United States Patent [19]

Starling

[11] **3,709,065**

[45] **Jan. 9, 1973**

[54] COMPACT FLUID SYSTEM FOR SHIFTING A TRANSMISSION

[75] Inventor: **James G. Starling**, Pekin, Ill.

[73] Assignee: **Caterpillar Tractor Co.**, Peoria, Ill.

[22] Filed: **March 8, 1971**

[21] Appl. No.: **121,810**

[52] **U.S. Cl.** .....**74/753**, 192/109 F

[51] **Int. Cl.**.....**F16h 3/44**

[58] **Field of Search** .....74/733, 753; 192/109 F

[56] **References Cited**

UNITED STATES PATENTS

3,468,194	9/1969	Horsch et al.	74/753
3,181,394	5/1965	Ramsel et al.	74/753
3,389,770	6/1968	Golan et al.	192/109 F

Primary Examiner—C. J. Husar

Attorney—Fryer, Tjensvold, Feix, Phillips & Lempio

[57] **ABSTRACT**

Means for applying fluid pressure to selected pairs of the drive conditioning devices of a vehicle transmission in response to control lever movement includes a pressure modulating valve for establishing a gradual pressure rise at the selected drive devices and a safety differential spool valve provides for a delayed lesser pressure rise at the one of the devices which re-establishes drive through the transmission. The safety differential spool valve performs the further function of blocking fluid pressure from one of the selected devices if the vehicle engine should be started up with the control levers at a position other than neutral. Two valves thus provide transmission control functions which have heretofore required more complex valving assemblies.

6 Claims, 4 Drawing Figures

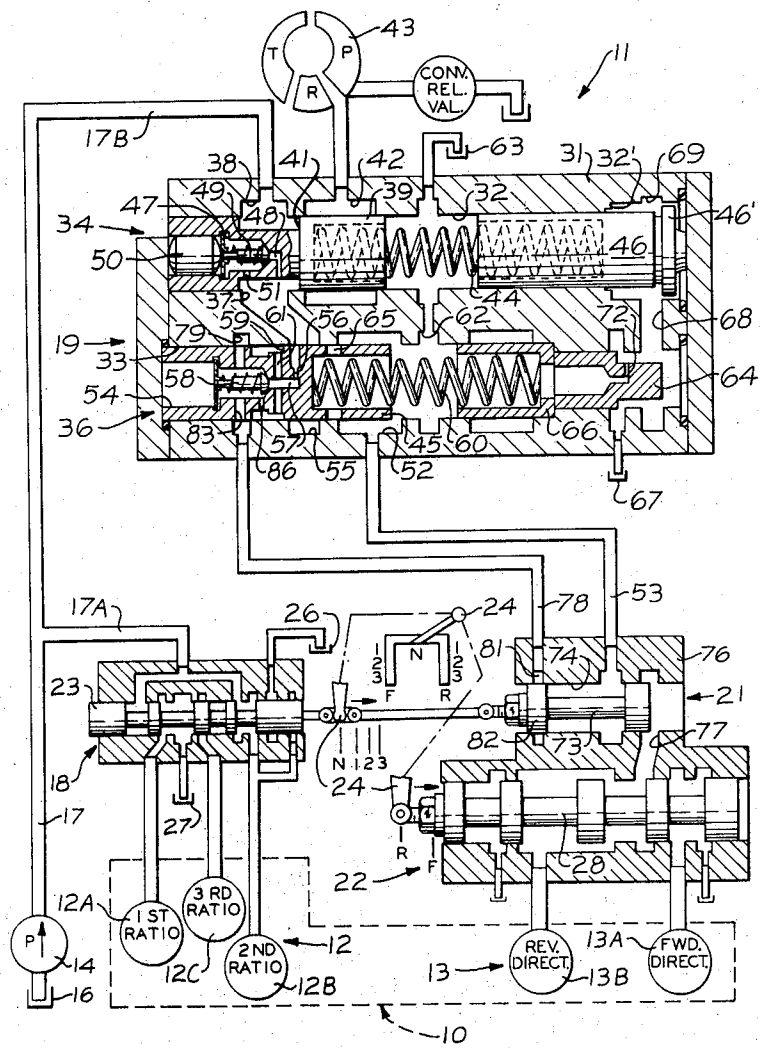
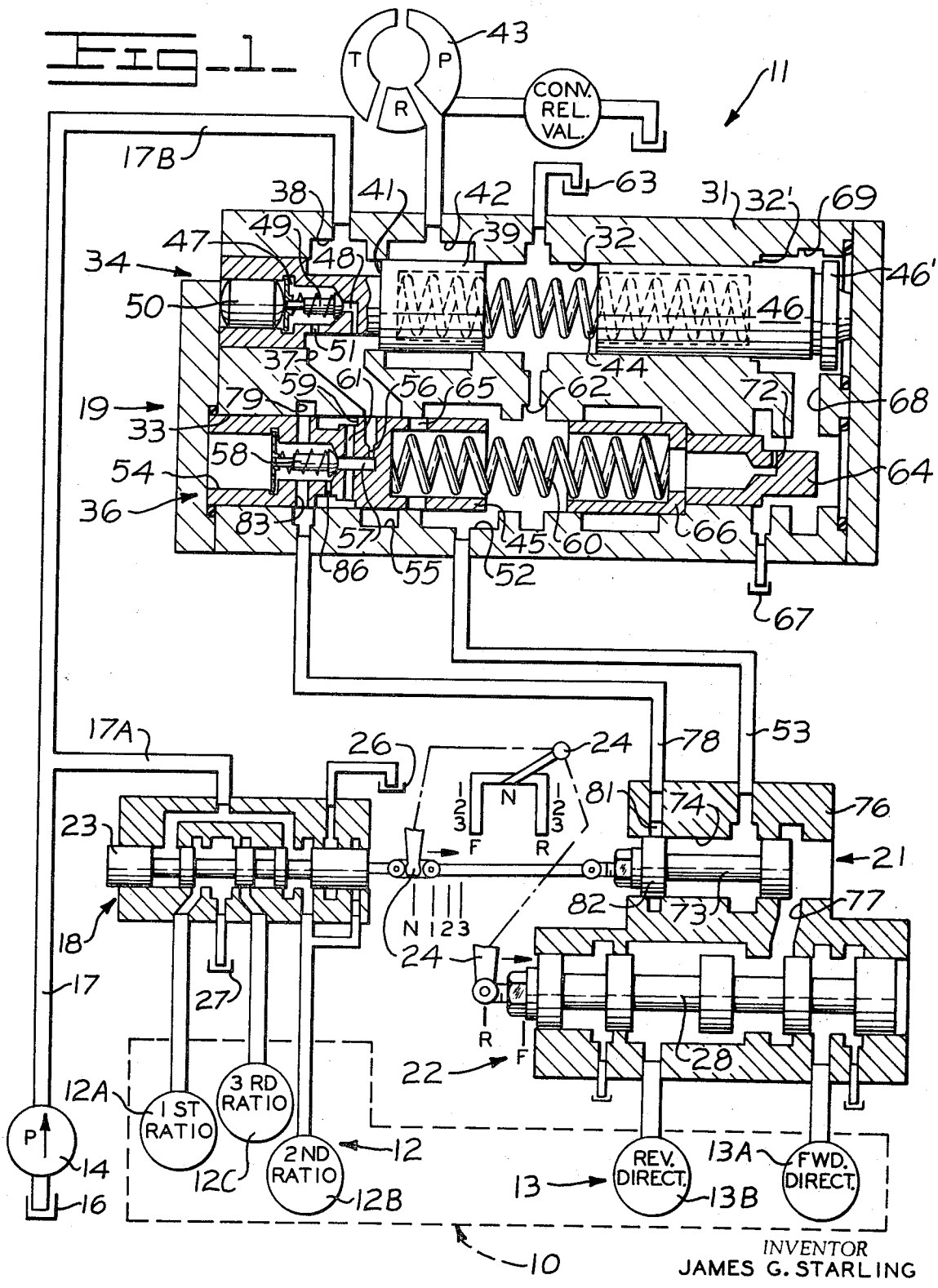


