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COMPRESSOR UNLOADER

Original Filed April 5, 1930

Fig. 1.

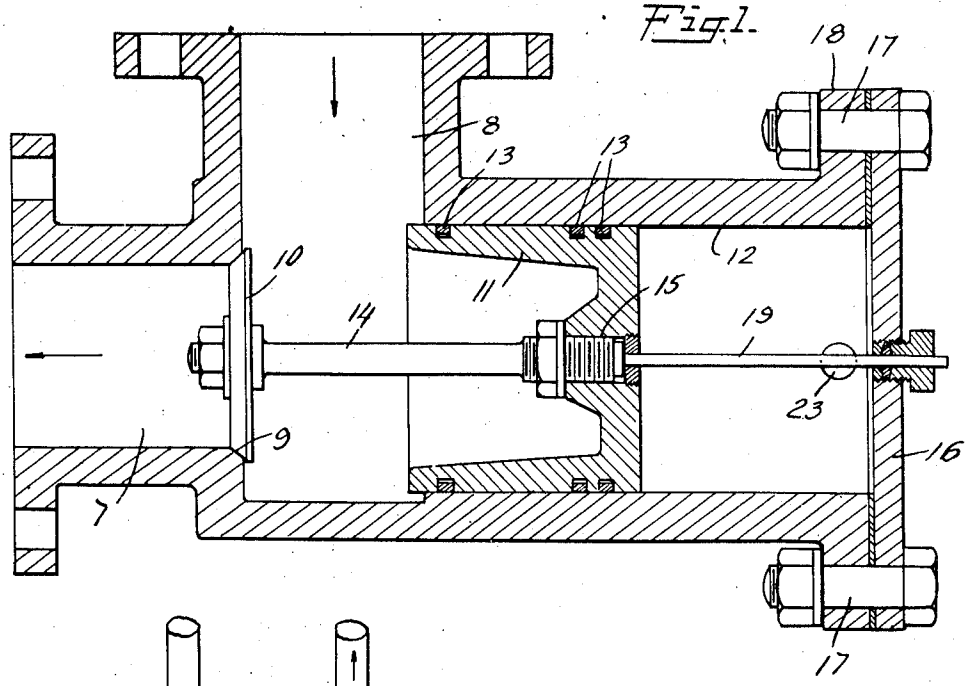
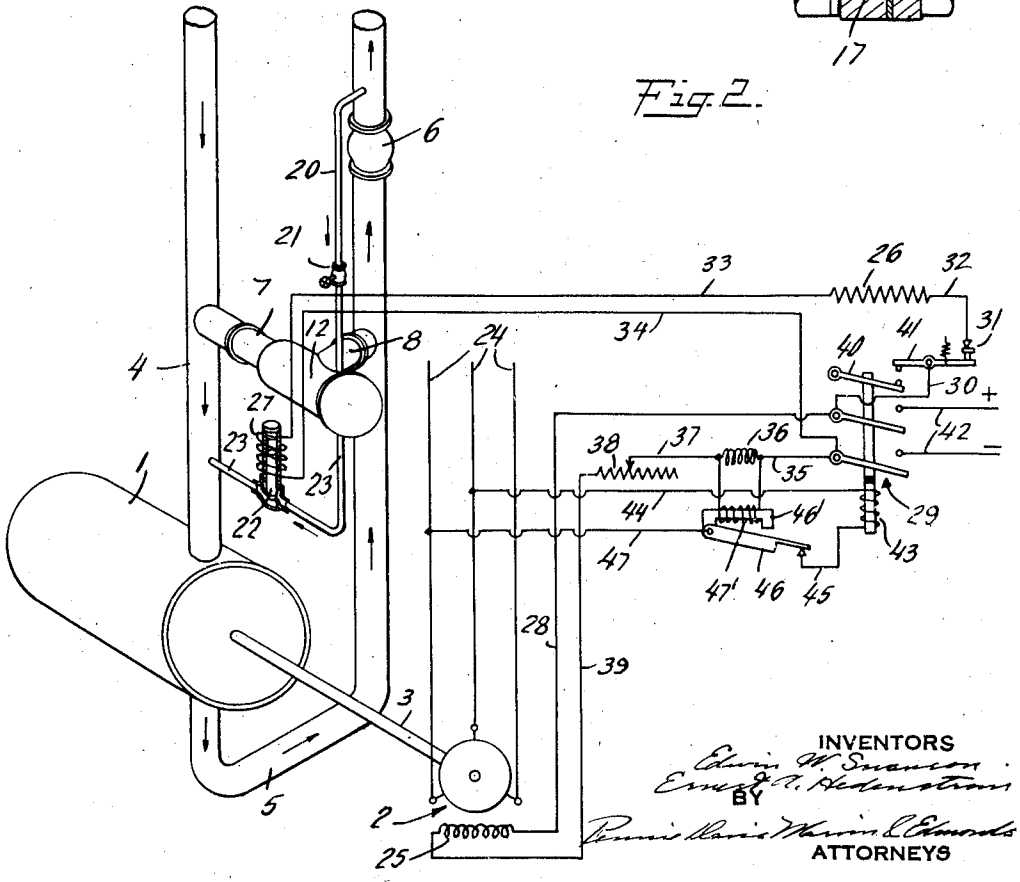


