

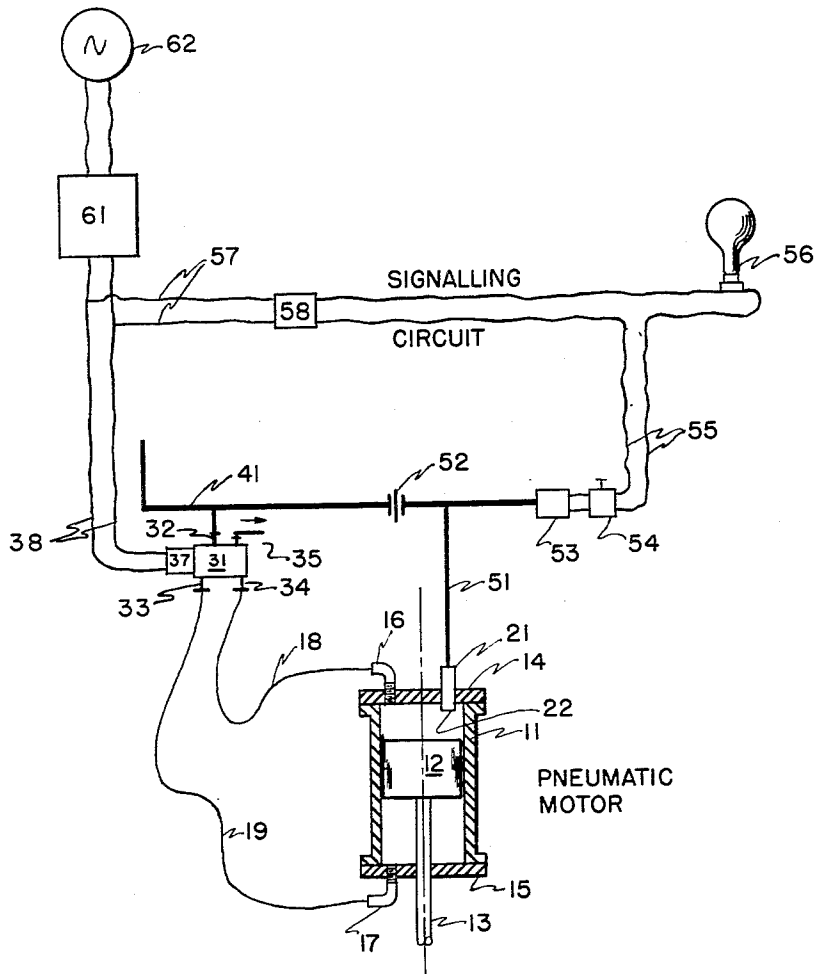
June 7, 1960

H. E. SANDERS

2,940,070

MALFUNCTION DETECTOR AND INDICATOR

Filed Oct. 17, 1956



1

2,940,070

MALFUNCTION DETECTOR AND INDICATOR

Homer E. Sanders, Baton Rouge, La., assignor to Ethyl Corporation, New York, N.Y., a corporation of Delaware

Filed Oct. 17, 1956, Ser. No. 616,573

2 Claims. (Cl. 340—271)

This invention relates to gas powered or pneumatic reciprocating devices. More specifically this invention relates to a malfunction detecting and indicating apparatus associated and coordinated with a pneumatic, reciprocating drive for various mechanisms.

