No. 805,648. PATENTED NOV. 28, 1905.

S. L. G. KNOX.

MEANS FOR STORING AND APPLYING ENERGY.

APPLICATION FILED FEB. 24, 1902.

2 SHEETS—SHEET 1

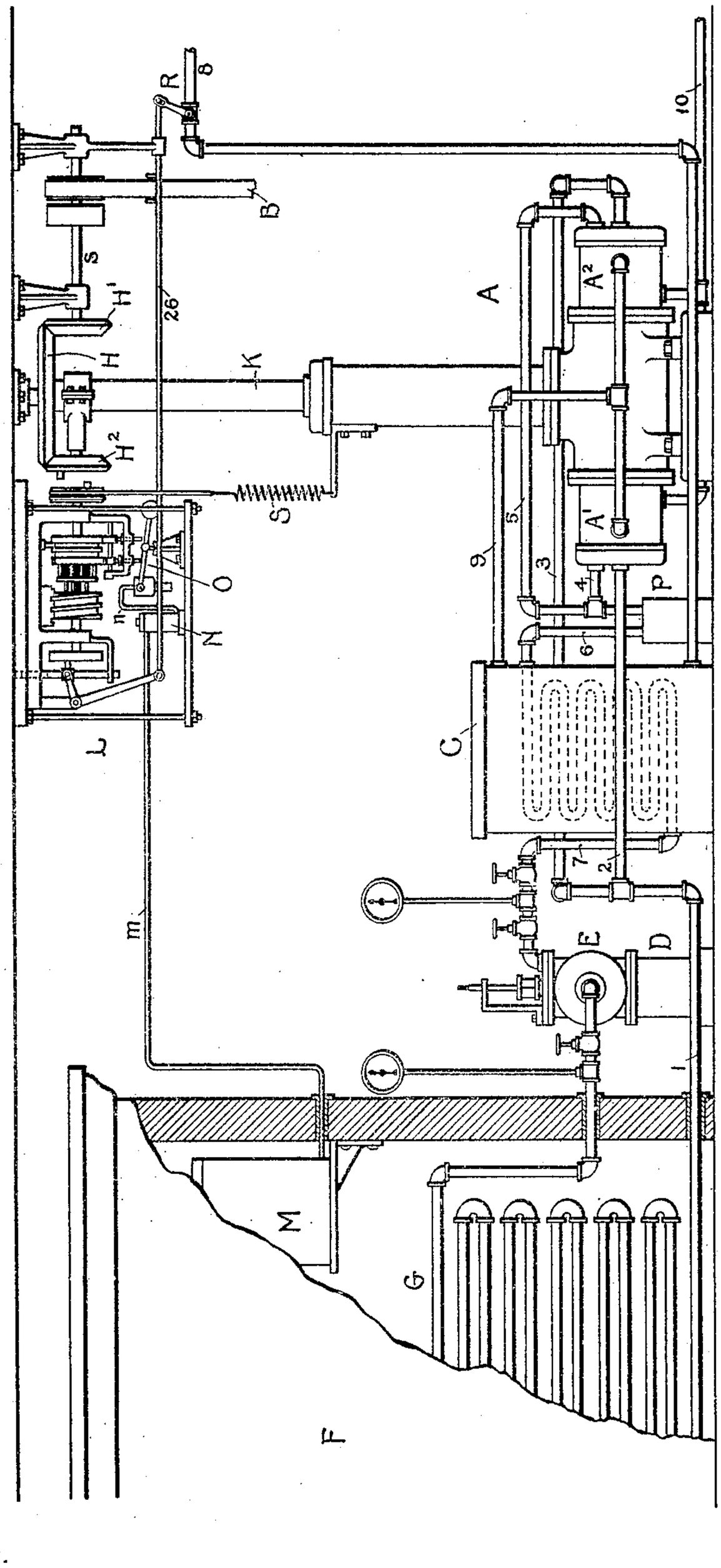

Fig. 1

Witnesses.
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2 SHEETS—SHEET 2.

Fig. 2.

