted more rapidly than by means of an intermittent current or by the methods at present in use; for, as it is unnecessary to discharge the cable before a new signal can be made, the lagging of cable-signals is prevented; fifth, and that as the circuit is never broken a spark-arrester becomes unnecessary.

It has long been known that when a permanent magnet is caused to approach the pole of an electro-magnet a current of electricity is induced in the coils of the latter, and that when it is made to recede a current of opposite polarity to the first appears upon the wire. When, therefore, a permanent magnet is caused to vibrate in front of the pole of an electro-magnet an undulatory current of electricity is induced in the coils of the electro-magnet, the

undulations of which correspond, in rapidity of succession, to the vibrations of the magnet, in polarity to the direction of its motion, and in intensity to the amplitude of its vibration.

That the difference between an undulatory and an intermittent current may be more clearly understood I shall describe the condition of the electrical current when the attempt is made to transmit two musical notes simultaneously—first upon the one plan and then upon the other. Let the interval between the two sounds be a major third; then their rates of vibration are in the ratio of 4 to 5. Now, when the intermittent current is used the circuit is made and broken four times by one transmitting-instrument in the same time that five makes and breaks are caused by the other. A and B, Figs. 1, 2, and 3, represent the intermittent currents produced, four impulses of B being made in the same time as five impulses of A. *c c c*, &c., show where and for how long time the circuit is made, and *d d d*, &c., indicate the duration of the breaks of the circuit. The line A and B shows the total effect upon the current when the transmitting-instruments for A and B are caused simultaneously to make and break the same circuit. The resultant effect depends very much upon the duration of the make relatively to the break. In Fig. 1 the ratio is as 1 to 4; in Fig. 2, as 1 to 2; and in Fig. 3 the makes and breaks are of equal duration. The combined effect, A and B, Fig. 3, is very nearly equivalent to a continuous current.

When many transmitting-instruments of different rates of vibration are simultaneously making and breaking the same circuit the current upon the main line becomes for all practical purposes continuous.

Next, consider the effect when an undulatory current is employed. Electrical undulations, induced by the vibration of a body capable of inductive action, can be represented graphically, without error, by the same sinusoidal curve which expresses the vibration of the inducing body itself, and the effect of its vibration upon the air; for, as above stated, the rate of oscillation in the electrical current corresponds to the rate of vibration of the inducing body—that is, to the pitch of the sound produced. The intensity of the current varies with the amplitude of the vibration—that is, with the loudness of the sound; and the polarity of the current corresponds to the direction of the vibrating body—that is, to the condensations and rarefactions of air produced by the vibration. Hence, the sinusoidal curve A or B, Fig. 4, represents, graphically, the electrical undulations induced in a circuit by the vibration of a body capable of inductive action.

The horizontal line *a d e f*, &c., represents the zero of current. The elevations *b b b*, &c., indicate impulses of positive electricity. The depressions *c c c*, &c., show impulses of negative electricity. The vertical distance *b d* or *c f* of any portion of the curve from the zero-line expresses the intensity of the positive or negative impulse at the part observed, and the horizontal distance *a a* indicates the duration of the electrical oscillation. The vibrations represented by the sinusoidal curves B and A, Fig. 4, are in the ratio aforesaid, of 4 to 5—that is, four oscillations of B are made in the same time as five oscillations of A.

The combined effect of A and B, when induced simultaneously on the same circuit, is expressed by the curve A+B, Fig. 4, which is the algebraical sum of the sinusoidal curves A and B. This curve A+B also indicates the actual motion of the air when the two musical notes considered are sounded simultaneously. Thus, when electrical undulations of different rates are simultaneously induced in the same circuit, an effect is produced exactly analogous to that occasioned in the air by the vibration of the inducing bodies. Hence, the coexistence upon a telegraphic circuit of electrical vibrations of different pitch is manifested, not by the obliteration of the vibratory character of the current, but by peculiarities in the shapes of the electrical undulations, or, in other words, by peculiarities in the shapes of the curves which represent those undulations.

