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G. MEYER

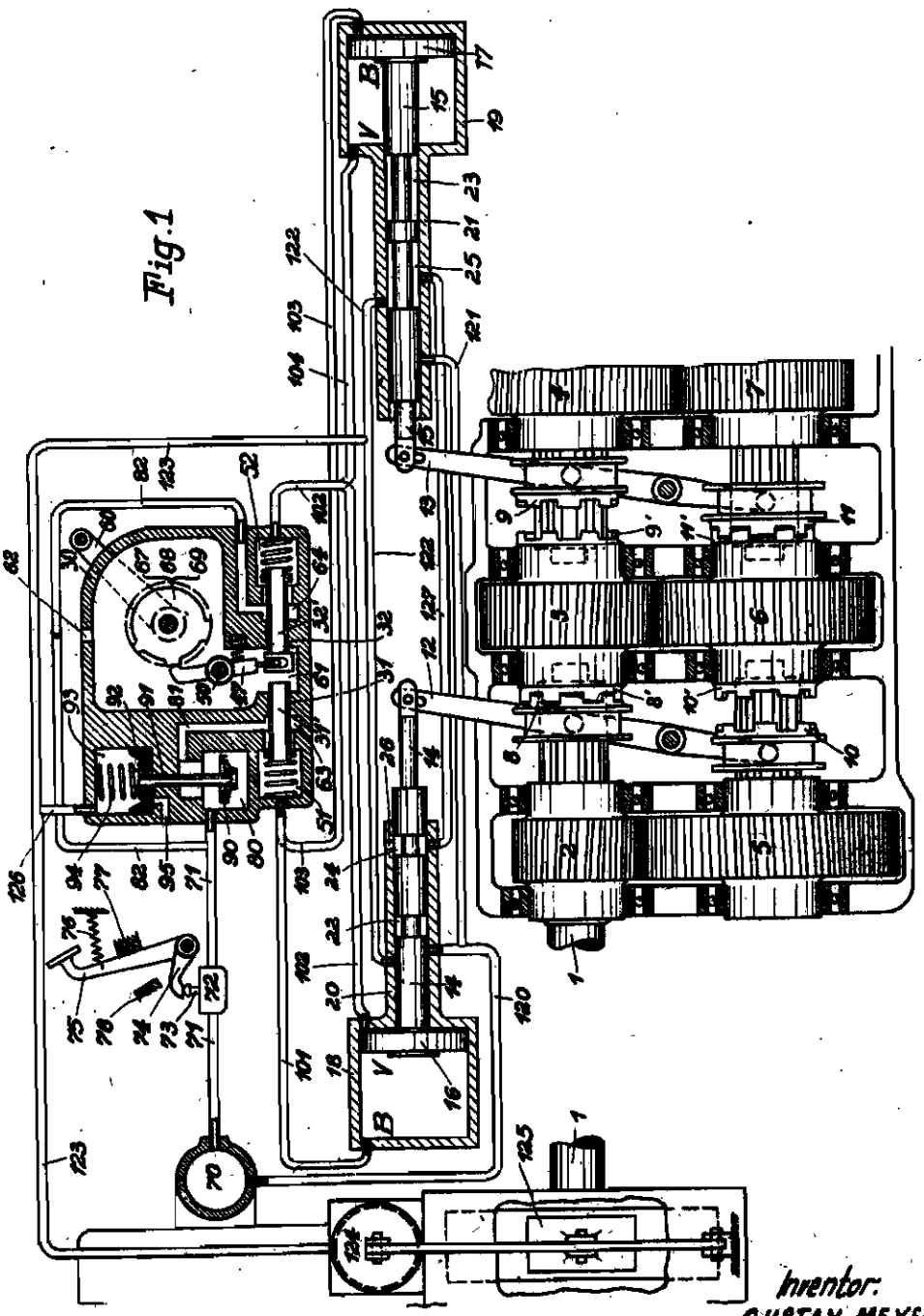
SHIFT CONTROL MECHANISM FOR GEAR TRANSMISSIONS

Filed June 30, 1939

Serial No. 282,309

2 Sheets-Sheet 1

Fig. 1



Inventor:
GUSTAV MEYER
by Edmund N. Paragh
Attorney

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Fig. 2

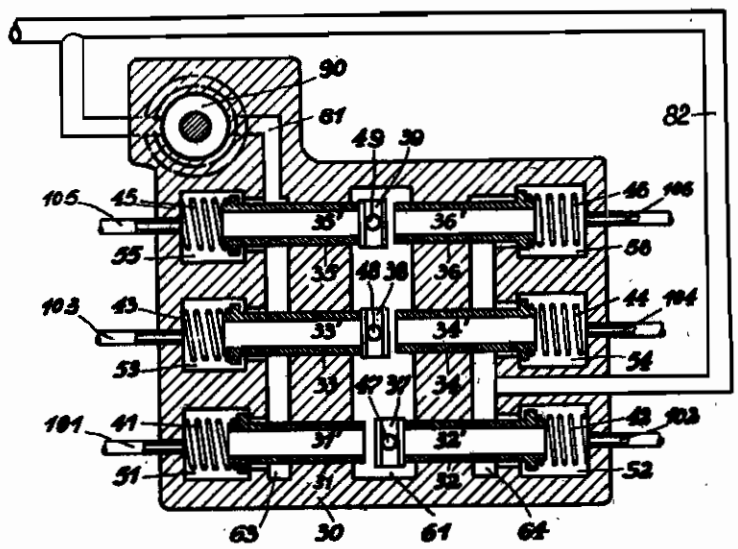
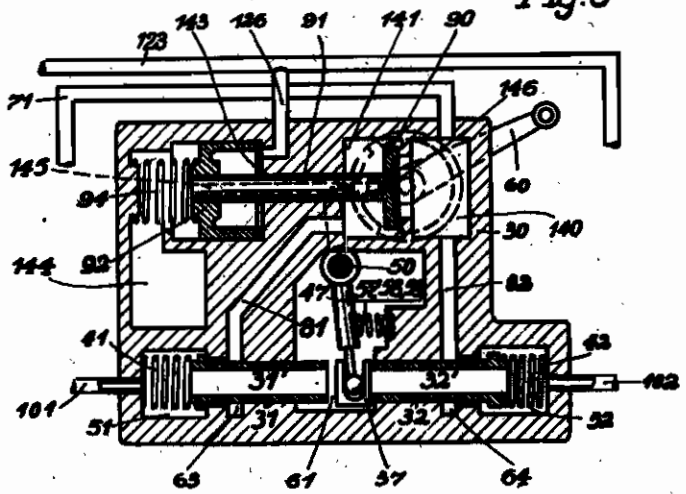


Fig. 3



Inventor:
GUSTAV MEYER
By Edmund H. Young
Attorney

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SHIFT CONTROL MECHANISM FOR GEAR TRANSMISSIONS

Gustav Meyer, Friedrichshafen, Bodensee, Germany; vested in the Alien Property Custodian

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This invention relates to multiple speed gear transmissions as used in motor vehicles and wherein the setting of at least certain speed selections necessitates the shifting of a plurality of pairs of gears. The essential object of the invention is to provide a control mechanism which will prevent the setting of the different pairs of gears simultaneously, and which will insure successive operation such that the shifting of one pair of gears into engagement will not begin until after another pair of gears involved in the shift to produce the same speed selection has been fully engaged.

It has heretofore been proposed to use power operated gear shifting means for gear transmissions. Usually such mechanism involves a plurality of shifting motors operative each to effect engagement and disengagement of certain sets of gears of the transmission so that in cooperation with each other the several motors produce any speed selection of which the transmission is capable. The motors are usually of a fluid pressure type, operating either under positive pressure or partial vacuum, but in some instances the motors may be of a mechanical or electrical type.

The present invention is particularly designed to control the power of the several shift motors of a gear shifting mechanism so that they will operate in successive timed relation with respect to one another. One motor is caused to shift the pairs of gears which it controls, in some instances into engagement and in other instances away from engagement, before the other motor becomes operative to shift other sets of gears.