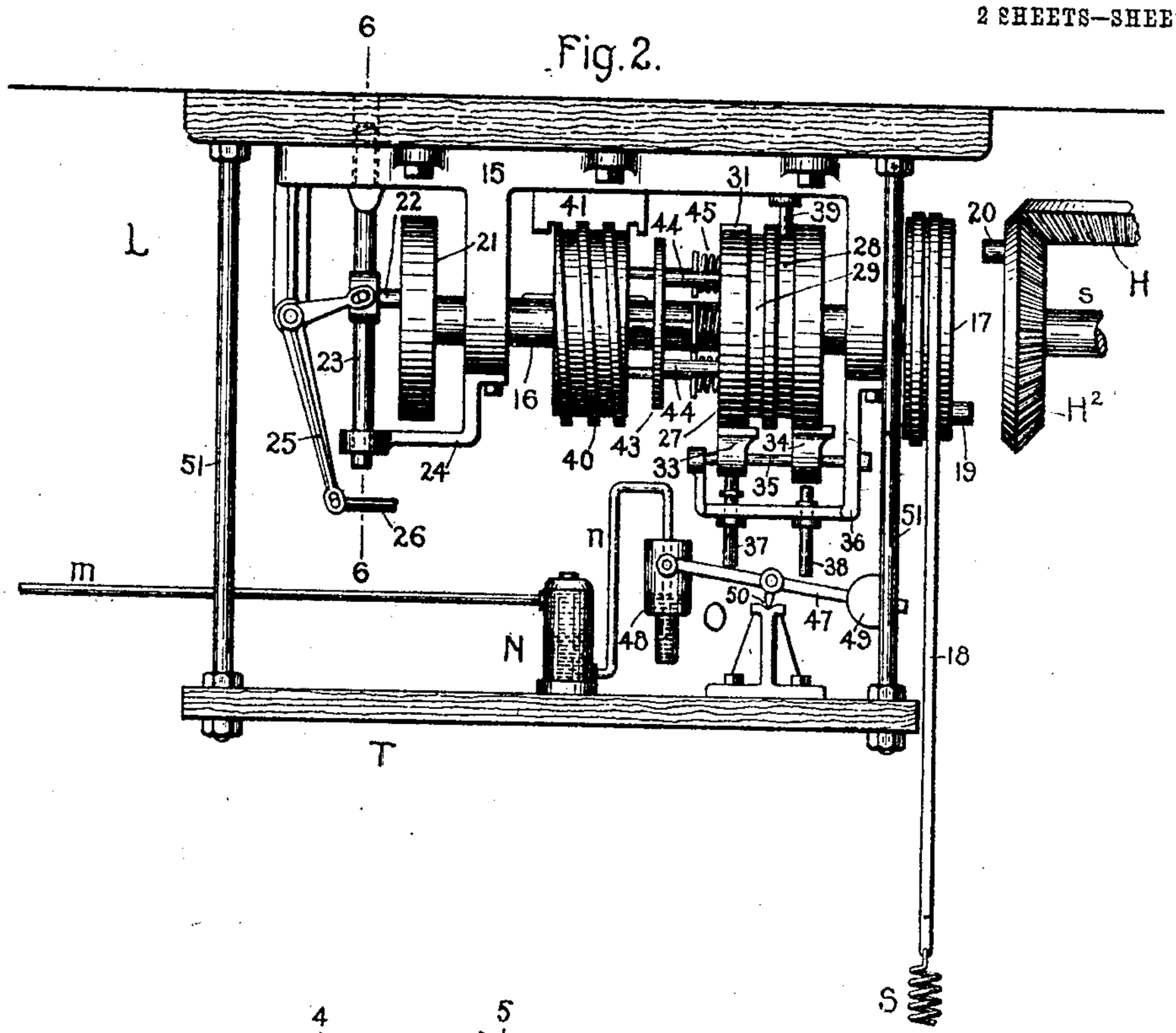


Fig. 3.

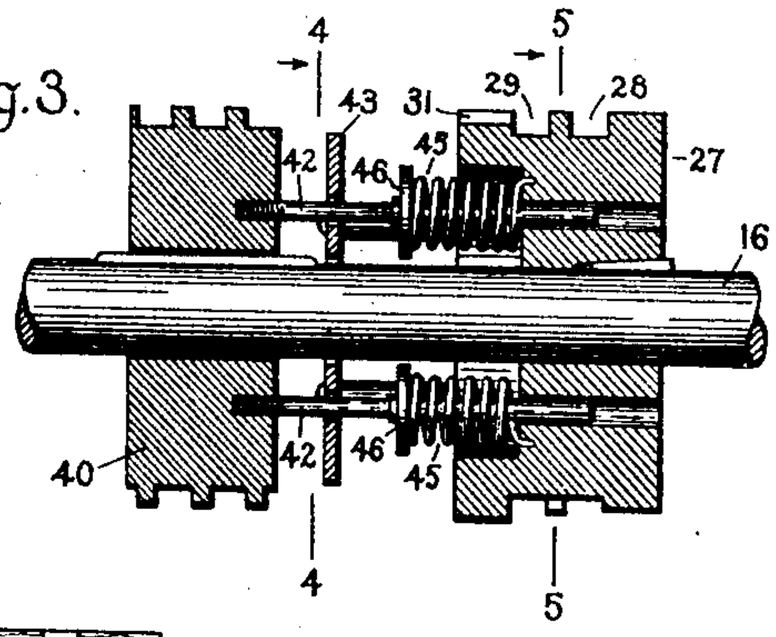


Fig. 5.