Reciprocating gas powered piston-cylinder drive units are frequently employed in a variety of industrial mechanisms. Thus, such prime mover devices are incorporated as integral parts of pneumatically powered tools similar to concrete chippers, mining drills, and similar mechanisms requiring a moderately rapid reciprocating action. Another highly specialized device using a reciprocating pneumatically powered "engine" or prime mover is found in the process industries, specifically in the electrolysis of fused alkali metal halides for the production of pure alkali metals. In the upward flow of relatively impure molten alkali metal to a riser pipe, from a fused salt electrolysis cell, metal impurities tend to deposit on the wall thereof under the influence of external air cooling. This would cause a clogging of the discharge pipe unless remedial measures were taken. One device for solving this problem is the so-called "tickler" described in the Hulse et al. U.S. Patent 2,068,681. The Hulse device adverted to was a manually operated device. However, new powered mechanisms have been developed which perform a similar or even better function than the Hulse et al. apparatus accomplishes. One such device is the pneumatic powered mechanism disclosed in the Honea U.S. Patent 2,770,364. The Honea device employs a specially designed mechanism for dislodging the contaminant metal deposits from the interior wall of a discharge pipe or riser pipe from a sodium cell, and in addition provides a highly effective pneumatic drive mechanism and cam and guiding means.

Another type of powered cleaning device for application such as that of the Honea apparatus is the apparatus shown in the Fentress U.S. Patent 2,770,592. The Fentress device also employs a type of reciprocating motion, but does not ordinarily employ a pneumatic type drive. However, some slight modification of the Fentress apparatus would render it very adaptable to a pneumatic type drive; by pneumatic, it being understood that a reciprocating cylinder-piston drive element is intended.

Generally in these several types of pneumatic actuated implements or devices, there is resistance, frequently variable, to the reciprocating motion applied by the piston-cylinder motor. The uniformity of such resistance of course depends upon the specific use of the driven apparatus. In some cases, as for example, in the Honea tickler above mentioned, the resistance to driving is a significant variable, being a function of the degree of uniformity of the deposits on the wall of the riser pipe in which the driven tickler mechanism is inserted or used. Thus, a particularly heavy deposit of calcium solid may prevent a full stroke operation of a tickler mechanism.

2

The details of this type of problem will be more easily understood from the description given hereinafter. Generally, in substantially all forms of these mechanisms, with their associated, reciprocating, pneumatic drives, no readily available indicating or correcting device was available to show malfunctioning. By malfunctioning is meant a failure of the driving and driven elements to traverse the full strokes of a normal reciprocating cycle. It will be readily understood that in a reciprocating mechanism having an automatic repetitive cycling means, that the full stroke operation is not necessarily a concomitant of continuous operation. In other words, the failure of a piston in a given piston-cylinder combination to reach the end of a normal stroke does not necessarily terminate continued operation. It merely signifies that the amplitude of the reciprocating movement is diminished. Since the effectiveness of the operation of the driven apparatus or device is normally closely related to the amplitude of the drive movement, then it is apparent that some indicia of curtailed amplitude of reciprocating movement is highly desirable and essential. Adverting again to the Honea apparatus described above and more specifically in U.S. Patent 2,770,364, the reciprocating movement applied to the dislodging device of Honea is fully effective only if a complete reciprocating cycle of normal amplitude is applied. This is because the reciprocating movement is accompanied by a rotative movement, this being applied by a double cam arrangement working on a clevis and follower forming a portion of the driven element. Thus, the failure of a piston to move the apparatus through a full upward or downward stroke will result in a discontinuance of the desired rotative movement.

It is apparent that a real and significant need has existed for a malfunction indicating device and apparatus in combination with pneumatic powered reciprocating drives for devices of the character discussed above.

The object of the present invention is to provide an improved pneumatic powered reciprocating drive mechanism including a malfunction sensing apparatus for readily signaling the failure of the driving piston of a piston cylinder combination to traverse a full reciprocating cycle. A more specific object is to provide such an apparatus which is extremely simple and utilizes a portion of the normal drive mechanism to perform a dual function in combination with other elements for this malfunctioning detection and signalling. An additional object of certain preferred embodiments of the invention is to provide in combination a drive mechanism of the pneumatic powered reciprocating piston-cylinder type having a malfunction detecting apparatus incorporated therewith, said malfunction detector being further refined in that it distinguishes between an "expected malfunction" and a "true" malfunction. This terminology requires elaboration. By "expected malfunction" is meant a type of decreased amplitude which is normally expectable, but wherein the resistance to apparatus movement occasioning this type of malfunction is terminated by a short period of repetitive movement. Different than the "expected malfunction" type of operation is the "true" malfunction, which refers to malfunctioning in the true sense of the word. The characteristics of these severable types of malfunctioning and the means invented for their segregation will be understood more fully from the description and examples given hereinafter. Other objects of the invention will be apparent from the detailed description given hereinafter.

