This invention relates to fluid impulse operation of mechanism such as valves and the like, and refers in particular to an improved fluid flow control device for hydraulic actuating systems for the purpose indicated, which may be readily and closely adjusted for regulating the release or return flow of fluid pressure therethrough to any desired degree.

Another object of the invention is to provide a relatively compact and effective control valve device for the purpose indicated, which may be readily employed in fluid pressure systems generally, wherein control devices of this character are required or preferred to afford predetermined desired fluid flow characteristics, the device is particularly suited to hydraulic valve actuating systems for internal combustion engines and the like. Accordingly, it is preferred herein to describe and illustrate the device in operative association with an engine valve actuating system of hydraulic impulse type, of the form and arrangement disclosed in Patent No. 2,396,392 hereinafter. Associated with the cylinder head 35 of the cylinder 11 is a valve assembly embodying a valve (not shown) which is actuated by a hydraulic motor indicated generally at 40 incorporated in the valve assembly as a part thereof. Actuating fluid is delivered to the motor 40 by the pump 23, through a conduit 42 and the control valve device 43 forming the subject of the present invention and hereinafter to be described, the latter by preference being arranged at the discharge end 44 of the pump.

Turning now to the fluid pump and control valve unit 22—23 the pump thereof includes a supporting frame or casing 154 having a mounting flange 155 near its lower end, for assembly securing upon the upper wall of the camshaft housing 22 (Fig. 1), as by mounting studs or bolts 159. The pump plunger (not shown) within casing 154 includes a cam-follower frame 172, the latter operatively supporting a cam-follower roller 175 which engages a cam 176 of a predetermined preferably symmetrical contour not here illustrated, fixed upon the engine camshaft 26 referred to hereinafter. A suitable compression spring not shown, is provided to urge the pump plunger and cam follower downwardly as for maintaining cam-following engagement of the roller 175 with the cam 176.

The fluid pressure delivery from the pump 23
3 is directed through the valve device 43 presently to be described, and through conduit 42 (Fig. 1) to the pressure chamber of the valve motor 48, and upon pressure release of the fluid delivery to the motor as effected by the pump, the fluid is returned to the pump back into the supply header 28. The principal function of the valve device 43 is to check or throttle the return flow of fluid from the valve motor, to a predetermined extent, whereby to prevent oscillatory surging of the fluid column between the pump and valve motor upon pressure release by the pump, as otherwise a hydraulic ramming or so-called hammer effect would or might be produced upon the engine valve, with attendant disruption of smooth engine operation by reason of the resulting ineffective valve closure. By thus throttling the fluid return flow upon pump pressure release, the fluid pressure on the valve motor is relatively gradually released, which thereby allows a correspondingly gradual or attenuated closure of the engine valve in a positive and relatively quiet manner.