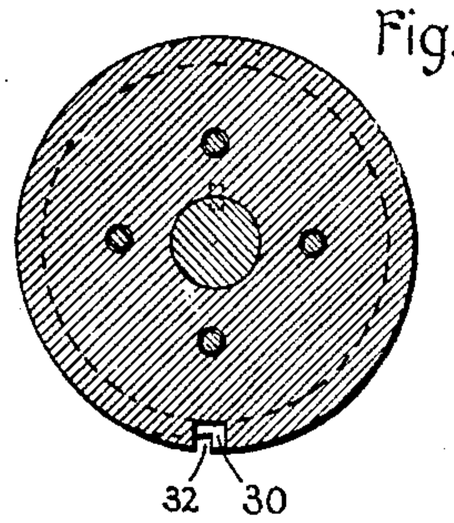
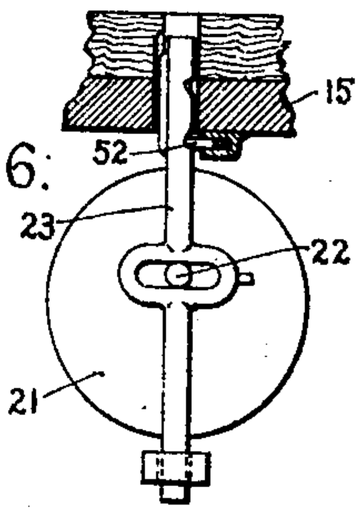


Fig. 6.



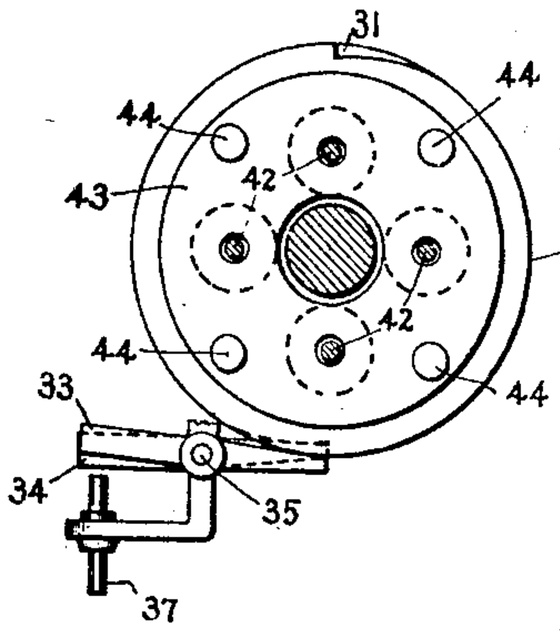


Fig. 4.

Witnesses.
J. Ellis Glenn.
M. E. Jacobson

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by Cutting & Buck.
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UNITED STATES PATENT OFFICE

SAMUEL LIPPINCOTT GRISWOLD KNOX, OF SCHENECTADY, NEW YORK

MEANS FOR STORING AND APPLYING ENERGY.

No. 805,648. Specification of Letters Patent. Patented Nov. 28, 1905.

Application filed February 24, 1902. Serial No 95,258.

To all whom it may concern:

Be it known that I, SAMUEL LIPPINCOTT GRISWOLD KNOX, a citizen of the United States, residing at Schenectady, county of Schenectady, State of New York, have invented certain new and useful Improvements in Means for Storing and Applying Energy, of which the following is a specification.

My invention relates to means for storing and applying energy; and in the particular organization which I have illustrated in my present application it has for its object to render a refrigerating system automatic in its operation, so that the temperature of the refrigerating-chamber will be maintained within certain predetermined limits.

The system in connection with which I have chosen to illustrate my invention comprises the usual compressor or pump driven from any suitable source of power, a condenser through which the compressed gases are passed to liquefy the same, a receiver for containing the liquefied gas, and expansion-coils located within a refrigerating-chamber. An automatic mechanism comprising a motive device operates in the refrigerating system to throw the power on and off in accordance with changes of temperature in the refrigerating-chamber and a thermostat and associated tripping mechanism arranged to secure the operation of the motive device at the desired times.

