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Schaible, deceased et al.

[11] **3,711,223**

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[54] **HYDRAULIC CONTROL SYSTEM FOR CONCRETE PLACER**

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[52] **U.S. Cl.** **417/342**
[51] **Int. Cl.** **F04b 9/08**
[58] **Field of Search** ....417/342, 900; 60/52 VS

[56] **References Cited**

UNITED STATES PATENTS

2,892,312	6/1959	Allen et al.	60/52 VS
3,168,295	2/1965	Dorrell et al.	60/52 VS
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[57] **ABSTRACT**

A concrete pumping apparatus having a pair of fluid rams cooperating with conduits for delivering material through the conduits by supplying pressured fluid from a hydraulic control circuit to the rams. The hydraulic control circuit includes a pump delivering fluid to the rams at varying flow rates and pressures with a member in the pump positionable to a plurality of positions to adjust the flow rate of the fluid. The member is adjustable by a manual control means and automatic compensator means communicating with the output of the pump with an element of the compensator means positioned as a function of the pressure of fluid from the pump. A linkage means is interposed between the element and the member to move the member at varying inclements as the pressure of fluid is increased.

11 Claims, 4 Drawing Figures

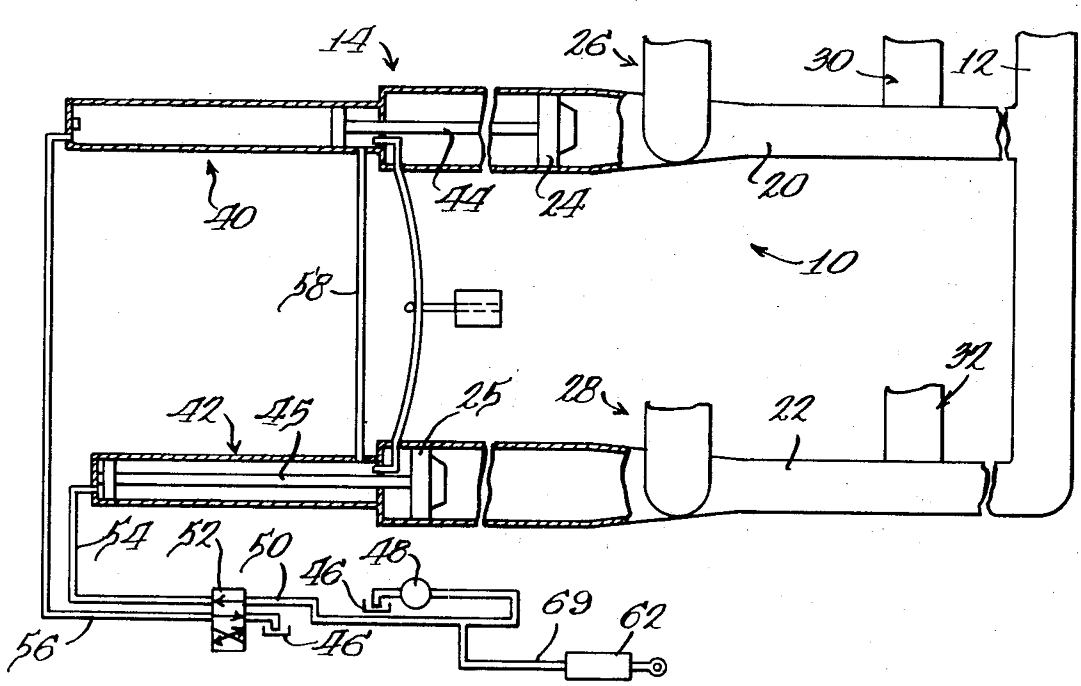
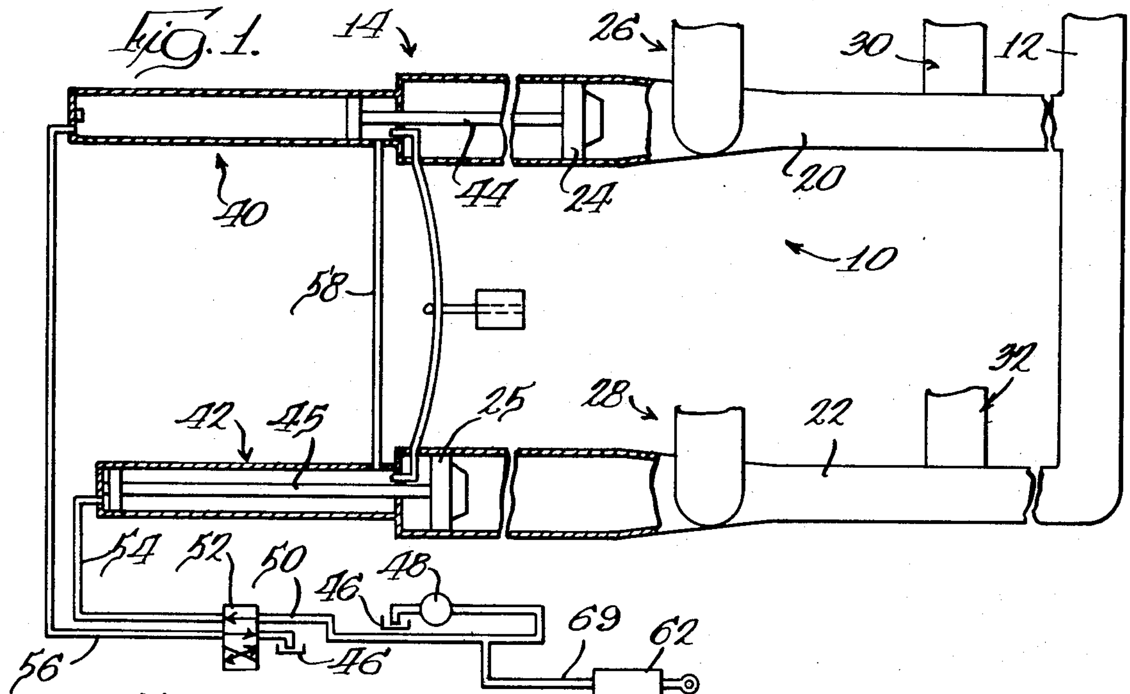