Fig. 2.



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COMPRESSOR UNLOADER

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This invention relates to by-pass systems for pumps, compressors and the like and more particularly to by-pass unloader systems suitable for removing the load from a motor or other driving means connected to a compressor or pump.

It is an object of this invention to provide a simple and inexpensive by-pass valve and control mechanism therefor, especially adapted to the purpose of unloading a motor driven compressor during the starting period of the motor, whereby the motor can be brought up to speed under no load conditions and thereafter the load may be applied. The efficient and reliable by-pass unloader system which we have developed may be used in conjunction with an induction motor, or other driving means for a compressor and is especially suitable for use with a synchronous motor connected to a compressor or pump. The system may operate in such a manner that the by-pass valve controls the flow of fluid from the high pressure or discharge side of the compressor to the low pressure or suction side of the compressor, and the position of this by-pass valve may be determined by some condition of the driving motor. For example, the valve may be brought to or maintained in a certain position in accordance with a condition obtaining during the initial portion of the starting period of the motor, and it may be moved to another position by means responsive to a condition of the motor obtaining when normal running speed has nearly been reached. The position of the by-pass valve may be controlled electro-magnetically and a control circuit may be employed which renders the valve responsive to current induced in a secondary circuit of the driving motor, for example, in the closed field circuit of a synchronous motor during the starting period of the motor. The by-pass valve may be opened in response to the electrical condition in the secondary motor circuit and closed when currents of either low frequency or low amperage flow in this secondary circuit which is the electrical condition of the secondary current when the rotor is pulling into synchronism. Furthermore means responsive to the induced secondary current may control the secondary circuit to change the secondary connections from starting to running conditions as by connecting the field winding of a synchronous motor to a source of direct current during the final portion of the starting period of the motor.

In general our improved by-pass construction includes a by-pass conduit communicating with the suction and discharge passages of the compressor or pump, the by-pass conduit having a valve seat therein cooperating with a valve which is preferably disposed so as to be maintained in its closed position by direct pressure of the fluid in the discharge passage. This insures permanent closing of the by-pass valve during normal operation of the compressor and in spite of such pulsations, or rapid variations of pressure as may occur in the discharge passage. Our by-pass valve may be actuated by a valve actuating member which is preferably operated by the fluid pressure in the discharge passage of the compressor, whereby the valve is opened to connect the discharge passage to the suction passage and unload the motor driving the compressor. Means are provided for holding the valve operating member in a position to maintain the by-pass valve closed during normal operation of the compressor, the valve operating member being thus held against the pressure in the discharge passage. Means are also provided for releasing the valve operating member, whereby the same responds to the pressure in the discharge passage and opens the by-pass valve to unload the motor. This releasing means is preferably controlled by some condition of the driving motor; for example, the releasing means may function during the starting period of the motor, whereby the load is removed from the motor until it has been brought up to speed.

