Aug. 16, 1966 E. P. BRINKEL ET AL 3,266,521

VALVE

Filed Feb. 20, 1963 2 Sheets-Sheet 1

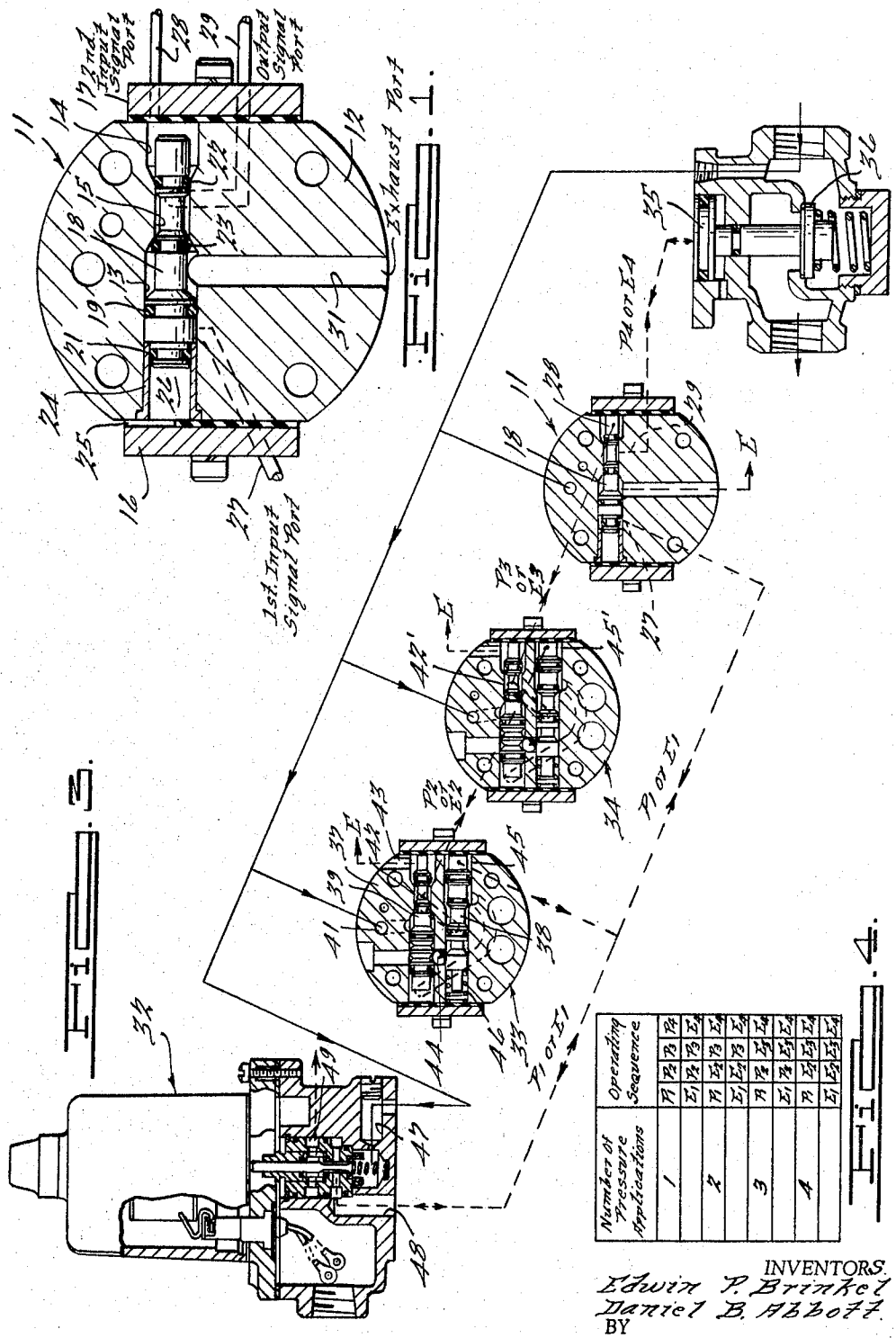


FIG. 1.

FIG. 2.

FIG. 3.

FIG. 4.