Fig. 1.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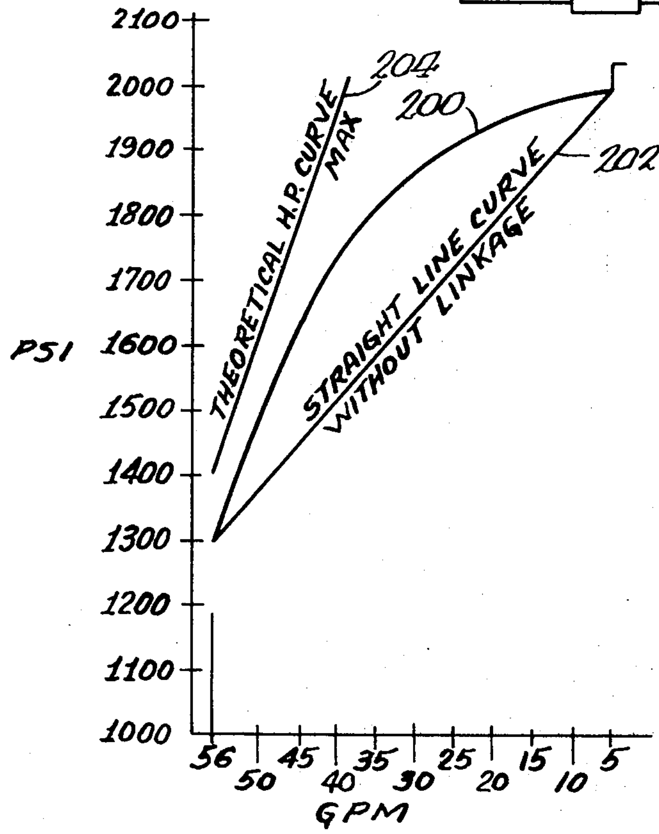
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Fig. 4

