Feb. 7, 1950 S. L. GILLESPIE 2,496,284

CONTROL APPARATUS

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Fig. 1

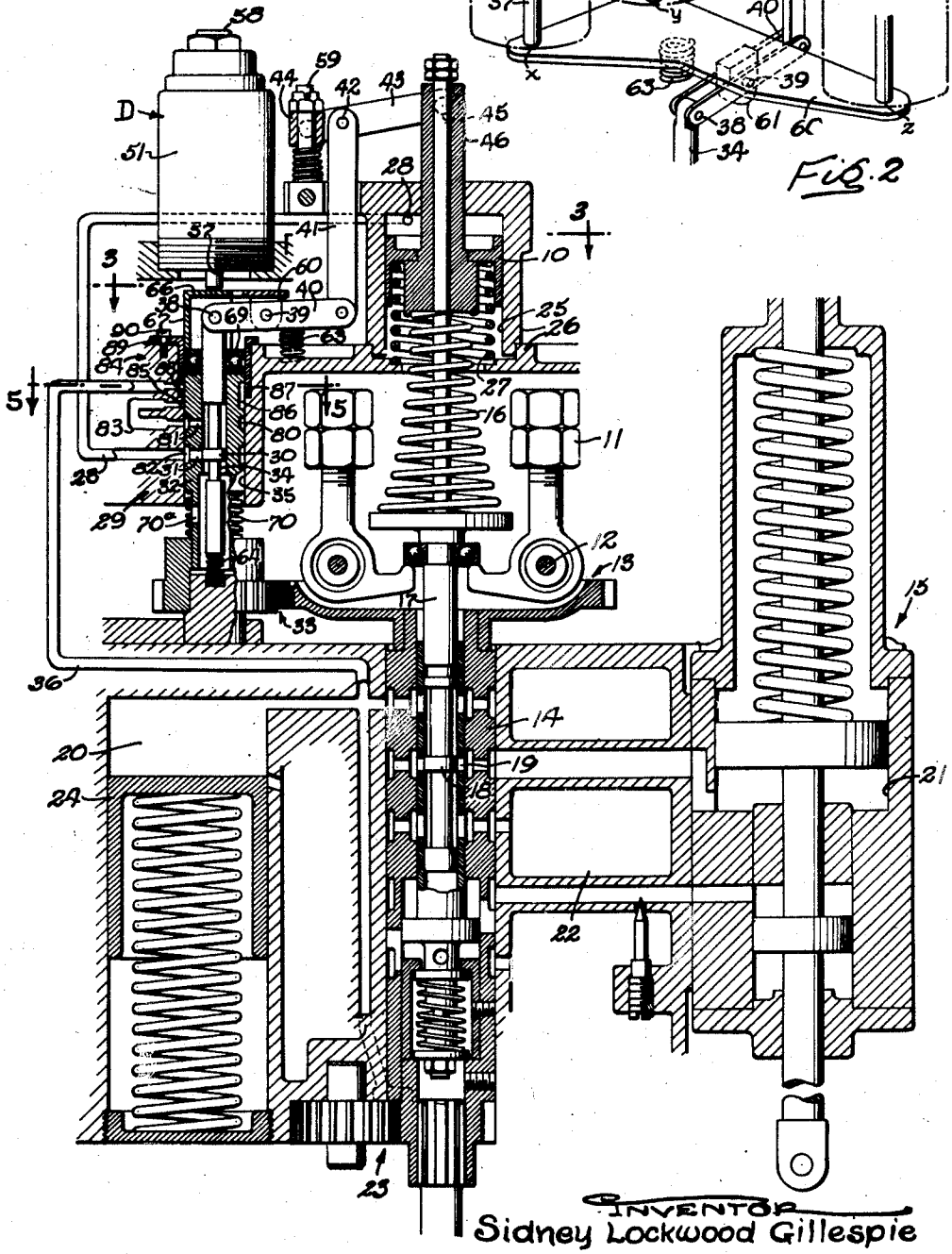


Fig. 2

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Fig. 3

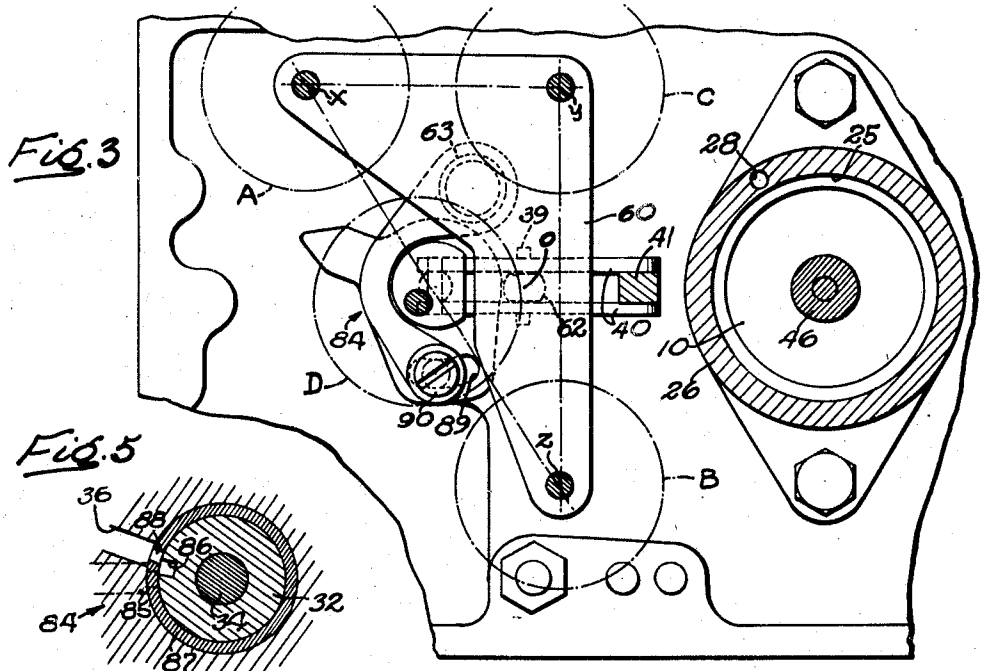
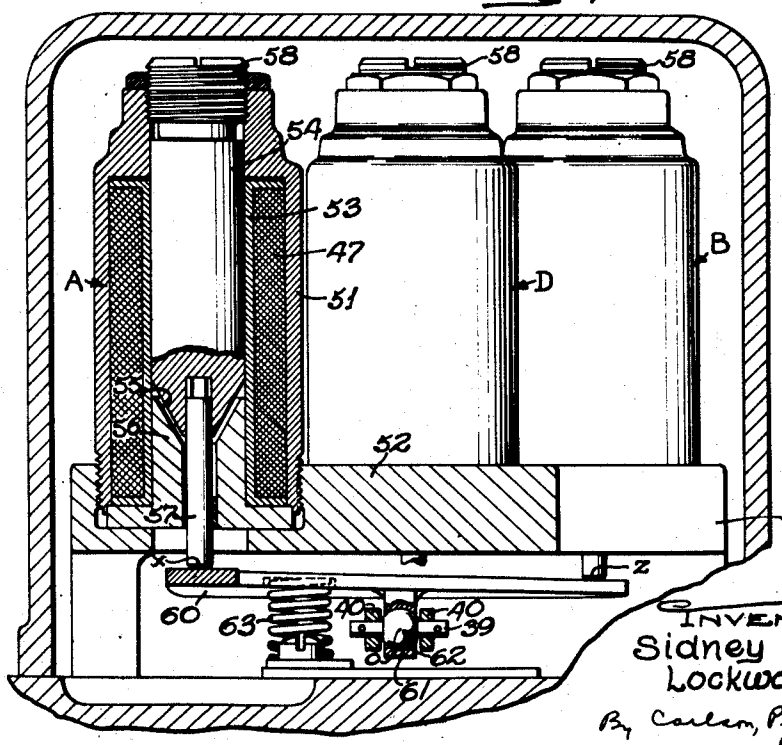


Fig. 5

Fig. 4



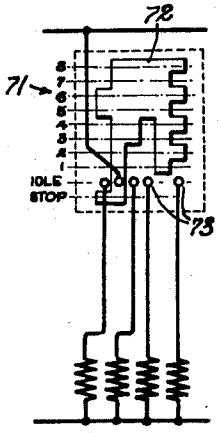


Fig. 6

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Patented Feb. 7, 1950 2,496,284

UNITED STATES PATENT OFFICE

2,496,284

CONTROL APPARATUS

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Application May 3, 1945, Serial No. 591,809

2 Claims. (Cl. 318—27)

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This invention relates to an apparatus controllable selectively at one point to correspondingly position an actuated element at a remote point and in certain of its aspects has more particular reference to an apparatus in which the actuated element is positioned by selective energization of a plurality of electromagnets in different combinations.