The valve operating member may take the form of a piston operating within a cylinder, the piston having one end thereof exposed to the pressure in the discharge passage of the compressor. One end of the cylinder may be closed by a cylinder head and a position indicator may be connected to the piston and

project through the cylinder head to indicate the position of the piston and of the by-pass valve connected to the piston. Fluid pressure from any suitable source, and preferably from the discharge passage or receiver communicating therewith, may be applied to the end of the piston remote from the discharge passage of the compressor, whereby the piston is subjected to balanced pressure under normal conditions and the by-pass valve is maintained closed by the discharge pressure acting directly upon the valve member. Whenever it is desirable to open the by-pass valve the fluid pressure in the cylinder may be released, whereupon the piston moves in the cylinder in response to the pressure in the discharge passage and the valve is opened to unload the pump. The fluid pressure may be supplied to the cylinder through a restricted passage and, if desired, the fluid pressure in the cylinder may be released into the suction passage of the compressor.

The various objects and advantages of our invention will be more apparent upon considering the following detailed description which is to be taken in conjunction with the accompanying drawings. In the accompanying drawings

Fig. 1 represents a vertical section view of a by-pass valve device embodying our invention and

Fig. 2 comprises a diagrammatic illustration of a perspective view of a compressor unloader system including automatic control and representing an illustrative embodiment of the invention, a portion of the apparatus being shown in section to illustrate details of construction.

The illustrative embodiment of our invention shown in the accompanying drawings comprises an unloader system especially suitable for ammonia compressors and the like. Such compressors are ordinarily unloaded by opening a by-pass valve, the valve being operated by hand. Where several compressors are in the care of one operator there is a considerable loss in production if shut-downs are frequent and this because of the time and care required in unloading the several compressors, starting the driving motors and then applying the load to the motors.

Referring first to Fig. 2 of the accompanying drawings we have illustrated in diagrammatic form a compressor 1 connected to a motor 2 by means of a shaft 3 and having an inlet or suction passage 4 and an outlet or discharge passage 5. A check valve 6 may be located in the discharge passage in accordance with usual practice.

Our improved by-pass mechanism comprises a pipe connection or passage shown at 7 and 8, this passage or conduit communicating with the suction passage 4 and with the discharge passage 5 and preferably the connection with the discharge passage is at a point between the compressor 1 and the check valve 6.

The details of the by-pass mechanism are best illustrated in Fig. 1 wherein the by-pass conduit 7, 8 is represented in section and as provided with a valve seat 9. A by-pass valve 10 cooperates with the valve seat 9 and it will be noted that fluid pressure in the portion 8 of the by-pass conduit acts directly against the valve 10 to hold the same against the valve seat 9. Reference to Fig. 2 shows that the portion 8 of the by-pass conduit communicates directly with the discharge passage 5 and accordingly the pressure in the discharge passage is communicated directly to the valve 10 and under normal operating conditions this pressure serves to hold the valve firmly against the valve seat 9 and this regardless of variations in pressure in the discharge passage. The portion 7 of the by-pass conduit communicates directly with the suction passage 4.

For operating the by-pass valve we may provide an operating member in the form of a piston 11 cooperating with a cylinder 12. The piston may be provided with rings 13 making a fluid-tight connection between the piston and the cylinder, and one end of the piston is exposed to the portion 8 of the by-pass conduit, whereby the fluid pressure in the discharge passage may act directly upon this end of the piston. The piston is connected to the valve 10 by any suitable means, such as the connecting rod 14 which may be adjustably secured to the piston as by the threaded connection shown at 15.

A cylinder head 16 serves to close one end of the cylinder 12, the cylinder head being maintained in place by bolts 17 passing through the cylinder head and through a flange 18 on the cylinder. An indicating rod 19 may be connected to the piston 11 and may project through an opening in the cylinder head 16. The portion of this rod exposed to view on the outside of the cylinder gives an indication of the position of the piston 11 and accordingly of the by-pass valve 10.

Under normal operating conditions the piston 11 is maintained in the position shown in Fig. 1 by fluid pressure in the cylinder 12, which acts upon the end of the piston remote from the valve 10 and serves to balance the pressure acting on the other end of the piston. This fluid pressure is admitted to the cylinder 12 through a passage 20. In Fig. 2 an adjustable valve 21 is shown in the pipe connection or passage 20, which valve may be adjusted to restrict the flow of fluid through this pipe connection to the desired extent. The pipe 20 communicates with the discharge passage 5 of the compressor at a point beyond the check valve 6 thus insuring adequate pressure at all times for balancing the

pressure on the piston 11. It will be understood that with the pressures balanced at both ends of the piston 11 the pressure in the portion 8 of the by-pass conduit is more than sufficient to hold the valve 10 against its seat.