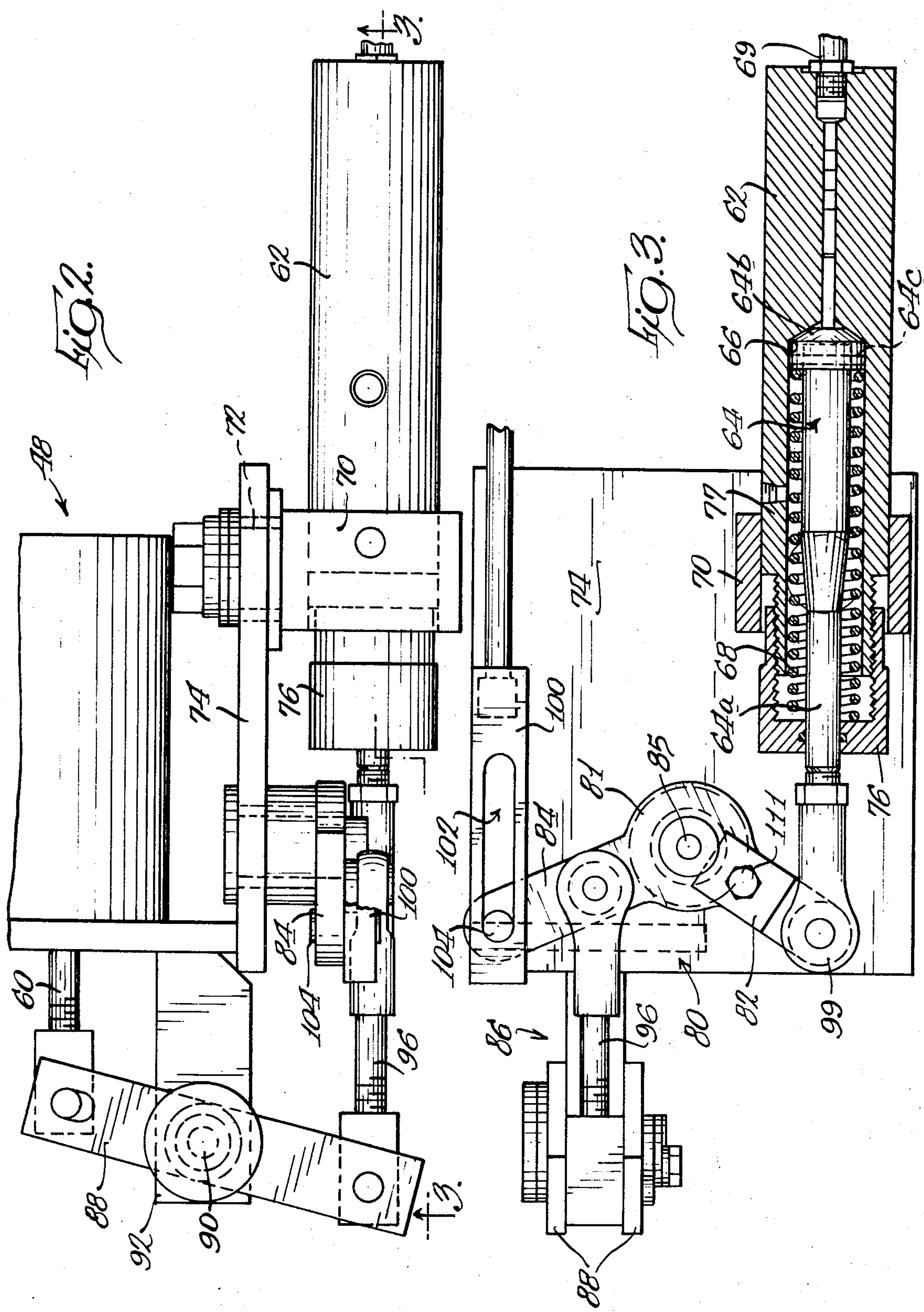
Fig. 2.
Fig. 3.

HYDRAULIC CONTROL SYSTEM FOR CONCRETE PLACER

The present invention relates generally to concrete placement apparatus and more particularly an improved hydraulic control system for controlling the rate of flow in response to changes in pressure of the fluid.

