

Jan. 9, 1962

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3,016,046

REGULATOR VALVE

Filed May 5, 1960

FIG. 1

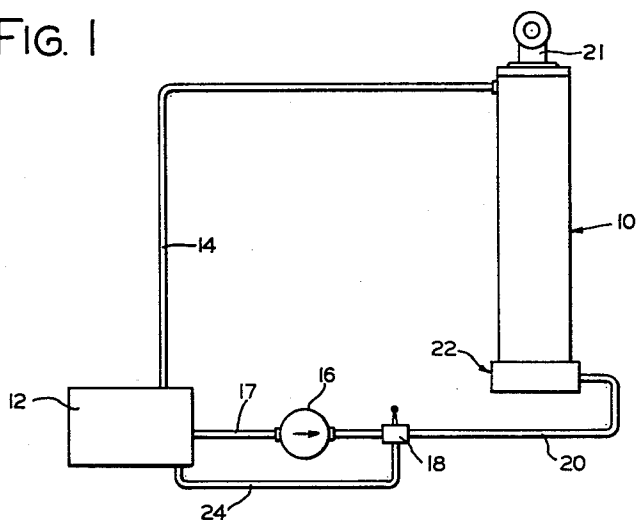


FIG. 2

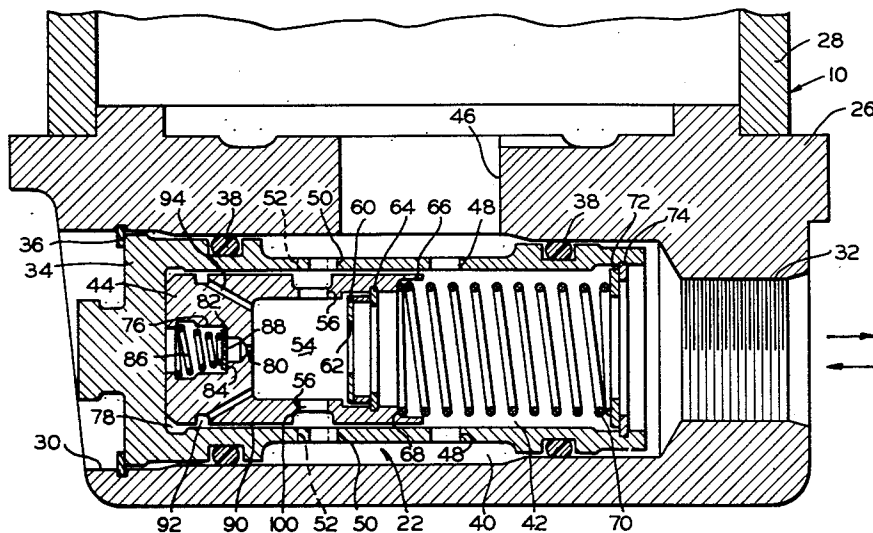
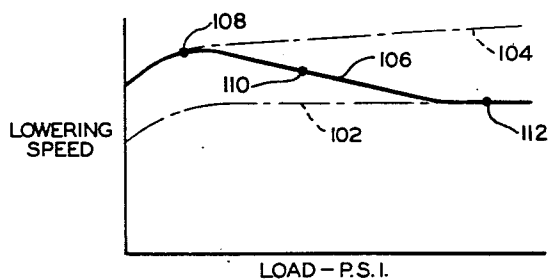


FIG. 3



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3,016,046

REGULATOR VALVE

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17 Claims. (Cl. 121—38)

This invention relates to a fluid flow control device and more particularly to a flow regulating valve device.

Although many and diverse uses of the invention will no doubt become apparent to persons skilled in the art as the description proceeds, I find it desirable to relate in detail only one application of the invention which has proven in commercial use to be of great value.

In the operation of industrial lift trucks, such as the type shown in U.S. Patent No. 2,906,373, granted September 29, 1959, loads supported by the lifting hoist motor during vertical movement of the telescopic mast located at the front of the truck vary widely. The tendency during lowering movement of the load is that the lowering speed increases as the mass of the load supported by the elevating device and hoist motor increases, which is undesirable.

It is the primary object of the present invention to provide an improved regulator valve for use with hydraulic devices of certain types.