As shown by Fig. 2, the valve device 43 comprises as a casing 214 formed to provide a fluid chamber 250 open at the casing end 261, the open end of the chamber normally being closed by a threaded head or cap element 252 sealed against fluid leakage at the opening by a suitable gasket 254. In the intermediate zone of the chamber 250, the casing is formed to provide an annular bevelled shoulder 255 constituting a valve seat for the valve head 256 of a valve element 258. As controlled by valve element 258, the seat 255 may be said to define the main valve port of the device. The valve element which is of substantially tubular form to provide a central longitudinal bore or passage 259, and is externally flanged or spidered rearwardly from the valve head 256, is movable longitudinally in the chamber 250, being guided in such movement by engagement of its changes with the casing wall portion 260 of reduced diameter near the inner end 262 of the chamber. A suitable compression spring 263 bearing at one end against the cap 252 and at its opposite end against a seat 264 on the valve head 256 serves to bias the valve element inwardly of the chamber 250 to seat the valve head on the chamber seat 255. The valve passage 259 at one end 266 thereof, is outwardly bevelled to form an aperture or port opening 267 for cooperation with the pointed end 268 of a needle valve 270, formed of a thermally-sensitive material such as an aluminum alloy, for a purpose to appear, extending axially into the chamber 250 through a casing guide passage 271. The needle-valve passage 271 is internally threaded as at 278, to provide a threaded seat for an enlarged threaded portion 279 on the needle-valve 270. The threaded portion 279 may be provided by a separate collar suitably secured on the needle-valve 270, or as presently preferred, may be formed as an integral part of the valve. As will appear now, the needle-valve 270 is automatically mounted for longitudinal adjustment through its threaded portion 279 in the threaded seat 275, effected upon rotation of the needle-valve element, so as to regulate the position of the port, controlling end 268 thereof relative to the port 267 in the valve main port 259. For preventing fluid leakage along the needle-valve, it is retained and suitably compressed therein by a gland nut or collar 283 in threaded engagement with the casing. The needle-valve is projected outwardly beyond the collar 283, and has secured thereto as by set screw 284, a hand control or knob 286 by which the needle-valve may be manually rotated for effecting adjustment thereof. In order to indicate externally of the valve device, the relative position of the valve tip 288 on needle-valve 270, and the port 267 controlled thereby, any adjusted position of the needle-valve, a pointer 287 may be carried by the knob 286 for cooperation with an appropriate scale (not shown) on the outer end of the casing. Additionally, a readjustable cover or cap 298 may be threaded onto the casing end 266 for protecting the manual control end of the needle-valve.

Fluid communication between the valve chamber 250 at the inner end 262 of port 267 and the discharge passage of the pump, effected by the passage 218 laterally in the valve casing 214 in the case of the cap element 211. On the opposite side of the valve 256 and near the end 251 of chamber 250, is a fluid passage 232 extending from the chamber through a valve casing extension or lateral boss 234, and communicating with this passage is one end of the conduit 42 extending to valve motor 40. Connection of the conduit 42 to the casing extension 234 may be effected by a suitable coupling 235 (Fig. 1). A relief port 296 is provided in a side wall portion of the valve 258, for a purpose which will appear presently.

Turning now to the operation of the presently described control valve, it will be observed that upon the suction or down stroke of the pump plunger, fluid under the upstroke head afforded by the fluid supply source 27, will flow into the pump cylinder and therefrom to the valve chamber 250 through the passage 218. As the engine camshaft through cam 176 thereon, effects upward or delivery displacement of the pump plunger, the fluid ahead of the plunger will be placed under considerable pressure and will react against the valve 258 to displace the same against the bias of valve spring 263, for establishing full fluid discharge through the main port 259 of the fluid under pressure thus passing through port 259 and about the seat 258, and thence through conduit 42 to the engine valve motor 49, causes motor operation to open the engine valve.

Upon pressure release by the pump as the pump plunger approaches or attains the end of its delivery stroke, the fluid in conduit 42 will be released for return through valve device 43 and the pump, to the supply header 28. By reason of the restriction or throttling action of the fluid return flow by the valve device 43, will be presently described, sudden closure of the engine valve is effectively prevented. If such were permitted, a rapid fluctuation or surging of the fluid column between the valve motor and pump, normally would be present, which would tend to produce a fluid hammer effect upon the motor and there-through, upon the engine valve, tending to perhaps cause a rapid partial opening and closure of the valve, with attendant disadvantages of abnormal wear of the valve parts and a noisy valve operation.

Upon pressure release in the system, the spring 263 of valve assembly 43, displaces needle-valve 270 to port-closing position (Fig. 2) relative to the main port 265. However, when this occurs the return flow of fluid to the pump is established at a greatly reduced or attenuated rate of flow, through the valve passage 259 and the port opening 267. The restriction of fluid return-flow through port 267 as determined and controlled by the adjust-

417,217
5. able needle-valve 270 through regulated projection of its port control tip end 288 in the bevelled port opening 267, thus results in retarding closing movement of the engine valve to an extent which corresponds relatively closely to the degree of liquid return flow restriction imposed by the coacting port 267 and needle-valve 270 in any adjusted position of the latter. Although a very small portion of the fluid returned through the pump, normally will be by-passed about the needle-valve controlled port 267 through the small lateral opening 285 in the valve 288, the opening 286 serves principally as a pressure relief expedient, and serves also to dampen oscillations or surges, hence acts to prevent local pressure build-up in the fluid return line from the valve motor 40. In the event the needle-valve 270 is projected inwardly inadvertently or otherwise, to an extent such as to close the throttling port 267 by the valve tip 288. In normal operation, the small leakage at the opening 286 may be readily compensated for by proper adjustment of the needle-valve.