One type of concrete placement apparatus which has found a remarkable degree of commercial success includes a pumping unit in which a pair of fluid rams cooperate with a pair of pistons slidable in conduits. Pressured fluid is supplied to the rams to reciprocate the pistons and move fluent material, such as concrete, to a common outlet where it is delivered to a job site. In order to increase the versatility of a unit of this type, extremely long conduits are utilized so that the pumping unit may be placed in one location and concrete may be delivered to anyone of a plurality of locations. Pumping units of this type are shown in U.S. Pat. Nos. Re. 26,820; 3,327,641; and 3,425,356.

SUMMARY OF THE INVENTION

The present invention relates specifically to a hydraulic control system for supplying pressured fluid to a concrete placement unit of the type disclosed in Pat. No. 3,494,290, assigned to the assignee of the present application.

According to the present invention, a pressure compensating mechanism is incorporated into the hydraulic control and automatically reduces the output flow of a pump as the pressure increases beyond a predetermined limit.

More specifically, the present invention contemplates a hydraulic control circuit for a concrete placement apparatus which has first and second fluid rams cooperating with pistons reciprocated in conduits to deliver a continuous supply of material through a single outlet conduit. The control mechanism includes a pump having a servo-stem or member movable to a plurality of positions to define various flow rates for the pump. The member is movable to anyone of a plurality of positions by a manual control means and automatic pressure compensating means cooperate with the member to correspondingly reduce the output flow of the pump as the pressure exceeds a corresponding predetermined limit.

The pressure compensating means is in the form of an element reciprocable within a chamber and biased to a first position with one end of the chamber in communication with the outlet for the pump. As the pressure of fluid increases, the element is moved from the first position to automatically move the member to a corresponding reduced flow rate.

According to one aspect of the present invention, the pressure compensating means incorporates linkage means between the element and the member which is in the form of a bell crank having first and second angularly related links, each of which defines an effective moment arm respectively for the element and the member. The ratio between the moment arm for the member and the element progressively increases as the element is moved from a first position so that the member is moved in progressively increasing increments for each increment of movement from the first position of the element. The particular arrangement allows for more efficient operation of the entire unit and

results in more accurate control in flow rates as the pressure increases.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF DRAWINGS

FIG. **1** is a fragmentary schematic view of the hydraulic control circuit as well as a portion of the concrete placement system;

FIG. **2** is an enlarged plan view of the compensating means forming part of the hydraulic control circuit;

FIG. **3** is a view, partly in section, taken generally along line **3—3** of FIG. **2**; and

FIG. **4** (appearing with FIG. **1**) is a graph showing the pressure versus the flow rate of fluid from the pump controlled by the linkage of the present invention.

DETAILED DESCRIPTION

While this invention is susceptible of embodiment in many different forms, there is shown in the drawings and will herein be described in detail one specific embodiment, with the understanding that the present disclosure is to be considered as an exemplification of the principles of the invention and is not intended to limit the invention to the embodiment illustrated.

A concrete pumping apparatus for which the present invention is particularly adapted is schematically shown in FIG. **1** and is generally designated by the reference numeral **10**. The concrete pumping apparatus includes a concrete placement conduit **12** which receives material from a concrete pumping unit **14** for delivery to a work site through an articulated boom (not shown) supporting a further conduit (not shown). Since the articulated boom and the conduit cooperating with the boom form no part of the present invention and are disclosed and claimed in co-pending application Ser. No. 105,266, filed Jan. 11, 1971, no detailed description thereof appears to be necessary.

The concrete pumping unit **14** for delivering material to conduit **12** is schematically illustrated in FIG. **1** and includes first and second delivery lines **20** and **22** respectively having pistons **24** and **25** reciprocated therein. The conduits **20** and **22** communicate with the placement conduit **12** at their outer ends and also are in communication with the source of concrete (not shown) through conduits **26** and **28** with valves in the respective conduits **26** and **28**. The conduits **20** and **22** also have valves **30** and **32** in communication therewith. The respective valves are selectively actuatable to place one of the conduits **20** or **22** in communication with the concrete source while placing the other of the conduits in communication with the outlet conduit **12**. As more clearly set forth in the above mentioned Pat. No. 3,494,290, as piston **24** is being moved forwardly, control valve **30** is open while control valve in conduit **26** is closed so that concrete material within conduit **20** is being delivered to the placement conduit **12**. At this time, valve **32** in conduit **22** is closed while the valve in conduit **28** is open and the retraction of the right-hand piston **25** will draw concrete from the source (not shown) into the conduit **22** for subsequent delivery to the main placement line **12**.