My invention will be better understood by reference to the following description, taken in connection with the accompanying drawings, while its scope will be pointed out in the appended claims.

In the drawings, Figure 1 is a diagrammatic view of an automatic refrigerating system, showing one embodiment of my invention. Fig. 2 is a detail view of the thermostatic tripping mechanism and the motive device by the operation of which the connection to the source of power is made and broken. Fig. 3 is a view in cross-section of a portion of the mechanism shown in Fig. 2. Figs. 4 and 5 are views in cross-section along the lines 4 4 and 5 5, respectively, in Fig. 3. Fig. 6 is a view in partial cross-section along the line 6 6 in Fig. 2.

Referring first to Fig. 1, A is a gas-pumping machine arranged to be operated from a suitable source of power through a belt B, which is adapted to be shifted from a loose to a fixed pulley, and vice versa, on the shaft *s*. C is a condenser through which the compressed gas is passed in order to liquefy the same, D is a receptacle for containing the liquefied gas, G is a set of tubes constituting the expansion-coils by means of which the refrigerating-chamber F is cooled, and E is a reducing-valve between the receptacle D and the expansion-coils. The gas after it has been expanded is drawn away from the coils by the action of the gas-pump, which, as shown in the drawings, is provided with two cylinders A′ and A². The gas enters the pump through pipe 1 and its branches 2 and 3, and after being compressed is expelled through pipes 4 and 5, leading to an oil-separator P. From the separator it passes by way of pipe 6 to the condenser-coils and thence through pipe 7 to the receptacle D, from whence it escapes through the reducing-valve E into the expansion-coils. The cold-water supply for the condenser is through the valve R in the pipe 8, and the water after leaving the condenser is passed through pipe 9 into water-jackets surrounding the two cylinders of the gas-pump and is then carried off through the waste-pipe 10. The pistons in the two cylinders of the gas-pumping machine are simultaneously operated by means of a shaft passing down through the casing K and having at its upper end a bevel-gear H, which is driven from the belt B through the gear H′ and the fixed pulley on the shaft *s* when the belt is shifted thereon.

The belt-shifting or other mechanism which determines the starting and stopping of the gas-pump, is operated upon the occurrence of certain predetermined changes in the temperature of the refrigerating-chamber. It is operated by a motive device L in which energy for actuating the belt-shifting mechanism is stored whenever the gas-pump is started, a tripping device O for releasing the motive device and permitting it to operate to shift the belt off or on, and a thermostat for operating the tripping device whenever the temperature either rises above or falls below certain predetermined limits.

The motive device is purely mechanical in its operation and may be arranged to shift a belt, open and close a switch, open and close a valve, or operate any other mechanism which will start and stop the pump-actuating mechanism. It consists primarily (see Fig. 2) of a shaft 16, mounted in bearings carried by a frame 15 and free to rotate and to

