No. 843,070. PATENTED FEB. 5, 1907.

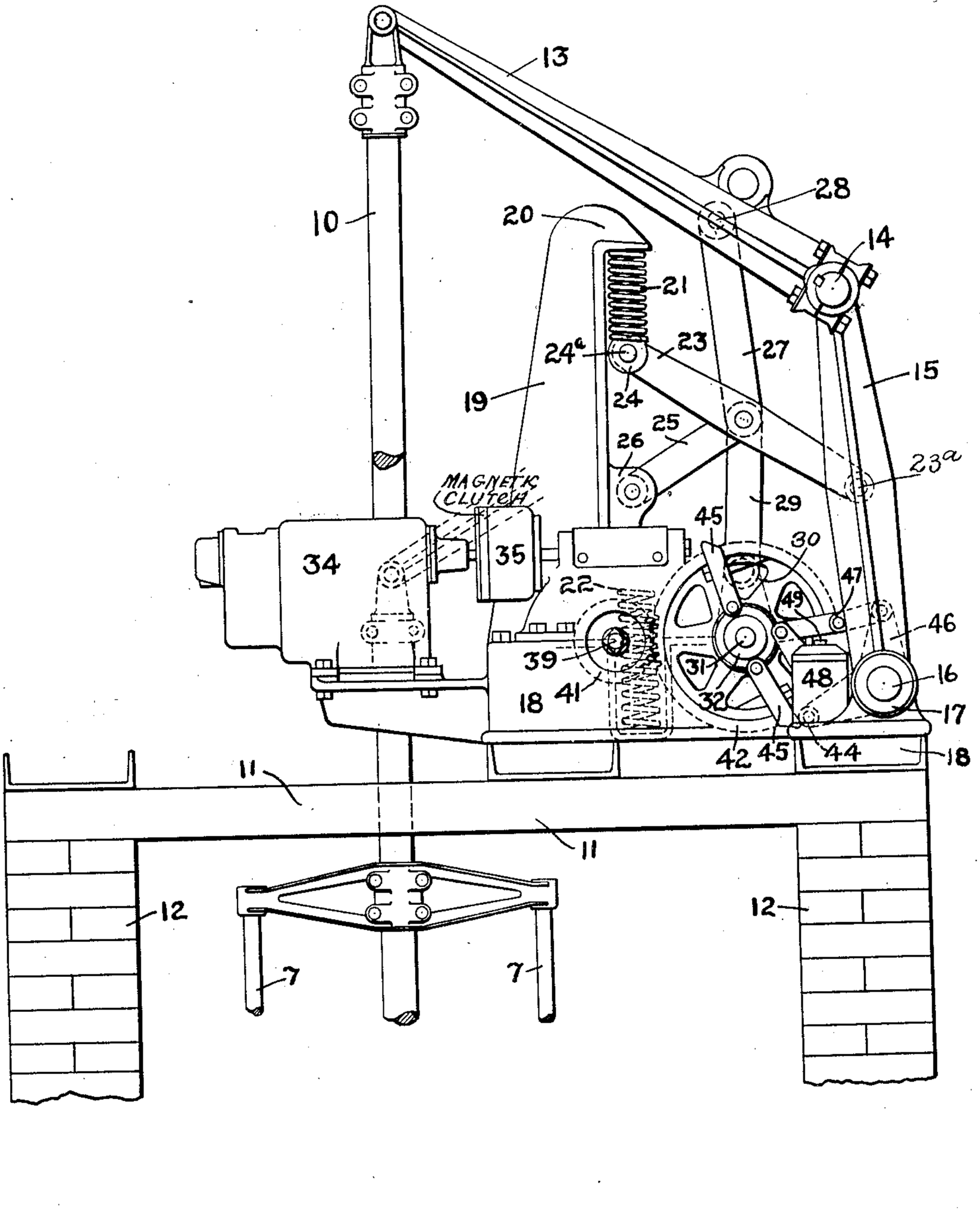
T. E. BUTTON.

SWITCH OPERATING MECHANISM.

APPLICATION FILED OCT. 11, 1904.

5 SHEETS—SHEET 1.

Fig. 1.

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## SWITCH OPERATING MECHANISM.

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5 SHEETS—SHEET 2.