The reciprocation of the respective pistons is accomplished through first and second fluid rams **40** and **42** respectively having piston and rod assemblies **44** and **45** reciprocated therein and connected to the respective pistons 24 and 25. The pressured fluid is supplied from a reservoir or source 46 through a pump 48, a conduit 50, a control valve 52 and conduits 54 and 56 to the head ends of the respective fluid rams 40 and 42. The two position control valve 52 is adapted to supply fluid through one of the conduits 54 or 56 while connecting the opposite conduit to the reservoir 46. The rod ends of of the respective cylinders forming part of the fluid rams 40 and 42 are interconnected by a single conduit 58 so that one of the pistons will be extending while the second piston is being retracted.

According to the present invention, the hydraulic control circuit further includes manual means for adjusting the flow rate of the pump and automatic pressure compensating means for adjusting the flow rate of the pump as a function of the pressure of the fluid to decrease the flow rate when the pressure exceeds a predetermined level.

Referring particularly to FIGS. 2 and 3 of the drawings, the pump 48, which may be of the commercially available type manufactured and sold by Vickers Division of Sperry Rand, Troy, Mich., under the designation PVC45-10 has a servo stem 60 incorporated therein. The servo stem or member is positionable to a plurality of positions to adjust the flow rate of fluid from the pump.

The automatic compensating means cooperates with the stem or member 60 and includes a cylinder 62 having an element or piston and rod assembly 64 reciprocated within a chamber 66. The element 64 is normally biased to a first position by biasing means or spring 68 which has a constant spring rate while the chamber 66 is in fluid communication with the outlet of the pump through a branch conduit 69 (See FIG. 1). The cylinder is supported by a trunnion mounting 70 having a bolt 72 extending through a support plate 74 secured to the pump 48 so that the cylinder can pivot relative to the support for a purpose to be described later.

In the illustrated embodiment, the element 64 includes a rod 64*a* having an enlarged portion or piston 64*b* secured to one end thereof by a pin 64*c*. The rod extends through an end cap 76 threaded on one end of the cylinder 62 to enclose the chamber 66 and a drain opening 77 is located on one side of the piston to drain any fluid which leaks past the piston.

Thus, as the pressure of the fluid increases, the force of the fluid acts on the free end of piston 64*b* to move the element 64 against the bias of the spring 68 from the first position shown in FIG. 3.

The opposite or free end of the element 64 is connected through linkage means 80 to the member 60 to move the member 60 at varying increments as the pressure of the fluid in conduit 50 is increased. For this purpose, the linkage means 80 includes a bell crank having a hub 81 supporting first and second links 82 and 84 which are angularly related to each other and the hub 81 is rotatable on a pin 85 extending from plate 74. The link 82 is pivotally connected to the element 64 while the other link 84 cooperates with the member 60 through a linkage 86. As is shown in FIGS. 2 and 3, the linkage 86 includes a first pair of links 88 pivoted intermediate their ends at 90 on an arm 92 extending from the support plate 74 while the opposite ends of the links 88 are connected through a further link or arm 96 to the link 84. An inspection of FIGS. 2 and 3 will show that the member or servo stem 60 is moved through the linkage means as a function of the movement of the element 64.

The pump 48 is designed such that a ten pound force will be acting on the member 60 tending to move the element outwardly to a no-flow condition at any time the pressure of the fluid from a pump exceeds a lower minimum limit, such as 350 P.S.I. This force, tending to return the member 60 to a no-flow condition, is at all times acting upon the linkage system including links 88, 96 and the bell crank.

The force from the pump, having a tendency to return the linkage to a no-flow condition, will tend to pivot the bell crank 80 in a clockwise direction, as viewed in FIG. 3, whenever the force from the fluid in chamber 66 exceeds the force exerted by the spring 68.