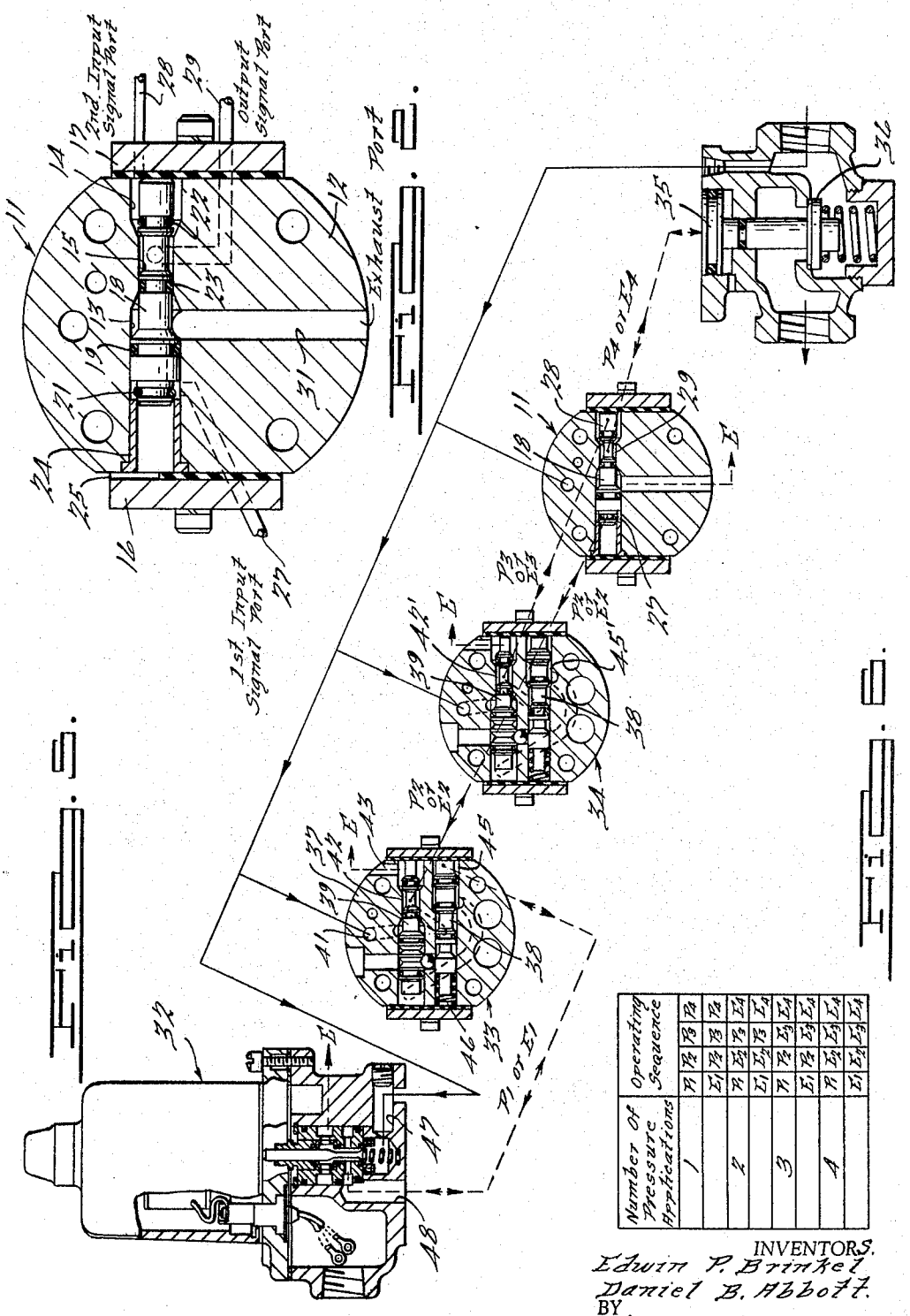
Number of Pressure Applications	Operating Sequence									
1	P1	E1								
2	P1	P2	E1	E2						
	P1	E1	P3	E3						
3	P1	P2	E1	E2	P3	E3				
	P1	E1	P2	E2	P3	E3				
	P1	P2	E1	E2	P3	E3				
4	P1	P2	E1	E2	P3	E3	P4	E4		
	P1	P2	E1	E2	P3	E3	P4	E4		
	P1	P2	E1	E2	P3	E3	P4	E4		
	P1	P2	E1	E2	P3	E3	P4	E4		

