

[54] **COMPENSATED MULTI-FUNCTION
 HYDRAULIC SYSTEM**

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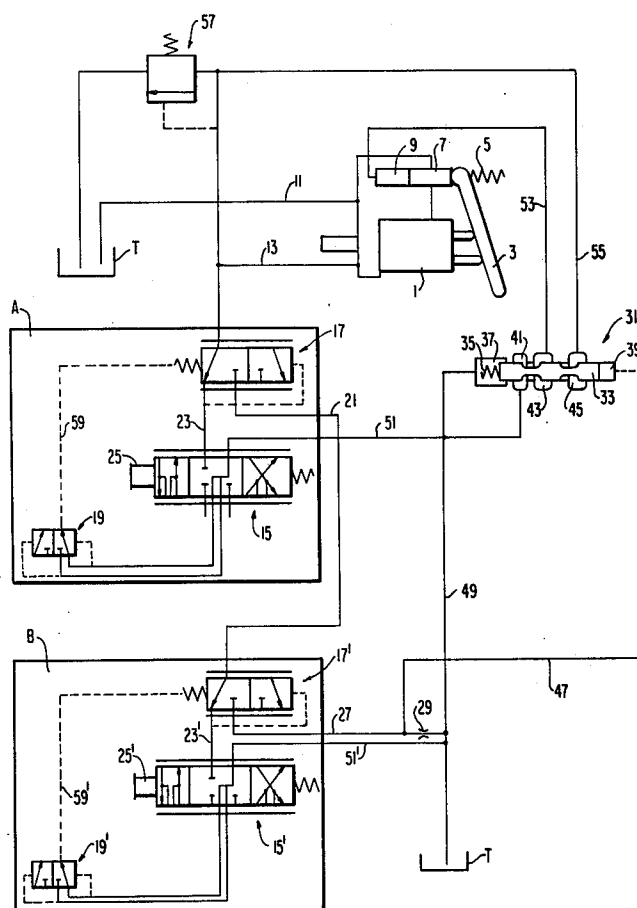
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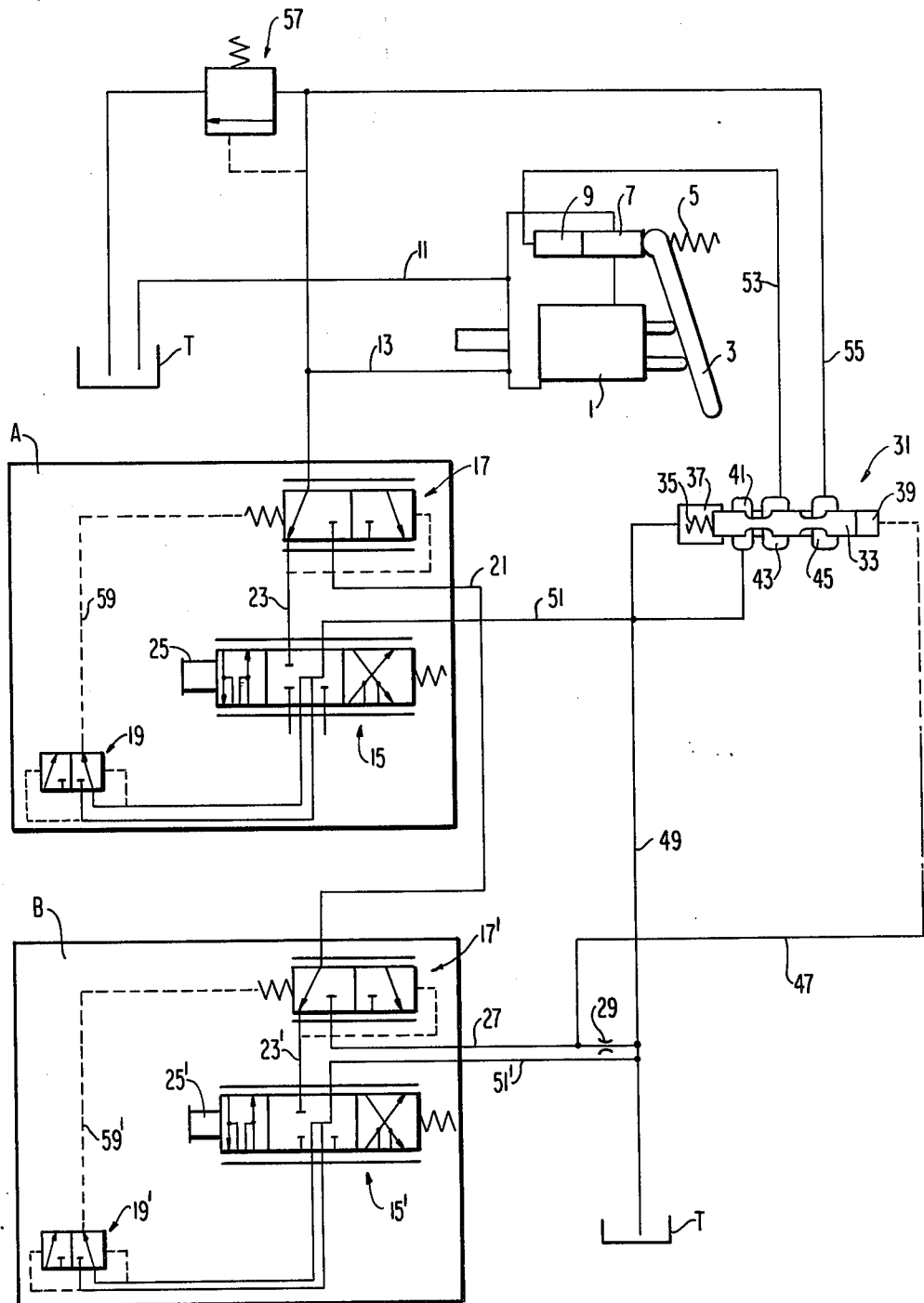
a variable delivery pump in response to the varying demands of any one of at least two hydraulically operated functions, the system comprising at least two control valve means each capable of performing a separate function. Each of the valve means is connected to its own separate compensator valve means, the said compensator valve means being connected in series one with the other and being capable of delivering the necessary amount of hydraulic fluid to its respective control means in accordance with the full needs thereof and diverting the remainder of the fluid to the next following compensator valve means. The system also includes means connected to the compensator valve means farthest from said pump for sensing the total requirement of the system and for adjusting the output of the pump in response thereto. In preferred embodiments, the means for sensing and adjusting include a restricted orifice means, a valve means, and means for sensing the pressure across the orifice means, the valve means being connected through one of its ports to an adjustor means for adjusting the output of the pump, and being normally biased by the means for sensing the pressure drop so as to actuate said adjustor means in favor of providing a minimal continuous flow through said system regardless of the total requirements of the system.