Fig. 1



INVENTOR
JAMES G. STARLING

BY

Fryer, Tjensvold, Feix, Phillips & Lempio

ATTORNEYS

Fig-2-

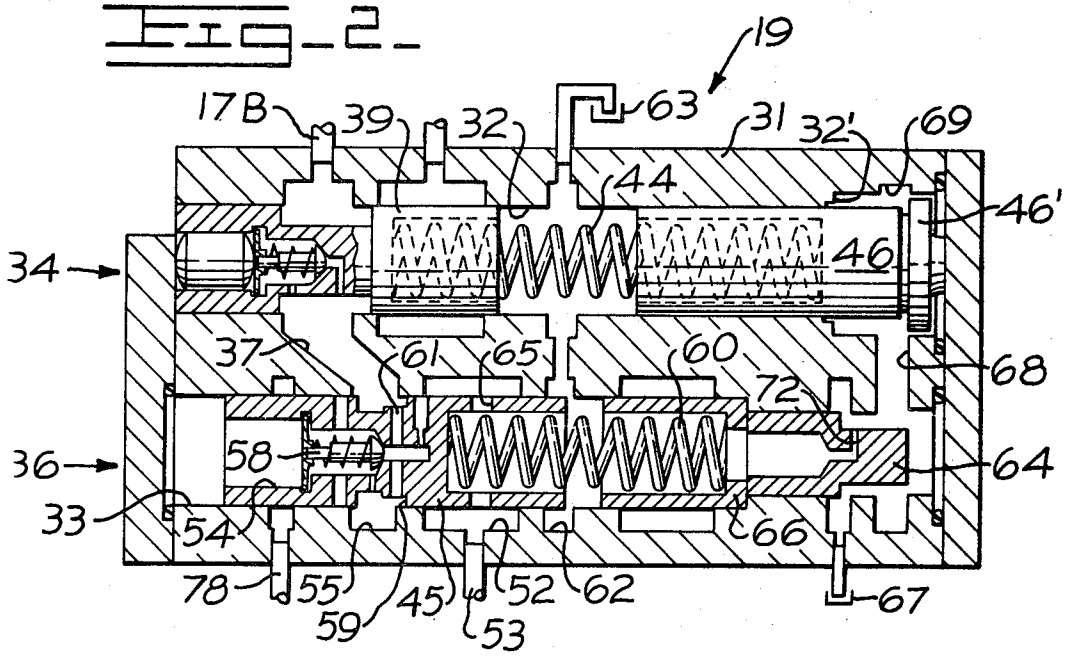
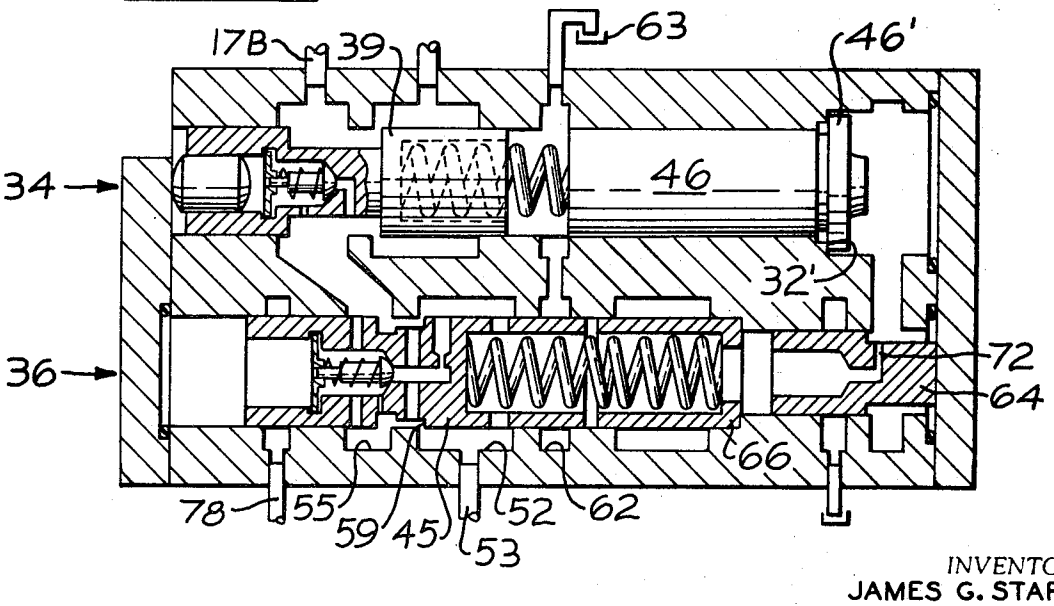


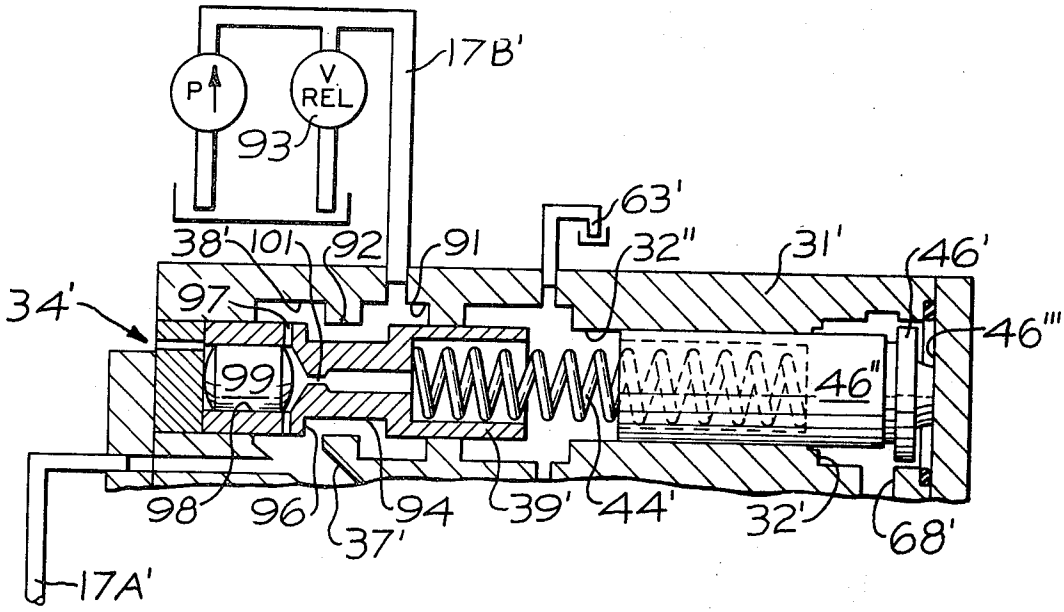
Fig-3-



INVENTOR
JAMES G. STARLING

BY
Fryer, Tjensvold, Feix, Phillips & Lempio
ATTORNEYS

Fig. 4



INVENTOR
JAMES G. STARLING

BY
Fryer, Tjensvold, Feix, Phillips & Lempio
ATTORNEYS

COMPACT FLUID SYSTEM FOR SHIFTING A TRANSMISSION

BACKGROUND OF THE INVENTION

This invention relates to vehicle transmissions of the form which are shifted by applying fluid pressure to selected ones of a plurality of drive conditioning devices within the transmission and more particularly to fluid circuits which establish and control the fluid pressures in response to movement of the operator's control levers or the like.