There are many ways of producing undulatory currents of electricity, dependent for effect upon the vibrations or motions of bodies capable of inductive action. A few of the methods that may be employed I shall here specify. When a wire, through which a continuous current of electricity is passing, is caused to vibrate in the neighborhood of another wire, an undulatory current of electricity is induced in the latter. When a cylinder, upon which are arranged bar-magnets, is made to rotate in front of the pole of an electro-magnet, an undulatory current of electricity is induced in the coils of the electro-magnet.

Undulations are caused in a continuous voltaic current by the vibration or motion of bodies capable of inductive action; or by the vibration of the conducting-wire itself in the neighborhood of such bodies. Electrical undulations may also be caused by alternately increasing and diminishing the resistance of the circuit, or by alternately increasing and diminishing the power of the battery. The internal resistance of a battery is diminished by bringing the voltaic elements nearer together, and increased by placing them farther apart. The reciprocal vibration of the elements of a battery, therefore, occasions an undulatory action in the voltaic current. The external resistance may also be varied. For instance, let mercury or some other liquid form part of a voltaic circuit, then the more deeply the conducting-wire is immersed in the mercury or other liquid, the less resistance does the liquid offer to the passage of the current. Hence, the vibration of the conducting-wire in mercury or other liquid included in the circuit occasions undulations in the current. The vertical vibrations of the elements of a battery in the liquid in which

they are immersed produces an undulatory action in the current by alternately increasing and diminishing the power of the battery.

In illustration of the method of creating electrical undulations, I shall show and describe one form of apparatus for producing the effect. I prefer to employ for this purpose an electro-magnet, A, Fig. 5, having a coil upon only one of its legs *b*. A steel-spring armature, *c*, is firmly clamped by one extremity to the uncovered leg *d* of the magnet, and its free end is allowed to project above the pole of the covered leg. The armature *c* can be set in vibration in a variety of ways, one of which is by wind, and, in vibrating, it produces a musical note of a certain definite pitch.

When the instrument A is placed in a voltaic circuit, *g b e f g*, the armature *c* becomes magnetic, and the polarity of its free end is opposed to that of the magnet underneath. So long as the armature *c* remains at rest, no effect is produced upon the voltaic current, but the moment it is set in vibration to produce its musical note a powerful inductive action takes place, and electrical undulations traverse the circuit *g b e f g*. The vibratory current passing through the coil of the electro-magnet *f* causes vibration in its armature *h* when the armatures *c h* of the two instruments A I are normally in unison with one another; but the armature *h* is unaffected by the passage of the undulatory current when the pitches of the two instruments are different.

A number of instruments may be placed upon a telegraphic circuit, as in Fig. 6. When the armature of any one of the instruments is set in vibration all the other instruments upon the circuit which are in unison with it respond, but those which have normally a different rate of vibration remain silent. Thus, if A, Fig. 6, is set in vibration, the armatures of A^1 and A^2 will vibrate also, but all the others on the circuit will remain still. So if B^1 is caused to emit its musical note the instruments B B^2 respond. They continue sounding so long as the mechanical vibration of B^1 is continued, but become silent with the cessation of its motion. The duration of the sound may be used to indicate the dot or dash of the Morse alphabet, and thus a telegraphic dispatch may be indicated by alternately interrupting and renewing the sound.

When two or more instruments of different pitch are simultaneously caused to vibrate, all the instruments of corresponding pitches upon the circuit are set in vibration, each responding to that one only of the transmitting instruments with which it is in unison. Thus the signals of A, Fig. 6, are repeated by A^1 and A^2, but by no other instrument upon the circuit; the signals of B^2 by B and B^1; and the signals of C^1 by C and C^2—whether A, B^2, and C^2 are successively or simultaneously caused to vibrate. Hence by these instruments two or more telegraphic signals or messages may be sent simultaneously over the same circuit without interfering with one another.

