March 8, 1949. D. H. NEWHALL 2,463,552

HIGH-PRESSURE HYDRAULIC SYSTEM

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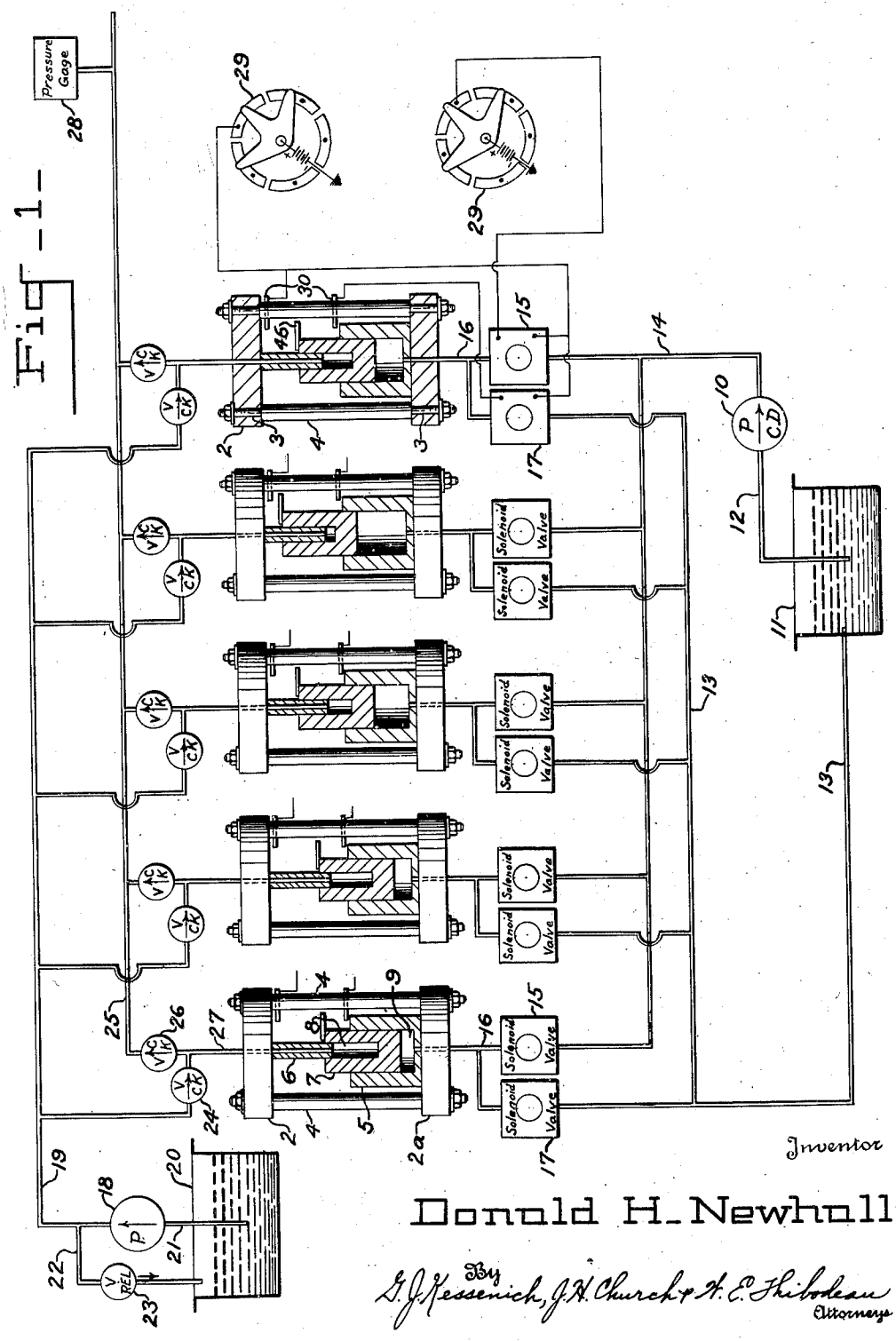
Fig. 1.