An important object of the invention is to provide improved regulator valve means for use with fluid actuated hoist motors wherein the speed with which a load is lowered by the hoist decreases as the load thereupon increases.

A further object of the invention is to provide improved anti-hunting means in regulator valve devices for use with hydraulic motor means of certain types.

In carrying out the above objects I provide a flow regulator valve device which, as disclosed herein, is associated with a load elevating type hoist motor subject to loads of widely varying mass. The valve device preferably does not restrict the flow of pressure fluid to the motor during elevation of a load thereon, but controls the velocity of lowering the load from an elevated position inversely as a function of the load applied to the motor and between pre-determined maximum and minimum limits. In addition, the valve device provides improved oscillation dampening means operable to first permit a slight "over-shoot" of the valve during control of fluid flow from the hoist motor, and to then cause the valve to return to the required flow regulating position with little or no "hunting."

The above and further objects, features, and advantages of my invention will become apparent to those familiar with the art from the following detailed description of a preferred embodiment of the invention, as illustrated in the accompanying drawing wherein:

FIGURE 1 is a schematic view of a fluid actuated hoist motor, and elements associated therewith providing pressure fluid to the hoist motor through a regulator valve device located in the base end of the cylinder;

FIGURE 2 is an enlarged sectional view taken axially through the regulator valve assembly in association with the base end of the cylinder of FIGURE 1; and

FIGURE 3 is a chart illustrating a typical performance curve of the valve device.

Turning now to the details of the present invention, as illustrated in the drawing, FIGURE 1 illustrates a hydraulic hoist motor 10 of the cylinder-piston type which may be used, for example, in elevating loads of widely varying mass as in the lifting mast structure of an industrial lift truck. The motor 10, as illustrated, is of the single-acting type, the top end being vented to a sump 12 by way of a conduit 14, the sump 12 being connected to a pump means 16 by a conduit 17. The pump may be of any suitable type for supplying pressure fluid, at the selec-

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tion of an operator, through a selector valve 18 and by way of conduit 20 to the working end of a piston, not shown, connected to an extensible piston rod 21 of motor 10 through a regulator valve device 22 which is attached to the base end of the cylinder of motor 10. During retraction of piston rod 21 hydraulic fluid returns to the sump 12 through valve device 22, conduit 20, selector valve 18, and a fluid return conduit 24. Valve device 22 comprises the subject matter of the present invention, and will now be described in detail in conjunction with FIGURES 2 and 3.

In the base end of cylinder 28 of the motor 10 is secured a housing 28 of valve device 22 having an opening 30 extending therethrough, at the one end of which is formed a threaded port 32 adapted to be connected with conduit 20. The valve device 22 is mounted within opening 30, as shown, and comprises generally a cup-shaped sleeve 34 located by a snap ring 36 abutting the closed end thereof and providing peripheral annular recesses housing sealing rings 38. Sleeve 34 is open at the right hand end thereof and is formed to provide an outer annular chamber 40 with housing 26 and an inner valve chamber 42 in which is housed a flow regulator valve piston 44 and parts associated therewith. An opening 46 in housing 26 communicates cylinder 28 with chamber 42 by way of annular chamber 40, a plurality of circumferential ports or openings 48 formed in sleeve 34 beyond the right hand end of valve piston 44, and a plurality of circumferential and staggered ports or openings 50 and 52 also provided in sleeve 34 and located so as to communicate with valve chamber 54 by way of a plurality of circumferential valve ports 56. A throttle plate 60 having a fixed orifice 62 therein is located in valve chamber 54 by means of an annular member 64 located in an inner circumferential slot of the valve piston, as illustrated. The right hand end of the valve piston provides an annular extension 66 for controlling the effective area of openings 48 and an annular shoulder 68 providing an abutment for the one end of a valve regulator spring 70 which abuts at its opposite end an annular plate 72 secured in position by a ring 74 in registry with an inner circumferential slot of sleeve 34.