[57] **ABSTRACT**

A hydraulic system capable of adjusting the output of

10 Claims, 1 Drawing Figure





COMPENSATED MULTI-FUNCTION HYDRAULIC SYSTEM

BACKGROUND OF THE INVENTION

This invention relates to compensated multi-function hydraulic systems. More particularly, this invention relates to a unique system for adjusting the output of a variable delivery pump in response to the varying needs of any one of a plurality of hydraulically operated control valves, without regard to which control valve varies in its demands.

With the advent of an increased need for heavy mechanical technology has come an increased demand for heavier and more complex hydraulic systems. With this increased demand has come a significant demand for hydraulic systems capable of performing a plurality of functions either in sequence or simultaneously one with the other. Seeking to meet this need, there has arisen an active interest in the development of a hydraulic system capable of performing a multitude of functions efficiently, and without undue power losses (e.g., undue heat losses).

An excellent example of the need for such a system is displayed on a crawler-mounted excavator. In this circuit it is often desirable, and in many instances necessary, to operate the main boom, the stick arm, and the bucket simultaneously. All this must be accomplished during conditions when loads at many or all points within the system vary due to dynamic inputs from another function. This, of course, requires extremely close control of flow and pressure.

Several attempts have been made to effect such controls. For example, one known technique employs the use of several pumps, each supplying a portion of the circuit. Such a circuit usually requires means which combine the pump flows under certain conditions when high speed of one function is required. There are several drawbacks to such a system, the most obvious one being the need to employ several pumps with combined flow means and the expense and complexity connected therewith.

Another known technique for achieving control of a system when it is performing a multitude of functions is to use what are known as "pressure-compensated valve components" in the system. These valve components, generally of the closed center type, usually effect a compensation at the pump or at the valve. In order to handle a plurality of functions, there is usually employed a tandem or priority type valve circuit for establishing the necessary control of flow. Such systems have been somewhat successful in providing efficient control to any function since they have the characteristic of supplying a set flow (variable by positioning of the valve) to the function regardless of the pressure requirement. While such systems have achieved a modicum of success, their disadvantage is that they have usually employed a fixed displacement pump such that the pump must supply full flow at whatever is required by the highest pressure function being performed.

