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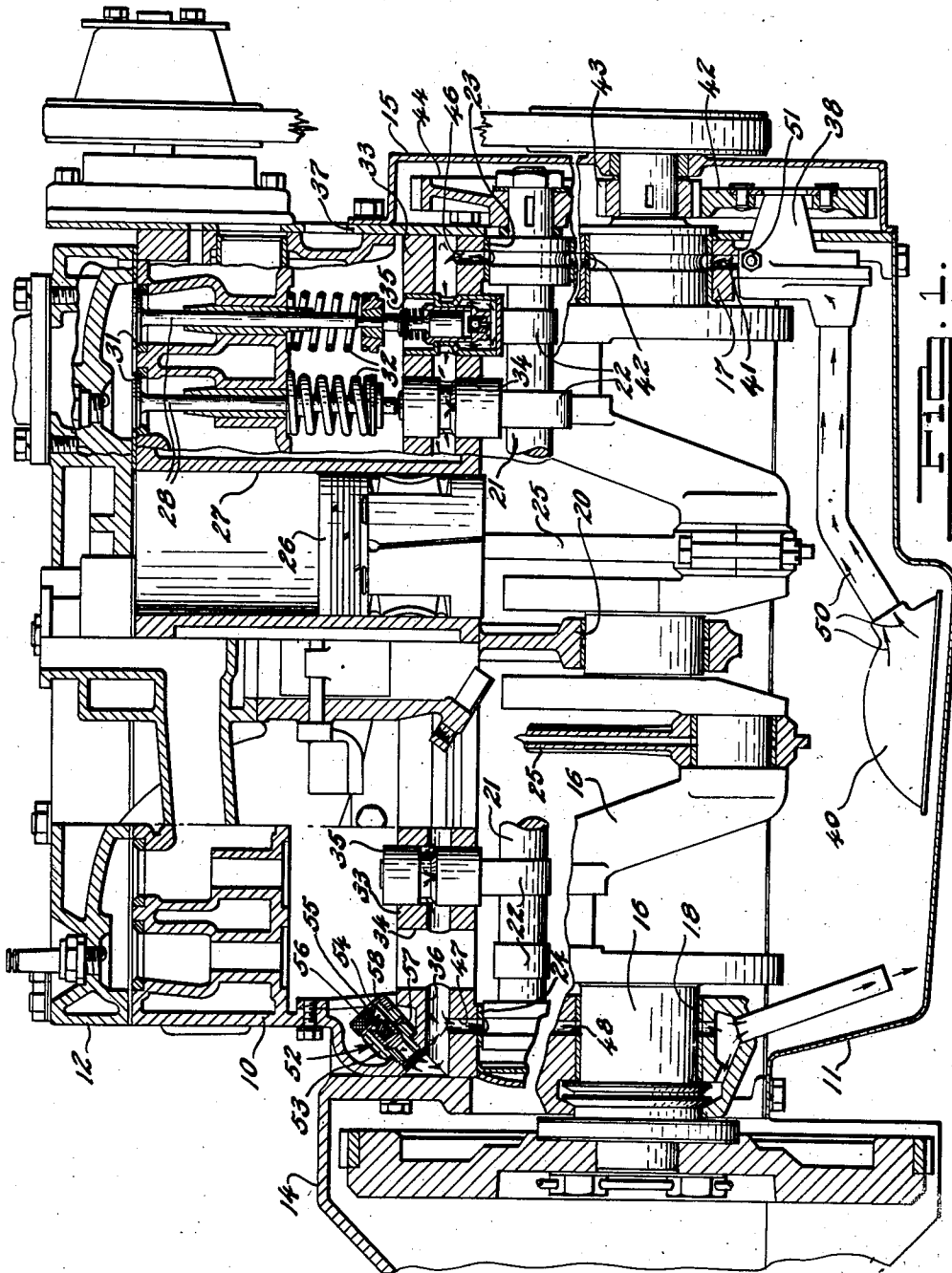
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2,178,732