When it is desired to unload the compressor motor the fluid pressure in the cylinder 12 must released and this may be accomplished by opening a valve 22 in a release conduit or passage 23 which is shown as communicating with the cylinder 12 and with the suction passage 4 of the compressor. When the valve 22 is opened the pressures at the two ends of the piston 11 are no longer balanced and the piston is immediately moved in response to the pressure in the by-pass conduit 8, thereby opening the valve 10 and placing the suction and discharge passages of the compressor in direct communication with each other through the by-pass conduit. This result occurs because of the fact that the end of the piston 11 directly opposite the valve 10 is of somewhat larger area than the valve 10. Accordingly the force tending to open the valve 10 is greater than the force tending to close this valve and accordingly the valve is pulled open by the piston 11, against the pressure in the discharge passage of the compressor.

In Fig. 2 we have illustrated means for controlling the operation of the by-pass valve automatically. The motor 2 is represented as a synchronous motor connected to leads 24 representing a source of polyphase alternating current and having a field winding 25 which during the starting period of the motor is connected in closed circuit across a field discharge resistance 26. The control valve 22 for controlling the flow of fluid from the cylinder 12 into the suction passage 4 is illustrated as an electromagnetic valve having a core integral with the valve member proper and having an operating coil 27. During the starting period the motor field winding 25 carries an induced current of slip frequency which flows, not only through the field discharge resistance 26 but also through the valve operating coil 27, the circuit being as follows: field winding 25, wire 28, field switch 29, wire 30, contacts 31, wire 32, discharge resistance 26, wire 33, valve operating coil 27, wire 34, field switch 29, wire 35, reactance coil 36, wire 37, variable resistance 38 and wire 39 to the motor field winding 25. It will be understood that at the instant of supplying current to the motor 2, a current is induced in the closed field circuit of substantially line frequency and that the frequency of this current decreases as the speed increases until at synchronous speed the frequency becomes zero. Throughout the starting period the magnitude of the induced field current remains approximately constant and this induced current serves to energize the operating coil of the control valve 22 throughout the starting period of the motor. As previously explained the opening of valve 22 serves to operate the by-pass mechanism whereby the load is taken off the motor. When the motor reaches a speed close to the synchronous speed the field switch 29 is operated in a manner hereinafter described and upon the closing of this switch an auxiliary arm 40 of the field switch actuates the switch 41 associated therewith, to open the contacts 31 and disconnect the field winding of the motor from the discharge resistance 26 and from the operating coil of the control valve 22. Simultaneous with the opening of contacts 31 the field winding is connected across a source of direct current represented by the leads 42.

The field switch 29 is illustrated as being of the electromagnetically operated type and is accordingly provided with an operating coil 43 adapted to derive its energizing current from the alternating current supply leads 24 through leads 44 and 45, relay armature 46 and lead 47. The relay 46′ has an operating coil 47′ connected across the reactance 36 which is in circuit with the motor field winding at all times. During the initial portion of the starting period of the motor the frequency of the induced field current is high and accordingly some of this current is shunted around the reactance 36 through the operating coil 47′ of the relay 46′. Accordingly the relay picks up its armature immediately after current is supplied to the armature of the motor, thus breaking the circuit for the operating coil of the field switch before this switch has had an opportunity to close. The relay 46′ remains energized until the motor has nearly reached synchronous speed whereupon the induced current in the motor field circuit is of such low frequency that only a minor portion thereof traverses the operating coil of the relay and it is of such small magnitude that the relay is no longer effectively energized. When this occurs the relay armature is released, current is supplied to the field switch operating coil 43, and the starting connections for the field winding are interrupted and the running connections established.

From the foregoing description it appears that the by-pass control valve 22 is operated in accordance with a condition of the motor obtaining during the initial portion of the starting period and the position of the by-pass valve is again changed in accordance with a condition of the motor obtaining when the motor has nearly reached its normal running speed. Thus the motor is entirely relieved of its load, except for the torque required to operate the compressor under no load conditions, and this is accomplished by temporarily releasing the operating piston connected to the by-pass valve, whereby this valve is opened to establish direct communi-

cation between the discharge passage of the compressor and the suction passage of the compressor.