All embodiments of the invention include a pneumatic reciprocating motor and a malfunction detecting and indicating apparatus. The malfunction detecting-indicating assembly includes a gas supply line, a pressure responsive means or switch, indicating means, and a sensing as-

3

sembly. The sensing assembly includes a conduit or chamber having an opening through the cylinder wall or head of the pneumatic motor and a further restricted opening communicating to the gas supply line. The pressure responsive element is operatively connected to the conduit interior, and the indicating means is operatively connected to the pressure switch. The conduit opening in the cylinder wall is carefully positioned to be closed by the piston when the piston is at its terminal position, i.e. at the end of a stroke.

In generic operation of the apparatus as above defined, the gas supply line mentioned is maintained with a supply of gas generally at the pressure used for powering the pneumatic motor. The restricted passage or orifice tends to permit bleeding of this gas into the sensing conduit at a small rate. In other words this conduit is semi-isolated from the gas supply line, but when the opening within the cylinder is closed, the pressure in this sensing conduit builds up to the pressure of the gas supply line.

During operation of the piston of the motor it will be readily understood that as it approaches the end of the cylinder wherein the sensing conduit opening is positioned, there is normally a low pressure in the cylinder because the gas is allowed to exhaust during this operation. Thus it would be expected that the pressure in the sensing conduit would be released, thus allowing the switch means which is activated according to the pressure in the sensing conduit to indicate a drop in pressure. However, by appropriate proportioning of the apparatus portions and the restricted connection to the gas supply line, and the opening within the cylinder, it has been discovered that the rapid upward movement of the piston toward the opening, even though this is an exhausting operation, nevertheless tends to compress the gas within the sensing conduit and apparently prevent its escape at such a rate that the pressure switch is actuated. During acceptable operation, the piston completes a full stroke and effectively closes the conduit opening. This position is immediately followed by an application of full powering gas line pressure to this face of the piston and as it moves away, the gas pressure itself prevents escape of the entrapped gas within the sensing conduit and prevents the pressure switch from indicating a drop in pressure. The above functioning refers to acceptable operation. When the motor is operating under a malfunction condition accompanied by a curtailment of the stroke of the powered piston, the failure of the piston to effectively seal the opening by full movement toward that position allows the reserve pressure in the sensing conduit to drop, thus actuating the pressure switch, and the pressure switch actuating the signalling or indicating means associated therewith.

In a highly preferred embodiment of the invention, the malfunctioning signalling operation generally described above is further refined by additional means which serve to isolate or distinguish between a normal malfunction and a true malfunction. The details of this particular embodiment will be more readily understood from the figure following and the detailed description hereinafter. The invention, in a preferred and refined embodiment, is illustrated by the figure, which is a schematic illustration showing a pneumatically powered piston-cylinder motor with the malfunction sensing apparatus associated therewith.

Referring to the figure, a sectional elevation of a pneumatic motor is shown, including a cylinder 11, having a piston 12 therein, the piston actuating a piston shaft 13 passing through one of the cylinder heads 15 by appropriate stuffing box or seal mechanism. The piston shaft 13 is coupled with the driven mechanism whatever its character, not shown.