I desire here to remark that there are many other uses to which these instruments may be put, such as the simultaneous transmission of musical notes, differing in loudness as well as in pitch, and the telegraphic transmission of noises or sounds of any kind.

When the armature *c*, Fig. 5, is set in vibration the armature *h* responds not only in pitch, but in loudness. Thus, when *c* vibrates with little amplitude, a very soft musical note proceeds from *h*; and when *c* vibrates forcibly the amplitude of the vibration of *h* is considerably increased, and the resulting sound becomes louder. So, if A and B, Fig. 6, are sounded simultaneously, (A loudly and B softly,) the instruments A^1 and A^2 repeat loudly the signals of A, and B^1 B^2 repeat softly those of B.

One of the ways in which the armature *c*, Fig. 5, may be set in vibration has been stated above to be by wind. Another mode is shown in Fig. 7, whereby motion can be imparted to the armature by the human voice or by means of a musical instrument.

The armature *c*, Fig. 7, is fastened loosely by one extremity to the uncovered leg *d* of the electro-magnet *b*, and its other extremity is attached to the center of a stretched membrane, *a*. A cone, A, is used to converge sound-vibrations upon the membrane. When a sound is uttered in the cone the membrane *a* is set in vibration, the armature *c* is forced to partake of the motion, and thus electrical undulations are created upon the circuit E *b e f g*. These undulations are similar in form to the air vibrations caused by the sound—that is, they are represented graphically by similar curves.

The undulatory current passing through the electro-magnet *f* influences its armature *h* to copy the motion of the armature *c*. A similar sound to that uttered into A is then heard to proceed from L.

In this specification the three words "oscillation," "vibration," and "undulation," are used synonymously, and in contradistinction to the terms "intermittent" and "pulsatory." By the terms "body capable of inductive action," I mean a body which, when in motion, produces dynamical electricity. I include in the category of bodies capable of inductive action—brass, copper, and other metals, as well as iron and steel.

Having described my invention, what I claim, and desire to secure by Letters Patent is as follows:

1. A system of telegraphy in which the receiver is set in vibration by the employment of undulatory currents of electricity, substantially as set forth.

2. The combination, substantially as set forth, of a permanent magnet or other body capable of inductive action, with a closed circuit, so that the vibration of the one shall occasion electrical undulations in the other, or in itself, and this I claim, whether the permanent magnet be set in vibration in the neighborhood of the conducting-wire form-

ing the circuit, or whether the conducting-wire be set in vibration in the neighborhood of the permanent magnet, or whether the conducting-wire and the permanent magnet both simultaneously be set in vibration in each other's neighborhood.

3. The method of producing undulations in a continuous voltaic current by the vibration or motion of bodies capable of inductive action, or by the vibration or motion of the conducting-wire itself, in the neighborhood of such bodies, as set forth.

4. The method of producing undulations in a continuous voltaic circuit by gradually increasing and diminishing the resistance of the circuit, or by gradually increasing and diminishing the power of the battery, as set forth.

5. The method of, and apparatus for, transmitting vocal or other sounds telegraphically, as herein described, by causing electrical undulations, similar in form to the vibrations of the air accompanying the said vocal or other sound, substantially as set forth.

In testimony whereof I have hereunto signed my name this 20th day of January, A. D. 1876.

ALEX. GRAHAM BELL.

Witnesses:
THOMAS E. BARRY,
P. D. RICHARDS.

No. 708,553. Patented Sept. 9, 1902.

J. P. HOLLAND.

SUBMARINE BOAT.

(Application filed Aug. 7, 1901.)

(No Model.) 2 Sheets—Sheet 1.