move longitudinally therein. Rigidly attached to the shaft at its two ends are disks 17 and 21, the former provided with a projection or lug 19, adapted when the shaft is at the limit of its longitudinal movement in one direction to project into the path of a corresponding lug on a gear H^2, driven by the pump-actuating mechanism, and the latter carrying a pin 22, adapted when the shaft is at the limit of its movement in the opposite direction to project into a transverse slot or opening in a member 23, which is slidingly mounted at one end in the frame 15 and at the other end in a bearing carried by the bracket 24. The shaft 16 also carries a fixed member consisting of a grooved disk 27 and a longitudinally-movable member consisting of a worm 40. The disk is rigidly keyed to the shaft; but the worm is merely splined thereto, as clearly shown in Fig. 3, so that it is free to move axially along the shaft, but is compelled to rotate therewith. A pin 39, mounted on the frame, engages one or the other of the grooves 28 and 29 in the disk 27, according to the axial position of the shaft 16, and a threaded block 41, also rigidly secured to the frame 15, engages with the worm 40. The disks 27 and 40 are elastically connected by means of springs 45, which are connected at one end to the disk 27 and at the other to small disks 46, mounted on rods 42. These rods are rigidly connected at one end to the disk 40 and at the other project into openings in the disk 27. A guide-plate 43 for the rods is mounted on posts 44, projecting from the disk 27. The outer flanges on the disk 27 are provided with teeth or notches 31 and 32, Figs. 3, 4, and 5, located substantially one hundred and eighty degrees apart and arranged to be engaged by pawls 33 and 34, pivotally mounted on a shaft 35, supported by a bracket 36. The pawls are tripped by means of the pins 37 and 38, one of which is actuated whenever the lever-arm 47 is overbalanced one way or the other. This lever-arm is controlled by a thermostat and is moved into one or the other of its extreme positions in accordance with the rise or fall of the temperature in the refrigerating-chamber. The operation of the thermostat will be hereinafter described. The power for operating the motive device whenever one of the pawls is tripped is stored in a spring S, secured at one end to a strap 18, passing around the periphery of the disk 17. The operation of this portion of my invention is as follows: When the compressor is first started in any way—say by shifting the belt by hand—the shaft 16 will be in its extreme position to the right, so that the projection 19 will be in the path of movement of the projection 20 on the gear-wheel H^2, the pin 39 will be in the groove 29 of the disk 27, and the pin 22 will be out of engagement with the slotted opening in the member 23. As soon as the shaft *s* begins to rotate the projection 20 will be brought into engagement with the projection 19, and thereafter the disk 17 and the shaft 16 will rotate with the gear-wheel H^2. The shaft 16 will be prevented from moving axially by the pin 39, which will then be in engagement with the groove 29 on the other side of the central web from that shown in the drawings, and the rotation of the shaft will wind the strap 18 around the disk 17, putting the spring S under tension. As the shaft rotates, the worm 40, because of its engagement with the fixed threaded block 41, will be caused to move along the shaft to the left. The disk 27 being rigidly secured to the shaft, the longitudinal movement of the disk 40 will operate to put the springs 45 under tension. When the shaft 16 driven through the projection 20 has made a complete revolution, the pin 39 will come opposite an opening 30 (see Fig. 5) in the central web on the member 27, and the shaft impelled by the springs 45 will be moved longitudinally into the position shown in Fig. 2, carrying the projection 19 out of the path of movement of the projection 20 on the gear-wheel and moving the pin 22 into engagement with the slot in the member 23, this member being held in the proper position for the pin to enter the slot by means of a spring-pin 52, (see Fig. 6,) which engages a notch on one side of the bar 23. The disengagement of the pin 19 would leave the shaft 16 free to return to its original position under stress of the strap 18 were it not for the pawls 33 and 34, which engage with notches one hundred and eighty degrees apart on the outer flanges of the disk 27. One of these notches 31 is in a position to be engaged by its corresponding pawl 33 when the opening in the central web comes opposite the pin 39, and the shaft is therefore held in the position to which it has been brought until this pawl is tripped. The compressor-actuating mechanism continues to operate after the shaft 16 has been axially shifted without further affecting the motive device, which is now "primed," so to speak, ready to do its work, the spring S being under its maximum tension. When the compressor has been running long enough to reduce the temperature to the predetermined limit, the tripping device will be operated by the thermostat to trip the pawl 33, and the shaft 16 will be rotated under the influence of the spring S through one hundred and eighty degrees until the pawl 34 catches in the notch 32. During this half-rotation the pin 22 moves the reciprocating member 23 into the position shown in the drawings, and through the bell-crank lever 25 and the connecting-rod 26 the belt B is shifted from the fixed to the loose pulley and the compressor stopped. At the same time the water-supply for the condenser may be shut off by the movement

of the valve R, operated by the same connecting-rod. The rotation of the shaft under the influence of the spring S also operates to compress the springs 45 between the disks 27 and 40; but the shaft is prevented from moving to the right by the pin 39, which is now in the groove 28. After the compressor has remained idle long enough to permit the temperature in the refrigerating-chamber to rise to the predetermined upper limit the tripping device will be again operated by the thermostat (this time in the opposite direction) to trip the pawl 34. The tripping of this pawl will permit the shaft 16 to rotate through another one hundred and eighty degrees, shifting the member 23 back into its original position and again throwing the belt onto the fixed pulley on the shaft *s*. During this rotation the compression of the springs 45 will be continually increased, and when the shaft reaches its original position and the opening in the central web on the disk 27 again comes opposite the pin 38 the shaft will be shifted under the stress in the springs 45 into its extreme right-hand position, the pin 22 being withdrawn from the slot in the member 23 and the pin 19 being again projected into the path of movement of the pin 20. The compressor having been again started by this movement of the motive device, the shaft 16 will be immediately rotated by the engagement of the pin 20 with the pin 19 until at the end of a complete cycle or revolution the shaft will be again thrown to the left by the springs 45, and the motive device will again be in its primed condition ready to throw the belt off when the temperature is sufficiently reduced and on again when it has risen to the predetermined limit.