INTERNAL COMBUSTION ENGINE

Filed April 14, 1938

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

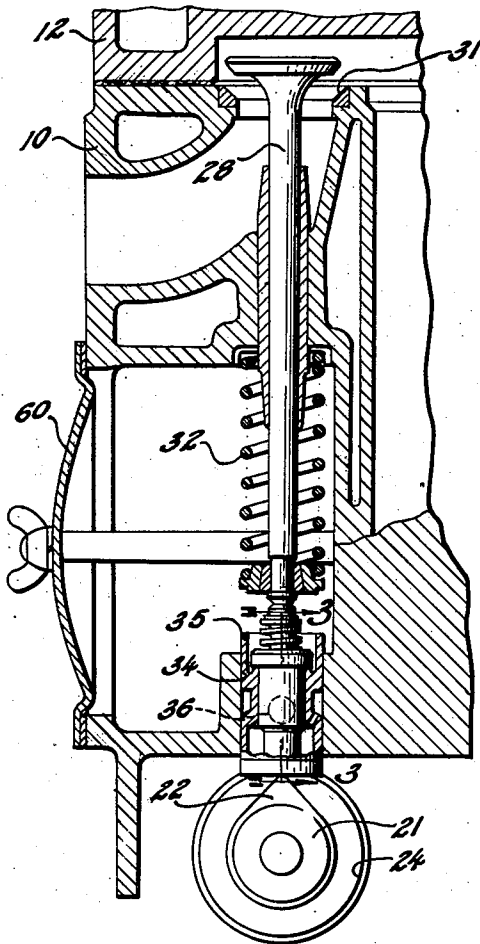


FIG. 2.

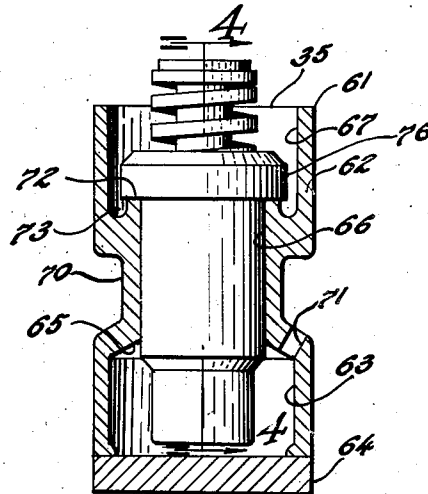


FIG. 3.

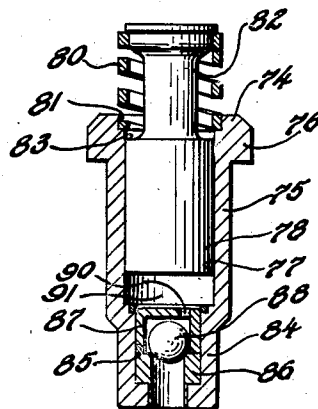


FIG. 4.

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## UNITED STATES PATENT OFFICE

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## INTERNAL COMBUSTION ENGINE

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7 Claims. (Cl. 123—90)

This invention relates to internal combustion engines and more especially to hydraulic, self compensating tappets for the valves of such engines, as well as to the initial and operating supply of liquid medium for such tappets.

The principal object of the invention is to improve the art of internal combustion engines.

Another object of the invention is to provide an improved liquid supply system for hydraulic, self compensating tappets of an internal combustion engine.

A further object is to provide a liquid supply system for filling tappets with liquids and expelling air from such tappets when the engine is conditioned for operation.

Another object is to provide a novel type of hydraulic, self compensating tappet for internal combustion engines.

A further object is to provide a novel method of sealing a separate cylinder of a tappet plunger with reference to the tappet body to prevent leakage of liquid between such elements.

A still further object is to provide a self compensating type of hydraulic tappet of such a design and with parts so proportioned that the tappet will not elongate and follow an engine valve to such an extent as to cause breakage of the engine cylinder head, the engine valve, the tappet, or similar parts, in the event that a sticking condition of an engine valve occurs or an engine valve spring becomes broken or disabled.