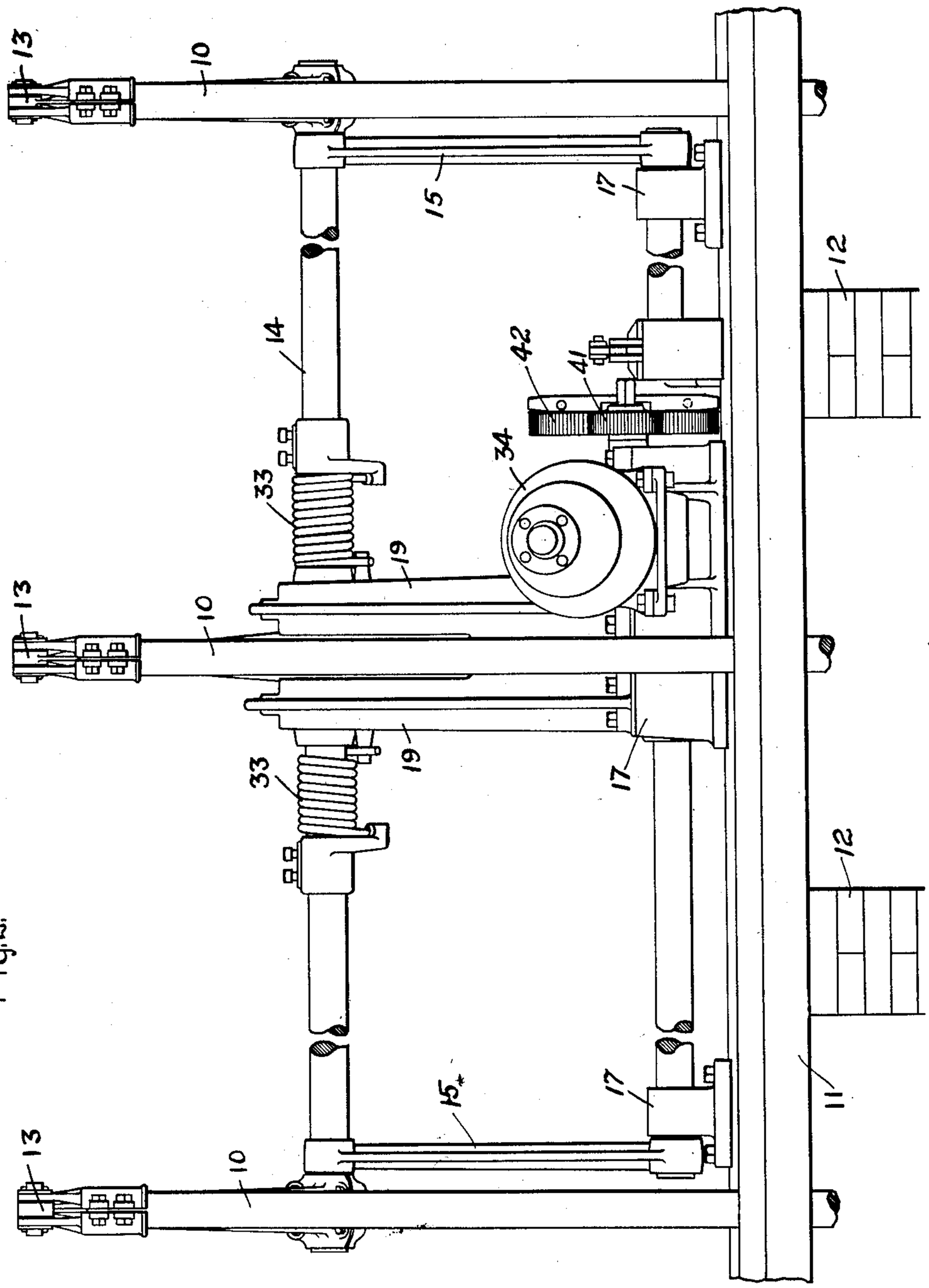


Fig. 2.

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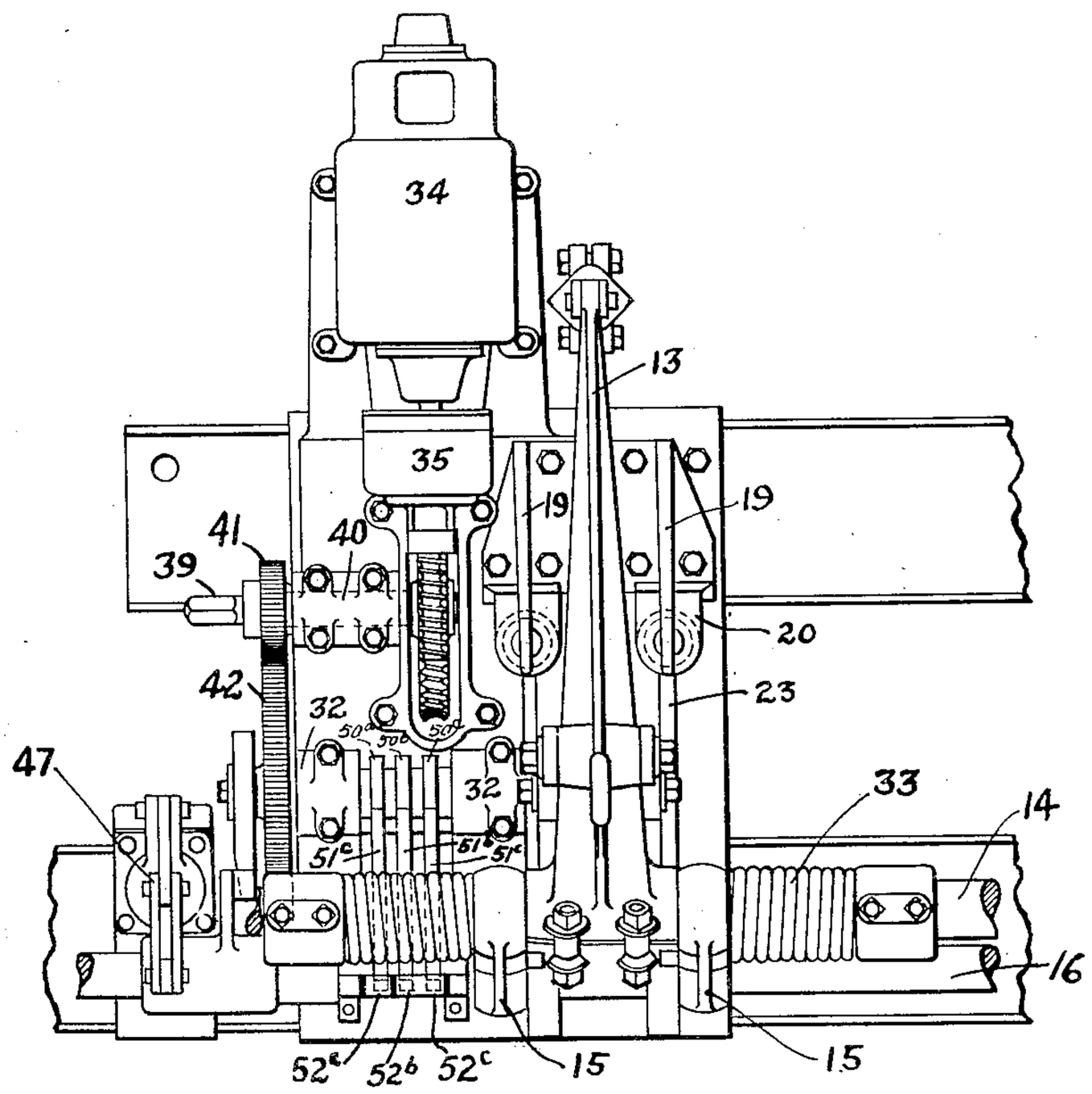
5 SHEETS—SHEET 3.