Another system known to the art, and of more recent origin, incorporates a pressure-compensated pump attached to a modified parallel circuit valve. In this circuit the pump is controlled both in pressure and in flow; thereby exhibiting considerable horse power savings over the previously described systems. The primary disadvantage inherent within such a system is caused by the fact that only one function, that having

the highest pressure, is flow-compensated. Thus, only that portion of the circuit has the precise control desired.

Another more recent, and somewhat successful attempt to meet this need in the art has been to provide a compensator system which generally comprises a variable delivery pump, the output of which is controlled by a signal delivered from a modified open centered control valve. The system includes a control cylinder having a piston for operating a control cam of the variable delivery pump, first and second feedback circuits provided to govern operation of the control cylinder, the first feedback cylinder including an open center position of the control valve and the second feedback circuit including a circuit through a pressure differential valve. Such a system can provide a series of control valves, each of which can be compensated. While such a system is quite advantageous, it has the disadvantage that compensation can only be applied on one valve at a time and thus there is not provided, a fully compensated system.

It is evident from the above that there exists a need in the art for a system which can provide compensation of all functions regardless of the fact that the functions have different requirements. It is also apparent, that there exists a need in the art for such a compensating system, which includes many of the advantages of the above-described prior art, particularly with respect to the advantages achieved by using pressure compensated valve components, but which either mitigates or eliminates the disadvantages attendant therewith.

SUMMARY OF THE INVENTION

It is a purpose of this invention to fulfill the above-described needs in the art, and other needs which will become more apparent to the skilled artisan once given the following disclosure.

In general, the unique systems of this invention comprise hydraulic systems capable of adjusting the output of a variable delivery pump in response to the varying demands of any one of at least two hydraulically operated functions, the system comprising at least two control valve means each capable of performing a separate function, each of said valve means being connected to its own compensator valve means, said compensator valve means being connected in series one with the other and being capable of delivering the necessary amount of hydraulic fluid to its respective control valve means in accordance with the full needs thereof and diverting the remainder of the fluid to the next following compensator valve means, and means connected to the compensator valve means farthest from said pump for sensing the total requirement of the system and for adjusting the output of the pump in response thereto.

In certain preferred embodiments, the means for sensing and adjusting the output of the pump includes a restricted orifice means, a control valve, and means for sensing the pressure drop across said restricted orifice means, said control valve being connected through a port to an adjustor means for adjusting the output of said pump and being normally biased by said means for sensing said pressure drop so as to actuate said adjustor means in favor of providing a minimal continuous flow of fluid through said system regardless of the total requirements of the system.

This invention will now be described with more particularity and with reference to various illustrations wherein:

IN THE DRAWINGS

The accompanying FIGURE is a schematic illustration of a particularly preferred embodiment of this invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring to the FIGURE there is presented a system for controlling a plurality (in this instance, two) of functions simultaneously, economically, with low heat loss and excellent control, despite the use of only a single pump means. In this FIGURE, there is illustrated a pump 1 preferably of the variable delivery (i.e., variable volume) type. The delivery of pump 1 is variable by spring biased lever 3 which is actuated against its biasing spring 5 by movement of piston 7 located in cylinder 9. Pump 1 is provided with a tank outlet line 11 and a fluid output line 13. Line 11 leads from tank, represented as T, while line 13 leads to the work function areas designated as A and B.

While this FIGURE illustrates the compensation of only two work function areas A and B, it is understood that more than two areas could be compensated for merely by providing such areas between A and B and in like series therewith. The limitation on the number of work function areas is governed primarily by way of the practical limits placed upon pump 1 in that the pump 1 must provide the total requirements of all of the functions being performed.

In the embodiment shown, function areas A and B may perform separate and distinct functions such as for example, function area A lifting a boom while function area B moves a bucket. In this embodiment, then, function area A is provided with a conventional closed center control valve 15, a conventional pressure compensator valve 17 and a conventional shuttle valve 19. Work function area B is provided with similar components and they have been similarly numbered with the corresponding primed reference characters.

Compensator valve 17 is connected in series with valve 17' via line 21. Each of the compensator valves 17 and 17' is connected to its respective control valve 15 and 15' via lines 23 and 23' respectively. In addition, the compensator valves 17 and 17' are biased to their correct position for flow or nonflow by way of movement of control spools 25 and 25', respectively (as by an operator), via conventional shuttle valves 19 and 19', respectively.