The ports 267 and 286, because small in effective area, exhibit a marked effect in damping out line surges, particularly just after closing of the associated engine valve. As heretofore indicated, the needle-valve 270 is formed from a thermally-sensitive material such as a special aluminum alloy, whereby to provide for automatic or self-adjustment in the return-flow throttling function of the valve device, attained responsively and in accordance with temperature differences in the actuating fluid employed in the system. For example, during initial start or restarting of the engine embodying the present valve-actuating system, the valve-actuating fluid may be relatively cool and hence subject to a greater flow-inertia than obtains when the fluid is relatively warm or at a higher temperature. The thermal contraction of needle-valve 270 results from and in direct proportion to the low temperature of the actuating fluid, thus affords an increased opening of the return-flow port 267 by the retractive displacement of the needle-valve tip 288 relative to the port-opening 267, whereby to compensate for the greater flow-inertia of the fluid throttled in its return-flow through the valve device. Normally and as a result of continued engine operation, the temperature of the actuating fluid may rise to an appreciable degree, in consequence whereof, the needle-valve element 270 will undergo thermal expansion in proportion to the rise in fluid temperature, to increase thereby and in corresponding degree, the return-flow restriction effected by the needle-valve at the port 267. Accordingly, the needle-valve control is thus manually adjustable for regulating the return-flow throttling function of the valve device 43 in accordance with given conditions of engine operation, and is self-adjustable in any control setting of the needle-valve, to compensate for temperature differences of the actuating fluid in the system. The latter as now appears, serves to equalize the throttled return-flow of fluid through the valve device, as changes occur in the temperature of the actuating fluid.

During the throttled return-flow of fluid from the valve motor, a certain portion of the fluid normally will be returned through the pump to the supply header 28, under a pressure determined in part, by the pressure exerted on the fluid by the action of the valve motor 40 in closing the engine valve. That portion of the fluid attaining the header 23 is, however, under sufficient pressure to maintain fluid flow along the header and into the return pipe 32, for return to the fluid source 27.

The foregoing indicates the character of hydraulic engine valve actuation attained by the presently described exemplary system and the control function therein of the throttling valve device forming the subject of the Jention. The control of valve closure afforded by the device 43 upon pump release of fluid pressure on the engine valve, is of particular advantage in the attainment of smooth, quiet and efficient valve operation. While the improved control valve assembly has been described and illustrated herein in association with a fluid impulse actuating system for engine cylinder valves, the application thereof is not so limited, as the device may be readily employed in fluid pressure systems for actuating or controlling the actuation of mechanism other than valves and the like, and for the damping of unwanted oscillation in hydraulic systems generally.

It will be understood, of course, that certain changes or modifications in the several elements of the control valve mechanism and in the arrangement thereof may be effected without departing from the spirit and full intended scope of the invention, as defined by the appended claim.

I claim:

In a discharge valve assembly for a high pressure plunger type pump, a structure forming a valve body having an inlet and an outlet, a valve seat in said body providing communication between the inlet and the outlet, a valve Coaching with said seat, a spring urging the valve into closing position on said seat, said valve having a passage extending therethrough, and an adjustable throttling element mounted in the inlet of the valve body coating with said passage when the valve approaches seating position, the valve being so formed as to provide a second passage therein establishing a continuously open path for fluid flow through the valve at all times, whereby to prevent complete obstruction of flow by the throttling element, or otherwise, in any position of the valve.

HENRY SCHRECK.

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