Fig. 3.

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5 SHEETS—SHEET 4.

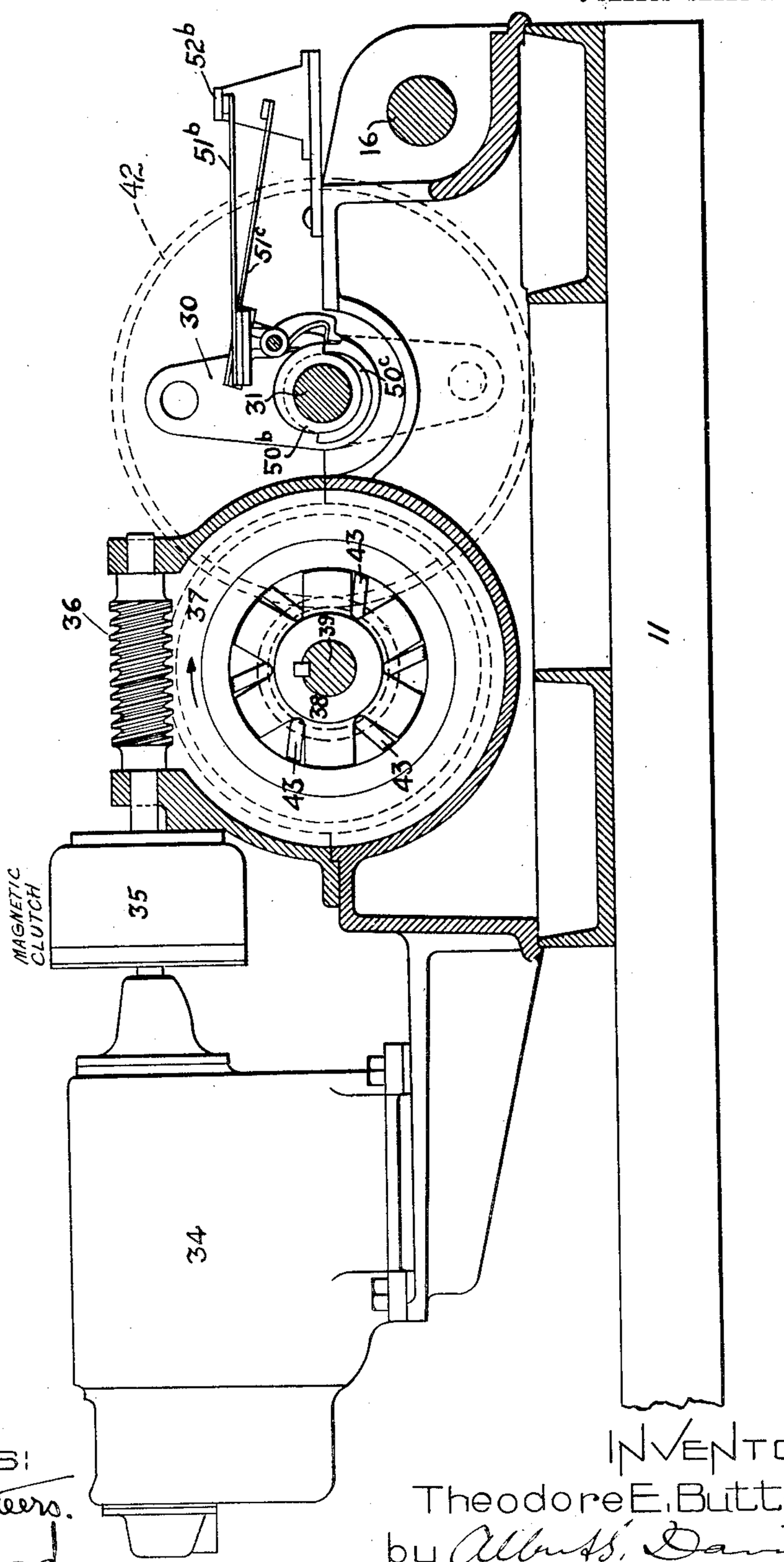


Fig. 4.

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5 SHEETS—SHEET 5.

Fig. 5.