In order to speed up the shifting of gears in the transmission from one speed selection to another, it has heretofore been proposed to provide in association with the shift mechanism proper auxiliary devices for bringing parts of the transmission to be engaged which are rotating at considerably different speeds, due to the different gear ratios in the transmission, to substantially the same speed at which they can be engaged. In certain instances faster moving transmission parts must be retarded so that they may be engaged with originally slower moving parts, and for this purpose it has been proposed to use a retarding mechanism in the form of a braking device. In other instances, it is necessary to speed up an originally slower moving part of the transmission to hasten engagement with a faster moving part. Various forms of accelerating devices for this purpose have been proposed. One type of such mechanism involves an arrangement by which during the course of the shifting operation the vehicle clutch is momentarily engaged and the vehicle engine speeded up so as to increase the speed of slower moving parts of the transmission.

The present invention is useful in connection with gear shift mechanisms wherein auxiliary devces of the character mentioned are employed in association with the shift mechanism proper. Furthermore, it is contemplated according to the invention that the control mechanism through which the different shift motors are caused to operate successively may operate in dependency on the auxiliary retarding and/or accelerating devices.

While it is believed that the invention is new in its basic features, it is to be noted that the design of the control mechanism is important in securing most successful operation. It is a further feature of the invention to provide a control mechanism of the type described which has particular operating advantages for reasons which will hereafter fully appear.

According to the invention the control mechanism includes a plurality of control members for different gear pairs of the transmission, which members are arranged in two groups. One group will serve to control one set of transmission parts which are to be brought into engagement, and the other group of control members will serve to control other gear parts when they are to be engaged. Preferably one group will control those gear parts which require retardation in order to be engaged with coacting parts, and the other group of control members will preferably control the parts which require speeding up in order to be engaged with coacting parts.

The gear shifting operation will be initiated ordinarily through a manually controlled speed selecting lever which will set the proper control members necessary to result in the proper setting of gears for a particular speed selection. Auxiliary control means is provided in association with the several groups of control members so that not only will the several gear shifting motors be caused to operate in the proper directions to produce the desired gear selection, but also the power will be supplied to the several motors in proper timed relation so that they will not operate simultaneously.

The subject-matter of the invention is illustrated in the accompanying drawings wherein:

Fig. 1 is an assembly view, more or less diagrammatic, of a fragmentary portion of a multiple speed gear transmission of the type involving constantly meshing gear pairs which are ren-

dered operative and inoperative through claw clutches, and showing further vacuum operated gear shifting motors and the control mechanism therefor;

Fig. 2 is a horizontal section, looking down, of the control mechanism shown in Fig. 1; and

Fig. 3 is a sectional elevation of a modified form of control mechanism.

In Fig. 1 the drive shaft of the change speed gear transmission is designated 1. The main shaft train includes gears 2, 3 and 4 and the counter shaft train gears 5, 6 and 7. The freely rotatable gear pair 3 and 6 are connected to gears 2 or 4 or 5 or 7, respectively, by means of the movable jaw clutch members 8, 9, 10 and 11 meshing with the jaw clutch portions 6', 9', 10' and 11'. The clutch members 8 and 10 are moved alternately by the lever 12 and the clutch members 9 and 11 by the lever 13. The lever 12 is connected to the rod 14 of the shifting piston 18. 19 is the shifting cylinder with the extension bore 20. 22 and 24 are grooves in the piston rod 14, 26 a vent in the bore 20. The lever 13 is connected to the rod 15 of the shift piston 17. The corresponding shift cylinder is marked 19 and is provided with an extension bore 21. 23 and 25 are grooves in the piston rod 15.

Each group of control members is connected to a source of auxiliary power and each contains a closing member which prevents simultaneous operation of retarded and accelerated shifts. The closing member which prevents simultaneous operation of retarded and accelerated shifts is made dependent on the shift position of the parts to be connected. For this purpose the closing member may be made dependent on an auxiliary device which serves to accelerate the shifting operation and the auxiliary device in turn is made dependent on the parts to be connected. Preferably the closing member is actuated by the same pressure medium which is effective in the auxiliary device to accelerate the shift. The pressure medium is controlled by the rods of the shifting pistons in known manner.