Inventor

Donald H. Newhall

By G. J. Kessenich, J. N. Church & H. E. Thibodeau

Attorneys

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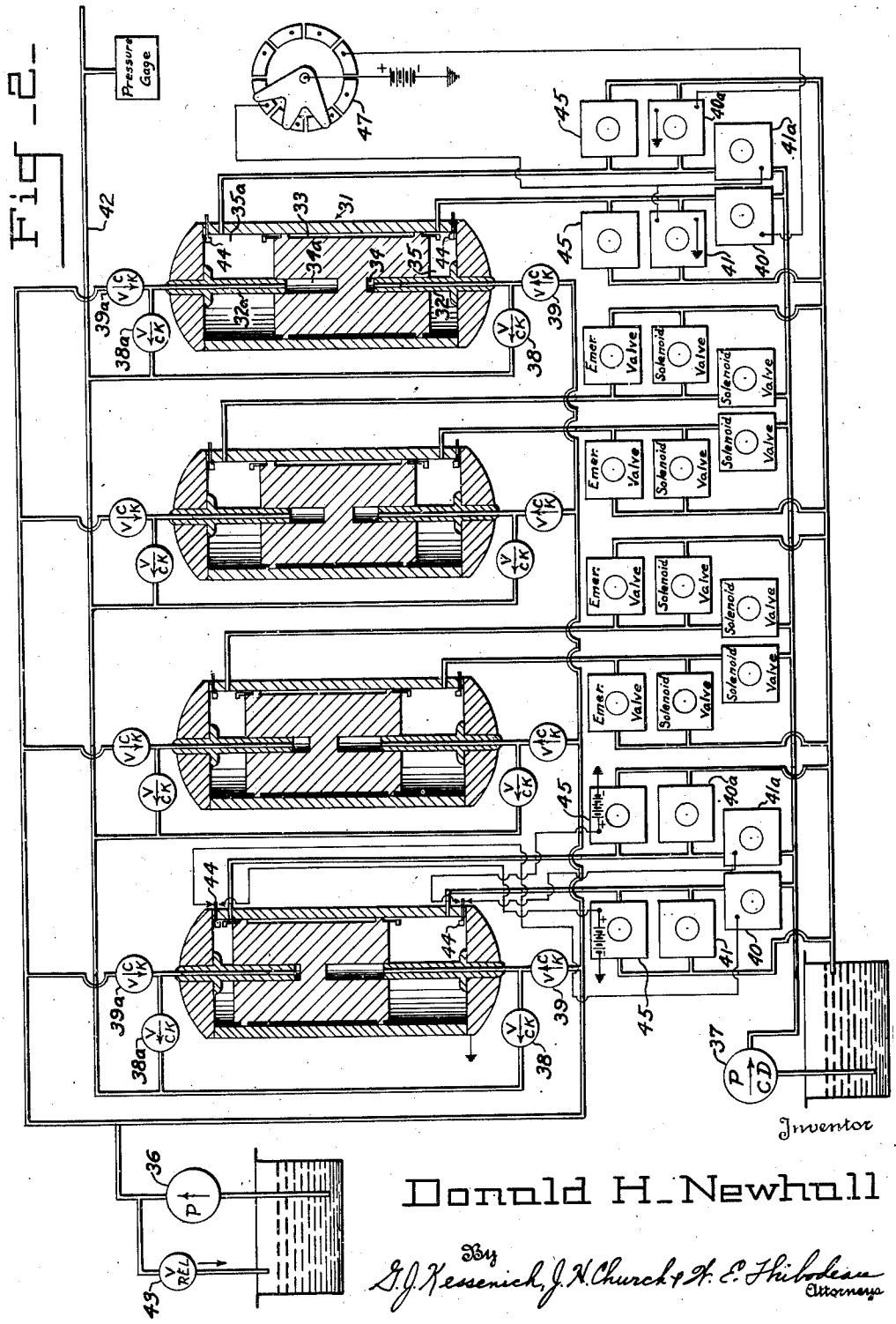
Fig. 2.