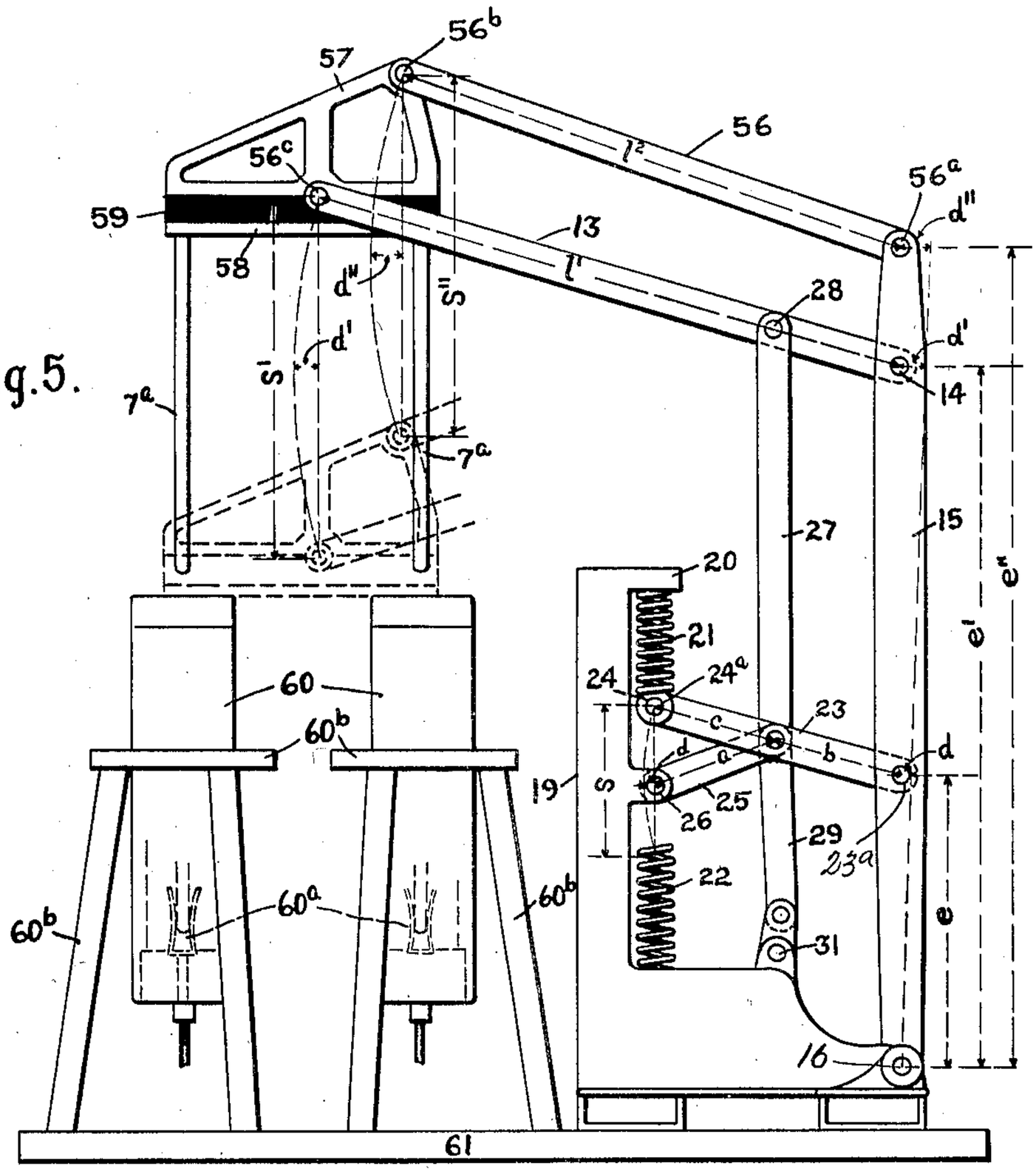
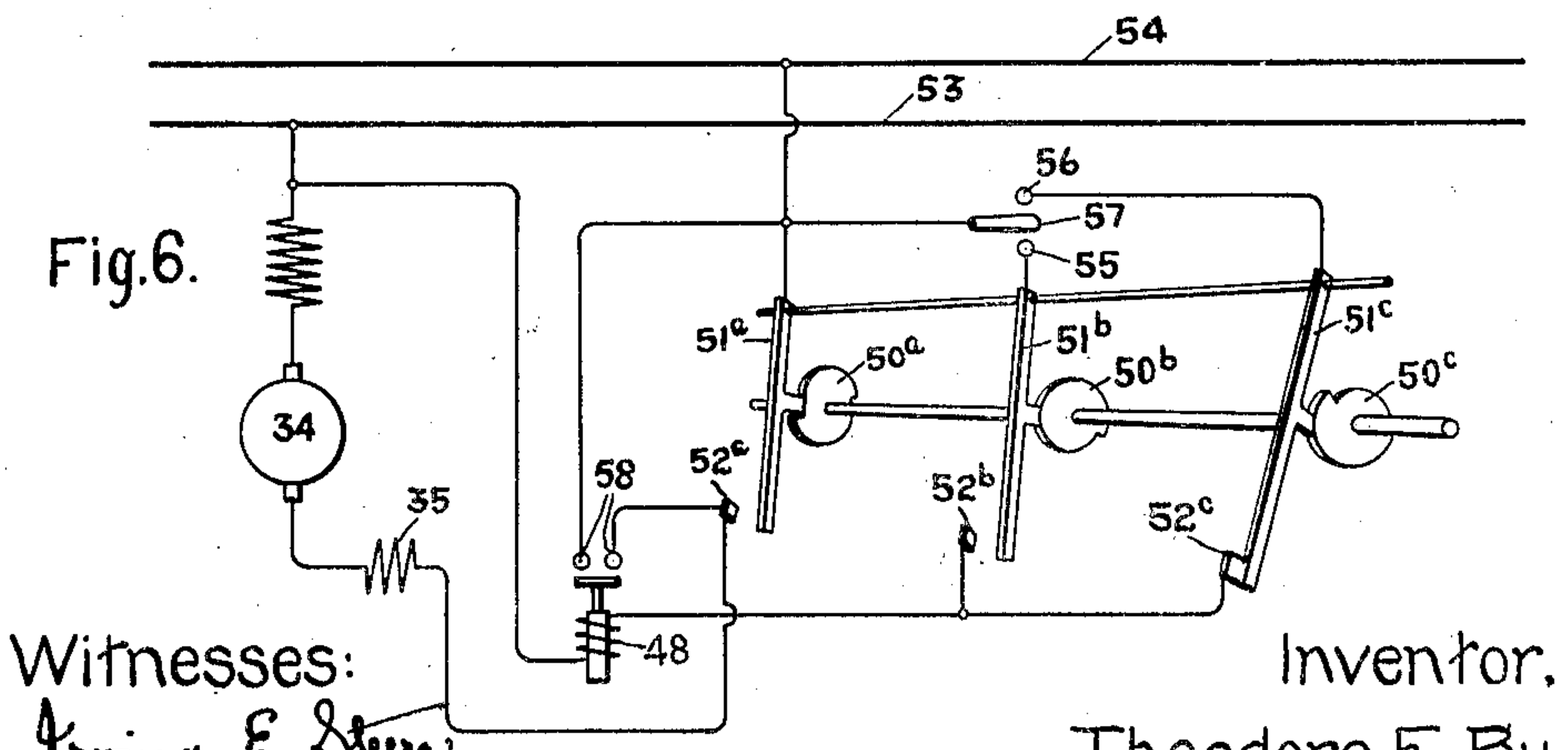



Fig. 6.

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# UNITED STATES PATENT OFFICE.