The operation of the closing member can be effected in such a manner that it is closed by the pressure acting on the auxiliary accelerating device and is opened by the shift pressure. By auxiliary pressure is understood the pressure which is effective in an auxiliary device which serves to accelerate the shift. Shift pressure is the pressure which is effective on the shift pistons and which serves to shift the various gear pairs.

A housing is marked 30 and contains on the one side in one group the control members 31, 33, 35 and opposite them a second group of control members 32, 34, 36. These control members are mounted in the chambers 51 to 56 by means of the springs 41 to 46. 37, 38 and 39 are moving and closing members for the control members 31 to 36 which are provided with central bores 31' to 36'. One of the moving and closing members 37, 38 and 39 lies between each pair of control members 31 and 32, 33 and 34, and 35 and 36. The manually operated gear shift lever 60 moves these moving and closing members into the positions corresponding to the desired gear selection through cam discs 67, 68 and 69 which operate on the levers 47, 48 and 49 journaled on a common shaft 50, and move them, and hence the moving and closing members, against the pull of the springs 57, 58 and 59. As a result the corresponding control members are brought into position.

70 is the intake manifold with a partial vacuum line 71 which carries shift pressure and contains the valve box 72. 73 is an operating knob which is moved by the crank 74, 75. In the example shown 75 is the clutch pedal. In principle any special lever may replace the clutch pedal.

76 is a tension spring for the clutch pedal 75, 77 and 78 are stops for the same pedal. The line 71 opens into the chamber 80. 81 is a further line which opens into the chamber 63. The left chamber 63 is connected to the further chambers 51, 53, 55 whose closing members 31, 33, 35 are lifted by the moving or closing members 37, 38 or 39. 82 is a branch line for the chamber 64 on the opposite side. The right chamber 64 is connected to the chambers 52, 54, 56 by lifting the corresponding control members 32, 34, 36. 61 is a chamber, vented to the atmosphere through the vent 62, in which the control members 31 to 36 open. The closing member 90 is arranged in the chamber 80 and is connected to the piston 92 through the shaft 91, the piston moving in the chamber 83 and being loaded by the spring 94. 95 is a vent. 101, 103, 105 are pressure lines which depend on the left group of control members 31, 33, 35 acting as an accelerating group. 102, 104, 106 are dependent on the control members 32, 34, 36 at the right forming a retarding group. In Fig. 1 a part only of the gear transmission is shown with the two shifting cylinders 18 and 19 in order to simplify matters. The line 101 opens at the left of left shift cylinder 16 and the line 102 at the right while line 103 opens at the right of right cylinder 19 and line 104 at the left. The connections for the lines 105 and 106 indicated in Fig. 2 are intended for a third shift cylinder and hence are not further illustrated. The line 120 branches off from the intake manifold 70 and carries auxiliary pressure, opening into the extension bore 20 of the cylinder 18. A branch 121 of this line also opens into the extension bore 21 of the cylinder 19. 122 is a further line which connects the two bores 20 and 21 and is connected to the line 123 which opens into the cylinder 124 of the auxiliary device 125 designed as a brake for accelerating the shift. The line 126 branches from the line 123 carrying auxiliary pressure to chamber 93.

Assuming that the gearing has been operating at a speed selection in which jaw clutches 8, 8' and 11, 11' are disengaged, and jaw clutches 9, 9' and 10, 10' engaged, the gear selection represented in Fig. 1 is obtained as follows: The control members 31 to 36 are brought into the position shown in Fig. 2 by pushing the control member 32 into its right hand position by means of the moving and closing member 37. Partial vacuum from line 82 reaches the chamber 52 and from there through the line 102 into the chamber to the right of the piston 16 of the left shift motor while at the same time atmospheric pressure entering through casing vent 62 flows through the bore 31' of the control member 31 into the chamber 51 and thence through the line 101 into the chamber to the left of the piston 16 of the left shift motor. As a result piston 16 moves to its right end position and the clutch member 8 engages with the jaw member 8' of the gear 3. The movement of the control member 33 into its left position causes partial vacuum to reach through the chamber 53 and the line 103 to the right of the piston 17 and atmospheric pressure reaches to the space to the left of piston 17 through the bore 34' of the control member 34, the chamber 54 and the line 104. The pis-

ton 17 is moved into its extreme right hand position and hence the clutch member 11 meshes with the jaws 11' of the gear 6. A further shifting cylinder is controlled in an analogous manner by the control members 35 and 36.