The closed end of valve piston 44 provides an opening 76 of varying diameter for communicating valve chamber 54 with a chamber 78 formed between the opposed surfaces of the valve piston and the closed end of the valve sleeve. A relatively large orifice 80 is located at the right hand end of opening 76, and an orifice plate 82 normally abuts shoulder 84 of opening 76 under the influence of a relatively light spring 86. An orifice 88, which is small relative to orifice 80, is formed in plate 82. Plate 82 is adapted in operation to communicate pressure fluid between chambers 54 and 78 around the plate when it is actuated to compress spring 86 and/or through the orifice 88 under conditions to be described.

The valve piston 44 is preferably housed in non-sealing relation with the inner wall of sleeve 34 to provide a small annular clearance chamber 90 whereby to prevent stickiness in operation and to minimize machining costs. Clearance chamber 90 communicates with chamber 54 by way of an annular notch 92 and a plurality of inwardly directed passages 94 for a purpose to be explained.

In operation, pressure fluid is directed by selector valve 18 from pump 16 to motor 10 to actuate piston rod 21 outwardly of the motor by way of conduit 20, port 32, chamber 42, throttle plate 60, chamber 54, ports 56, 50, 52 and 48, and opening 46. During extension of piston rod 21 fluid is conducted from the upper end thereof of sump 12 by way of conduit 14, and valve 44 is maintained in the position illustrated in FIGURE 2 by regulator spring 70. The valve does not function to restrict in any manner pressure fluid flow into cylinder 28, and

the rate of outward movement of the piston rod is a function solely of the fluid flow from pump 16 under any given load on piston rod 21 resisting outward movement thereof.

Assume that a given load has been elevated by piston rod 21 and that the operator now desires to lower same. The operator merely actuates selector valve 18 to a position in which fluid in the cylinder 28 below the piston is caused to flow, under the influence of the load on piston rod 21, in a reverse direction through opening 46, the various openings in sleeve 34 and valve piston 44, chambers 54 and 42, orifice plate 60, and conduits 20 and 24 to the sump 12. The design of valve 22 is such that the greater the load acting axially inwardly or downwardly of piston rod 21, within minimum and maximum limits, the less is the velocity with which the load is lowered, which is desirable. In addition, the valve provides orifice plate 82 and elements associated therewith in opening 76 for the purpose of preventing hunting of valve 44. The area of opening 62 in orifice plate 60 and the rate of spring 70 may, of course, be varied as desired in design to provide a pre-determined substantially fixed flow through opening 62 at a selected pressure drop thereacross during retraction of the piston rod and throughout the effective range of movement of valve piston 44 rightwardly to control the effective flow areas of ports 48, 50 and 52. Annular extension 66 is adapted to decrease the effective area of ports 48 during rightward movement of the valve piston, whereas an annular shoulder 100 decreases the effective area of ports 50 and 52 during such movement.

For the immediate purpose of explanation let it be assumed that ports 48 are not present in the valve sleeve 34, and that all fluid flow from cylinder 28 must pass through ports 50 and 52, orifice plate 60, and thence to the sump through the valve chamber 42 and conduits. In such a construction, retraction of the piston forces fluid under pressure through the ports into valve chamber 54 and establishes a substantially constant pressure drop, across opening 62. A portion of the fluid flowing into chamber 54 flows through orifice 80 and smaller orifice 88 into the chamber 78 behind the valve 44. Inasmuch as orifice 80 is substantially larger than orifice 88 an increase in pressure in the space between the orifices occurs and causes plate 82 to move compressing the light spring 86 and permitting flow to take place both through and around plate 82 to fill the chamber 78 rather rapidly and condition valve 44 for movement rightwardly in opposition to control spring 70 and to the fluid pressure in chamber 42. As the valve moves rightwardly the annular control edge 100 begins to first cover the area of ports 52 and then the area of ports 50 in order to regulate the flow from cylinder 28 into chamber 54 so as to maintain substantially constant the pressure drop across throttle plate 60.