THEODORE E. BUTTON, OF SCHENECTADY, NEW YORK, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

## SWITCH-OPERATING MECHANISM

No. 843,070. Specification of Letters Patent. Patented Feb. 5, 1907.

Application filed October 11, 1904. Serial No. 228,005.

*To all whom it may concern:*

Be it known that I, THEODORE E. BUTTON, a citizen of the United States, residing at Schenectady, in the county of Schenectady and State of New York, have invented certain new and useful Improvements in Switch-Operating Mechanisms, of which the following is a specification.

The present invention relates to operating mechanism for electric switches, particularly power-driven switches of the oil-break type, designed for controlling circuits of high-potential and large amperage.

In the class of oil-switches to which my invention is particularly adapted the circuits are ruptured in oil-pots located in fireproof cells constituting an inclosing structure for the switch, and the operating mechanism therefor is usually located on the top of the cell structure, and the movable switch-contacts are vertically reciprocated. It has been the practice heretofore in switches of this character to connect the upper ends of the rods which carry the movable contacts to a single cross-bar or yoke which is bodily reciprocated upon the opening and closing of the switch, some motive mechanism, preferably an electric motor, being employed to produce this motion. With this construction it is found that when the contact-carrying rods are spaced some distance apart it becomes necessary to enlarge the size, and consequently the weight, of the connecting-yoke. This necessitates a corresponding increase in the size of the actuating parts and the operating motor.

The principal object of the present invention is to provide a novel operating mechanism which shall be suitable to the above requirements of service and at the same time light and simple in structure and effective in operation and one in which any number of contacts spaced any desired distance apart may be employed or new contacts may be added without necessitating a material increase in the weight of the existing parts.

A more complete understanding of the organization and mode of operation of my invention, together with the advantages of the same, will be had by reference to the following description, taken in connection with the accompanying drawings.

In said drawings, Figure 1 is an end view of the upper portion of an oil-switch structure upon which is mounted an operating mechanism constructed in accordance with the present invention. Fig. 2 is a side elevation of the same. Fig. 3 is a plan view of the operating mechanism. Fig. 4 is a partial sectional view illustrating the actuating motor and gearing and the circuit-controlling contact-fingers actuated thereby. Fig. 5 is a view illustrating a modification, and Fig. 6 is a diagram of the controlling-circuits by which the switch-operating mechanism is actuated.

The switch to which I have shown my operating mechanism applied is adapted for rupturing current on a high-potential triphase alternating-current circuit. The invention, however, although particularly applicable to high-potential switches, may be used in connection with any switches in which a reciprocating switch movement is employed.

In the present organization the movable switch-contacts 7 are secured by yokes to the lower ends of the vertical wooden rods 10, which project through openings in the supporting-cap 11 of the cell structure of the switch. The cap 11 is mounted upon brick walls 12, which divide the supporting structure into a plurality of inclosing cells, one for each phase of the switch.

The vertical supporting-rods 10 are pivotally connected at their upper ends to the laterally-extending rock-arms 13, which are securely keyed at their opposite ends to a longitudinally-extending shaft 14, supported at the upper ends of the struts 15. These struts are pivotally mounted upon a second longitudinally-extending shaft 16, carried by suitable bearings 17, secured to the top of the cell structure and to the frame 18 of the motor-actuating mechanism. Mounted upon this same base 18 is a pair of upright brackets 19, which are provided at their upper ends with overhanging portions 20, to which the coiled compression-springs 21 are firmly secured. Similar compression-springs 22 are located in suitable seats or depressions in the base 18 in line with the springs 21. These springs constitute the actuating mechanism by which the switch-contacts are given a quick opening and closing movement. These springs are adapted to be engaged by the end of levers 23 or suitable engaging members, such as the antifriction spherical rollers 24,

mounted thereon at 24ª. The levers 23 are connected at their opposite ends to the central supporting-struts 15 15 at 23ª, and one or more links 25 connect the center of the levers 23 to a fixed point 26 on the brackets 19. One or more links 27 also connect the center of this lever with the central rock-arm 13 at the point 28. A connecting-rod 29 also connects the center of the lever 23 to a crank 30 on the shaft 31, mounted in the bearings 32 on the base 18. This system of links constitutes a parallel-motion mechanism by which when the crank 30 is rotated the antifriction member 24, which engages the springs, and the supporting-rods 10 are reciprocated in parallel right lines. The proportion of the parts is such that the complete rotation of the crank causes the lever 23 to compress the springs 21 and 22 alternately.

From the above it will be seen that if the crank 30 is moved to dead-center, or approximately dead-center, and held there the springs 21 or 22 will be maintained under strain. If then the holding means be removed, the mechanism will be unlocked, and the compressed springs will be free to throw outward the reciprocating member 24, thereby producing a quick movement of the movable switch-contacts. In order to minimize the work required of the springs 21 22, the weight of the movable contacts and their supporting parts is neutralized by means of counterbalancing torsion-springs 33, coiled about the shaft 14 and connected at their opposite ends to said shaft and to the adjacent struts 15, as clearly illustrated in Fig. 2. The crank-shaft 31 is rotated by means of an electric motor 34, mounted upon the base 18 and adapted to be thrown into engagement with a train of gearing connected to said shaft by the magnetic clutch 35. This train of gearing comprises a worm 36, engaging with a worm-gear 37, which forms the exterior member of a friction-ratchet, whose interior member 38 is keyed to a shaft 39, mounted in a bearing 40 upon the base 18. This shaft 39 carries a pinion 41, which engages a gear-wheel 42, mounted on the crank-shaft 31. The interior ratchet member 38 carries a number of engaging pawls 43, which are eccentrically mounted and free to rotate in the bearings at their inner ends and to bite into or disengage the interior surface of the exterior member 37 at their outer ends. In operation the ratchet is always rotated in the same direction—that is, in the direction indicated by the arrow in Fig. 4; but the interior member is free to run ahead of the exterior member From this it follows that when the motor is driving the crank-shaft 31 against the opposing pressure of the springs 21 or 22 the members 37 and 38 of the ratchet are in transmitting engagement; but as soon as the crank 30 is moved beyond dead-center, so that the springs 21 and 22 are free to act, if unrestrained, the crank 30 will be rapidly rotated thereby in advance of the rotation produced by the motor. At such a time the interior member 38 will outrun the exterior member 37, and the teeth of the pawls 43 will slip over the interior surface of the member 37. However, when the exterior member catches up to the interior member the full load will be thrown on the motor, and the pawls 43 will be rotated about their bearings, so as to bite into the interior surface of the member 37 and transmit the motion imparted thereto to the shaft 38, and thence to the crank-shaft 31. In order to hold the crank 30 against rotation when the appropriate set of springs has been compressed, so that the switch may be held in either closed or open position, a movable stop 44 is provided. This stop is adapted to be engaged by arms 45, which project from opposite sides of the crank-shaft 31. The stops 45 are located so that they stop the crank 30 just after it has passed dead-center. The stop 44 is located on the outer end of bell-crank lever 46, which is actuated by means of a toggle 47, connected between one of its arms and a fixed point on the base 18. The toggle normally holds the stop 44 in its engaging position through the action of gravity; but the toggle may be actuated to throw the stop 44 out of engaging position by means of the trip-magnet 48. This magnet is located directly beneath the toggle 47, so that its core 49 when drawn upward by the energization of its magnet-coil will deliver a blow sufficient to actuate the toggle, and thereby free the shaft 31.