A new gear is to be chosen in which both the piston 16 and the piston 17 are moved from their right hand position as shown into their left hand position whereby the clutch 9 engages the jaws 9' of the gear 3 and the clutch 10 engages the jaws 10' of the gear 6. The gear shift lever 60 moves the moving and closing member 37 to the left thus closing the bore 31' of the control member 31 from the atmosphere, this member is lifted against the pressure of the spring 41 and thereby the line 61 is connected to the line 101 through the chamber 63 and the chamber 51. The control member 32 is pressed back into its left hand position by the spring 42, cuts off the connection between the chamber 64 and the chamber 42 and at the same time connects the latter to the chamber 61 through the bore 32' which is vented to atmosphere through the vent 62. The moving and closing member 35 is moved to the right, closes the bore 34' of the control member 34, moves the latter to the right against the pressure of the spring 44 and connects the line 62 to the line 104 through the chamber 64 and the chamber 54. The control member 33 is moved to the right by the spring 43, breaks the connection between the chamber 53 and the chamber 53 and connects the chamber 53 to the atmosphere through the bore 33' and the chamber 61.

When the driver throws out the clutch by pressing down the pedal 75 and at the same time moves the operating knob 73 through the crank 74 the partial vacuum of the intake manifold 70 is connected to the line 71. This can be done in known manner either by operating a simple valve setting free the shifting pressure or the movement of the knob 73 may set free the shifting pressure by the interconnection of a relay device.

After setting free the shift pressure this reaches on the one hand the chamber 60 and on the other hand through the line 62 the chamber 64. The design (chamber size, throttling) is so chosen that the partial vacuum from line 62 becomes effective in the right chamber 64 before partial vacuum from chamber 60 and line 61 become effective in left chamber 63. From the chamber 64 the shift pressure reaches the space to the left of the piston 17 through the opened control member 34, the chamber 54 and the line 104 while at the same time the space on the right of the piston 17 is connected to atmosphere through the line 103, the chamber 53, the bore 33' of the control member 33, the chamber 61 and the vent 62. The end positions of the pistons 16 and 17 are marked B and V respectively. the movement to the position B representing an accelerated shift and that to the position V a retarded shift. Thus movement of piston 16 of of the left shift motor to its left end position, and movement of piston 17 of the right shift motor to its right end position represent an accelerated shift. Conversely, movement of piston 16 to its right end position, and movement of piston 17 to its left end position represent a retarded shift.

Under the action of the partial vacuum the piston 17 moves to the left, the clutch member 11 is disconnected from the jaws 11' and after moving through a neutral position the clutch member 6 meshes with the jaws 6' of the gear 3. In order to bring the clutch member 6 into mesh with member 6', the latter member, which is connected to the driving side, must be retarded because the clutch member 6 is turning more slowly. In this position the piston 17 has moved to the left far enough so that the opening of the line 121 is connected through the groove 25 of the piston rod 15 to the opening of the line 122. Therefore, partial vacuum from the intake manifold 70 reaches through the line 126 and the line 121 to the groove 25 in the line 122. From this line the partial vacuum acting as auxiliary pressure flows through the line 123 to the cylinder 124 of the braking device 125. At the same time this pressure reaches the chamber 93 above the piston 92 through the line 126 which branches off from line 123. The piston 92 is raised against the pressure of the spring 94 so that the closing member 90 is forced against its seat by the shaft 91 and chamber 66 is disconnected from the line 61. No shifting pressure therefore can reach the control member group 31, 33, 35 by means of which accelerated shifts are effected.

As soon as the r. p. m. of the jaws 9' on the gear 3 has been sufficiently reduced so that clutch members 9 and 6' rotate at substantially the same speed, meshing thereof takes place in known manner as a result of the beveled faces of the teeth.