The area of orifice 80 is preferably large enough to permit a sufficiently rapid build-up of fluid pressure in chamber 78 so that fairly rapid initial regulating movement of valve 44 is effected and it will over-travel slightly the location at which area control shoulder 100 limits the flow through the ports 50 and 52 in order to maintain constant the differential across orifice plate 60. The slight over-travel of valve 44 causes somewhat more than the required amount of fluid to be restricted at ports 50 and 52, whereby the pressure within cylinder 28 increases slightly which would normally cause the flow to again increase and result in an oscillation or hunting of the valve piston if it were allowed to follow freely the resulting oscillating pressure. In order to prevent this condition from occurring, orifice plate 82 is actuated by spring 86 into abutment with shoulder 84 immediately upon an equalization of pressure in chambers 54 and 78, at which time flow between these chambers ceases. Thus, hydraulic fluid can flow from chamber 78 only through small orifice 88 in a reverse direction, as when valve 44 begins to return from its aforementioned slight over-travel position, or, for that matter, whenever the force

balance between the pressure differential across orifice plate 60 and control spring 70 is disturbed in a direction which causes valve piston 44 to move leftwardly.

It will now be apparent to persons of skill in the art that the design and operation of orifice 80, orifice plate 82 and spring 86 in valve piston 44 prevents undesirable hunting of the main valve by permitting a slight over-travel thereof in a flow cut-off direction due to relatively rapid movement of the valve permitted in that direction, while permitting only a relatively slow return of the valve from said over-travel position in order to eliminate over-travel in the opposite or compensating direction, with consequent elimination of hunting or oscillation of the valve. I have found that a proper selection of area of orifice 88 so severely damps the motion of the valve in a leftward direction that essentially no oscillation or resulting variation in lowering speed of piston rod 21 occurs, other than the relatively initial fast movement and deceleration to normal movement as the valve 44 reaches its desired regulating position. The circumferential series of ports 50 and 52 are staggered circumferentially of sleeve 34 so as to dampen the effect of flow area change during movement of the valve, as will be clearly understood by persons skilled in the art.

I have found that the provision of passages 94 communicating annular clearance chamber 90 with valve chamber 54 is of importance in valve constructions of the type contemplated wherein no sealing means is provided between the sleeve and valve piston axially intermediate the control ports 50 and 52 and pressure chamber 78. It will be understood that the pressure in cylinder 28 may, for example, be 1500 p.s.i., whereas the drop across ports 50 and 52 may effect a pressure level of, say, 200 p.s.i. in valve chamber 54 in order to maintain, for example, a substantially constant pressure drop of 50 p.s.i. across throttle plate 60. Under such conditions it will be readily understood that considerable leakage of pressure fluid will occur between the valve piston and valve sleeve through annular chamber 90, which, but for the provision of passages 94, would cause a build-up in pressure in chambers 78 and consequent undesired rightward control movement of valve 44, which would interfere seriously with the proper regulating function of the valve. Of course, if desired, a lapped seal or other sealing means may be provided between the adjacent peripheries of the valve and sleeve, in which case passages 94 may be eliminated. However, I have found that more satisfactory operation can be obtained in a less expensive valve construction as disclosed herein.

From the foregoing, still assuming that ports 48 are not present in sleeve 34, it will be understood that irrespective of the mass of load tending to cause retracting movement of piston rod 21, as reflected in the level of pressure in cylinder 28, that the speed of such retracting movement will be a substantially constant value, as illustrated by the dot-dash curve illustrated at numeral 102 in FIGURE 3. The provision of circumferential ports 48 which by-pass valve 44 by communicating directly cylinder 28 with chamber 42, provides for increased lowering speed over that indicated by curve 102. But for the annular area control portion 66 of valve 44, ports 48 would tend to increase lowering speed over that indicated by curve 102 along a somewhat increasing slope with increasing load, as indicated by curve 104. The slope of the curve 104 varies somewhat depending upon the area relationship between ports 48 and ports 50 and 52, that which is illustrated being merely representative, as will be understood. However, as valve 44 moves rightwardly to a control position, area control end portion 66 decreases the effective area of ports 48 an amount which varies with the load on the piston rod, whereby to decrease lowering speed as a function of increasing load. This result is illustrated by curve 106 which represents a typical result wherein valve control portion 66 does not effect any decrease in effective area of ports 48 during a pre-determined small rightward

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movement thereof whereby a relatively small load, as represented by point 108 in FIGURE 3, causes the load to be retracted at maximum speed. A load of the magnitude indicated at point 110 is lowered at a lesser speed wherein ports 48 are partially closed by valve control portion 66, and a load of the magnitude indicated at point 112 is lowered at minimum speed which coincides with the outer flat portion of curve 102, in which condition ports 48 are fully covered by valve portion 66 while ports 50 and 52 remain partially open. It is, of course, an important design consideration that the edges of valve control portions 66 and 100 be carefully located in relationship to the respective ports controlled thereby in sleeve 34 so that the characteristic slope and position desired of cross-over curve 106 may be obtained.