In order to cut off the power of the motor at the right instant and to otherwise vary the motor connections, the shaft 31 is provided with three cams 50ª, 50ᵇ, and 50ᶜ, which coöperate with three contact-fingers 51ª 51ᵇ 51ᶜ to rock them into and out of engagement with the fixed contacts 52ª, 52ᵇ, and 52ᶜ. The operation of the cams and their coöperating switch-contacts will be best understood from the diagram shown in Fig. 6. As clearly illustrated in this diagram, the motor 34 and the magnetic clutch 35 are connected in series between the leg 53 of the supply-circuit and the contact 52ª. The trip-coil 48 is connected between the leg 53 and the contacts 52ᵇ and 52ᶜ, which are connected together. The contact-finger 51ª, which is known as the "master-finger," is connected directly to the other leg 54 of the supply-line, and the contact-fingers 51ᵇ and 51ᶜ, which are known as the "opening" and "closing" fingers are connected to the terminals 55 and 56 of a double-throw switch, whose contact-blade 57 is connected to the leg 54 of supply-circuit. The cam 50ª is provided with two oppositely-disposed depressions, while the cams 50ᵇ and 50ᶜ are provided with

projecting portions, which are so located with reference to the depressions on the cam $50^a$ as to close either the finger $51^b$ or the finger $51^c$ when the master-finger $51^a$ is open. The trip-coil is provided with two contacts 58, which are connected one with the master-finger contact $52^a$ and the other with the leg 54 of the supply-circuit. With this organization, assuming that the parts are in the position illustrated, which corresponds to the closed position of the switch, and that it is desired to open the switch, the contact 57 of the manual controlling-switch, which is usually located some distance from the high-potential switch, is thrown into engagement with the contact 56, so as to complete the circuit through the opening-finger $51^c$, contact $52^c$, and trip-coil 48. The coil 48 is thereby energized and by its upward movement actuates the toggle 47, so as to remove the stop 44 from the path of the stop-arm 45 and at the same time bridges the contacts 58. Current is then free to flow through the motor by way of the contacts 58 and $52^a$. This at the same time starts the motor and energizes the clutch 35. As soon as the crank-shaft is freed by the removal of the stop 44, the springs 22, which have been held under strain while the switch remained closed, throw the engaging end of the lever 23 upward, and with it the contacts of the switch. During this operation the interior member 38 of the ratchet moves freely within the exterior member 37 and in advance of the same, as previously pointed out. As soon as the crank-shaft 31 rotates a short distance the master-finger $51^a$ is moved to its closed position by riding upon the cam $50^a$, and as soon as it is closed the closing-finger $51^c$ passes from its cam projection, and it drops to the open position. The effect of this change is to deënergize the trip-coil 48 and allow the stop 44 to return to its engaging position to catch the shaft 31 when it has made one half-revolution and also to open the circuit at the contacts 58, leaving the motor-circuit completed through the master-finger $51^a$ and its contact $52^a$. In this operation about the time the spring-engaging member 24 has reached the upper actuating-springs 21 the relative speed of the parts will be such that the ratchet will take hold, and the accumulated energy of the motor will be transmitted to complete the semirotation of the crank-shaft 31. In doing this the springs 21 will be compressed, and the movement of the parts will cease only when the crank-shaft 31 has rotated far enough to allow the master contact-finger $51^a$ to drop out of engagement with the contact $52^a$. This will occur when the stops 44 and 45 come into engagement. When the shaft 31 has rotated far enough to permit the master-finger to separate from its contact, the projecting portion of the cam $50^b$ will have forced the opening contact-finger $51^b$ into engagement with its contact $52^b$, thus leaving the parts in readiness for the opening of the switch upon movement of the manual controlling-switch to complete the circuit through its terminal 55.