The system described above is adapted, not only to unload the motor during the starting period, but also to unload the motor whenever the motor pulls out of step for any reason, such as a voltage dip on the line. When the motor speed drops below synchronous speed an alternating current is induced in the field winding and this energizes the relay 46' to interrupt the supply of current to the operating coil 43 of the field switch 29. The field switch opens and in so doing it permits the contacts 31 of the auxiliary switch 41 to close thus connecting the field winding in closed circuit through the operating coil of the control valve 22 and the motor is immediately unloaded.

It is to be understood that our invention is not limited to the specific embodiment forming the subject matter of the foregoing detailed description and illustrated in the accompanying drawings but includes such modifications thereof as fall within the scope of the appended claims.

We claim:—

1. A compressor unloader system comprising a fluid compressor, suction and discharge passages therefor, a by-pass conduit communicating with said passages and having a valve seat, a valve for said seat arranged to open against the pressure in said discharge passage, a valve operating member connected to said valve and having a surface exposed to the pressure in said discharge passage, means for holding said member in a position to maintain the valve closed, and means for releasing said member, whereby pressure in said discharge passage moves said member to open said valve and unload the compressor.

2. A compressor unloader system comprising a fluid compressor, suction and discharge passages therefor, a by-pass conduit communicating with said passages and having a valve seat, a valve for said seat arranged to open against the pressure in said discharge passage, a valve operating member connected to said valve and having a surface exposed to the pressure in said discharge passage, fluid pressure means for holding said member in a position to maintain the valve closed, and means for releasing said member, whereby pressure in said discharge passage moves said member to open said valve and unload the compressor.

3. A compressor unloader system comprising a fluid compressor, suction and discharge passages therefor, a by-pass conduit communicating with said passages and having a valve seat, a valve for said seat arranged to open against the pressure in said discharge passage, a valve operating member connected to said valve and having a surface exposed to the pressure in said discharge passage, fluid pressure means for holding said member in position to maintain the valve closed, said fluid pressure means comprising a conduit communicating with said discharge passage and with one surface of said operating member, whereby said member is normally subjected to balanced pressures, means for restricting the flow of fluid through said last mentioned conduit, and means for releasing the pressure normally acting on said last mentioned surface of the valve operating member, whereby pressure in said discharge passage moves said member to open said valve and unload the compressor.

4. A compressor unloader system comprising a fluid compressor, suction and discharge passages therefor, a by-pass conduit communicating with said passages and having a valve seat therein, a valve for said seat arranged to open against the pressure in said discharge passage, a cylinder, a piston within said cylinder, said piston having one end thereof exposed to the pressure in said discharge passage, means for connecting said piston to said valve, a restricted passage communicating with said discharge passage and with said cylinder, whereby fluid pressure is normally applied against the other end of said piston, and means for releasing the fluid in said cylinder.

5. A compressor unloader system comprising a fluid compressor, suction and discharge passages therefor, a by-pass conduit communicating with said passages and having a valve seat therein, a valve for said seat arranged to open against the pressure in said discharge passage, a cylinder, a piston within said cylinder, said piston having one end thereof exposed to the pressure in said discharge passage, means for connecting said piston to said valve, a restricted passage communicating with said discharge passage and with said cylinder, whereby fluid pressure is normally applied against the other end of said piston, and means for connecting said cylinder to the suction passage to release the fluid in said cylinder.

6. A compressor unloader system comprising a fluid compressor, suction and discharge passages therefor, a by-pass conduit communicating with said passages and having a valve seat therein, a valve for said seat arranged to open against the pressure in said discharge passage, a cylinder, a piston within said cylinder, said piston having one end thereof exposed to the pressure in said discharge passage, means for connecting said piston to said valve, a restricted passage communicating with said discharge passage and with said cylinder, whereby fluid pressure is normally applied against the other end of said piston, means for releasing the fluid in said cylinder, a cylinder head closing one end of said cylinder, and means connected to the pis-

ton and projecting through the cylinder head for indicating the position of the said valve.

7. A compressor unloader system comprising a fluid compressor, suction and discharge passages therefor, a by-pass conduit communicating with said passages and having a valve seat, a valve for said seat arranged to open against the pressure in said discharge passage, a valve operating member connected to said valve and having a surface exposed to the pressure in said discharge passage, means for holding said member in a position to maintain the valve closed, a motor for driving said compressor, and means responsive to a condition of the motor during the initial portion of the starting period of the same for leasing said member, and responsive to a condition of the motor during the final portion of the starting period for causing said valve to move to its closed position.