The pneumatic motor illustrated is of the double acting type, that is, powered by compressed gas through both strokes up and down. The powering gas is supplied to

4

nozzles in the cylinder heads 16, 17. The nozzles are connected by conduits, which are preferably flexible hoses, 18, 19 to a pressurized gas supply source discussed later. A nozzle 21 is provided in the cylinder head 14. This nozzle is a carefully inserted tube, the interior extremity or face 22 thereof being precisely positioned so that movement of the piston 12 to the terminus or end of its stroke results in substantial closure of the opening of the nozzle 21.

Reciprocating operation of the piston 12 is of course provided by cyclically applying high pressure gas to alternate faces of the piston and during its movement under the influence of such pressure, exhausting the gas from the other side. The timing or cycling of this function is provided by a mechanism 31, which is desirably a solenoid type actuated valve. Generally, the valve 31 has four conduit connections, these connections including a gas supply connection 32, an exhaust connection 35, and two similar or equivalent connections 33, 34, which are connected to the flexible conduits 18, 19, which supply the gas to and from the pneumatic motor. An exhaust line 35 is provided for venting spent gas to the atmosphere.

The valve timing mechanism 31 can be any of several types, however a highly appropriate type is that which employs a solenoid or electrically operated pilot valve to cause cycling of the valve mechanism of the apparatus 31. In this embodiment an electrical power supply through wires 38 is provided to actuate a solenoid type mechanism 37 operatively connected to the mechanism 31. In operation a supply of gas is introduced from a supply line or manifold 41 through the connection of nozzle 32. A valve mechanism in the apparatus 31 provides for cyclically feeding this high pressure gas through the lines 18, 19 alternately to opposite ends of the pneumatic motor cylinder 11 to provide reciprocation of the piston 12. The frequency of this oscillation or reciprocation varies of course with the details of any specific apparatus, but typically from one to up to about five double strokes per second are applied to the apparatus.

Turning to the detailed parts of the malfunction detecting mechanism, a conduit 51 is provided, usually branched as shown. This connects to the sensing nozzle or opening 21 mounted as described in the cylinder head of the pneumatic motor. The conduit 51 joins a high pressure gas supply line by means of a restriction or an orifice 52, the high pressure gas line being suitably the same line or manifold 41 which supplies the powering gas through the valve mechanism 31 to the pneumatic motor. The sensing conduit 51 also is operatively connected to a pressure responsive device or a pressure switch 53. The pressure switch 53 is, preferably, of the type requiring a drop in pressure below a defined set point to close a switch in a desired electrical circuit for indicating purposes.

The pressure switch 53, is connected to leads 55 of the signalling or indicating circuit. Included in the signalling circuit is an electric signalling device, such as a light bulb 56. Also in a preferred embodiment of the invention a delay device 58 is a portion of the circuit. Further, in preferred embodiments as illustrated, a manual reset or disconnect apparatus 54 is included in the indicating circuit.

In operation, it will be seen that the maintenance of a desired pressure in the sensing conduit 51 will prevent the pressure switch 53 from closing a signalling circuit in leads 55. If, however, the pressure in the sensing conduit 51 falls below a selected set point the circuit is closed and the electric indicating device 56, such as a bulb or alarm will be actuated. The power for the signalling circuit is supplied through leads 57 which can be directly connected to a prime voltage source, or, as in this instance through a timing mechanism 61, supplied from a power source 62.

The timing mechanism 61 is not an absolute essential

component of all embodiments of the invention. Generally its function is to provide for desired short periods of operation of the pneumatic motor device at specific intervals. Accordingly, it is readily adaptable for providing the power for the electrical circuit of the malfunction sensing apparatus of the invention. The delay mechanism 58 is particularly adaptable for this species of application of the invention wherein operation is not continuous but is at timed interval. Thus, if it is desired to have a motor operate for a thirty second period every five minutes, the timing mechanism 61 is particularly beneficial. In this environment the time delay mechanism 58 is also particularly effective.