In the construction hereinbefore described the wooden rods 10, which carry the movable switch-contacts, are pendulously supported from the outer ends of the rock-arms 13, and the operating mechanism is such that the outer ends of these arms move in vertical right lines; but in order to prevent the rods from swinging some light guide for each of the rods is required. This in the present instance is provided by the openings through the cap of the cell through which these rods pass. In Fig. 5 of the accompanying drawings I have illustrated a modified construction in which the movable switch-contacts are positively actuated in a right line and are prevented from movement out of that line without the employment of guiding means. This is accomplished by constructing the supporting mechanism of each of the movable switch-contacts so that there is an additional point which has a right-line movement parallel to that of the outer end of the supporting rock-arm 13. In this instance this point is the outer end of the rock-arm or link 56. The inner end of this link is pivoted at $56^a$ to an extension of the rocking strut 15, and its outer end and the outer end of the rock-arm 13 are pivotally connected at the points $56^b$ and $56^c$, respectively, to a rigid frame 57, which maintains these ends in fixed relation. This frame supports the moving switch-contacts $7^a$, which are electrically connected by the bridging-piece 58. which is insulated from the frame 57 by a strip of wood or other suitable insulation 59, In this figure I have also shown the oil-pots 60, which contain the contacts $60^a$, with which the moving contacts $7^a$ coöperate. In this type of switch the line-terminals are connected to the fixed contacts $60^a$, and the circuit between said contacts is completed by the bridging-contact. These oil-pots are suitably mounted upon supports $60^b$, of wood or other suitable insulating material, having legs resting upon the base 61, which supports the switch-operating mechanism. In this figure I have not shown the motor or other driving mechanism for the rocking shaft 31; but the mechanism hereinbefore described may be employed, and obviously it may be located at any desired point and connected to the crank-shaft 31 by suitable gearing.

In the mechanism heretofore described, by which the contacts are given their right-line motions, the parts bear certain definite relations to each other as to length and points of connection which must be observed in designing the switch-operating mechanism. The links 23 and 25 and the rocking strut 15, connected up in the manner shown and de-

scribed, constitute a parallel-motion mechanism of a well-known type, in which the free end of the link 23 moves in a right line and in which the lengths of the parts and their connections are such that the relation expressed in the proportion $a:b=b:c$ exists, where $a$, $b$, and $c$ represent the distances indicated in Fig. 5. Preferably these links are so connected in proportion that $a$, $b$, and $c$ are equal. Consequently, in the operation of the mechanism these links 23 and 25 swing through equal angular distances. Now it is obvious that where two links of different lengths are attached each to a pivot at one end and are given the same angular movement the depths of the arcs formed by their free ends are directly proportional to the lengths of the links. Consequently, in the present instance, since $a$, $b$, and $c$ are equal, the depths of the arcs struck by $a$ and $b$ as radii are equal, and each is equal to one-half the depth $d$ of the arc struck by the radius $(b+c)$. Due to the relation of the parts, the fulcrum $23^a$ is given a lateral movement equal to the sum of the depths of the arcs formed by $a$ and $b$ as radii. This sum, as previously indicated, equals the depth $d$ of the arc struck by $a+b$ as a radius. Since $a+b$ equals the length of the link 23, it will be seen that the arc is entirely removed from the motion of the free end of said link, and the latter is caused to move in a right line. In this operation of the parts each stroke of the crank moves the free end of the link 23 through a definite stroke S, which is the chord of the arc having the depth $d$. Consequently, the distance $d$ may also be expressed in terms of the radius and chord—that is, in terms of $l$ and $s$, where $l$ equals $(b+c.)$ Obviously the distance between the points $23^a$ and 26, which may be designated $m$, plus $d$ equals $l$. Now the distance $m$ equals

$$\sqrt{l^2-\left(\frac{s}{2}\right)^2}.$$

Therefore

$$d=l-\sqrt{l^2-\left(\frac{s}{2}\right)^2}$$

The principal feature of the present invention resides in the means for causing this one parallel-motion mechanism to affect a plurality of points as it affects the free end of the link 23—that is, to cause these points to move in right lines parallel to the right-line path of the free end of said link. One of the points which is to be moved in such a right-line path is the outer end of the rock-arm 13, and the distance through which it is to be moved equals the length of the stroke required by the moving contacts of the switch. This distance is designated $s'$ in Fig. 5. Obviously by locating the point 28, which is the point of connection between the link 27 and the rock-arm 13, at a distance from the shaft 14 equal to $b$ the arm 13 will be caused to rock through the same angle as the link 23 when the parts are operated. Therefore, since the angular distance through which the link 23 and the rock-arm 13 are to pass is the same, then if $l$ and $l'$ represent the length of the link 23 and the arm 13, respectively, and $s$ $s'$ the length of stroke of their free ends the value of $l'$ (or the length of the arm 13) may be determined from the proportion $s:s'=l:l'$, since the values of $s$, $s'$, and $l$ are known. In a similar manner the depth of the arc which will be struck by the arm 13 may be determined by the proportion $d:d'=l:l'$, where $d$ and $d'$ represent the depths of the arcs struck by the lengths $l$ and $l'$, respectively, since $d$, $l$, and $l'$ are known. This value $d'$ is the distance through which the shaft 14 must be moved laterally in order to maintain the movement of the free end of the arm 13 in a right line. To accomplish this, the distance between the shafts 14 and 16, (designated $e'$,) must be a certain amount. This is obtained by solving for $e'$, in the proportion $e:e'=d:d'$, where $e$ equals the distance of the fulcrum $23^a$ above the shaft 16. Obviously by making the shafts 14 and 16 and the connecting-struts 16 sufficiently strong to transmit this same lateral movement to the shaft 14 throughout its entire length any number of rock-arms may be placed on it and a corresponding number of switch-contacts operated thereby.

When it is desired to employ the form of the invention disclosed in Fig. 5, the length of the link 56 may be determined as follows: The additional length of the strut 15 beyond the shaft 14 may be arbitrarily assumed. If then $e''$ represents the distance of the pivot-point $56^a$ above the shaft 16 along the strut 15, then the lateral distance through which the pivot $56^a$ will move will be found from the proportion $e:e''=d:d''$, where $d''$ indicates this lateral distance. Now in order that the lever 56 may be given a length sufficient to produce an arc having a depth equal to $d''$ it must satisfy the conditions of the equation:

$$d=l-\sqrt{l^2-\left(\frac{s}{2}\right)^2}$$

previously given, where $d$, $l$, and $s$ have the values of $d''$, $l''$, and $s''$. Of these $d''$ and $s''$ are known, the former being obtained in the manner just described and the latter being the length of the stroke of the movable switch-contacts. Solving for $l''$ (or $l$) the length of the link 56 is obtained.

In either of the forms of the invention it is not absolutely essential that the free end of the link 23 move in a right line, since it is only necessary that it engage the springs 21 and 22 at the ends of its stroke, and they might be slightly shifted to obtain a proper bearing and thrust upon the outer end of the link.