From the foregoing description it will be seen that the motive device is a self-contained energy-storing mechanism capable of stopping and starting the pump-actuating mechanism at the desired times and so related to the said mechanism that it will be wound up or primed ready for the next cycle in its operation during the first few revolutions of the pump-actuating mechanism.

The thermostat, by means of which the tripping devices are operated at the proper times, consists, essentially, of three parts, first, a large vessel—say of several gallons capacity—containing brine or some liquid having a comparatively large coefficient of expansion at or near the temperature which it is desired to maintain; second, a smaller vessel containing some liquid of high specific gravity, such as mercury, in which case it may have a capacity, say, of about eight ounces, and, third, a scale-beam mounted in unstable equilibrium and carrying at one end a cup to receive the mercury and at the other end a counterweight. The large vessel containing the brine is indicated by the letter M, Fig. 1, and is located within the refrigerating-chamber. It is preferably entirely filled with the liquid and is tightly sealed except for a small pipe *m* about one-sixteenth of an inch inside diameter, through which it is connected with the small vessel N, located near the tripping mechanism. This latter vessel is also tightly sealed and contains both brine and mercury in varying proportions. The pipe *m* leads into it at the top, and the pipe *n*, leading from the bottom, dips into a well at the bottom of a mercury-cup 48, freely suspended at one end of the scale-beam 47. The scale-beam is counterweighted at its other end by the weight 49 and is mounted in unstable equilibrium on a knife-edge bearing 50.

The operation of the entire system may now be explained as follows: Assuming that the refrigerating-chamber is at or near the desired temperature and that the different parts of the system are as indicated in Figs. 1 and 2, the compressor will be at rest and the temperature in the refrigerating-chamber will be gradually rising. When the temperature has increased by a certain predetermined amount—say 6°—a sufficient quantity of the brine in the vessel M will have been forced through the tube *m* and into the small vessel N to displace several ounces of mercury from the latter vessel into the cup 48. As soon as enough mercury has been forced into the cup to overbalance the counterweight 49 the scale-beam will fall into its other extreme position and in so falling will come into contact with the pin 38 and force it into engagement with the pawl 34, thereby tripping the pawl. The motive device will then rotate through half a revolution, throwing the belt B onto the fixed pulley on the shaft *s* and starting the compressor. At the same time the shaft 16 of the motive device will be thrown into its extreme right-hand position, and during the first few revolutions of the compressor-actuating mechanism it will be wound up or primed and held in its primed position by the pawl 33 in engagement with the notch 31 on the member 27. The compressor will continue to operate until the temperature of the refrigerator has been reduced by, say, 6°, when the brine in the vessel M will have contracted sufficiently to withdraw mercury enough from the cup 48, so that its weight will be overbalanced by the counterweight 49. The scale-beam will then fall into the position shown in the drawing, releasing the pawl 34 and tripping the pawl 33. The motive device will rotate through a half-revolution, throwing off the belt B through the medium of the belt-shifting rod 26, until it is caught by the pawl 34, engaging in the notch 32, thus completing the cycle of operation and leaving the tripping mechanism in a condition to be operated by a rise of temperature, as before. The tube *n*, leading from the vessel N to the cup

48, projects into a well at the bottom of the cup, so that its end is never uncovered in the operation of the device.

By the above arrangement a comparatively small amount of a liquid of high specific gravity, such as mercury, can by its weight operate the tripping mechanism, whereas were the expansion of the mercury itself depended upon to operate the device a very large quantity would be required. Although I have suggested the use of brine as a liquid to be used in the vessel in the refrigerating-chamber, it will of course be understood that any other liquid having a suitable coefficient of expansion may be used. As another example of such a liquid I may mention alcohol.

Since the water-supply for the condenser C is required only when the compressor is in operation, I provide a valve R in the supply-pipe 8 and connect the valve-actuating lever to the belt-shifting or other actuating mechanism, by means of which the compressor is started and stopped.

I have illustrated my invention in connection with a mechanical belt-shifter for connecting and disconnecting the source of power from the device to be driven; but evidently the form of the connecting device constitutes no part of my invention. I therefore desire it to be understood that any means whatsoever which operates to secure the starting and the stopping of a device to be driven by making and breaking the connection between the said device and the ultimate source of power from which it is driven may be substituted in place of the particular belt-shifting mechanism shown, and although I have described my invention as applied to a refrigerating system it is to be understood that it is not limited to such application, and in the claims hereto appended I aim to cover the said invention in whatever connection it may be applied.