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VALVE

Filed Feb. 20, 1963 2 Sheets-Sheet 2



Number of Pressure Applications	Operating Sequence									
1	P1	E1	P2	E2	P3	E3	P4	E4		
2	P1	E1	P2	P3	E2	E3	P4	E4		
3	P1	E1	P2	P3	E2	P4	E3	E4		
4	P1	E1	P2	P3	E2	P4	E3	P5	E4	E5

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VALVE

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7 Claims. (Cl. 137—625.66)

This invention relates to valves, and more particularly to pressure signal-responsive valves for controlling the occurrence and sequence of successive output signals.

It is an object of the invention to provide a novel and improved pressure signal-responsive valve which will produce an output pressure pulse only when two input pressure signals are present and occur in the proper sequence, and will cancel the output pressure signal immediately when either one of the input pressure signals is removed.

It is another object to provide an improved valve of this nature which is usable in conjunction with one or more pressure-operated signal sequence mechanisms of the pulse divider type which provide equal distribution between the application and removal phases of the output pressure signal, the combination of the present valve with such mechanisms producing an output with an unequal distribution of the application and removal phases.

It is also an object to provide an improved valve having the above characteristics, which can be connected in various ways with respect to a number of the above-mentioned pulse divider mechanisms, thus being capable of producing different output signal phase distributions.

Other objects, features, and advantages of the present invention will become apparent from the subsequent description, taken in conjunction with the accompanying drawings, in which:

FIGURE 1 is a cross-sectional view of a suitable embodiment of the invention shown in its removal or exhaust position;

FIGURE 2 is a view similar to FIGURE 1 showing the valve in its enabling position;

FIGURE 3 is an exploded partially schematic diagram showing the invention in conjunction with two pulse divider mechanisms of the type disclosed and claimed in Brinkel Patent No. 2,921,602 issued January 19, 1960. one signal input port of the valve of this invention being connected to the primary input signal of the system;

FIGURE 4 is a chart showing the operating sequence of the arrangement of FIGURE 3;

FIGURE 5 is a partially schematic diagram similar to FIGURE 3 but with one signal port of the valve of this invention connected to the output from one of the pulse divider mechanisms; and

FIGURE 6 is a chart showing the operating sequence of the arrangement of FIGURE 5.

Briefly, the illustrated embodiment of the invention comprises a spool valve member having first and second input signal ports, an output signal port and an exhaust port. The valve spool has a first seal area connected to the first input signal port and a second and smaller seal area which is connected to the first input signal port when the valve is in its removal or exhaust position, the second area partially counteracting the effect of the first area. When the valve is shifted to its enabling position, the second area is no longer effective.

The valve has third and fourth seal areas which are of equal size and smaller than the second seal area. The third seal area separates the second input signal port from the output signal port when the valve is in its exhaust position, these ports being connected when the valve is in its enabling position. The fourth seal area

separates the outlet port from the exhaust port when the valve is in its enabling position, these ports being connected when the valve is in its exhaust position.

Upon application and maintenance of a pressure pulse at the first input signal port, the valve will shift to its enabling position. Upon later application and maintenance of a pressure signal at the second input signal port, a pressure signal will be applied to the output signal port. If either pressure signal is thereafter canceled, the output signal will also be canceled. If the pressure signal at the first input signal port is canceled while the output signal is being applied, the pressure acting on the fourth seal area will shift the valve to its exhaust position. If the pressure signal is removed from the second input signal port while the output signal is being applied, this will automatically cancel the output signal, since the latter is supplied from the second input signal port.

If, both input signal ports being exhausted, pressure is first applied to the second input signal port and thereafter to the first input signal port, an output signal will not occur. This is because pressure applied to the second input signal port will act on the third seal area, and pressure applied to the first input signal port will act only upon the differential area between the first and second seal areas. This differential area is less than the effective areas of either the third or fourth seal areas.