As meshing of the clutch halves 6, 9' is completed the piston 17 of the right shift motor reaches its left end position V under the operation of the shifting pressure which is continuously supplied through the line 104. By this means finally the opening of the line 122 is closed from the line 121 by the portion of the rod 15 lying between the grooves 25 and 23 and is connected through the groove 23 to the line 127. This in turn is connected through the groove 24 of the piston rod 14 and the vent 26 to the atmosphere. In this manner both the lines 123 and 126 are vented so that on the one hand the braking action of the auxiliary device 125 stops and on the other hand the piston 92 is moved by the spring 94 back into its lower position and the closing member 90 lifted from its seat. The shifting pressure now reaches to the line 61, thence through the chamber 63 and the opened control member 31 into the chamber 51 and through the line 101 to the chamber at the left of the piston 16. As a result the piston 16 of the left shift motor moves to the left, the clutch member 6 is moved out of mesh with the jaws 6' of the gear 3 and the clutch member 10 is moved against the jaws 10' of the gear 6. Meshing of the clutch portions 10 and 10' requires an acceleration of the clutch half 10 which can be effected either manually by the driver or by means of a special shift auxiliary mechanism of known design. At the instant of overtaking the clutch halves 10 and 10' mesh in known manner and the piston 16 moves into its left end position B.

When the piston 16 is to be moved from its left end position B to the right end position V shown in Fig. 1, that is to say when a retarded shift is to be effected, this is accomplished in a manner analogous to that which was described for the movement of the piston 17 from its right to its left end position in which the clutch halves 6 and 8' just strike each other. The auxiliary pressure passes through the groove 22 from the line 120 into the line 122 and through the line 123 to the brake cylinder 124 and also through the line 126 to the chamber 93 above the piston

92, thus causing the closing member 90 to close and preventing the operation of an accelerated shift while the retarded shift is taking place.

The control of the braking device 125 during a retarded shift by the grooves 22 and 25 in the piston rods 14 and 15, which at the same time prevent an initiation of an accelerated shift, has no effect during the movement of the piston 16 from its right position into its left end position B or the movement of the piston 17 from its left into its right end position B, that is to say in an accelerated shift, because on disengagement of the corresponding connection the control path is very rapidly traversed. Hence no material lowering of pressure takes place either in the line 123 or the brake cylinder 124, or in the chamber 93.

The control mechanism is also effective in fundamentally the same manner if both a member of the clutch members 8 or 10 and also one of the clutch members 9 or 11 are disengaged simultaneously and one each of the clutch members is just ready to engage. If for example on the one hand the clutch half 8 and on the other hand the clutch half 11 are about to mesh, the line 120 is connected to the line 122 through the groove 22. As a result, as described above, the retarding device 125 becomes active and the closing member 90 is closed. The operation of the braking device 125 retards the clutch member 8 so that this finally meshes with the jaws 8'. Thereafter the clutch member 11 can mesh with the jaws 11' by increasing the r. p. m. of the jaws 11', by opening the throttle or by an auxiliary accelerating device until the meshing r. p. m. is reached.

If the clutch members 10 and 11 are disengaged simultaneously and the clutch members 8 and 8 are about to mesh with the jaws 8' and 9', involving two retarded shifts, the line 122 is connected to the line 129 not only through the groove 22 but also through the groove 25 to the line 121. Partial vacuum is led to the braking device 124, 125 through both controls. In this manner after the r. p. m. of the clutch 8 has reached the meshing r. p. m. and the two clutch halves have meshed the r. p. m. of the clutch half 9' is still further lowered until this meshes with the clutch 9.

If in such a case, that is to say when both clutch members 8 and 9 are about to mesh, the r. p. m. of the free gear pair 3, 6 drops more rapidly than the r. p. m. of the clutch half 8 which is to mesh by reason of the braking device 124, 125, which result can take place by reason of the small mass of the gear pair or lubricant friction, the clutch half 9' will first mesh with the clutch half 8, thereafter the r. p. m. of the clutch 8 will be further decreased by the brake until meshing r. p. m. is reached and the clutch half 8 meshes with the jaws 8'. Naturally all of this occurs very quickly.

The device described through very simple mechanism prevents the start of accelerated shifts as long as any retarded shifts have not been completed. The device can be used in fundamentally the same manner with transmissions having a different type of gear shift elements than the jaw clutches shown.