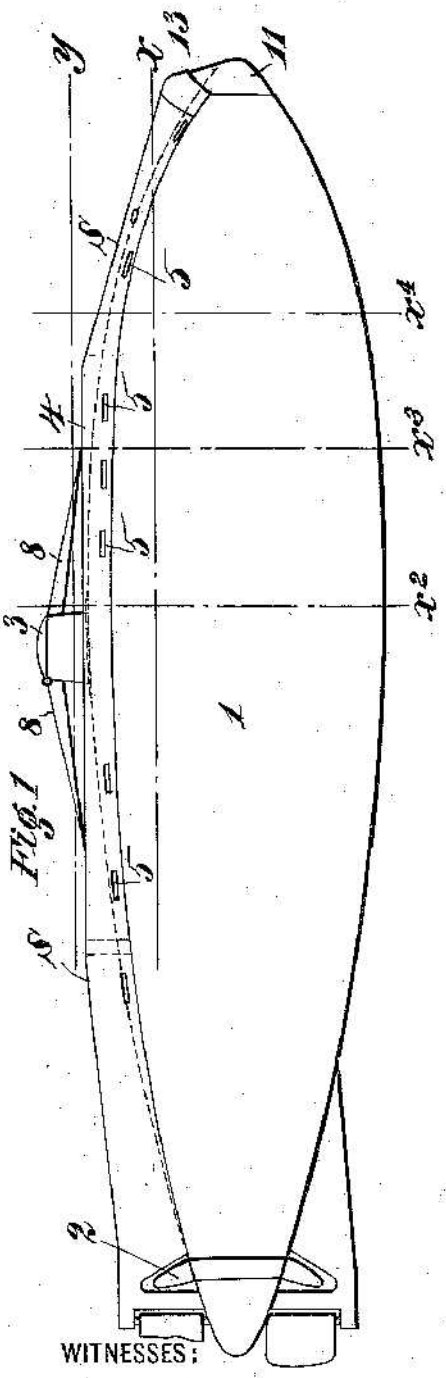

Fig. 1

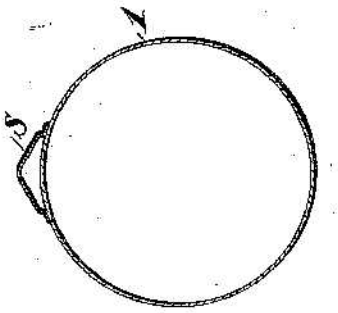

Fig. 4

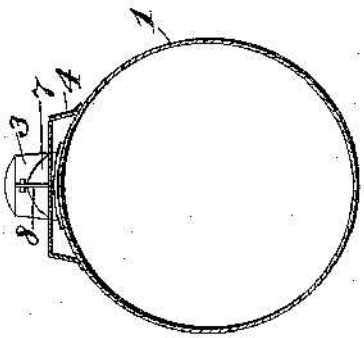

Fig. 3

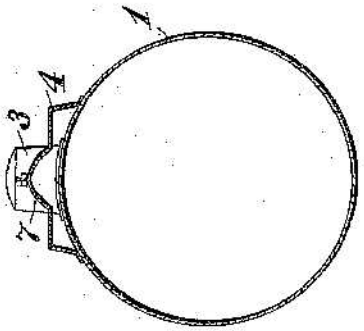

Fig. 2

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No. 708,553. Patented Sept. 9, 1902.

J. P. HOLLAND.

SUBMARINE BOAT.

(Application filed Aug. 7, 1901.)

(No Model.) 2 Sheets—Sheet 2.