The relationships indicated in FIGURE 3 are, of course, representative only and changes in design may be readily made to obtain substantially different results within the scope of the invention.

From the foregoing it will be now apparent that I have provided an improved flow valve construction of relatively simple and low cost design having means for providing a speed control of a working member which varies as an inverse function of the load on the member between maximum and minimum limits, uniquely combined with an anti-hunting construction and a relatively loose-fitting valve piston in a valve sleeve, whereby to effect accurate flow control in various applications with which the present invention may be utilized. It should be clearly understood that specific pressure values, examples and the like which have been mentioned above, characteristic operational curves such as illustrated in FIGURE 3, certain specific design features, and the particular application described relative to a hydraulic hoist motor, have been related herein in the interests of clarification and understanding, and are not intended to limit the scope of the invention in any manner except as may be required in the claims appended.

Now while I have shown and described what I believe to be a preferred embodiment of the present invention, it will be understood that various re-arrangements and modifications may be made therein without departing from the spirit and scope of my invention.

I claim:

1. A valve device for use with a hydraulic motor comprising conduit means connected to the motor, an elongated valve sleeve fixedly located in the conduit having one open end and one closed end and defining first and second axially spaced circumferential openings communicating the conduit with the motor, a valve member located in the valve sleeve and movable axially thereof, resilient means urging the valve member toward the closed end of the sleeve, and flow control orifice means associated with the valve member and axially intermediate the said first and second spaced openings, said valve member being actuatable in opposition to said resilient means for controlling the area of said first and second spaced openings.

2. A valve device for use with a hydraulic motor comprising conduit means connected to the motor, an elongated valve sleeve fixedly located in the conduit in communication therewith at one end thereof and first and second axially spaced, circumferential openings communicating the conduit with the motor, means effecting closure of the opposite end of the valve sleeve, a reciprocable valve member located in the valve sleeve, yielding means urging the valve member toward the closure means, and flow control orifice means associated with the valve member normally located axially intermediate the first and second spaced openings, said valve member being actuatable in opposition to said yielding means for controlling the effective area of said first and second openings.

3. A valve device as claimed in claim 2 wherein said first opening is in series flow relation with said control orifice means and said second opening is in parallel flow relation with said control orifice means, said valve device

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being adapted to provide a decreasing flow of fluid there-through from the motor as the motor fluid pressure increases.

4. A valve device as claimed in claim 2 wherein the valve member is provided with a first area control element cooperating with said first opening, and a second area control element cooperating with the second opening, said first control element being adapted to vary the flow through said first opening for maintaining a substantially constant drop in fluid pressure across the control orifice means, and said second opening being located in parallel flow relation with said control orifice means.

5. In a conduit a fluid pressure responsive valve device controlling volume fluid flow from a pressure source comprising a cup-shaped valve sleeve having first and second axially spaced circumferential openings communicating the pressure source with the conduit, a cup-shaped valve member mounted for reciprocable movement within the sleeve having first and second axially spaced circumferential control elements adapted to cooperate with said first and second spaced openings, respectively, for controlling the effective areas thereof, resilient means urging said valve member toward the closed end of the sleeve member, orifice means in the valve member normally located axially intermediate the said first and second openings, and a chamber formed between the ends of said sleeve and valve member adapted to communicate with the source of pressure for actuating the valve member in opposition to the resilient means.

6. A valve device as claimed in claim 5 wherein said orifice means has a fixed area and said first control element is adapted to maintain a substantially constant pressure drop across said orifice means, said second control element being arranged to close said second spaced opening prior to closure of said first spaced opening by said control element.