Many transmissions for tractors and other vehicles include a number of clutches or brakes which are actuated by fluid pressure to establish selected drive conditions within the transmission in response to movement of operator's shift levers. One of a first group of the drive conditioning devices is actuated to select a drive ratio through the transmission and one of a second group of the devices is actuated to establish either forward or reverse drive.

To avoid shock loads and excessive wear during shifting, careful control of the rate of pressure rise at the selected devices is desirable and it is desirable that the selected one of one particular group be engaged slightly after the selected device of the other group. The last engaging group of devices are of a more massive and wear resistant construction as the last engaging device must recouple the vehicle engine and drive line and is therefore subjected to the most severe loads.

For optimum performance and for safety reasons, a transmission control system should also provide certain functions in addition to pressure modulation and coordination. In particular, it can be hazardous to personnel and equipment if the vehicle should be started up while the transmission controls are positioned at something other than the neutral position. Accordingly, it is customary to provide a safety mechanism which prevents actuation of one of the selected drive conditioning devices of the transmission when fluid pressure is first supplied to the system unless the shift control lever is in neutral or until such time as the control lever is momentarily returned to neutral.

A variety of shift control circuits have been devised for the foregoing purposes. These prior systems have in general been undesirably complex and require considerable maintenance. U.S. Pat. No. 3,091,976 discloses a typical prior system wherein the safety function necessitates a complex spool valve assembly additional to two spool valve assemblies required for modulating pressures at the drive conditioning devices during a shift. Further, the safety spool valve mechanism requires springs sufficiently heavy to move the operator's shift lever for the purpose of establishing a neutral condition. Other control systems for this general purpose tend to be still more complex and costly and are often prone to severe maintenance problems.

SUMMARY OF THE INVENTION

This invention provides a fluid circuit of the general type discussed above which is extremely compact, simple and reliable. The safety function of maintaining a neutral condition in the transmission if the vehicle engine is started up with the operator's control lever at a position other than neutral is performed by the same spool valve assembly that provides fluid pressure control for the last engaging drive conditioning device.

This is accomplished without physical movement of the operator's control lever to provide the safety function and the system is fail safe in the sense that vehicle immobility is assured if fluid passages associated with the safety valve spool become plugged.

Accordingly, it is an object of this invention to provide a more compact and reliable fluid circuit for controlling the application of fluid pressure to drive establishing devices in a vehicle transmission in response to movements of an operator's shift control lever or the like.

The invention together with further objects and advantages thereof will best be understood by reference to the following description of a preferred embodiment taken in conjunction with the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

In the accompanying drawing:

FIG. 1 illustrates a shift control system for a vehicle transmission with certain elements being shown in section and certain other elements being shown schematically, movable elements being shown in the positions which are assumed during shutdown of the vehicle,

FIG. 2 is a section view of a portion of the valve mechanism of FIG. 1 showing positions which the components assume in the course of preparing for a transmission shift immediately after movement of the operator's control lever,

FIG. 3 is a view of the valve mechanism of FIG. 2 showing the positions which components assume at the completion of the shift transient, and

FIG. 4 is a view illustrating a modification of a portion of the shift control system.

DESCRIPTION OF A PREFERRED EMBODIMENT

Referring now to the drawing and more particularly to FIG. 1 thereof there is shown a transmission control system 11 applicable to multispeed transmissions 10 of the form which have a first group of fluid pressure operated drive establishing devices 12 for selecting a drive ratio and a second group of fluid pressure operated devices 13 for determining drive direction and wherein a selected single one of the devices 12 and a selected single one of the devices 13 are actuated to establish drive through the transmission at a desired ratio and direction. For example, three devices, 12A, 12B and 12C, may be present for establishing first, second and third gear ratios and devices 13A and 13B provide for either forward drive or reverse drive respectively. The drive conditioning devices 12 and 13 may variously be clutches or brakes within the transmission, suitable designs for such devices being well known to the art. The transmission 10 may also be of a known construction and accordingly the transmission 10 and devices 12 and 13 are shown in schematic form in FIG. 1 to avoid unnecessary complication of the drawing.