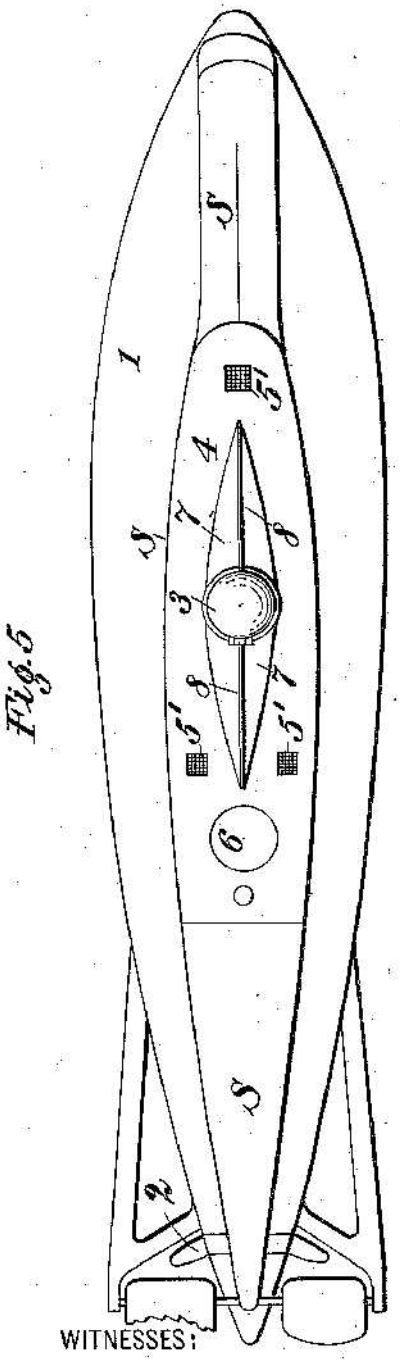

Fig. 5

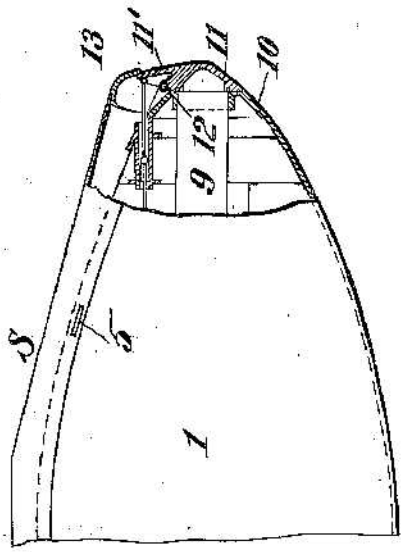

Fig. 7

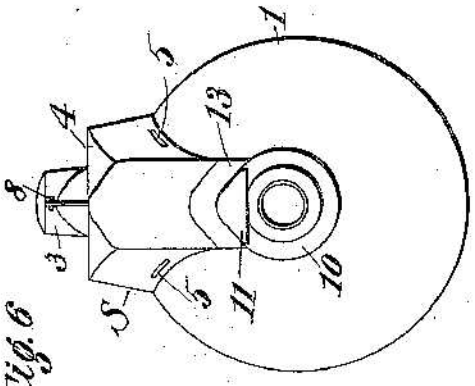

Fig. 6

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JOHN P. HOLLAND, OF NEWARK, NEW JERSEY.

SUBMARINE BOAT.

SPECIFICATION forming part of Letters Patent No. 708,553, dated September 9, 1902.

Application filed August 7, 1901. Serial No. 71,130. (No model.)

To all whom it may concern:

Be it known that I, JOHN P. HOLLAND, a citizen of the United States, residing at Newark, in the county of Essex and State of New Jersey, have invented certain new and useful Improvements in Submarine Boats, of which the following is a specification.

This invention relates to the class of boats or vessels which are adapted to be operated or maneuvered both on the surface of the water and submerged; and the object is, in the main, to provide the boat, which will have the known spindle form or contour, with a deck or promenade for the crew when the boat is operating on the surface and such a superstructure for this purpose as will permit the boat to dive and operate submerged without impediment or hindrance.

In the accompanying drawings, which illustrate the invention embodied, Figure 1 is a side elevation of a submarine boat. Figs. 2, 3, and 4 are transverse sections of the same at the points in Fig. 1 indicated, respectively, by the lines x^2, x^3, and x^4. Fig. 5 is a plan of the boat. Fig. 6 is a bow end view of the boat, showing the cap of the expulsion-tube open. Fig. 7 is a sectional side elevation of the bow portion of the boat, showing the construction of the hinged cap of the expulsion-tube and the superstructure at the bow.