Referring more particularly to the drawings, the valve is generally indicated at **11** and is shown in detail in FIGURES 1 and 2, FIGURE 1 showing the valve in its left-hand or exhaust position and FIGURE 2 in its right-hand or enabling position. The valve has a body **12** with a bore having enlarged end sections **13** and **14** with a narrowed intermediate section **15**. End caps **16** and **17** are provided at the opposite end of the bore, these caps being secured to flattened sides of housing **12**.

A spool **18** is slidably mounted in the bore, the spool having a first seal area **19**, a second seal area **21**, a third seal area **22**, and a fourth seal area **23**. Seal area **19** is slidable in bore section **13**, and a bushing **24** is provided in the left-hand end of bore section **13**, seal area **21** being slidable within bushing **24** when the spool is in its left-hand or exhaust position as shown in FIGURE 1. A vent **25** is provided for the chamber **26** formed within bushing **24** by seal area **21**.

Housing **12** is provided with a first input signal port **27** connected to bore section **13** inwardly of bushing **24**, a second input signal port **28** connected to bore section **14**, an output signal port **29** connected to bore section **15**, and an exhaust port **31** connected to bore section **13** inwardly of port **27**, seal area **19** separating ports **27** and **31** at all times.

Seal area **21** is smaller than seal area **19**, and seal areas **22** and **23** are of uniform size, smaller than area **21**, and larger than the difference between areas **19** and **21**. When spool **18** is in its left-hand or exhaust position, seal area **22** fits within bore section **15** and separates ports **28** and **29**. At the same time, seal area **23** is disposed within bore section **13** so that ports **29** and **31** are connected. When spool **18** is in its right-hand or enabling position as shown in FIGURE 2, seal area **21** is withdrawn from bushing **24**, seal area **23** fits within bore section **15**, and seal area **22** is within bore section **14**. Thus, ports **29** and **31** are separated and ports **28** and **29** are connected.

In operation, assuming an initial position of spool **18** as shown in FIGURE 1, a pressure signal applied to first input signal port **27** will cause pressure to act on seal area **19** tending to urge spool **18** to the right, and on seal **21**, which is within bushing **24**, tending to urge spool **18** to the left. Since seal area **19** is larger than seal area

21, spool 18 will shift to its right-hand or enabling position shown in FIGURE 2. As it shifts, seal area 21 will be withdrawn from bushing 24 so that the entire area of seal 19 will thereafter be effective. At this time, however, there will be no pressure applied to output signal port 29.

Should a pressure signal be applied to second input signal port 28 while spool 18 is held in its right-hand or enabling position by the maintenance of pressure at port 27, pressure will flow from bore section 14 to bore section 15 and into output signal port 29. This pressure will also act against seal area 23, but since this area is less than that of seal area 19, spool 18 will remain in its right-hand position.

Should pressure be removed from first signal port 27, the pressure acting on seal area 23 will cause shifting of spool 18 to the left, connecting bore section 15 with exhaust port 31 and separating pressurized bore section 14 from output signal port 29. The output signal port will thus be exhausted, and the pressure acting on seal area 22 will maintain the spool in its left-hand or exhaust position. Removal of pressure from second input signal port 28 after shifting of spool 18 to its left-hand or exhaust position will not affect the position of spool 18. Should the pressure at first input signal port 27 be reapplied before the pressure at second input signal port 28 is removed, spool 18 will still remain in its left-hand or exhaust position since seal area 21 will have re-entered bushing 24, and the differential area between seals 19 and 21 is less than the area of seal 22. In order to reapply a pressure signal at output signal port 29, it would be necessary to first remove the pressure at second input signal port 28, and then apply a signal to first input signal port 27 and thereafter to second input signal port 28.

Assuming that spool 18 is in its right-hand position with pressure being applied to both signal ports 27 and 28, removal of pressure at second input signal port 28 will cause cancellation of the pressure signal at output signal port 29, even though spool 18 will remain in its right-hand or enabling position. This is because the pressure at port 29 can only be supplied from port 28. Should the pressure at port 28 be reapplied while pressure is maintained at port 27, a pressure signal will again be applied to output signal port 29. Should the pressure at port 27 be removed after the pressure at port 28, there will still be no shifting of spool 18 from its right-hand position. However, should the pressure at port 28 then be reapplied before it is restored at port 27, spool 18 will shift to its left-hand position, the pressure acting on seal area 23 and then on seal area 22, and no signal will be applied to output signal port 29.