Other objects, features and advantages will become apparent from the following description and appended claims taken in conjunction with the accompanying drawings, in which:

Figure 1 is a central longitudinal section of an internal combustion engine with portions broken away to show parts in elevation and depicting the arrangement of tappets for the engine valves and the arrangement of a liquid supply system for such tappets;

Fig. 2 is an enlarged transverse and vertical section taken through a portion of the engine shown in Fig. 1, such section being taken centrally through an engine valve and its tappets and showing certain parts in elevation;

Fig. 3 is a further enlarged section of the tappet such as shown in Figs. 1 and 2, the section being taken on the line 3—3 of Fig. 2; and

Fig. 4 is a section taken on the line 4—4 of Fig. 3.

According to one aspect, the invention involves a liquid supply system for the valve tappets of an internal combustion engine, which system in-

sure a supply of liquid to all of the tappets during operation of the engine and insures filling of the tappets with liquid medium and purging the tappets of air when the engine is initially conditioned for operation, or conditioned for operation after a long idle period.

According to another aspect, the invention involves a novel construction of tappet which in conjunction with the above indicated liquid supply system insures an effective seal between the separate cylinder of a tappet and a tappet body without requiring extremely close fit and polishing surfaces of such elements. The design of the tappet also insures purging the same of air or gas during engine operation, or while conditioning the engine for operation, and at the same time prevents tappets from following a stuck engine valve, or from following an engine valve in the event that its valve spring becomes broken or disabled.

For the purpose of illustrating the genus of the invention, a typical concrete embodiment of an internal combustion engine is illustrated in Fig. 1 and comprises an engine block 10 having a crank case pan 11 and a cylinder head 12 bolted thereto. The flywheel housing 14, and the gear housing 15 are also bolted to the engine block 10 and crank case pan 11. The crank shaft 16 is journaled for rotation in a front main line bearing 17 and a rear main line bearing 18 as well as in an intermediate main line bearing 20, the latter being indicative of any desired number of intermediate bearings, the number employed being mainly dependent upon the number of cylinders provided in the internal combustion engine. A cam shaft 21 provided with valve lifting cams 22 is journaled for rotation in a front bearing 23 and a rear bearing 24. Connecting rods 25 operatively join the crank shaft 16 with pistons 26, which are disposed in the cylinders 27. A pair of intake and exhaust valves 28 are provided for each cylinder 27 and such valves are normally biased into contact with their valve seats 31 by the engine valve springs 32, except when such engine valves are raised from their valve seats 31 by the cams 22.

The engine block 10 is provided with a longitudinally extending portion 33 which in the illustrated embodiment is provided with a plurality of borings 34 disposed vertically and in a common plane as illustrated in Fig. 1, for the reception of the engine tappets 35. The longitudinally extending portion 33 of the engine block 10 is also provided with a longitudinally extending boring 36 interconnecting all of the vertical-

ly disposed borings 34, the forward end of the boring 36 being closed by a plate 37 bolted to the engine block 10 along with the gear housing 15 and the rear end of the boring 36 being closed by the flywheel and clutch housing 14. An oil pump 38 draws oil through the suction pipe 40 from the crank case oil pan 11 and exhausts oil through an outlet 41 which leads into the front main line bearing 17 for the crank shaft 16. The pump 38 is driven by a gear 42 which meshes with a gear 43 fixed to the crank shaft 16 and the latter also drives a gear 44 keyed to the cam shaft 21. A passage 45 connects the front main line bearing 17 to the front bearing 23 of the cam shaft 21 and a passage 46 connects the bearing 23 to the longitudinal boring 36 which supplies oil to the several tappets 35.

Adjacent its rear end, the longitudinal passage 36 is connected by a passage 47 to the rear bearing 24 for the crank shaft 21 and this bearing is connected by means of a passage 48 to the rear main line bearing 18 for crank shaft 16, the oil dumping from bearing 18 back into the crank case pan 11. The movement of oil from the crank case pan 11 to the pump 38, through the front bearings 17 and 23 for the crank shaft and cam shaft, through the tappets 35 through the supply passage 36 therefor, and through the rear bearings 24 and 18 for the cam shaft and crank shaft, is indicated by the arrows 50.