The modification of the invention of Fig. 3 involves a particular design of closing member and its actuation. In accordance with the invention the closing member is held closed by a spring; furthermore one side of the operating member for the closing member is exposed to the auxiliary pressure whereas the other side is connected to a chamber to which shift pressure is led with retardation. The forces acting on the closing member by reason of the spring and the two pressure media are so adjusted that on the one hand the closing member is held closed by the auxiliary pressure against the action of the shift pressure, whereas on the other hand when the auxiliary pressure is removed the closing member is opened by the shift pressure against the force of the spring.

In Fig. 3 the shift pressure line 71 opens into the chamber 140 to which is connected the line 82 for the retarding group of control members 32, 34, 36. The chamber 140 is closed off from the chamber 141 by the closing member 90 which is under the pressure of the spring 94 through the piston 82 and the shaft 91. The line 81 for the accelerating group of control members 31, 33, 35 connects to the chamber 141. To the right of the piston 92 is the chamber 143 in which opens the line 126 which can supply auxiliary pressure from the line 123. To the left of the piston 92 there is the chamber 144 in which delayed shifting pressure flows from the chamber 140 through the bore 145. 146 is a throttling portion in the bore 145.

The operation of the particular design of closing member shown in Fig. 3 is as follows: Immediately after initiating flow of the shift pressure at the valve box 72 shift pressure passes through the line 71 into the chamber 148 and from there through the line 82 into the chamber 64 and, depending on the position of the control members 32, 34, 36 for retarded shifts, reaches line 128, 104, or 106 and thence the corresponding gear shifting cylinders.

The spring 94 holds the closing member 90 in its right hand position and closes off chamber 140 from chamber 141. Therefore after the shifting pressure is set free no shift pressure reaches the control members 31, 33, 35 and hence no accelerated shift can be initiated. In the mean time shift pressure slowly flows through the throttling orifice 148 and the bore 145 into the chamber 144. At the same time the retarded shifts which are already proceeding carry auxiliary pressure through the line 120 or 121, through the corresponding grooves in the piston rods 14 or 15, into the line 122 and the line 123, and thence into the line 126 into the chamber 143. The auxiliary pressure operates to hold the closing member 90 against its seat. If after a while pressure is equalized in chambers 140 and 144 through the bore 145, the closing member 90 still remains closed as it is pressed by the combined action of the spring 94 and the auxiliary pressure existing in the chamber 143, which overbalance the shift pressure operating on the left side of the piston 92. When the retarded shifts are completed and the auxiliary pressure disappears from the lines 123, 126 and 143, the shift pressure on the left side of the piston 92 exceeds the pressure of the spring 94 and the partial vacuum on the right side of the closing member 90. As a result the closing member 90 is opened, and shift pressure flows from chamber 140 to chamber 141 and through line 91 to the accelerated shift.

The device according to Fig. 3 operates as follows in the various possible shift cases:

(a) If both retarded and accelerated shifts are necessary for the gear chosen the retarded shifts are initiated immediately and the accelerated shifts can only proceed when the auxiliary pressure has disappeared from the chamber 143 and

the closing member 90 is opened by the shift pressure which has in the meantime become effective in the chamber 144.

(b) When only retarded shifts are necessary these proceed without further ado. The fact that thereafter the closing member 90 is open and shift pressure reaches the line 81 has no effect since no accelerated shifts are chosen.

(c) When only accelerated shifts are demanded there is only a slight delay because the closing member 90 is rapidly opened since there is no auxiliary pressure in the line 123 and hence in the chamber 143 by reason of the absence of the retarded shifts.

It will be evident to those skilled in the art that the control mechanism of the invention provides an efficient arrangement for improving shifting in multiple speed gear transmissions wherein the setting of a designated speed selection necessitates shifting of a plurality of transmission parts. By preventing more than one shift occurring at one time, interference will be avoided. Also the invention enables auxiliary shifting devices, for speeding up slower parts and retarding faster parts to be engaged with other parts in quickly attaining completion of the shift operation, to operate efficiently. The basic features of the invention can be incorporated in other forms than here illustrated, and may be employed with gear shifting motors and with multiple speed gear transmissions other than those shown. Accordingly, the scope of the invention is to be determined in accordance with the appended claims.

GUSTAV MEYER.