In such case the distance *c* would be more or less than the distances *a* or *b*.

It is obvious that other mechanism may be employed for giving the crank-shaft 31 its requisite movement, and the means which I have herein disclosed constitutes no part of the present invention, but is inserted for the purpose of describing a completely-operative device.

It will also be obvious to those skilled in the art that many changes in the proportions of the parts and in features of construction may be made without departing from the spirit and scope of my invention. I therefore do not wish to be limited to the specific matter illustrated, but aim to cover by the terms of the appended claims all such alterations and modifications.

What I claim as new, and desire to secure by Letters Patent of the United States, is—

1. An electric switch comprising a plurality of pivoted rock-arms, a contact carried by each of said arms, and common means for actuating said arms to give said contacts a right-line motion.

2. An electric switch comprising a rock-shaft, supporting-arms extending laterally therefrom, a contact carried by each of said arms, and means for rocking and shifting said shaft to give said contacts a right-line motion.

3. An electric switch comprising a rock-shaft, supporting-arms extending laterally therefrom, a contact carried by each of said arms, an actuating-motor, and connecting means between said motor and shaft for rocking and shifting the latter to give said contacts a right-line motion.

4. An electric switch comprising a plurality of pivoted rock-arms, a contact carried by each of said arms, an actuating-motor, and parallel-motion connections between said arms and motor for moving said contacts in a right line.

5. An electric switch comprising parallel-motion mechanism having two points movable in parallel right lines, actuating means adapted to engage said mechanism at one of said points, and a movable switch-contact pivotally connected to the mechanism at the other point.

6. An electric switch comprising parallel-motion mechanism having two points movable in parallel right lines, an actuating-spring lying in the path of movement of one point, and a movable switch-contact pivotally connected to the mechanism at the other-point.

7. An electric switch comprising parallel-motion mechanism having two points movable in parallel right lines, an actuating-spring lying in the path of movement of one point, a movable switch-contact pivotally connected to the mechanism at the other point, and a motor for storing energy in said spring.

8. An electric switch comprising parallel-motion mechanism including two pivoted movable members and connections between them for causing two points, one on each of said members, to move in parallel right lines, actuating means adapted to engage said mechanism at one of said points, and a movable switch-contact connected to the mechanism at the other point.

9. An electric switch comprising parallel-motion mechanism including two pivoted movable members and connections between them for causing two points, one on each of said members, to move in parallel right lines, an actuating-spring lying in the path of movement of one point, and a movable switch-contact connected to the mechanism at the other point.

10. An electric switch comprising parallel-motion mechanism including two pivoted movable members and connections between them for causing two points, one on each of said members, to move in parallel right lines, an actuating-spring lying in the path of movement of one point, a movable switch-contact connected to the mechanism at the other point, and a motor for storing energy in said spring.

11. An electric switch provided with a movable contact, opposing springs disposed in a line parallel to the line of motion of said contact, a member adapted to be projected to and fro between said springs, and parallel-motion connections between said member and said contact for giving them parallel right-line motions.

12. An electric switch provided with a movable contact, opposing springs disposed in a line parallel to the line of motion of said contact, a member adapted to be projected to and fro between said springs, parallel-motion connections between said member and said contact for giving them parallel right-line motions, and means for storing energy in said springs.

13. An electric switch comprising a frame, a movable contact, an actuating-spring, a lever having one end adapted to engage the spring, a motor-crank connected to the center of the lever, a link pivotally connected at one end to a fixed point on the frame and at the other to the center of the lever, said link being one-half the length of said lever, means for permitting a lateral movement of the free end of the lever whereby its engaging end is reciprocated in a right line, and connections between said lever and contact for moving the latter in a right line.

14. An electric switch comprising a frame, a movable contact, an actuating-spring, a lever having one end adapted to engage the spring, a motor-crank connected to the center

of the lever, a link pivotally connected at one end to a fixed point on the frame and at the other to the center of the lever, said link being one-half the length of said lever, means for permitting a lateral movement of the free end of the lever whereby its engaging end is reciprocated in a right line, a rock-arm connected at its outer end to said contact, and connecting means between said lever and rock-arm whereby said contact is reciprocated in a right line.

15. An electric switch comprising a movable contact, a contact-support carrying said contact, motive mechanism for shifting the contact, and actuating connections between said motive mechanism and contact-support for giving the latter a right-line motion and holding it against transverse movement.

16. An electric switch comprising a movable contact, a contact-support carrying said contact, motive mechanism for shifting the contact, and actuating connections between said motive mechanism and contact-support for moving the latter and compelling it to move in a right line.

17. An electric switch comprising a movable contact, motive mechanism for shifting the contact, a support to which said contact is rigidly connected, and connecting means between said motive mechanism and contact-support pivotally connected to the latter at two points and operative to move said contact and its support in a right line.

18. An electric switch comprising parallel-motion mechanism having three points movable in parallel right lines, actuating means adapted to engage said mechanism at one of said points, and a movable switch-contact pivotally connected to said mechanism at the other points.

19. An electric switch comprising parallel-motion mechanism having three points movable in parallel right lines, an actuating-spring lying in the path of movement of one point, and a movable switch-contact pivotally connected to the mechanism at the other points.

20. An electric switch comprising parallel-motion mechanism including three pivoted movable members and connections between them for causing three points, one on each of said members, to move in parallel right lines, actuating means adapted to engage said mechanism at one of said points, and a movable switch-contact connected to said mechanism at the other points.

21. An electric switch comprising parallel-motion mechanism including three pivoted movable members and connections between them for causing three points, one on each of said members, to move in parallel right lines, an actuating-spring lying in the path of movement of one point, and a movable switch-contact connected to the mechanism at the other points.

In witness whereof I have hereunto set my hand this 10th day of October, 1904.

THEODORE E. BUTTON.

Witnesses:

EDWARD WILLIAMS, Jr.,

HELEN ORFORD.