At some point adjacent the forward end of the longitudinal passage 36 or within some passage communicating therewith, provision is made for injecting from a point exteriorly of the engine, oil under a pressure of eighty pounds per square inch, or more, for the purpose of filling the tappets 35 with oil and expelling air therefrom. Any suitable connection may be employed for this purpose. However, in the present instance this is preferably effected by means of a conduit and one-way valve 51 provided at the outlet side of the pump 38 adjacent the passage 41, the conduit extending to a point on the exterior of the engine for accessibility. Adjacent the rear end of the longitudinally extending passage 36 a pressure relief valve 52 is provided.

This valve preferably consists of a fitting 53 threaded to the engine block 10 and provided with an interior cylinder 54 in which a slidably received piston 55 is normally urged by a spring 56 into a position to close a vent passage 57 extending through a wall of the fitting 53. A cap member 58 is threaded on the fitting 53 and may be employed for adjusting the tension of spring 56. The purpose of this pressure relief valve 52 will be described at a later point, and access may be had to this valve upon removal of the inspection plate indicated at 60 in Fig. 2.

Reference may now be had to Figs. 2, 3 and 4 which depict the construction of the preferred form of tappet employed. The tappet 35 comprises a body portion 61 which includes a tubular element 62 of medium tappet steel or steel alloy machined to the form indicated in Fig. 3 and a hard metal cam engaging disc 64 welded thereto. The tubular body 62, prior to the welding of the disc 64 thereto is drilled from the lower end to provide the enlarged bore 63, the tapered bore 65, and a smaller central bore 66. The tubular portion 62 is also bored from the opposite end to provide a large bore 67 of essentially the same diameter as the enlarged bore 63. Approximately midway of its length, the tubular portion 62 of body 61 is provided with a peripheral groove 70 to supply oil or similar liquid medium from the lon-

gitudinal passage 36 to the interior of the tappet through a boring 71. In drilling the boring 67, a square cut shoulder 72 is provided in the tubular portion 62 of tappet body 61 and a recess 73 is countersunk outside the shoulder 72.

Referring more especially to Figs. 3 and 4, the arrangement of a self compensating unit 74 is illustrated which comprises a separate cylinder element 75 provided with an outwardly directed annular flange 76 at its upper end which is adapted to rest upon and be supported by the square cut shoulder 72 above described. The separate cylinder element 75 makes a free sliding fit in the bore 66 of the tubular portion 62 of tappet body 61, which permits the self compensating unit to be dropped into the tappet body. The separate cylinder unit 75 is provided with a cylindrical bore 77 in which the plunger 78 makes a close but sliding fit so that there will be the proper leakdown rate between the periphery of the plunger and the bore 77 in which it is received. A plunger spring 80 frictionally contracts and engages at its upper end with the head portion of the plunger 78 and expands at its lower end into a notch 81 provided at the upper end of the separate cylinder 75. The head portion of the plunger 78 is cut away as indicated at 82 to prevent interference with the spring 80, and to provide a shoulder 83 engageable with the lower coil of spring 80 which frictionally engages the notch 81 to prevent excessive extension of the plunger 78 outwardly from the separate cylinder 75. The lower end of the separate cylinder element 75 is of reduced diameter as indicated at 84, and in a reduced diametered bore 85 thereof are press fitted a valve seat insert and suction tube 86 and a valve retaining cage 87. A ball check valve 88 is assembled within the cage 87 and restricted thereby to limited movement relative to the valve seat insert 86. The valve retainer or cage 87 is perforated as indicated at 90 to permit upward movement of liquid therethrough.

The enlarged boring 63 at the lower end of the tappet body 61 and the beveled passage 65 constitutes a reservoir or oil supply chamber from the lower end of which oil may be drawn upwardly through the valve seat insert and suction tube 86, past the check valve 88 and through the valve retainer cage 87 into a hydraulic compression chamber 91 as the plunger 78 is extended outwardly relative to the separate cylinder 75 under the influence of spring 80. This permits the self compensating unit to maintain a no clearance relation between the engine valve 28 and the upper end of the plunger 78 under decreasing temperature conditions of the engine and as the valve 28 and engine block 10 contract. During increasing temperature conditions of the engine block and engine valves 10 and 28, pressure on the upper end of the plunger causes a slight leakage between the plunger 78 and the bore 77 permitting the tappet to contract to compensate for elongation of engine valve and engine block. As the engine valve 28 is lifted by the cam 21, pressure on the upper end of the plunger 78 increases the pressure upon the oil within the hydraulic compression chamber and forces the check valve 88 against the valve seat insert 86 to maintain the plunger 78 in the desired adjusted position. The check valve 88 normally seats under the influence of gravity against the valve seat insert 86 except as it is lifted from its seat because of vacuum conditions created within the hydraulic compression chamber 91