FIGURES 3 and 4 show an application of valve 11 to a system in which a pilot valve generally indicated at 32, first and second pulse dividing mechanisms generally indicated at 33 and 34, and a unit 11 are in stacked and interconnected relation for controlling output signal pulses to a fluid motor 35 such as that for a valve 36. The pulse divider mechanisms 33 and 34 are similar to those described and claimed in the aforementioned Patent No. 2,921,602 of Brinkel, issued January 19, 1960.

Although a detailed description of the construction of units 33 and 34 is believed unnecessary for the purpose of understanding the present invention, it may be stated generally that each unit has a housing 37, a control spool 38, and an actuating spool 39, the spools being slidably mounted within the housing. Housing 37 has a supply port 41, an output signal port 42 and an exhaust port 43, and actuating spool 39 is movable between a right-hand position as shown in the figures in which output signal port 42 is connected with exhaust port 43, and a left-hand position in which supply port 41 is connected to output signal port 42. A detent 44 is provided which is controlled by spool 38 and acts on spool 39. Spool 38 is movable between a right-hand position as shown in the figures, in which detent 44 locks spool 39 in either of the positions, and a left-hand position in which detent 44 is released from spool 39. An input signal port or chamber 45 is provided at the right-hand end of control spool 38, pressure at this port tending to move spool 38 to the left. A spring 46 is provided for moving spool 38 to the right.

The interconnections between the various chambers and ports of units 33 or 34 are such that application and subsequent removal of a pressure signal at port 45 will cause spool 39 to shift from its pressure position to its exhaust position or vice versa, and remain in the shifted position until application and removal of a second pressure pulse to input signal port 45 which will cause spool 39 to return to and remain in it original position. Each unit 33, 34 thus acts as a pulse divider in that the number of output pressure pulses will be half the number of input pulses. If the output signal port 42 of one unit such as unit 33 is connected to the input signal port 45' of another unit such as unit 34, the output signal port 42' of unit 34 will have one fourth the number of pulses of input signal port 45 of unit 33.

In general terms, each unit 33 or 34 will require a predetermined number of applied and removed input pulses (whether directly connected or remote) to create a single application of its output pulse, and the same number of input pulses thereafter to create a single removal of its output pulse. This is apparent from a study of FIGURE 4 which is a chart or diagram of the operating sequence of the various signal ports. In this diagram, and in FIGURE 3, the primary signals at port 45 are referred to as P_1 (pressure) or E_1 (exhaust), those at port 42 and 45' as P_2 or E_2 and those at port 42' as P_3 or E_3. Pilot valve 32 is a 3-way solenoid operated valve which when energized will connect a supply port 47 to an outlet port 48, the outlet port being connected to port 45. When the solenoid operated pilot valve is de-energized, outlet port 48 will be connected to an exhaust port 49.

It will be seen from FIGURE 4 that upon the first application of pressure P_1, P_2 and P_3 will simultaneously appear. Upon removal of P_1 (first occurrence of E_1), P_2 and P_3 will remain. Upon the second application of P_1, P_2 will change to E_2 but P_3 will remain. Upon the second occurrence of E_1, E_2 and P_3 will remain.

Upon the third application of P_1, P_2 will again appear. This will cause removal of P_3 or occurrence of E_3. The third occurrence of P_1 will not cause any change in P_2 or E_3. When P_1 is applied for the fourth time, P_2 will change to E_2 but E_3 will remain undisturbed. Upon the fourth occurrence of E_1, all signals P_1, P_2 and P_3 will have been removed, and the fifth application of P_1 will have the same result as the first, causing application of P_2 and P_3.

This requirement of an equal number of input signals for each shift of the output signal between its applied and removed condition has been found unsuitable for some applications of pulse dividing equipment. For example, in some installations it is desired that after a certain number of parts have been produced by a machine and collected in a single collection area, a quick ejection of the collected parts be accomplished and the ejection apparatus be rapidly retracted so that the next batch of parts may be collected. To accomplish this end, it would be desirable to create, say, the pressure phase of the output signal only after a large number of input signals, with the next exhaust phase occurring after only the succeeding input signal, or even the next shift of the input signal from one phase to the other

FIGURE 3 shows valve 11 as having its first input signal port 27 connected to output port 48 of pilot valve 32, that is to P_1, and its second input signal port 28 to output signal port 42' of unit 34, that is to P_3, output signal port 29 being connected to motor 35 of valve 36 and being termed P_4.