7. A valve device as claimed in claim 5 wherein said axially spaced openings and said control elements therefor are arranged in the valve device such that flow there-through from the pressure source decreases between predetermined maximum and minimum values of fluid flow inversely as a function of fluid pressure at the source and over a predetermined range of pressure at the source.

8. A valve device as claimed in claim 5 wherein a passageway extends through the closed end of the valve member to conduct pressure fluid to said chamber, and valve means in said passageway providing relatively unrestricted flow to said chamber and relatively restricted flow from said chamber such that valve oscillation in operation is minimized.

9. In a conduit connected to a source of pressure fluid, a fluid flow control valve device comprising a fixed sleeve member having an open end, a closed end and port means communicating the conduit with the pressure source, valve means movable axially of the sleeve member having a control orifice downstream of said port means and controlling said port means for controlling the pressure drop across the control orifice, resilient means urging the valve means toward the closed end of the sleeve member, said valve means having an open end adjacent the resilient means and a piston end adjacent the closed end of the sleeve member, and passage means in the piston end communicating a valve chamber interior of the valve means with a valve chamber exterior of the valve means, and second valve means in said passage means permitting pressure fluid flow in both directions therethrough.

10. A valve device as claimed in claim 9 wherein said second valve means is arranged such that volume fluid flow through said passage means per unit time is greater from the internal to the external chamber than vice versa.

11. A valve device as claimed in claim 10 wherein pressure fluid in said external chamber actuates the first valve means beyond a desired control position upon a change in pressure fluid and permits a relatively slow return of the first valve means to said desired control

position as a portion of said external chamber pressure fluid flows to the internal valve chamber through the second valve means.

12. A valve device as claimed in claim 9 wherein second port means is located in said sleeve member in parallel relation with said control orifice.

13. A valve device as claimed in claim 9 wherein said first valve means is mounted within the sleeve member in non-sealing peripheral relation thereto, and other passage means extending through the piston end of the first valve means for communicating pressure fluid leakage flow from the area between the sleeve member and first valve to means to the internal chamber.

14. A valve device for use with a hydraulic cylinder-piston hoist motor which is subjected to loads of varying mass comprising a conduit connected to the lower end of the cylinder, a valve sleeve located in sealing relation with the conduit, said valve sleeve having an open end and a plurality of axially spaced circumferential ports communicating the conduit with the cylinder, valve means movable axially of the valve sleeve for controlling the effective area of said axially spaced ports, control orifice means in said valve means located intermediate said ports, means urging said valve means away from to the said open end of the valve sleeve, and means forming with said valve means at the end thereof opposite the open end of the valve sleeve a pressure fluid chamber for actuating said valve means in opposition to said urging means for controlling the effective area of said axially spaced ports.

15. A valve device as claimed in claim 14 wherein

said valve means provides for relatively unrestricted pressure fluid flow from said conduit to the cylinder, and is actuatable to control the effective area of the axially spaced ports to restrict the flow from the cylinder to the conduit inversely as a function of pressure in the cylinder.

16. A valve device comprising an elongated valve sleeve open at one end and closed at the opposite end, an elongated valve member reciprocable within the sleeve and forming with the inner periphery of the sleeve an annular clearance chamber, chamber means formed between the one end of the valve member and the closed end of the sleeve, a chamber formed in the valve member, and passage means connecting said latter chamber with said annular clearance chamber for venting pressure fluid flow from the clearance chamber to the said latter chamber.

17. A valve device comprising an elongated valve sleeve closed at one end, an elongated valve member reciprocable within the sleeve and forming with the inner periphery of the sleeve an annular clearance chamber, chamber means formed between the one end of the valve member and the closed end of the sleeve, a chamber formed in the valve member, and passage means connecting said latter chamber with said annular clearance chamber for venting pressure fluid flow from the clearance chamber to the said latter chamber.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,016,046

January 9, 1962

Elmer R. Backofen

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 2, lines 58 and 59, for "stickness" read -- stickiness --; line 68, for "ot" read -- to --; column 6, line 35, after "said" insert -- first --; column 7, line 13, strike out "to", first occurrence; line 24, strike out "to".

Signed and sealed this 31st day of July 1962.

(SEAL)

Attest:

ERNEST W. SWIDER
Attesting Officer

DAVID L. LADD
Commissioner of Patents