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HIGH-PRESSURE HYDRAULIC SYSTEM

Donald H. Newhall, Walpole, Mass.

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2 Claims. (Cl. 103—48)

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The invention described in the following specification and claims may be manufactured and used by or for the Government for governmental purposes without the payment to me of any royalty thereon.

This invention relates to a high-pressure hydraulic system and more particularly to one adapted for developing a continuous flow of liquids or gases at a steady high pressure.

In many applications where excessively high hydraulic pressures are required, steadiness of pressure in the flow of liquids or gases is of great importance but is difficult to attain.

The fixation of nitrogen for the manufacture of explosives is but one of the many applications in which a continuous pressure is particularly invaluable. Without a steady and continuous flow of fluid or gas at high pressure to a reactor vessel, the reactions desired would necessitate the handling of the chemicals involved in batch lots, a procedure which is obviously expensive and time-consuming. Another important application where a constant flow of fluids or gases at extremely high pressures is essential lies in the art of prestressing the bore of cannon barrels by cold working to effect an increased yield strength of the steel constituting such barrels.

It is therefore an object of this invention to provide a system whereby very high hydraulic pressures can be generated and whereby such pressures will yield a steady flow of fluid.

It is a particular object of this invention to provide a system comprising a series of hydraulic intensifier units arranged in functional parallelism and operated in a progressive overlapping sequence to obtain a steady flow of fluid at high pressures.

The specific nature of the invention as well as other objects and advantages thereof will clearly appear from a description of a preferred embodiment as shown in the accompanying drawings in which:

Fig. 1 shows a schematic arrangement for a series of single-acting hydraulic intensifier units connected in functional parallelism.

Fig. 2 shows a schematic arrangement for a series of double-acting hydraulic intensifier units connected in functional parallelism.

In the preferred embodiment of Fig. 1 there is shown a plurality of intensifier units each consisting of an outer structure having a top and bottom circular plate 2 and 2a bolted as shown at 3 in cylindrical relationship by tie rods 4. Within this structure, a cylinder 5 is rigidly mounted to bottom plate 2a and a piston member

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6 is rigidly secured to top plate 2 in axial alignment with cylinder 5. A cylindrical ram member 7 having an axial cylindrical recess 8 is mounted for reciprocating movement within cylinder 5. Piston 6 and ram 7 cooperate in a piston-cylinder relationship and ram 7 and cylinder 5 also cooperate in a piston-cylinder relationship. It is apparent therefore that ram 7 functions as a piston in its relation to cylinder 5 and as a cylinder in its relation to piston 6. Cylindrical recess 8 thus defines a high-pressure chamber for the pressure fluid of the system while the interior of cylinder 5 acts as a medium-pressure chamber 9 for the operating fluid of the system.

A pump 10 provides a constant supply of fluid under medium pressure for operation of the intensifier units. Such fluid is obtained from a reservoir 11 connected to pump 10 by a feed line 12. A relief line 13 also communicates with reservoir 11 for the passage of operating fluid when the intensifier unit is in the down stroke. The fluid is pumped through a supply line 14 and then through a conventional solenoid-operated valve 15 to a lead-in line 16 which extends into medium-pressure chamber 9. Relief line 13 communicates with lead-in line 16 and includes a second solenoid-operated valve 17 which when open returns fluid to reservoir 11.

In the preferred embodiment, an auxiliary pump 18 is provided for furnishing fluid at low pressure through a supply line 19, such fluid being eventually delivered from the intensifier units at the high pressure for which the system is designed. This fluid is originally obtained from a reservoir 20 connected to pump 18 by a feed line 21. In the event of a temporary failure of one or more intensifier units, a safety line 22 having a safety valve 23 therein, by-passes pump 18, and prevents any dangerous build-up of pressure. It is to be distinctly understood, however, that this invention contemplates in addition, the case where the fluid provided by pump 10 for operation of the intensifier units is also to be admitted to chamber 8 for delivery at high pressure, thus requiring the use of but one pump.