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

1. In combination, a device to be operated, a longitudinally-movable and rotatable shaft operatively connected thereto, an energy-storing motor connected to said shaft, a spring for moving said shaft longitudinally, means whereby the rotation of the shaft puts said spring under tension, operating mechanism for rewinding the energy-storing motor, and means for preventing a longitudinal movement of the shaft, the said means being so constructed and arranged that when a predetermined point in the rotation of the shaft is reached the said shaft will be released so that it may be moved under the influence of the spring into engagement with said operating mechanism.

2. In combination, an operating mechanism, a rotatable and longitudinally-movable shaft operatively connected thereto, a spring for moving the said shaft out of engagement with the operating mechanism, means for putting said spring under tension as the shaft is rotated, and means for preventing longitudinal movement of the said shaft, the said means being so constructed and arranged that when a predetermined point in the rotation of the shaft is reached the said shaft will be released so that it may be moved under the influence of said spring.

3. In combination, a rotatable and longitudinally-movable shaft, a member rigidly connected to said shaft, a second member longitudinally movable thereon, an elastic connection between said members, means whereby the longitudinally-movable member is moved along the shaft as the same is rotated, and means whereby the shaft is released when a certain point in its rotation is reached.

4. In combination, a rotatable and longitudinally-movable shaft, a member having a grooved periphery rigidly connected to said shaft, a fixed pin engaging the groove, a second member longitudinally movable on the shaft and having a threaded exterior, a fixed threaded block with which said threaded exterior engages, and an elastic connection between said members, the member having the grooved periphery being provided with a longitudinally-extending opening at one side of the groove into which the pin is caused to move whenever the shaft has been rotated through a predetermined angle.

5. In combination, a rotatable and longitudinally-movable shaft, a member rigidly connected to said shaft, the periphery of the said member being provided with two grooves separated by a web having an opening at one point therein, a fixed pin arranged to engage one or the other of said grooves and adapted to pass through said opening, a second member longitudinally movable on the shaft and having a threaded exterior, a fixed threaded block with which said threaded exterior engages, and an elastic connection between the members.

6. In combination, a source of power, a device to be driven therefrom, a connecting device for making and breaking the connection between the source of power and the device to be driven, and a motive device for operating the connecting device, the said motive device comprising a rotatable shaft arranged to operate the connecting device, means for rotating the shaft, pawls and a cooperating notched member for restraining and limiting the rotation of said shaft, and tripping devices coöperating with said pawls.

7. In combination, a source of power, a device to be driven therefrom, a connecting device for making and breaking the connection between the source of power and the device to be driven, an energy-storing motive device for operating the connecting device, means for operating said device to store en-

ergy therein, and means for controlling the operation of the said motive device.

8. In combination, a source of power, a device to be driven therefrom, a connecting device for making and breaking the connection between the source of power and the device to be driven, an energy-storing motive device for operating the connecting device, means for connecting the motive device to store energy whenever the connecting device makes the connection between the source of power and the device to be driven, and means for controlling the operation of the said motive device.

9. In combination, a source of power, a device to be driven therefrom, a connecting device for making and breaking the connection between the source of power and the device to be driven, and an energy-storing motive device for operating the connecting device, the said motive device comprising a rotatable and longitudinally-movable shaft, in one of its extreme positions operatively connected to the connecting device and in the other of its extreme positions to the said source of power.

10. In combination, a source of power, a device to be driven therefrom, a connecting device for making and breaking the connection between the source of power and the device to be driven, an energy-storing motive device for operating the connecting device, means for connecting the motive device to store energy whenever the connecting device makes the connection between the source of power and the device to be driven and for reconnecting the motive device to the connecting device after the storing of energy has been completed.

11. In combination, a source of power, a device to be driven therefrom, a connecting device for making and breaking the connection between the source of power and the device to be driven, an energy-storing motive device for operating the connecting device, the said motive device comprising a rotatable and longitudinally-movable shaft, in one of its extreme positions operatively connected to the connecting device and in the other of its extreme positions to the operating mechanism, means for shifting the shaft from one extreme position to the other, and means for controlling its rotation when operatively connected to the connecting device.

12. In combination, a source of power, a device to be driven therefrom, a connecting device for making and breaking the connection between the source of power and the device to be driven, a motive device for operating the connecting device, the said motive device comprising a rotatable and longitudinally-movable shaft, in one of its extreme positions operatively connected to the connecting device and in the other of its extreme positions to the operating mechanism, an energy-storing motor for rotating said shaft, pawls and a coöperating notched member for restraining and limiting the rotation of the shaft, means for retaining the shaft in operative relation with the connecting device during a complete cycle of operation, and means for causing the said shaft to be operatively connected to the operating mechanism at the beginning of each cycle until sufficient energy is stored in the energy-storing motor to carry the motive device through another cycle in its operation.