1 designates the spindle-shaped hull or body of the boat, 2 the propeller, and 3 the turret or conning-tower. These are or may be of the usual or known construction. In Fig. 1 the line x designates the water-level when the boat is adapted for surface running, and the line y designates the water-level when the boat is ballasted to put it awash or in diving condition.

On the rounded back or top of the boat is built and rigidly secured a hollow superstructure S, having a flat deck or promenade 4 extending both forward and aft of the conning-tower. This superstructure toward the bow has the form in cross-section seen in Fig. 4—that is, its top slopes off at each side from a central ridge in a vertical plane coincident with the axis of the boat; but at the bow it is arched, as seen in Fig. 6. Along the sides of the superstructure are scuppers 5 for the free escape of the water from the superstructure when the boat comes to the surface, and in the deck 4 are gratings 5', one or more, to permit the air to escape as the boat sinks beneath the surface. In the superstructure is shown a well 6 for a coil of rope, and about the conning-tower, fore and aft, is a rounded structure 7 above the deck 4 and sloping from the tower down to the deck. In a vertical plane passing through the longitudinal axis of the boat are thin fins 8, which abut against the conning-tower. The upper edges of these fins slope from the top of the tower down to the deck 4 and serve as skids to carry a hawser or line over the tower and prevent fouling. The purpose of this superstructure is in part to provide a deck and promenade for the crew, to afford a cover and protection for ventilators, relief-valves, exhaust-pipes, and mufflers, which are on the outside of the upper surface or back of the hull of the boat, and to provide a convenient stowage-space for the anchor, cable, and mooring-lines.

The construction at the bow of the boat is seen in Figs. 6 and 7.

9 is the expulsion-tube, and 10 the muzzle-casting, where the said tube and the boat-hull are joined.

11 is the cap of the expulsion-tube, coned to form the bow-tip or nose of the boat and hinged to the casting 9 at 12. On the front or bow end of the superstructure is a strong metal hood 13, which takes over and protects the shield-plate 11' of the cap 11 and houses the operating-gear of the cap. This hood not only protects the operating-gear of the cap, but it serves as a fender to prevent the accidental opening of the cap from collision with a dock or floating object. When the boat sinks, the water freely enters and fills the superstructure, and when the boat rises the water flows out freely. This construction avoids the necessity of providing an excess of water-ballast space in the interior of the boat to overcome or neutralize the buoyancy if the superstructure were made water-tight. The superstructure S extends the entire length of the boat from stem to stern, and the purpose in giving to it the inverted-V form seen in Fig. 4 is to reduce resistance in moving through the water. This also is the object of the

rounded structures 7 in front and rear of the conning-tower. They serve to part the water as the boat is running.

Having thus described my invention, I claim—

1. A submarine boat provided on its top or rounded back with a hollow superstructure having a flat, level promenade both forward and aft of the conning-tower, and having sloping portions extending from said level promenade down to the stem and stern of the boat, said hollow superstructure having at its sides always-open scuppers for the flow of water in and out, and having in its top always-open gratings for the flow of air in and out, substantially as set forth.

2. A submarine boat having on its top or rounded back a hollow superstructure with apertures for the free flow of water into and out of same, a conning-tower which extends up through said superstructure, the inclined structures, and the sloping fins 8 on the superstructure and abutting against the said tower to prevent the fouling of lines, substantially as set forth.

3. The combination with a submarine boat of spindle form and having an expulsion-tube, a muzzle-casting, and a cap 11 hinged to said casting and provided with a shield-plate 11′, of the hollow superstructure on the boat, provided with a hood 13 which houses the operative mechanism of the cap and the shield thereof, substantially as set forth.

4. A submarine boat having on its rounded top or back a hollow superstructure extending the entire length of the boat and open at all times for the outflow and inflow of air or water, said superstructure having at its middle part a flat, level, promenade-deck, and at its forward end an inverted-V form so as to reduce resistance in moving through the water, as set forth.