According to a prime aspect of the present invention, the angularly related links 82 and 84 are positioned on the hub 81 to define effective moment arms about the pivot 85 for the element 64 and the member 60. The links are arranged so that the ratio of the respective moment arms defined by links 84 and 82 respectively, is progressively increased as the element 64 is moved from the first position. Stated another way, with particular reference to FIGS. 2 and 3, in which the pump 48 and the compensating mechanisms are illustrated for a maximum flow condition for the pump, a constant output flow will be realized from the pump until such time as the pressure of the fluid is sufficient to overcome the force of the spring 68.

When the element 64 begins to move from its first position, shown in FIG. 3, the bell crank will be pivoted in a clockwise direction. The pivotal connection 99 between the element 64 and the link 82, as well as the pivotal mounting of the cylinder 62 and the angular relation of the link 82 on the hub 81, will result in a decrease in the effective moment arm for the element 64 about pivot 85 as the element is moved from the first position.

According to a further aspect of the present invention, the linkage system is arranged such that the effective moment arm of the element or piston 64, defined by link 82, about pivot axis 85, is greater than the effective moment arm for the member 60, defined by link 84 about pivot axis 85 during the first stages of movement of the element 64 against the bias of the spring 68. However, during the latter stages of movement, i.e. when the element is approaching the fully extended position relative to the cylinder 62, the effective moment arm defined by link 82 is less than the effective moment arm defined by link 84. This is accomplished by arranging the links 82 and 84 at an angle relative to the hub of bell crank 80 in the manner generally shown in FIG. 3. Stated another way, the effective moment arms for the member 60 and the element 64 about the pivot 85 have a progressively increasing ratio as the element 64 is moved from its first position. An example of the comparison of the moment arms, expressed in inches, is shown in the following table where A is the effective moment arm for the piston or element 64 while B is the effective moment arm for the element 60 about the pivot axis 85.

% of travel of 64	A	B	Ratio

0	1.67	1.23	.738
.1	1.61	1.27	.780
.2	1.56	1.29	.828
.3	1.50	1.31	.875
.4	1.44	1.32	.920
.5	1.36	1.33	.980
.6	1.27	1.32	1.040
.7	1.19	1.31	1.100
.8	1.09	1.29	1.180
.9	.97	1.27	1.310
1.0	.85	1.23	1.450

This arrangement will result in having a greater increment of movement of element **64** per increment of pressure change as the pressure in the system is increased. This is graphically illustrated in FIG. **4** where a line **200** is a plot of pressure of the fluid, in P.S.I., within the system versus the flow rate of the fluid, in G.P.M., from the pump **48**. A comparison of the line **200** with a line **202**, indicating the pressure vs. flow rate plot of the fluid for a system where the effective moment arms are equal reveals that the linkage arrangement of the present invention allows for more effective use of the maximum horsepower available from the power plant for operating the pump, which is shown by the line designated as **204** in the graph of FIG. 4. For example, operating at 1,800 P.S.I. pressure, the maximum flow for a straight line linkage between the pump control member **60** and the compensator element **64** will be approximately 19 gallons per minute while the flow for a linkage system wherein the effective moment arms define a progressively increasing ratio will be on the order of 35 gallons per minute. Viewing the chart again, it will be noted that there are only small increments of change of flow rate during approximately the first half of pressure compensation while there would be a considerable amount of change of flow during the latter half of pressure compensation, i.e. when the pressure is controlled between 1,300 and 2,000 P.S.I. Thus, up to approximately 1,700 P.S.I. pressure in the system, the pressure vs. flow rate curve **200** is approximately a straight line which parallels the maximum horsepower curve **204**. However, once the pressure of the system exceeds 1,700 P.S.I., the curve **200** begins to drop off sharply so as to have a greater change in flow rate for equal increments of pressure change. This arrangement allows for much more accurate control of the flow rate at higher pressures.

The control system of the present invention further includes manual control means for setting the flow rate of the output pump. The manual control means is in the form of a link **100** having an elongated slot **102** receiving a pin **104** which is carried by the link **84** at a location spaced from the pivotal connection for link **96**. The slot **102** and pin **104** define a lost motion connection between the bell crank and the link **100** with the lost motion connection accommodating relative movement of the two links **84** and **100** when the pressure of the fluid in the system exceeds a predetermined level for the flow rate set by the manual control. The slot **102** is of sufficient length to allow the pressure compensating means to move the element **60** to a fully extended or no-flow condition from the maximum flow condition shown in FIG. **2**.