13. In combination a source of power, a device to be driven therefrom, a connecting device for making and breaking the connection between the source of power and the said device, an energy-storing motive device for operating the connecting device, means for operating said device to store energy therein, and an automatic means for controlling the operation of the motive device.

14. In combination, a source of power, a device to be driven therefrom, a connecting device for making and breaking the connection between the source of power and the said device, an energy-storing motive device for operating the connecting device, means for connecting the motive device to the operating mechanism to store energy whenever the connecting device makes the connection between the source of power and the device to be driven and for reconnecting the motive device to the connecting device after the storing of energy has been completed, and means for controlling the operation of the motive device.

15. In combination, a source of power, a device to be driven therefrom, a connecting device for making and breaking the connection between the source of power and the said device, an energy-storing motive device for operating the connecting device, the said motive device comprising a rotatable and longitudinally-movable shaft, in one of its extreme positions operatively connected to the connecting device and in the other of its extreme positions to the operating mechanism, pawls and a coöperating notched member for restraining and limiting the rotation of the shaft, tripping devices coöperating with said pawls, means for retaining the shaft in operative relation with the connecting device during a complete cycle of operation, and means for causing the said shaft to be operatively connected to the operating mechanism at the beginning of each cycle until sufficient energy is stored in the energy-storing motor to carry the motive device through another cycle in its operation.

16. In combination, a source of power, a device to be driven therefrom, a connecting device for making and breaking the connection between the source of power and the said device, and an energy-storing motive device for operating the connecting device, the

said motive device comprising a rotatable and longitudinally-movable shaft, in one of its extreme positions operatively connected to the connecting device and in the other of its extreme positions operatively connected to the operating mechanism, pawls and a coöperating notched member for restraining and limiting the rotation of the shaft, tripping devices coöperating with said pawls, means for actuating said tripping devices, means for retaining the shaft in operative relation with the connecting device during a complete cycle of operation, and means for causing the said shaft to be operatively connected to the operating mechanism at the beginning of each cycle until sufficient energy is stored in the energy-storing motor to carry the motive device through another cycle in its operation.

17. In combination, a source of power, a device to be driven therefrom, means for making and breaking the connection between the source of power and the said device, an automatically-operating energy-storing motive device for actuating said means, means for operating said device to store energy therein, means for restraining the operation of the motive device, and means for removing said restraining means.

18. In combination, a source of power, a device to be driven therefrom, means for making and breaking the connection between the source of power and the said device, a motive device for actuating said means, an energy-storing device connected to the motive device, means for maintaining said motive device in a predetermined position, and means for releasing said device.

19. In combination, a source of power, a device to be driven therefrom, means for making and breaking the connection between the source of power and the said device, a motive device for actuating said means, means for putting said device under tension so that when released it will actuate the connection making and breaking means, a plurality of tripping devices determining the range of movement of the motive device, and means for operating one or the other of said tripping devices.

20. In combination, a source of power, a device to be driven therefrom, a motive device, connecting and disconnecting means arranged to be operated by said motive device to first break the connection between the source of power and the device to be driven and thereafter to remake said connection, a thermostat and means controlled thereby for releasing the motive device at a certain predetermined temperature so that it may operate to disconnect the device to be driven from the source of power, and for again releasing the motive device at a certain other predetermined temperature so that it may operate to again connect the device to be driven to the source of power.

21. In combination, a source of power, a device to be driven therefrom, a motive device arranged to be placed under tension by the operating mechanism and then automatically disconnected therefrom, connecting and disconnecting means arranged to be operated by said motive device to first break the connection between the source of power and the device to be driven and thereafter to remake said connection, a thermostat and means controlled thereby for releasing the motive device at a certain predetermined temperature so that the motive device may operate to disconnect the device to be driven from the source of power, and for again releasing the motive device at a certain other predetermined temperature so that it may operate to again connect the device to be driven to the source of power, and means operating automatically to connect the motive device to the operating mechanism whenever the connection between it and the source of power is completed.

In witness whereof I have hereunto set my hand this 13th day of February, 1902.

SAMUEL LIPPINCOTT GRISWOLD KNOX.

Witnesses:
ARTHUR A. BUCK,
BERTHA SECOR.