Fluid under pressure for actuating the drive conditioning devices 12 and 13 is delivered by a pump 14 from a reservoir 16, the pump being customarily driven by the engine of the vehicle with which the transmission is associated. Pump 14 has a branched outlet conduit 17 with a first branch 17A for transmitting fluid to a selected one of the ratio devices 12 through a drive ratio selector valve 18 and has a second branch 17B for

transmitting fluid to a selected one of the directional devices 13 through a pressure control valve group 19, cut-off valve 21 and directional selector valve 22.

Drive ratio selector valve 18 may be a spool valve for selectively communicating conduit 17A with one of the devices 12 according to the position of a spool 23 and may be shifted manually by an operator's control lever mechanism 24. Valve 18 has four positions in this example including a neutral position at which conduit 17A is communicated with the second drive ratio device 12B, a first gear position at which fluid from conduit 17A is directed to device 12A, a second gear position at which conduit 17A is again communicated with device 12B and a third gear position at which conduit 17A is communicated with device 12C, those devices 12 which are not communicated with conduits 17A at any selected setting other than neutral being communicated with drains 26 or 27. Similarly, directional selector valve 22 includes a spool 28 which may be manually shifted between forward and reverse positions by operator's control lever 24. At the forward position, directional selector valve 22 directs fluid, obtained through conduit 17B, pressure control group 19 and cut-off valve 21, to device 13A while venting device 13B. At the reverse setting selector valve 22 directs fluid to device 13B while venting device 13A.

Accordingly, any time that a shift is initiated by manipulation of control lever 24, while the vehicle is in operation, at least one of the drive conditioning devices 12 and 13 is disconnected from pump output conduit 17 and vented while another one of the drive conditioning devices is communicated with the conduit 17. As filling of the newly selected device 12 or 13 cannot occur instantaneously, the pressure in conduit 17 momentarily drops. The pressure control group 19 then functions to modulate the rate at which the pressure rises in the selected devices 12 and 13 and further functions to delay the pressure rise in the selected directional device 13 relative to the ratio device 12 and to establish a lesser final pressure in the directional device. For this purpose the pressure control group 19 includes a housing 31 having a pair of parallel bores 32 and 33 containing spool valve assemblies 34 and 36 respectively. Spool valve assembly 34 controls the rate of pressure rise in the selected devices 12 and 13 by functioning as a modulating relief valve while spool valve assembly 36 functions as a differential valve to delay the pressure rise at the directional device 13 relative to that at the ratio device 12, and to provide a smaller final pressure at the device 13. In accordance with the present invention, spool valve assembly 36 further provides a safety function by preventing application of fluid pressure to the selected directional device 13 if the shift control lever 24 is not at the neutral position when the pump 14 is first started up.

Considering now the configuration of the modulating relief spool valve assembly 34 in more detail, the pump outlet conduit 17B is communicated with an inlet passage 37 to safety-differential valve assembly 36 through a groove 38 in the wall defining bore 32. A spool 39 is disposed in bore 32 and has an edge 41 which defines a variable flow passage from groove 38 to a relief outlet groove 42 which in this particular example is communicated with a torque converter 43 of the transmission. In other instances, relief groove 42 may simply communicate with a drain. A compression spring 44 in bore 32 acts between the spool 39 and a load piston 46 in bore 32 to urge the spool in a direction at which land 41 tends to close the flow passage between grooves 38 and 42.

The fluid pressure within groove 38 is transmitted to a chamber 47 in the end of spool 39 opposite the spring 44 through a passage 48 in the spool and a check valve 49 disposed therein, the check valve being by-passed by a smaller reset orifice passage 51. Thus, spring 44 tends to close the relief flow passage past land 41 while fluid pressure in chamber 47 reacts against a slug 50 and against the spool in a direction tending to open the relief flow passage. Spool valve assembly 34 functions as a relief valve in that the flow passage past land 41 is opened when the force exerted on spool 39 by fluid in chamber 47 exceeds the counteracting force of spring 44. Valve assembly 34 thereby determines the conduit 17 pressure applied to the selected ratio device 12 and to the inlet passage 37 to the safety-differential spool valve assembly 36. This pressure is modulated during the shift of the transmission by movement of the load piston 46 in a direction tending to increase the compression of spring 44, the load piston movement being brought about by means to be hereinafter described.

Considering now the construction of the safety-differential spool valve assembly 36 in more detail, inlet passage 37 communicates with a groove 55 of bore 33 which contains a spool 45 acted upon by a spring 60. Spring 60 urges the spool 45 in a direction at which the spool blocks communication between groove 55 and an adjacent groove 52 which is communicated with a conduit 53 for supplying pressurized fluid to the directional devices 13 through cut-off valve 21 and directional selector valve 22.

To shift the spool 45 against spring 60 to supply fluid to conduit 53, fluid pressure from inlet passage 37 is transmitted to a chamber 54 in the end of spool 45 opposite from spring 60 through an orifice 56 which communicates with an axial passage 57 in the spool having a check valve 58 therein.