While line 21 is connected in series with compensator valve 17' (that is to say, each work function area A except for the last work function area, will have its line 21 connected to the next following pressure compensator valve), the last line 27 of the last compensator valve 17' leads to a means for sensing the total requirements of the system, and adjusting the output flow of pump in response thereto. Such a sensing and adjusting means includes a restrictive orifice 29 and a control valve generally illustrated at 31. Such a control valve 31 generally comprises a variable spool 33 biased to the right by spring 35, pilot signal ports 37 and 39, tank port 41, control port 43 and pressure port 45. Pilot signal port 39 allows fluid to bias spool 33 to the left against the action of its biasing spring 35 in an amount depending upon the flow sensed via line 47 at the upstream end of

restricted orifice 29. Similarly, spool 33 is biased in the direction of its spring 35 via signal from line 49 which senses the flow at the downstream end of restricted orifice 29.

Pressure port 45 receives pressure from pump via line 55. Control port 43 is connected to cylinder 9 via line 53 while tank port 41 is connected to tank T via line 49. Valve 57 represents a conventional relief valve to limit maximum pressure. Line 51' extends from control valve 15' to tank T.

The unique compensating features of this invention will now be more fully understood by reference to a typical operation of this system when put into use. Assume that initially, the system has no load imposed upon it and that it is desired to idle the system with a minimum amount of effort and power input. This is accomplished, for most systems contemplated by this invention, by allowing pump 1 to pump a sufficient amount of hydraulic fluid through the system such that the pressure drop across the system (i.e., for this system, through the compensator spool section of the valves) is maintained at whatever minimum pressure is required for control only. In most preferred circuits this may be accomplished by providing a 1-2 gallon per minute flow through orifice 29. Thus, by taking any given individual system and, through conventional engineering techniques coordinating size of orifice 29 with the bias of spring 35, a system will be provided to establish just such a flow. This may be accomplished as follows:

After orifice 29 and spring 35 are installed, pump 1 is turned on at some low value so as to establish flow in the system usually at a level above that minimal flow ultimately desired. Since no work function is being performed by either area A or area B, flow from pump 1 extends via line 13 through line 21 and outwardly to sensing means via line 27. The pressure upstream of restricted orifice 29 is sensed by line 47 and transmitted to pilot signal port 39 where it biases spool 33 against spring 35. The pressure drop across orifice 29 is then sensed via line 49 and transmitted to pilot signal port 37 which compensates, to the extent of the pressure drop, the biasing caused by the higher pressure in port 39. This bias causes spool 33 to be adjusted such that the requisite amount of pressure is transmitted via line 53 and into cylinder port 9 to actuate movement of piston 7 against the bias of spring 5 thus to adjust pump 1 so that, at idle, line 13 transmits sufficient fluid to maintain a minimal flow through and across restricted orifice 29. As stated hereinabove, a typical example of such minimal flow is about 1-2 gallons per minute across orifice 29 with a pressure drop of about 100 psi.

With the system now in its idle condition, an operator may wish to operate a function such as raise the main boom of an excavator. He may do so by actuating control spool handle 25 to the degree necessary to perform the function. This shift of spool 25 effects the necessary shift in valve 15 such that a signal is sent via shuttle valve 19 and line 59 to shift pressure compensator valve 17 so as to supply control valve 15 with the necessary amount of fluid to perform its function through its work ports. Thus, pressure compensator valve 17 provides all of the flow necessary to perform the function in work area A and diverts (if available) the remainder of the fluid via line 21 to pressure compensator valve 17'. In the event, of course, that there is insufficient fluid to perform the function in work area A, then, of

course, the sensing means will sense this lack, and increase the output of pump 1 via line 13 such that the necessary amount of flow is created to perform the work function and in addition to provide for the pressure drop across orifice 29 of the system in like manner as when idle.

Now with the excess fluid diverted via line 21 to pressure compensator valve 17', the function of work area B may be performed by activating spool 25'. When this is done, pilot line 59' signals, via shuttle valve 19', pressure compensator valve 17' to provide the necessary flow via line 23' to the work ports of control valve 15' to perform the necessary function. The excess (if present) passes via line 27 across orifice 29 and this differential pressure is again sensed via lines 49 and 47 similarly as with respect to work function area A above so as to compensate the output of pump 1 thereby providing for the necessary flow not only for work area A but work area B as well. A similar type of compensation, of course, also takes place should there not be any flow left or should there be insufficient flow to perform the work function in area B. In a similar manner, further additional work areas may be added between area A and area B to perform further functions and be similarly compensated.