One object is to provide a mechanism of simple and compact construction for combining the motions of more than two electromagnets to select a correspondingly larger number of positions of the actuated element.

Another object is to combine the magnet motions in a novel manner so as to obtain a large number of different positions of the actuated element.

A further object is to utilize the magnet motions to actuate the control valve of a hydraulic servo.

Still another object is to control the speed of response of the actuated member by controlling the rate of fluid flow in a novel manner.

Other objects and advantages of the invention will become apparent from the following detailed description taken in connection with the accompanying drawings, in which

Figure 1 is a cross-sectional view of a remotely controlled apparatus embodying the present invention.

Fig. 2 is a fragmentary perspective view of the solenoids and the differential mechanism actuated thereby.

Fig. 3 is a sectional view taken along the line 3—3 of Fig. 1.

Fig. 4 is an elevational view of the solenoids and differential mechanism with one of the solenoids shown in diametrical section.

Fig. 5 is a fragmentary section taken along the line 5—5 of Fig. 1.

Fig. 6 is a wiring diagram.

While the invention is of general utility, it is shown for purposes of illustration as a means for changing the position under control from a remote point of an actuated element 10 by which the speed setting of a hydraulic governor is adjusted. Briefly, the governor comprises fly-balls 11 pivoted at 12 on a ball-head 13 carried by the upper end of a ported sleeve 14 which is driven from its lower end by the prime mover whose speed is regulated by a hydraulic servo 15. Centrifugal force on the fly-balls is balanced against the stress of a compression type speeder spring 16 and the fly-ball motion caused by speed changes is applied to the stem 17 of a pilot valve

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having a land 18 which cooperates with ports 19 in the rotating sleeve 14 to permit fluid under constant pressure in a chamber 20 to flow into the servo cylinder 21 or to flow out of this cylinder to a drain chamber 22. Fluid is delivered to the pressure chamber 20 by a gear pump 23 and maintained at constant pressure by the action of a spring loaded accumulator piston 24.

The actuated or speed adjusting element 10 above referred to abuts against one end of the speeder spring 16 and is movable back and forth to increase and decrease the spring load and thereby correspondingly change the speed setting of the governor. Herein, the element 10 constitutes the piston of a hydraulic actuator and reciprocates in a cylinder 25 fastened to the governor casing 26. The piston is urged upwardly by a compression spring 27 and moved downwardly by the admission through a conduit 28 of hydraulic fluid at sufficient pressure to overcome the spring. Such fluid is supplied in the present instance from the pressure chamber 20 under the control of a valve 29 comprising a land 30 formed on a reciprocable stem 34 and cooperating with a port 31 in a sleeve 32. The latter is rotated continuously from the ball-head 13 by gears 33 and is journaled in a bore 35 of the casing 26. Fluid from the constant pressure chamber 20 is supplied to the interior of the sleeve 32 through a passage 36 whose end registers with a valve device 84 which controls the rate at which the energization of the servo may be changed, this being effected in this instance by permitting the flow of fluid to the servo intermittently. For this purpose, a passage 83 terminates in a port 85 in the bore 35 which port registers with a recess 86 extending along the exterior of the sleeve 32. The upper end of the recess is surrounded by a bushing 87 having a hole 88 therein in continuous registry with the end of the passage 36. The hole 88 also registers with the sleeve recess 86 during part of each revolution of the sleeve, and the angle of registry overlaps the angle of registry of the recess and the port 85 so that during such overlap only, a connection is provided between the valve outlet 85 and the servo supply passage 28. By adjusting the bushing 87, the amount of such overlap and therefore the average rate of fluid flow to the servo may be increased or decreased. Such adjustment is effected simply by turning the bushing 87 as permitted by a slot 89 formed in a flange of the bushing, which flange is clamped in adjusted position by a screw 90 threading into the casing

26. By this method of controlling the rate of fluid flow the desired slow rate is thus obtained through ports which are of comparatively large size and therefore not subject to clogging by foreign matter.