With this arrangement, the first application of P_1 will cause shifting of spool 18 to its enabling position, and with P_3 being applied to port 28 shortly after P_1 is ap-

plied to port **27**, an output pressure signal P_4 will be produced at port **29**. The reason signal P_3 will be received slightly later than signal P_1 is that P_3 must await the shifting of the spools in units **33** and **34**, whereas P_1 is transmitted directly from port **48** of valve **32**.

The first occurrence of E_1 will cause spool **18** to shift to the left since P_3 is still being applied. This will remove P_4 (creating E_4) for the reasons described above. Valve **36** will thus have been shifted by P_4 to its open position when pilot valve **32** was energized for the first time, and by E_4 to its closed position when pilot valve **32** was de-energized.

Upon the second energization of pilot valve **32**, P_1 will be applied to unit **11**, but spool **18** will remain in its E_4 position because P_3 is still being applied. This condition will hold when the second E_1 occurs. The third P_1 will result in E_3, so that spool **18** will shift to its right-hand or enabling position. However, E_4 will remain since P_4 can only be supplied by P_3. E_4 will hold during the third E_1 and the fourth P_1 and E_1. When P_1 and P_3 again appear in the proper sequence upon the fourth application of P_1, P_4 will again be applied and the cycle will be repeated.

FIGURE 5 shows a modified arrangement which is basically similar to that of FIGURE 3 but in which output signal port **42** of unit **33** is connected to first input signal port **27** of unit **11** as well as to input signal port **45'** of unit **34**, and output port **48** of pilot valve **32** is not connected to port **27**. The result will be that the pressure phase of the signal at output signal port **29** of unit **11** will have a longer duration, and more specifically will be equal to the duration of the first application of P_1 and the first occurrence of E_1.

The sequence of operation of the FIGURE 5 system is shown in FIGURE 6. Upon the first application of P_1, P_2 will be applied to port **45'** and to first input signal port **27** of unit **11**. Application of P_2 to port **45'** will cause P_3 to be applied to second input signal port **28** of unit **11**. P_2 will be applied to port **27** before P_3 is applied to port **28** because of the time required for shifting of spools **38** and **39** of unit **34**. Since the signals will have been applied in proper sequence to unit **11**, spool **18** thereof will shift to its right-hand or enabling position, and a pressure signal will be applied at output signal port **29**, this signal being referred to as P_4.

Upon the first occurrence of E_1, P_2 will remain, as will P_3. P_4 will therefore also remain, unlike the system of FIGURES 3 tnd 4 in which P_4 was removed by the first E_1.

When P_1 is applied for the second time, P_2 will become E_2. Since P_3 remains, spool **18** of unit **11** will be shifted to the left for the reasons described above, changing P_4 to E_4.

Upon the second E_1, E_2 and P_3 will remain, as will E_4. Upon the third application of P_1, P_2 will be reapplied. However, P_3 will change to E_3 at the same time. Spool **18** will therefore shift to its right-hand or enabling position, but since there is no P_3, E_4 will remain.

When E_1 occurs for the third time, P_2 will remain applied, but E_3 will remain. There will thus still be no application of P_4. Upon the fourth application of P_1, P_2 will be changed to E_2, and E_3 will remain. There will thus be no pressure applied to either the first or the second input signal ports of unit **11**, and E_4 will remain. The fourth E_1 will not affect E_2, E_3 or E_4. The fifth application of P_1 will be like the first, with P_2, P_3 and P_4 being reapplied to start repetition of the cycle.

While it will be apparent that the preferred embodiments of the invention disclosed are well calculated to fulfill the objects above stated, it will be appreviated that the invention is susceptible to modification, variation and change without departing from the proper scope or fair meaning of the subjoined claims.