As can be seen, the unique systems of this invention adopt many of the excellent features of pressure compensated valve components in that extremely good control to any single function is provided because pressure is maintained and determined by the highest load requirement while flow is compensated for in a uniquely efficient manner. On the other hand, the detriments of using only conventional noncompensated valves and of only compensating the highest requirement with the pump have been overcome. Thus, the subject invention has provided, through a unique system, a circuit which individually controls flow at each port or function and combines this with the ability to signal the pump to supply only that amount of flow required to satisfy any and every given function. In addition, any singular valve spool has the ability to supply full flow to its function, but, if a preceding spool is shifted to some intermediate position, then that spool has priority to some portion of the flow. Such a system, by building in this unique and small constant flow requirement, provides for a system which results in an extremely low horse power loss and low heat generation factor which, of course, provides for an extremely efficient and economical system.

Once given the above disclosure, various other features, modifications and improvements will become apparent to the skilled artisan. Such other features, modifications and improvements, therefore, are considered to be a part of this invention, the scope of which is to be determined by the following claims:

I claim:

1. A hydraulic system capable of adjusting the output of a variable delivery pump in response to the varying demands of any one of at least two hydraulically operated functions, the system comprising at least two control valve means each capable of performing a separate function, at least two of said control valve means each being connected to its own upstream compensator valve means, said compensator valve means being connected in series one with the other and each being capable of delivering the necessary amount of hydraulic fluid to its respective control valve means in accordance

with the full needs thereof and diverting the remainder of said fluid to the next following compensator valve means, and means connected to said compensator valve means farthest from said pump for sensing the total requirement of the system despite the varying demands of said functions and for adjusting the output of the pump in response thereto.

2. A hydraulic system according to claim 1 in which the pressure of the system is determined by the highest load requirement of a function and adjustment is achieved by varying the flow rate of said pump.

3. A hydraulic system capable of adjusting the output of a variable delivery pump in response to the varying demands of any one of at least two hydraulically operated functions, the system comprising at least two control valve means each capable of performing a separate function, each of said control valve means being connected to its own compensator valve means, said compensator valve means being connected in series one with the other and each being capable of delivering the necessary amount of hydraulic fluid to its respective control valve means in accordance with the full needs thereof and diverting the remainder of said fluid to the next following compensator valve means, and means connected to said compensator valve means farthest from said pump for sensing the total requirement of the system despite the varying demands of said functions and for adjusting the output of the pump in response thereto, said means for sensing and adjusting includes a restricted orifice means, a control valve, and means for sensing the pressure drop across said orifice means, said control valve being connected through a port to an adjustor means for adjusting the output of said pump, and being normally biased by said means for sensing said pressure drop so as to actuate said adjustor means in favor of providing a minimal continuous flow of fluid through the system regardless of the total requirement of the system.

4. A hydraulic system according to claim 3 wherein said means for sensing the pressure drop across said orifice means includes two flow lines, one on either side of said orifice, and said control valve includes a control valve spool and a biasing spring, and wherein the flow line upstream of said orifice is connected to bias said spool against its biasing spring and said flow line downstream of said orifice is connected to bias said spool with said spring.

5. A hydraulic system according to claim 4 wherein said adjustor means includes a cylinder connected through said port to said control valve, a piston located in said cylinder and being biased against fluid flow from said port by a spring, and a lever arm means actuated by movement of said cylinder for increasing or decreasing the output of said pump.

6. A hydraulic system according to claim 5 wherein said control valve means include control valves each of which is connected to a separate shuttle.

7. A hydraulic system according to claim 6 wherein each control valve is connected to its compensator valve means and shuttle valve such that when said control valve is actuated to perform a function, said shuttle valve senses the fluid requirement to perform said function and activates said compensator valves means to fulfill said requirement in full and to divert excess fluid to said next compensator valve means in said series.

8. A hydraulic system according to claim 7 in which the pressure of the system is determined by the highest

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load requirement of a function, and adjustment is achieved by varying the flow rate of said pump.

9. A hydraulic system according to claim 8 wherein said means for sensing and adjusting includes a restricted orifice means, a control valve, and means for sensing the pressure drop across said orifice means, said control valve being connected through a port to an adjustor means for adjusting the output of said pump, and being normally biased by said means for sensing

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said pressure drop so as to actuate said adjustor means in favor of providing a minimal continuous flow of fluid through the system regardless of the total requirement of the system.

10. A hydraulic system according to claim 9, wherein said compensator valve means are located upstream from each of their associated control valve means.

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