The stem 34 of the pilot valve 29 projects from the upper end of the sleeve 32 and is pivotally connected at 38 with one end of a lever 40 fulcrumed on a floating pin 39 and connected at its other end to the lower end of a link 41. The upper end of this link projects from the casing 26 and is pivotally connected at 42 intermediate the ends of a lever 43 fulcrumed on a collar 44 which may be adjusted vertically along a stud 59 projecting from the casing 26. The other end of this lever 43 is pivotally connected at 45 to the outwardly projecting end of the rod 46 of the actuator piston 10.

In accordance with the present invention, provision is made for shifting the lever fulcrum 39 into a relatively large number of positions and through the valve 29 and the hydraulic actuator controlled thereby cause the actuated element 10 to assume corresponding positions. Eight different positions of the valve fulcrum are produced in this instance by energizing three solenoids A, B, C and an auxiliary solenoid D individually or in different combinations. These solenoids are of the same construction, and each comprises a coil 47 within a magnetic shell 51 having one end screw threaded into a supporting plate 52 on the casing 26. A plunger 54 is slidable in the shell and a non-magnetic spool 53 on which the coil 47 is wound, the tapered lower end of the plunger projecting into the conical seat 55 in the upper end of a magnetic plug 56. An actuator pin 57 seated in the plunger 54 projects through the plug to transmit the plunger motion. When the coil 47 is de-energized, the plunger 54 is raised by spring means later to be described to a position determined by an adjustable plug 58. In response to energization of the coil 47, the plunger 54 moves downwardly until its tapered end engages the seat 55, freezing of the two together magnetically being prevented by a thin layer of non-magnetic plating on the tapered plunger end. In the present instance, the three solenoids, A, B, and C are adjusted so that the strokes of their plungers are of equal lengths and approximately .085 of an inch. The armature of the solenoid D moves about .041 of an inch.

The means for combining the motions of the solenoid armatures and actuating the valve stem 30 proportionally, comprises a differentially acting lever comprising a rigid triangle in the form of a plate 60 connected to the actuating pins 57 of the three solenoids A, B, and C at the three points x, z, y constituting the corners of the triangle and to the fulcrum pin 39 of the lever 40 at an intermediate point. The latter connection is formed by a universal joint comprising a ball 62 on the fulcrum pin 39 seated in a socket formed on a lug 61 (Fig. 4) rigid with and depending from the plate 60 so as to locate the center o of the ball within the triangle formed by the plate. A compression spring 63 seated on the casing 26 and a spring 64 acting on the lower end of the valve stem 30 coact to urge the plate 60 upwardly against the rounded lower ends of the actuator pins 57 whose points x, y, and z of contact with the plate define the corners of the triangle on the plate 60. By locating the point of application

of the force of the return spring 63 within the triangle defined by the points o, x, and y and preferably substantially at the center of this triangle as shown in Fig. 3, the triangular plate 60 is utilized as a lever to distribute the force of this spring differentially to the respective solenoids. The resultant forces thus applied for returning the solenoid armatures may thus be substantially equalized.

The perpendicular distances of the sides xy, yz, and xz from the connecting point o are made unequal and related to each other and to the lengths of the triangle sides so that the point o is moved different distances in response to energization of the individual solenoids when, as here, the motions of the solenoids are equal. For example, when the solenoid A alone is energized, the plate 60 pivots about the line yz and the point o moves a distance determined by the ratio of the distance xy to the spacing of o from the side yz, this motion being 16 percent of the motion of the A solenoid armature. The parts are so proportioned that when the solenoids B and C are energized individually, the point o moves 32 and 48 percent as far as the armatures of the solenoids. Various multiples of these one, two and three units of movement may be obtained by energizing the solenoids simultaneously in different combinations. Also, the number of different positions obtainable may be further increased by varying the distance ratios above described.