In these instances wherein intermittent operation of the motor is desired, it will be seen that in many cases the initial portion of any of such intermittent operational periods could be accompanied by a malfunctioning of the driven apparatus. This is more clearly understood, for example, by assuming that the driven apparatus is a sodium cell riser pipe cleaning device as disclosed by the Honea patent. In this instance, the initial operation of the tickler will require its dislodging of more massive deposits of deposited metal impurities from the riser pipe, than those deposited at a later time. It has been discovered then, that the cyclic operation of the Honea device frequently results in what is herein termed a "normal malfunction" during the first portion of an operating period. In other words, after a limited number of reciprocating strokes, even if these strokes do not go to the limit of normal amplitude, the disrupting condition affecting the driven apparatus will be terminated merely under the effect of this repetitive initial operation. Hence, for normal operation purposes, the malfunction, or short amplitude reciprocation, does not become a problem unless its existence continues beyond a defined number of initial strokes. If it continues beyond this point, then remedial measures may be required. For installations of this particular type, the delay apparatus 58 is particularly beneficial. The delay device 58 may be any of a variety of types, but a suitable example is a delay relay. The mode of operation of this apparatus is to maintain open an associated switch in the signalling circuit for a limited period after the timer 61 has initiated operation of the pneumatic motor. After this limited period has expired the delay timer 58 closes its circuit, thus making it possible for the pressure switch 53 to complete the circuit if actual malfunction exists.

The pressure switch 53 can operate in several ways. It is preferred that the switch be disposed to close a circuit if the pressure in the sensing conduit 51 drops below a set point. This set point is between the pressure maintained in the gas supply line or manifold 41 and atmospheric pressure. It will be seen that even though the pressure in the sensing conduit fluctuates, the pressure switch 53 will be activated only if the pressure falls below the set point.

The pressure switch 53 is preferably of the automatic reset type. In other words, a regain in pressure in the sensing conduit 51 would reposition the switch to again open the circuit to the indicating means 56. It will be seen that, if a malfunction lasts only a short period, that the signal from the indicator 56 might not be observed. A hold mechanism, or manual reset mechanism 54 is desirably provided for such circumstances. This hold and reset means 54 maintains the power to the indicator 56 once the circuit has been established, until it is manually reset. If, then, the malfunction still persists, the circuit will be re-established by the existent position of the pressure switch 53. If, on the other hand, the malfunction has terminated, then the reset will extinguish the signal from the indicator 56.

As an example of a typical type of installation, the following is representative. A pneumatic motor was provided to operate a reciprocating device using a stroke of about three inches. The motor employed a piston of

about three inches in diameter. A gas supply line, corresponding to supply line 41, had an air supply pressure of about 75 pounds per square inch maintained therein. A timing mechanism 61 provided for actuation, by a solenoid device 37, of the valving mechanism 31 at intervals of about 1 minute out of every 15 minutes. The rate of pulsing or reciprocation was a complete reciprocation in three fourths of a second.

The diameter of the sensing nozzle 21 was about $\frac{3}{16}$ inch. The restriction orifice 52 was $\frac{1}{16}$ inch in diameter. The delay mechanism 58 was set to maintain a switch in the signalling circuit open for a period of about 6 seconds after energizing by the timing mechanism 61. In operation, this apparatus operated highly successfully for an extended period. A check on its effectiveness was made by visual observation of the position of the parts of the mechanism driven by the motor. This check showed that the apparatus detected and signalled fully adequately the occurrence of a true malfunction.

It will be apparent that the apparatus of the present invention is susceptible of numerous different embodiments without departing from the scope thereof. In the description of a particular embodiment given above, the malfunctioning apparatus was applied to only one stroke of the double acting pneumatic motor. This is appropriate when it has been found that the malfunctioning normally occurs during that particular directional stroke. It will be apparent of course that a similar sensing and indicating apparatus, can be incorporated to detect a malfunctioning on the reverse stroke of the piston of the motor. Even more effectively, the same sensing conduit can have branches to openings communicating with both ends of a cylinder of a motor. In such instances, a check valve is supplied adjacent in each branch, to permit gas to flow only toward the corresponding cylinder space. It will be remembered that the principle of operation of the malfunction detector is a substantial prevention of flow of gas from the sensing conduit to the cylinder space (in absence of malfunction) by either (a) the powering gas pressure therein (b) the positive closure effected by the piston or (c) the lag in such flow during exhausting of the cylinder space. This latter factor can be considered either a result of fluid flow friction of the sensing conduit and opening, or as a pseudo-compression of cylinder charge gas during exhausting, or both.