The manual control means **100** can be utilized to set any flow rate for the pump and the compensating means will automatically reduce the flow rate when the pressure in the system exceeds the pressure corresponding to the flow rate set by the manual member **100**. For example, if the flow rate were set at 30 G.P.M. by pivoting the bell crank clockwise and compressing the spring **68**, by movement of the element **64**, the pressure of the fluid in the system will have to exceed approximately 1,875 P.S.I. before the force of the fluid on the element will exceed the opposing force of the spring **68**.

According to another aspect of the invention, the length of the link **82** is formed in two portions which are held together by a bolt **111** so that the length thereof can readily be adjusted.

The automatic pressure compensating means of the present invention provides for an accurate control of the flow rate from the pump and automatically overcomes the manual setting when additional hydraulic power is needed to move concrete under extremely adverse conditions. Furthermore, the system can readily be incorporated into existing pumping equipment without any major modifications of the existing system. An inspection of FIGS. **2** and **3** reveals that the entire unit is carried by the single plate **74**, which can readily be attached at an appropriate location on existing equipment.

We claim:

1. In a concrete pumping apparatus having a concrete placement conduit, first and second fluid rams cooperating with said conduit for delivering material through said conduit, a hydraulic control circuit for supplying pressured fluid to said rams comprising a pump delivering fluid to said rams at varying flow rates and pressures, said pump having a member positionable to a plurality of positions to adjust the flow rate of said fluid; automatic compensator means communicating with the outlet of said pump and having an element positioned as a function of the pressure of said fluid from said pump; and linkage means interconnecting said element and member, said linkage means moving said member at varying increments per increment of pressure of the fluid as the pressure of fluid is increased.

2. A concrete pumping apparatus as defined in claim **1**, in which said compensator means includes a cylinder having said element reciprocated therein; and biasing means normally maintaining said element in a first position with the pressure of said fluid moving said element from said first position.

3. A concrete pumping apparatus as defined in claim **2**, in which said biasing means comprises a spring having a constant spring rate.

4. A concrete pumping apparatus as defined in claim **1**, in which said last means includes linkage means between said element and said member.

5. A concrete pumping apparatus as defined in claim **4**, in which said linkage means includes a bell crank having angularly related links with one link cooperating with said element and a second link cooperating with said member.

6. A concrete pumping apparatus as defined in claim **5**, in which said links define varying effective moment arms for said element and said member and in which the effective moment arm for said element decreases as said element is moved from a first position.

7. A concrete pumping apparatus as defined in claim **1**, and further including manual means cooperating with said last means for adjusting said member to define a predetermined flow rate for said fluid.

8. A concrete pumping apparatus as defined in claim 7, in which said manual means and said last means includes a lost motion connection to accommodate relative movement when the pressure of fluid exceeds a predetermined level for said predetermined flow rate.

9. A concrete pump as defined in claim 1, in which said last means includes a bell crank pivoted about an axis with a first link cooperating with said member and a second link cooperating with said element, said links being arranged to define effective moment arms for said member and said element which have a progressively increasing ratio as said element is moved from a first position.

10. In a concrete pumping apparatus having a pair of rams, each cooperating with a piston reciprocated in a delivery line to deliver material to a placement conduit, a hydraulic control circuit including a reservoir; a pump supplying fluid from said reservoir to said rams, said pump having a member movable to a plurality of positions to adjust the flow rate of fluid from said pump; manual control means for adjusting said member to set various maximums of flow rate for said pump; compensator means for automatically adjusting said member as a function of the pressure of said fluid to decrease said flow rate when the pressure exceeds a predetermined level; and linkage means between said member, said manual means and said compensator means for decreasing said flow rate at varying increments per increment of pressure differential above said predetermined level.

11. A concrete pumping apparatus as defined in claim 10, in which said compensating means includes an element biased to a first position and movable from said first position in response to increases in pressure of said fluid; linkage means between said element and said member, said linkage means moving said member in progressively increasing increments for each increment of movement of said element from said first position, said manual means cooperating with said linkage means through a lost motion connection to accommodate relative movement between said linkage means and said manual control means when the pressure of the fluid exceeds said predetermined level.

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