In witness whereof I have hereunto signed my name, this 30th day of July, 1901, in the presence of two subscribing witnesses.

JOHN P. HOLLAND.

Witnesses:
PETER A. ROSS,
K. M. CAPLINGER.

W. Hovey,

Washing Machine,

Patented Feb. 4, 1837.

No. 117,

Fig. 2.

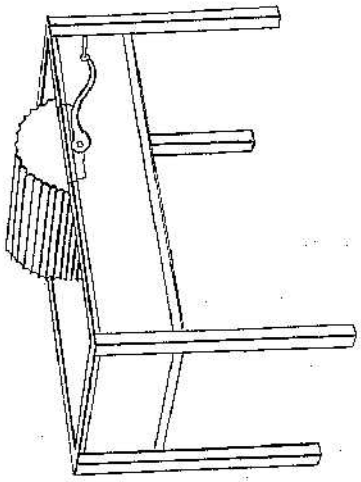
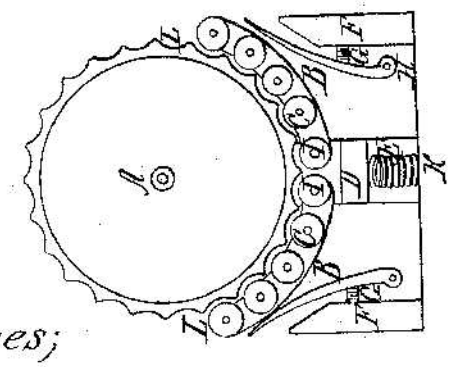


Fig. 1.



Witnesses;

O. M. Richardson

Chs. N. Richardson

Inventor;

William Hovey

UNITED STATES PATENT OFFICE.

WILLIAM HOVEY, OF WORCESTER, MASSACHUSETTS.

CYLINDER WASHING-MACHINE.

Specification of Letters Patent No. 117, dated February 4, 1837.

To all whom it may concern:

Be it known that I, WILLIAM HOVEY, of Worcester, in the county of Worcester, in the State of Massachusetts, have invented a new and useful Improvement in the Construction of Machines for Washing Clothes, called the "cylinder washing-machine," of which the following is a full and exact description.

This machine consists of a box or sink about three feet long and from ten to twelve inches deep and from twelve to eighteen inches wide. In this box or sink, near the middle from each end, I cut grooves in the side pieces of the box running up and down in a perpendicular manner about three-eighths of an inch deep, more or less, and two or three inches wide, as the builder may choose. This box or sink is then ready to receive the application of the washing apparatus, which is constructed as follows, viz: Fitted into the groves cut in the sides of the box or sink are two brass stands or slides, one on each side of the box opposite each other, calculated and fitted to slide up and down in the grooves cut in said box; they are let in flush and even with the inside of the box and are connected together near the bottom by a piece of wood the same width as the slides and about one inch thick running transversely across the box. This connects the two slides in such a manner that they will both rise or fall in the grooves as this bottom piece that connects them is raised or lowered. This horizontal piece of wood that connects the upright slides of brass or other metal not subject to corrode stands on two or more spiral or other springs which are supported by the bottom of the box or sink in such a manner that this frame, which is composed of one bottom piece of wood and the two metallic slides as above described, will sink down by pressure and rise as it is relieved. This frame I shall call the spring frame, which supports the first division of the washing apparatus, viz, the small rollers, which are fitted to come in contact with one large one and in conjunction with it constitute the whole washing apparatus or principle by which the washing is done; all other parts I consider merely as necessary appendages. This first division I describe as follows: I have as many small rollers about one inch in diameter, more or less, as will when laid close and parallel to each other make about five-twelfths of a circle of from eight to twelve inches diameter. These rollers are placed horizontally and parallel to each other with gudgeons of metal in each end, which run in circular pieces of brass or other metal not subject to corrode. These circular pieces of metal are so fitted that the small rollers, when fitted into them, form horizontally a surface conforming to the segment of a circle equal to that which I intend the outer surface or circle of the large cylinder shall be; which cylinder constitutes the second division of the washing apparatus. These circular pieces of metal in which the small rollers revolve are four in number, making two independent segments of the small rollers when fitted in their proper place. These segments of small rollers are hung in the spring frame on metallic pins projecting from near the bottom of the metallic slides or upright part of the spring frame in such a manner that the two segments of small rollers when hung in said spring frame will form a segment of a circle about five-twelfths of its circumference, more or less, with the concave side on the upper surface and running across the box. These segments of small rollers are hung on the pins in the upright slides in the spring frame by inserting the pins on which they hang into female centers made directly in a line with the centers of the two bottom rollers where the two segments meet and form the center hinge of the whole segment when they are united in the spring frame in such a manner that the upper edge of each of these wings or segments of small rollers can be moved out or in from the true circle of the whole segment without altering the lower rollers as they are hung in the spring frame. I then attach springs at each end of the upper edge of these segments near the top rollers, which springs are connected with the box or sink and serve to press the segments or rollers toward the center of the large cylinder which is fitted into the box so as to revolve in these segments of small rollers, its convex surface corresponding with the concave surface of the segment of small rollers. This roller or cylinder is fluted, so as to correspond with the small rollers in such a manner that when the springs have pressed them up they will all lie in the flutes of the large cylinder, and as this large cylinder is turned on its axis the springs will yield and let them out of