Also, the number of available positions of the actuated servo member 10 may be doubled through the provisions of a fourth solenoid D arranged to shift the other element or sleeve 32 of the control valve 29 between two positions. For this purpose, the actuating pin 57 of this solenoid is connected to one end 66 (Fig. 1) of an inverted cup 67 which is cut away on one side to permit the lever 40 to be connected to the valve stem 34. The cup 67 is slidable axially with the valve sleeve 32 to which it is connected through a ball thrust bearing 69 thereby permitting continuous rotation of the sleeve. The latter is urged upwardly by a compression spring 70.

Energization of the solenoids A, B, C, and D in different combinations may be effected through an ordinary drum type controller 71 (Fig. 6) formed on its periphery with a conducting area 72 which engages one or more contacts 73 according to the angular position of the drum. Engagement of each contact completes a circuit for energizing its corresponding solenoid, the combinations shown producing idle, stop, and eight other different relative positions of the ports of the valve 29.

For example, if the controller 71 is in the "idle" position as shown in Fig. 6, all four of the solenoids will be de-energized and the parts will be positioned as shown in Fig. 1, the speeder spring 16 of the governor being stressed to maintain an engine speed of 275 R. P. M. for example. Now, if the controller actuator is moved to the third position, the solenoid C is energized, shifting the plate 60 about the fulcrum line xz and moving point o and the valve land 30 downwardly a double increment. Such opening of the valve 29 admits pressure fluid through the periodically registering ports 88, 86, and 85, the valve 29, the passages 28, to the servo cylinder 25 causing the piston 10 to be lowered and with it the follow-up lever 43 and link 41. As the motion continues, the lever 40 swings about its fulcrum 39 gradu-

ally raising the valve stem until the land 30 has been restored to its neutral position with respect to the valve sleeve, whereupon the flow of fluid to the servo is interrupted with the piston 10 in a position corresponding to the changed position of the lever fulcrum 39. This may correspond to a speed setting of 500 R. P. M.

If the controller position is next changed to position No. 8, the three solenoids A, B, and C will all be energized and the lever fulcrum 39 and valve land 30 will be moved downwardly an additional four steps. A further flow of fluid to the servo occurs and in the ensuing follow-up action, the valve land is restored to neutral, when the servo piston 10 reaches a position corresponding to a speed setting of 800 R. P. M.

Assume now that the controller is turned back to No. 6 position in which the solenoid D as well as the solenoids A, B, and C are energized. The positions of the fulcrum 39 and the valve land 30 are not changed, but the valve sleeve 32 is lowered, thereby permitting draining of fluid out of the servo cylinder 25 through the valve 29 and a drain passage 70a at the lower end of the sleeve. In the ensuing raising of the servo piston 10 by the spring 27, the follow-up linkage lowers the valve land 30 gradually until neutral relation of the valve ports is restored with the servo piston in a position corresponding to a 650 R. P. M. speed setting.

In similar ways, the servo piston will be moved to the other available positions when the controller is moved to the corresponding positions. It will of course be apparent that the exact positions of the actuated element 10 for a given position of the controller may be varied somewhat by adjusting the plug 58 of the idle solenoids to thereby vary the position of the fulcrum 39 and therefore the position which the servo assumes when the valve parts are in neutral position. All of the different positions which the servo may assume are determined by the positively limited motions of the solenoid plungers which may be determined accurately so that the servo piston will assume precisely the same position upon each selection of that position by positioning of the controller.

I claim as my invention:

1. A servo control system comprising, three solenoids having armatures movable through strokes of substantially equal lengths, a rigid triangle mounted for bodily floating movement and having its three corners connected to the respective solenoid armatures so as to be moved in the same direction in response to energization of the individual solenoids, a device for controlling the energization of a servo and having a movable part, and means connecting said part to said triangle at a point within the latter spaced different distances from the three respective sides of the triangle, two of which distances are different whole multiples of the third distance.

2. A servo control system comprising, three solenoids having armatures movable through strokes of substantially equal lengths, a rigid triangle mounted for bodily floating movement and having its three corners connected to the respective solenoid armatures so as to be moved in the same direction in response to energization of the individual solenoids, a device for controlling the energization of a servo and having a movable part, means connecting said part to said triangle at a point within the latter spaced different distances from the three respective sides of the triangle, two of which distances are different whole multiples of the third and shortest distance, and a return spring acting on said triangle in opposition to said solenoids and at a single second point disposed within the triangle defined by such point and the side of said first triangle which is spaced farthest from said first point.

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