Supply line 19 is provided with check valves 24, one for each unit and arranged to permit the flow of fluid through piston 6 into chamber 8 but designed to prevent back flow into pump 18. A manifold supply line 25 having check valves 26 therein, one for each intensifier unit to prevent back-flow of fluid through piston 6, provides a passage for the high pressure fluid from chamber 8. Manifold line 25 and supply line 19 both communicate with a lead-in line 27 which extends

through piston 6 into chamber 8 of each intensifier unit. A pressure gage 28 is included in manifold supply line 25 for recording the pressure available for the work to be done.

A pair of motor driven multiple-point rotary switches 29 of conventional design are provided to operate valves 15 and 17 in proper sequence in such manner that at no time will all the intensifier units be in a pump-down phase or pump-up phase. Rather the units should operate in a progressive overlapping sequence. It should be understood that there are a variety of means adapted for the proper synchronization of the units, and this invention is not intended to cover any particular one of such means.

Assuming ram 7 to be in the starting position at the bottom of cylinder 5, the operating cycle of each intensifier unit begins with valve 15 opening and valve 17 closing. As a result, fluid from reservoir 11 is admitted under medium pressure into chamber 9. Under the force of this medium pressure, ram 7 moves upward compressing the fluid present in chamber 8 to build up a pressure directly proportional to the ratio of the pressure areas of ram 7 and piston 6. This high-pressure fluid is thus forced out of chamber 8 through lead-in line 27 and past check valve 26 and into manifold supply line 25. Check valve 24 prevents any of this fluid from being forced into supply line 19 and therefore into pump 18. When ram 7 has reached the end of its normal stroke, rotary switches 29 open valve 17 and close valve 15. Thereupon check valve 24 opens and check valve 26 closes due to the absence of high pressure fluid in lead-in line 27. Thus the fluid in chamber 9 is permitted to drain back to reservoir 11 and ram 7 consequently moves downwardly. The fluid being pumped from reservoir 20 under low pressure through piston 6 into chamber 8 in preparation for the next stroke of the intensifier unit helps return ram 7 to the starting position for the next cycle of operation. A double-pole safety switch 30 mounted in each intensifier unit prevents any further action of that particular unit in the event of a breakdown. A contact 46 projects from ram 7 and operates switch 30 in the event ram 7 is forced beyond its normal length of stroke in either direction. As a result valves 15 and 17 immediately reverse themselves thereby avoiding the damage which such high pressures would most certainly cause to the cylinders of the unit.

The intensifiers illustrated in Fig. 2 differ from those in Fig. 1 in that power strokes are made in each direction. To this end each unit consists of a cylinder 31 having oppositely disposed pistons 32 and 32*a* each rigidly secured within the interior of cylinder 31. Pistons 32 and 32*a* are concentric with cylinder 31 and in axial alignment with one another. A cylindrical ram member 33 having axial cylindrical recesses 34 and 34*a* in each end is mounted for reciprocating movement in cylinder 31. Recesses 34 and 34*a* align with and engage pistons 32 and 32*a* respectively in a cylinder-piston relation, whereas cylinder 31 and ram 33 also cooperate in a cylinder-piston relation. Thus medium-pressure chambers 35 and 35*a* and high-pressure chambers 34 and 34*a* are defined as ram 33 reciprocates.

A low-pressure pump 36 supplies fluid to chambers 34 and 34*a* and a medium pressure pump 37 supplies fluid to chambers 35 and 35*a* in a manner similar to that explained in Fig. 1. Check valves 38, 38*a*, 39 and 39*a* and solenoid operated valves 40, 40*a*, 41 and 41*a* also operate in the manner described for Fig. 1.