At start-up of the pump 14, the fluid pressure in chamber 54 shifts the spool 45 against spring 60 provided that control lever 24 is in neutral or is subsequently returned to neutral as will hereinafter be discussed in more detail. The movement is accelerated when an edge 59 of the spool 45 reaches groove 55 to open a larger passage 61 to chamber 54 through check valve 58. Prior to the above described initial movement of spool 45 against spring 60, groove 52 is communicated with an adjacent groove 62 which is open to a drain 63 thereby relieving any fluid pressure in conduit 53. Spool 45 has radial passages 65 which maintain the communication between grooves 52 and 62 after spool 45 intersects groove 52, as shown in FIG. 2, until the spool also closes groove 62 as shown in FIG. 3. After the spool has moved sufficiently to close drain groove 62, edge 59 of the spool provides a flow passage from inlet groove 55 to groove 52 thereby supplying fluid pressure to conduit 53 for actuating the selected directional device 13. Owing to the action of spring 60 on spool 45 a differential valve action is produced whereby the pressure in conduit 53 is maintained at a lesser value than the pressure in conduit 17A. As a consequence, valve assembly 36 does not open to pres-

surize a directional device 13 until after the pressure at the ratio device 12 has risen a predetermined amount thereby delaying the engagement of the device 13 relative to device 12.

Referring again to FIG. 1, to provide for the modulating action whereby the pressures at the selected devices 12 and 13 both rise in a gradual manner following manipulation of control lever 24, an apertured check valve 64 is disposed in the opposite end of bore 33 from spool 45. Check valve 64 may shift in the direction of spool 45 to seat against an annular spring retainer 66 at which position the check valve communicates a drain 67 with a passage 68. Passage 68 communicates with a groove 69 in the end of modulating relief valve passage 32 to relieve any fluid pressure on load piston 46 of the modulating relief valve when spool 45 shifts in response to the initial pressure drop at the beginning of a shift. During the shift period when spool 45 of the safety differential valve 36 moves against the spring 60 to admit fluid pressure to groove 52 while closing drain groove 62, fluid pressure is also caused to act against the check valve 64 through the radial passages 65 in spool 45 which communicate groove 52 with the check valve end of bore 33. At this point the fluid pressure shifts check valve 64 away from retainer 66 to isolate passage 68 from drain 67. The check valve has a restricted flow passage 72 which gradually transmits the fluid pressure to passage 68 and thus to groove 69 where the pressure acts against load piston 46 to gradually increase the compression of spring 44 against modulating relief valve spool 39. Thus, the modulating relief valve assembly 34 is caused to produce a gradual rise in pressure at the selected drive devices 12 and 13 to engage the associated transmission without abrupt shock loads with the pressure rise at the directional device 13 being delayed in time relative to that at the ratio device 12. The rate of the pressure rise is thus basically determined by the sizing of restricted passage 72 in check valve 64 and the final and maximum pressure applied to the devices 12 and 13 is fixed by the abutment of a flange 46' of load piston 46 against a step 32' of bore 32.

The cut-off valve 21 has a spool 73 in a bore 74 of a housing 76 which is shifted axially by movement of the operator's control lever 24. At the neutral position of control lever 24, spool 73 blocks communication between conduit 53 and the inlet passage 77 of directional selector valve 22 while venting the passage 77. At any of the other positions of operator shift lever 24, conduit 53 is communicated with passage 77. Thus, neither of the directional devices 13 can be pressurized by fluid from conduit 53 at the neutral position and no torque can be transmitted through the transmission under that condition.

Considering now the means by which the above described mechanisms provide the safety function at start-up in addition to providing the primary pressure control functions as described above, an additional conduit 78 extends between the pressure control group 19 and cut-off valve 21. Conduit 78 communicates a groove 79 of bore 33 of housing 31 with a groove 81 of bore 74 of cut-off valve 21. Groove 81 is positioned to be closed by a land 82 of spool 73 when the operator's control lever 24 is in the neutral position and is vented at any other position of the shift lever 24 and spool 73. Groove 79 at the safety-differential spool valve assembly bore 33 is positioned to communicate with chamber 54 of the spool 45 through radial passages 83 in the spool when the spool is shifted to the initial position at the end of bore 33 by spring 60. The spool shifts in this manner following a prolonged absence of fluid pressure in passage 37 as fluid pressure in chamber 54 is gradually relieved through an orifice 86 which is sized to prevent a significant pressure loss in chamber 54 during the brief pressure drop at the beginning of a shift.

When the vehicle has been shut down and pump 14 is inactive, the components of the pressure control group 19 assume the positions shown in FIG. 1 at which both spool valve assemblies 34 and 36 are moved fully to the left as viewed in the drawing.