What is claimed is:

1. In combination, a valve having a first input signal port, a second input signal port and an output signal port, means responsive to the application and maintenance of a pressure signal at said first input signal port and the later application and maintenance of a pressure signal at said second input signal port for applying a pressure signal at said output signal port, and means responsive to removal of the pressure signal at either input signal port for removing the pressure signal at said output signal port.

2. The combination according to claim **1**, further provided with means responsive to connection of either of said input signal ports to exhaust and application of pressure to the other input signal port for connecting said output signal port to exhaust.

3. In combination, a valve having a first input signal port, a second input signal port, an output signal port and an exhaust port, said valve being movable between an exhaust position in which said output signal port is connected to exhaust and an enabling position in which said output signal port is connected to said second input signal port, means responsive to the application and maintenance of pressure at said first input signal port and the later application and maintenance of pressure at said second input signal port for holding said valve in its enabling position, and means responsive to the application and maintenance of pressure at said second input signal port and the later application and maintenance of pressure at said first input signal port for holding said valve in its exhaust position.

4. In combination, a valve having a first input signal port, a second input signal port, and an exhaust port, a valve spool movable between an exhaust position and an enabling position, a first seal area on said spool connected to said first input signal port and responsive to pressure therein for urging said spool toward its enabling position, a second seal area on said spool smaller than said first seal area and connected to said first input signal port, said second seal area being responsive to pressure at said first input signal port when the spool is in its exhaust position to hold said spool in said exhaust position but being unresponsive to pressure at said first input signal port when said spool moves away from its exhaust position, a third seal area on said spool smaller than said first seal area and separating said second input signal port and said output signal port when said spool is in its exhaust position, said third seal area being responsive to pressure at said second input signal port when the spool is in its exhaust position to hold said spool in its exhaust position but being ineffective when said spool is in its enabling position, and a fourth seal area smaller than the first seal area and separating said output signal port and said exhaust port when said spool is in its enabling position, said fourth seal area being responsive to pressure at said second input signal port when said spool is in its enabling position to urge said spool toward its exhaust position but being ineffective when said spool is in its exhaust position.

5. In combination, a valve having a housing, a bore in said housing having two relatively wide sections separated by a relatively narrow section, a first input signal port connected to one of said wide bore sections, a second input signal port connected to the other wide bore section, an output signal port connected to said relatively narrow bore section, a spool slidable in said bore, a first seal area on said spool in said one wide bore section, an exhaust port connected to said one wide bore section, said first seal area separating said first input signal port and said exhaust port, a second seal area on said spool smaller than said first seal area, a vented chamber formed in the outer end of said one wide bore section, said spool being movable between an exhaust position in which said second seal area is slidable within said chamber and an enabling position in which said second seal area is withdrawn from said chamber, said first seal area being responsive to a pressure signal at first input signal port to urge said spool toward its enabling position, said second

seal area being responsive to a pressure signal at said first signal port when said spool is in its exhaust position to partially counteract the force on said first seal area but being ineffective when said second seal area is withdrawn from said chamber, and third and fourth seal areas on said spool, each of said seal areas being smaller than said first seal area but greater than the difference between said first and said second seal areas, said third and fourth seal areas being alternately slidable within said narrow bore section to separate said first input signal port and said output signal port when the spool is in its exhaust position and to separate said output signal port and said exhaust port when the spool is in its enabling position.

6. In combination, a source of input pressure signal pulses, and means responsive to a predetermined number of said input pulses for creating a single application of an output pulse and responsive thereafter to a different number of input pulses for creating a single removal of said output pulse.

7. The combination according to claim 6, said last-mentioned means comprising a pulse dividing mechanism having an input port connected to said input signal source and an output port, means in said mechanism responsive to a predetermined number of input pulses for creating a single application of an output pulse at its output port and responsive to the same number of input pulses for creating a single removal of said output pulse at said output port, a valve having a first input signal port connected to said input signal source, a second input signal port connected to the output port of said pulse dividing mechanism, and an output signal port for producing said first-mentioned output pulses, means in said valve responsive to the application and maintenance of pressure at said first input signal port and the later application and maintenance of pressure at said second input signal port for applying pressure at said output signal port, and means in said valve responsive to the removal of pressure at either of said input signal ports for removing pressure at said output signal port.

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