those flutes, and as they are pressed in and out by the springs and the fillets between the flutes alternately the washing is produced as the clothes are passed through between the surface of the large and small rollers. This large roller or cylinder runs by means of a crank and is turned around or backward and forward at will; it runs on a shaft or axis bearing on each side of the box; the best method of operating it is to turn it by hand backward and forward so as not to let the clothes run entirely out of the first division or small rollers nor should they wind around the large roller.

I disclaim all right to the principle or method of simply applying a fluted roller to a single segment of small rollers corresponding except such right as may be held in common with the public.

What I claim as my improvement consists in—

The method of dividing and applying the segment of small rollers as above described so as more fully to equalize the pressure between the surface of the small rollers and the fluted cylinder between which the washing is effected. I do not confine my claim to a single division of the small rollers any farther than simplicity and convenience may require to produce the desired effect. A division of each roller with springs pressing them toward the center of the fluted cylinder will more fully equalize the pressure between the small rollers and the fluted cylinder as they recede from or approach each other and will answer nearly as good a purpose as the one above described. I therefore claim the method of dividing and applying these segments of small rollers as above described or any other division that will serve to equalize the pressure between the surface of the small rollers and the fluted cylinder while in the operation of washing clothes of various thicknesses.

More fully to illustrate the construction of this machine reference is hereby made to the accompanying drawings, in which—

Figure 1 is a sectional view of the apparatus. Fig. 2 is a perspective view of the same.

In Fig. 1 A is an end view of the fluted cylinder. B B are the circular pieces of brass in which the small rollers run. I I are the center hinges or pins on which the brass pieces are hung to the spring frame. C C are the segments of small rollers divided between I I. D is a bottom section of the upright slides and end of the cross piece that connects them which constitute the spring frame. E is the spiral spring which supports the spring frame. F F are two cross partitions in the sink. G G are spiral springs which are let into the cross partitions F F and press against the dogs H H which in connection serve to press the upper part of the segments of small rollers C C toward the center of the fluted cylinder A as they hang on the hinges or pins I I. K is the bottom of the sink. L L are the places where the clothes are entered for washing between the fluted cylinder and the segment of small rollers.

In testimony whereof I, the said WILLIAM HOVEY, hereto subscribe my name in the presence of the witnesses whose names are hereto subscribed, on the tenth day of January, A. D. 1837.

WILLIAM HOVEY.

Signed in presence of—
J. H. RICHARDSON,
GEO. W. RICHARDSON.