Upon starting up of the pump 14 with the shift lever 24 in neutral, the spools 39 and 45 of pressure control group 19 shift initially to the positions shown in FIG. 2 as the second gear drive ratio device 12B fills with fluid. Thereafter spool valve assemblies 34 and 36 move further to the positions shown in FIG. 3. Referring again to FIG. 1, no torque transmission through the transmission can occur at this time inasmuch as the position of spool 73 of cut-off valve 21 blocks fluid pressure from both directional devices 13. If shift control lever 24 is then moved into a selected drive ratio setting, device 12B is drained and filling of the selected one of the devices commences. The initial fill period for the selected one of the ratio devices 12 produces a temporary pressure drop in conduit 17 and the spool assemblies 34 and 36 reset to the positions shown in FIG. 2. Spool assembly 36 does not return all the way to the FIG. 1 position as the pressure drop is not of sufficient duration to relieve all fluid pressure in chamber 54. Pressure group 19 then begins a modulated reapplication of pressure to the appropriate devices 12 and 13 as hereinbefore described until the valve positions of FIG. 3 are again reached at which point one each of the devices 12 and 13 is fully pressurized and the transmission transmits torque.

If the lever 24 is not at the neutral setting when pump 14 is first activated, safety-differential valve spool 45 is unable to shift against the action of spring 60 and thus conduit 53 remains vented to drain 63 and no fluid pressure can reach either of the directional devices 13. Valve spool 45 is unable to move against spring 60 under this condition as fluid pressure cannot build up in chamber 54 to any extent since the chamber is vented through conduit 78 and cut-off valve 21. Fluid pressure can begin to build up in chamber 54 only after the control lever is returned to the neutral position at least momentarily thereby blocking conduit 78.

The above described mechanism provides considerable fail safety relative to prior devices in that a blockage of certain of the restricted flow passages and orifices similarly prevents movement of the spool valve assembly 36 away from the safety position.

It will be apparent that modifications of the above described structure are possible within the scope of the invention. FIG. 4, for example, depicts a modification of the upper spool valve assembly 34'. The modified valve assembly 34' controls the rate of pressure rise following operation of the shift controls by functioning as a modulating reducing valve rather than as a modulat-

ing relief valve as in the corresponding assembly of the first described embodiment. The construction of the transmission control system as a whole may be similar to the embodiment previously described except as shown in FIG. 4 and hereinafter described with reference thereto.

The housing 31' of the pressure control group 19' again has a bore 32'' containing the modified spool valve assembly 34'. The pump outlet conduit 17B' communicates with an annular groove 91 in the wall which defines bore 32'', the groove 91 being spaced from the groove 38' which communicates with flow passage 37' and being separated therefrom by a land 92. As valve assembly 34' provides the desired pressure modulation by metering fluid flow from pump outlet conduit 17B' to passage 37' rather than by variably relieving pressure in the conduit as in the previous instance, a modification in the fluid circuit outside housing 31' is required. In particular, pump outlet conduit 17B' is not communicated directly with the speed selector valve supply conduit 17A' as in the previous instance. In the present embodiment, conduit 17A' is communicated with passage 37' to receive fluid metered across land 92. In addition, pump outlet conduit 17B' is connected to drain through a conventional pressure regulator valve 93 which maintains a predetermined constant supply pressure in the conduit. If the transmission includes a torque converter as in the previous example, fluid for the converter may be derived from the outlet of pressure regulator valve 93.

To meter fluid across land 92 to provide for a gradually rising pressure in passage 37', a modified spool 39' is disposed in bore 32'' and has an annular groove 94 defining an edge 96 which coacts with land 92 to provide a flow passage between grooves 91 and 38' that varies according to the axial position of the spool in the bore.

A load piston 46'' is also disposed in bore 32'' and a compression spring 44' is situated between the load piston and spool 39' to exert a force against the spool tending to open the flow passage between land 92 and edge 96. Radial passages 97 in spool 39' communicate groove 38' with a chamber 98 in the end of the spool opposite from spring 44'. Accordingly, fluid pressure acts against spool 39' in a direction opposite to the force of spring 44'. A reaction plug 99 may be disposed in chamber 98 and a constricted axial bleed passage 101 communicates chamber 98 with the region of bore 32'' between spool 39' and load piston 46, the region being communicated with a drain 63' as in the previous example.

Thus when the fluid pressure in passage 37' and groove 38' is momentarily vented at the beginning of a shift as previously described, spring 44' shifts spool 39' to provide the maximum flow passage between supply conduit 17B', past edge 96 to passages 37' and 17A'. After the selected transmission devices supplied through passages 37' and 17A' have filled, the pressure begins to rise in groove 38' and this pressure rise is transmitted to chamber 98 through passages 97. Accordingly, fluid pressure acts to move spool 39' to reduce the flow passage past edge 96 to avoid an overly abrupt pressure rise in passage 37'. In the absence of further provisions, this action would close off the flow from supply conduit 17B' to passage 37' at some point in the pressure rise determined by the dimensions of the spool 39' and the force of spring 44'. However, this action does not occur inasmuch as load piston 46'' is gradually shifted, to increase the force of spring 44' against spool 39' by the rising fluid pressure in a chamber 46''' at the end of bore 32'' which pressure is received through a passage 68' in the manner previously described for the first embodiment of the invention.