8. A compressor unloader system comprising a fluid compressor, suction and discharge passages therefor, a by-pass conduit communicating with said passages and having a valve seat, a valve for said seat arranged to open against the pressure in said discharge passage, a valve operating member connected to said valve and having a surface exposed to the pressure in said discharge passage, means for holding said member in a position to maintain the valve closed, a motor for driving said compressor, and means responsive to a condition of the motor during the initial portion of the starting period of the motor for releasing said member, whereby pressure in said discharge passage moves said member to open said valve and unload the compressor.

9. A compressor unloader system comprising a fluid compressor, suction and discharge passages therefor, a by-pass conduit communicating with said passages and having a valve seat, a valve for said seat arranged to open against the pressure in said discharge passage, a valve operating member connected to said valve and having a surface exposed to the pressure in said discharge passage, means for holding said member in a position to maintain the valve closed, a motor for driving said compressor, said motor having a secondary winding carrying an induced current during the starting period of the motor, and means responsive to the induced current in the secondary winding of the motor for temporarily releasing said valve operating member, whereby pressure in said discharge passage moves said member to open said valve and unload the compressor.

10. A compressor unloader system comprising a fluid compressor, suction and discharge passages therefor, a by-pass conduit communicating with said passage and having a valve seat, a valve for said seat arranged to open against the pressure in said discharge passage, a valve operating member connected to said valve and having a surface exposed to the pressure in said discharge passage, means for holding said member in a position to maintain the valve closed, a synchronous motor for driving said compresser, said motor having a field winding, a source of direct current, means responsive to current induced in the said field winding during the initial portion of the starting period for releasing said valve operating member, and means responsive to current induced in said field winding during the final portion of the starting period of the motor for connecting the field winding to said source of direct current and for rendering said releasing means inoperative.

11. A compressor unloader system comprising a fluid compressor, suction and discharge passages therefor, a by-pass conduit communicating with said passages and having a valve seat, a valve for said seat, said valve having a surface directly exposed to fluid pressure in said discharge passage, whereby said valve is normally held closed by said pressure on said surface, a valve operating member connected to said valve and having a surface exposed to the pressure in said discharge passage, means for holding said valve operating member in a position to maintain the valve closed, and means for releasing said member whereby pressure in said discharge passage moves said member to open said valve and unload the compressor.

12. A compressor unloader system comprising a fluid compressor, a suction passage therefor, a discharge passage therefor, a check valve in said discharge passage, a by-pass conduit communicating with said suction passage, and with said discharge passage at a point between the compressor and the said check valve, said by-pass conduit having a valve seat therein, a valve for said seat having a surface exposed to fluid pressure in said discharge passage, a cylinder, a piston within said cylinder, said piston having one end thereof exposed to fluid pressure in said discharge passage, means for connecting said piston to said valve, a restricted passage communicating with said cylinder, and with said discharge passage at a point beyond the check valve, whereby fluid pressure from said discharge passage is normally applied against the other end of said piston through said restricted passage, and means for releasing the fluid in said cylinder.

13. A compressor unloader system comprising a fluid compressor, suction and discharge passages therefor, a by-pass conduit communicating with said passages and having a valve seat, a valve for said seat arranged to open against the pressure in said discharge passage, a valve operating member connected to said valve and having a surface exposed to the pressure in said discharge passage, means for holding said member in a position to maintain the valve closed,

a synchronous motor for driving said compressor, said motor having a secondary winding carrying an induced current at subsynchronous speeds, and means responsive to the induced current in the secondary winding for releasing said valve operating member, whereby pressure in said discharge passage moves said member to open said valve and unload the compressor.

In testimony whereof we affix our signatures.

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CERTIFICATE OF CORRECTION.

Patent No. 1,847,229. **Granted March 1, 1932, to**

EDWIN W. SWANSON ET AL.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 1, line 58, after the word "by-pass" insert the word valve; page 3, line 8, after "must" insert the word be; page 5, line 17, claim 7, for "leasing" read releasing; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 17th day of May, A. D. 1932.

(Seal)

M. J. Moore,
Acting Commissioner of Patents.