The apparatus is not restricted to employ any specific device for the pressure sensing element or the malfunction signalling device. Thus, if it is not desired to utilize an electrical circuit actuated by a pressure switch, a Bourdon or diaphragm type pressure detecting device can be employed, with appropriate amplified mechanical linkage to suitable signalling apparatus. However, in virtually all instances, it will be found preferable to employ electrically actuated signalling circuits and devices.

The orientation of the sensing openings in the motor cylinder walls is also subject to variation. Not only can the closure be effected by the end face of the cylinder (as in the figure) but the opening may be in the cylinder side wall 11. This is, in fact, preferable, as in this case the positioning is not as critical, the piston closing the opening by sliding contact.

Similarly to the non-criticality of the pressure of air applied through the restriction orifice (as 52 in the foregoing illustration), the size of the restriction proper is not particularly critical, but ordinarily should be appropriately matched with the size of the opening of the sensing nozzle connecting the sensing conduit to the interior of the cylinder of the motor. Normally, orifices of the size of about one-thirty second to one eighth inch in diameter will be employed. The ratio of the sensing opening to the orifice or restriction opening will normally be in the range of about 5:1 to 15:1.

Having fully described the apparatus of the present invention, what is claimed is:

1. In combination, a pneumatic piston and cylinder

7

motor for a reciprocating device and a malfunction apparatus for detecting and indicating failure of the piston to complete normal full strokes, including a sensing assembly, a gas supply line, a switch responsive to a set point pressure, and indicating means; the sensing assembly including a conduit having an opening within the cylinder, said opening being substantially closed by the piston when at the end of a full stroke, the conduit also having a restricted opening from the gas supply line and further operatively connecting to the switch, the said opening being sized to supply gas to the conduit in quantities sufficient to maintain a pressure in the conduit above the set point pressure when the piston is reciprocating with full strokes, whereby a pressure always above the said set point pressure is maintained except when the piston terminates movements toward the conduit opening before reaching the normal end of full strokes, the indicating means being operatively associated with the switch for indicating such malfunction.

2. In combination a pneumatic piston-cylinder motor for a reciprocating device and a timing means for initiating and terminating intermittent operation, and a true malfunction apparatus for detecting and indicating failure of the piston to complete normal full strokes after a short period of operation, said apparatus including a sensing assembly as hereafter defined, a delay apparatus,

8

a gas supply line, a switch responsive to a set point pressure, and an indicating means; the sensing assembly including a conduit having an opening within the cylinder of the motor, said opening being positioned for being substantially closed by the piston when at the end of a full stroke, the conduit also having a restricted opening from the gas supply line and further operatively connecting to the switch, the said opening being sized to supply gas to the conduit in quantity sufficient to maintain the pressure therein above the set point pressure when the piston is reciprocating normally with full strokes, whereby a pressure is maintained in the conduit above the set point pressure except when the piston terminates movements toward the conduit opening before reaching the normal end of full strokes, the indicating means being operatively associated with the switch for indicating such malfunction, but the delay apparatus preventing operation of the indicating means for a limited period following initiation of operation of the motor by the timing means.

References Cited in the file of this patent

UNITED STATES PATENTS

2,339,532	Venable	Jan. 18, 1944
2,430,122	Grace	Nov. 4, 1947
2,790,163	Armstrong et al.	Apr. 23, 1955