Thus the rising fluid pressure tending to close the flow passage past edge 96 is temporarily resisted by an increasing spring force on spool 39' and the desired modulated pressure increase in passage 37' is realized. When the flange 46' on load piston 46'' abuts the step 32' of bore 32'', the modulating action ceases. The flow passage past edge 96 remains slightly open to compensate for flow through bleed passage 101 and any other leakage in the system while maintaining a constant predetermined pressure in the passage 37' and passage 17A'. Thus the end result of the modified valve assembly 34' is similar to that of the corresponding modulating relief valve assembly of the first described embodiment.

What is claimed is:

1. In a fluid circuit for shifting a transmission having a plurality of fluid pressure actuated drive conditioning devices and having an operator's shift control which has a neutral position and at least one drive position, the combination comprising

means for supplying fluid under pressure,

selector valve means for directing said fluid from said supply means to predetermined ones of said drive conditioning devices in response to movement of said shift control,

pressure control means for producing a gradual rise of fluid pressure at said predetermined ones of said drive conditioning devices following said movement of said operator's shift control, said pressure control means including a movable differential valve element defining a portion of the flow passage from said supply means to at least one of said predetermined ones of said drive conditioning devices and having resilient means acting on said valve element in a direction tending to close said flow passage and to shift said valve element to an initial position past that at which said flow passage is closed and having means defining a chamber wherein said fluid pressure acts on said valve element in a direction tending to open said flow passage,

means defining a drain passage which is communicated with said chamber when said valve element is in said initial position and which is blocked from said chamber by movement of said valve element when said valve element moves away from said initial position, and

a cut-off valve linked to said shift control and operated thereby for blocking said drain passage when said shift control is in said neutral position and for opening said drain passage when said shift control is away from said neutral position whereby an initial buildup of fluid pressure in said chamber to shift said valve element away from said initial position thereof can only occur when said shift control is in said neutral position.

2. The combination defined in claim 1 wherein said chamber receives said fluid through a constricted passage in said valve element and further comprising a check valve disposed in said passage of said valve element.

3. The combination defined in claim 2 wherein said valve element has an additional passage for transmitting said fluid to said chamber through said check valve, said additional passage bypassing said constriction and being positioned to be closed when said valve is at said initial position.

4. A fluid circuit for shifting a transmission having a first plurality of fluid pressure actuated drive conditioning devices for selecting a speed ratio through said transmission and having a second plurality of fluid pressure actuated drive conditioning devices for selecting a drive direction through said transmission, comprising:

an operator's shift control means having a neutral position and forward and reverse drive positions and a plurality of speed ratio positions,

a pump for supplying fluid under pressure,

a speed ratio selector valve linked to said operator's shift control means for directing fluid from said pump to predetermined ones of said speed ratio conditioning devices, as determined by the position of said shift control,

a drive direction selector valve for directing fluid from said pump to a predetermined one of said second plurality of drive conditioning devices as determined by the position of said shift control,

pressure control valve housing means defining a portion of the fluid flow path from said pump to said drive direction selector valve and having first and second bores therein wherein said fluid from said pump is transmitted to a portion of said first bore,

a pressure modulating valve assembly disposed in said first bore and having a spool with an edge defining a variable flow passage communicated with said first portion of said first bore for controlling the pressure of fluid supplied to a region of said second bore, said spool being spring biased in a direction tending to increase fluid pressure at said region of said second bore and having load piston means for varying said spring biasing in accordance with fluid pressure supplied to a second portion of said first bore,

a safety differential valve disposed in said second bore of said housing and having a spool movable in a first direction to block said region of said second bore from said drive direction selector valve and being further movable in the same direction to an initial position and being movable in an opposite direction to communicate said region of said second bore with said drive direction selector valve and having resilient biasing means acting thereon in said first direction,

means defining a fluid chamber wherein fluid pressure acts on said spool of said safety differential valve in said opposite direction tending to open communication between said region of said second bore and said drive direction selector valve, said chamber being communicated with said region of said second bore whereby fluid pressure is transmitted to said chamber,

means defining a drain passage which is communicated with said chamber when said safety-differential valve spool is at said initial position and which is blocked from said chamber when said safety-differential valve spool moves away from said initial position, and

a cut-off valve responsive to movement of said shift control to close said drain passage when said shift control is in said neutral position whereby said fluid pressure in said chamber is unable to shift said safety-differential valve spool away from said initial position except when said shift control is in said neutral position.

5. The combination defined in claim 4 wherein said cut-off valve blocks said flow path to said drive direction selector valve when said shift control is in said neutral position thereof.

6. The combination defined in claim 4 wherein said spool of said safety-differential valve opens said second portion of said first bore to a drain when said safety differential valve spool is at said closed position and transmits fluid pressure to said second portion of said first bore through a flow restriction when said region of said second bore is communicated with said drive direction selector valve, whereby said load piston is gradually shifted to increase said spring biasing on said spool of said modulating valve assembly whereby a gradual pressure rise is produced at said predetermined ones of said drive conditioning devices.

* * * * *