At the beginning of upstroke of ram 33, valves 40 and 40*a* are open and valves 41 and 41*a* are closed. This permits fluid to be pumped against the underside of ram 33 forcing it upward and permits the fluid in chamber 35*a* to drain back to the reservoir for pump 37. The fluid in chamber 34*a* is thus compressed and forced out at a high pressure thereby closing check valve 39*a* and opening check valve 38*a* when the pressure developed is in excess of that already existing in a manifold line 42. At the end of the upstroke solenoid-operated valves 41 and 41*a* open and valves 40 and 40*a* close. Thus the direction of ram 33 is reversed and high pressure is consequently developed in chamber 34, the fluid passing into manifold line 42 as explained above until solenoid-operated valves 40 and 40*a* open and valves 41 and 41*a* close to initiate another cycle of operation. A safety valve 43 for pump 36 and safety switches 44 for each intensifier unit operate in a manner similar to that shown in Fig. 1. However, additional emergency solenoid operated valves 45 are provided for immediate relief flow of fluid from each intensifier unit in the event safety switches 44 do not reverse valves 40, 40*a*, 41 and 41*a* quickly enough, thereby preventing damage to such intensifier unit which fails to operate normally. Each intensifier unit is grounded to permit such emergency relief action. The normal closing and opening of the regular solenoid-operated valves is controlled by a motor driven multiple-point rotary switch 47 of conventional design.

It is therefore apparent that by using a series of hydraulic intensifier units arranged in functional parallelism and operated in a progressive overlapping sequence whereby a plurality of the intensifier units are at all times in the compression phase, a steady flow of fluid or gases at high pressures can be easily obtained.

I claim:

1. A hydraulic system for delivering a continuous and steady flow of fluid at high pressure comprising in combination, a series of hydraulic intensifier units having a compression stroke and a relief stroke, each of said intensifier units having a medium pressure chamber and a high pressure chamber, said medium pressure chamber having a supply valve adapted to supply medium pressure fluid thereto during said compression stroke and a relief valve adapted to permit escape of said medium pressure fluid therefrom during said relief stroke, a first check valve for said high pressure chamber adapted to permit entry of low pressure fluid thereto during said relief stroke, a second check valve for said high pressure chamber adapted to permit delivery of fluid therefrom during said compression stroke, and means for successively adjusting said supply valves and said relief valves whereby said hydraulic intensifier units are operated in progressive overlapping sequence with a plurality of said intensifier units in compression stroke at all times.

2. A hydraulic system for delivering a continuous and steady flow of fluid at high pressure comprising in combination, a series of hydraulic cylinders having oppositely disposed cylinder heads, each of said cylinders being provided with oppositely disposed fixed pistons extending inwardly toward one another in axial alignment from said cylinder heads, a ram reciprocally engaged in each of said cylinders in a piston-cylinder relation,

said cylinder and said ram thereby defining a medium pressure chamber in each end of said cylinder, said ram having a recess in each end thereof adapted to slidably engage said corresponding fixed piston in a cylinder-piston relation thereby defining a high pressure chamber in each end of said ram, each said medium pressure chamber and each said high pressure chamber cooperating to form a compression unit, each of said hydraulic cylinders thereby comprising a pair of oppositely acting said compression units arranged whereby the compression phase for one of said compression units corresponds to the relief phase of the other end oppositely acting said compression unit, a supply valve for each medium pressure chamber adapted to supply medium pressure fluid thereto, thereby instituting movement of said ram whereby each of said recesses therein cooperates with said corresponding oppositely disposed fixed piston in compression phase, a relief valve for each of said medium pressure chambers adapted to permit escape of said medium pressure fluid therefrom during said relief phase, a first check valve for each of said high pressure chambers adapted to permit entry of low pressure fluid thereto during said relief phase, a second check valve for each of said high pressure chambers adapted to permit delivery of fluid therefrom during said compression phase, and means for successively adjusting said supply valves and said relief valves whereby said hydraulic intensifier units are operated with said compression units functioning in overlapping sequence, a plurality of said compression units being in compression phase at all times.

DONALD H. NEWHALL.

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