as the spring 80 causes outward movement of the plunger 78 relative to the separate cylinder 75. As previously indicated, no attempt is made to effect a close fit between the outer periphery of the separate cylinder 75 and the boring 66 so that oil could leak freely therebetween except as checked and sealed by engagement of the supporting and sealing flange 76 on the square cut shoulder 72 of the tappet body 61.

The flange 76 and square cut shoulder 72 provide an upper end suspension means for the self compensating unit 74. The provision of the flange 76 and square cut shoulder 72 provides a far more effective seal than would be possible if attempt were made to effect a close fit and polished cooperating surfaces between the periphery of the separate cylinder 75 and the bore 66.

Referring to Figs. 2 and 3, it will be noted that the flange 76 is spaced from the wall of the bore 67 so that no oil seal can be effected between the periphery of flange 76 and the wall of bore 67. This spacing of the flange 76 relative to the wall of the boring 67 prevents the liquid supplied from the normal lubricating system of the engine from lifting the self compensating unit by force applied to an effective area greater than that of the central portion of the separate cylinder unit 75. If the flange 76 were large enough to make a close fit with the wall of bore 67, it would increase the effective cross-sectional area of the self compensating unit to an area approximately equal to that of the bore 67. This would make it much easier for the lubricant of the conventional lubricating system of an automobile to lift the self compensating unit. If, for example, it is assumed that a  $\frac{1}{8}$ " diameter plunger 78 is employed, and that the oil pressure of the engine lubricating system does not reach a maximum of over fifty pounds per square inch, during normal operation of an engine, then the area acted upon by the oil pressure tending to force the plunger outwardly of the cylinder would be approximately  $\frac{15}{100}$  of one square inch, and the plunger would tend to be forced outwardly by a force of approximately seven and one-half pounds. The lubricant under pressure would also tend to lift the self compensating unit and would act upon a cross-sectional area approximately that of the bore 66 which would be about 0.277 square inches, but since the pressure tending to force the plunger outwardly relative to the separate cylinder reacts to hold the separate cylinder in the bore of the tappet body, the maximum force tending to lift the tappet cylinder relative to the tappet body would be the product of the maximum oil pressure, for example, about fifty pounds per square inch, times the difference in area of the separate cylinder and plunger which is approximately 0.127 or approximately a force of 6.35 pounds tending to push the self compensating unit out of the bore of the tappet body. Thus within the operating range, a seven to ten pound plunger spring 80 would hold the self compensating unit in the bore 66 against the pressure of the oil in the lubricating system of the engine. However, in the event of a stuck engine valve or broken or disabled valve spring, when the plunger 78 moves upwardly approximately  $\frac{1}{4}$  of an inch from operating position, the bottom coil of the spring 80, which is frictionally engaged with the wall of the groove 81, engages the shoulder 83 of plunger 78 which eliminates the effect of the plunger spring 80 so far as holding the unit in

its cylinder is concerned and leaves the pressure of about 6.35 pounds tending to lift the unit out of the tappet body. In as much as oil supplied to the tappet does not pass through any non-return valve except the check valve 88 and the plunger is prevented from moving outwardly by means of the plunger spring 80 and cooperable shoulder 83, the self compensating unit can be moved back rapidly into the tappet body with a pressure slightly over six pounds and no damage can be done to the cylinder head, engine valves, or tappet parts. As soon as the self compensating unit has been lifted to unseat the flange 76 from the square cut shoulder 72, the seal between the self compensating unit and the tappet body is broken. This will also tend to lessen the force required for lowering the compensating unit into the tappet body in the event of a stuck engine valve or broken or disabled engine valve spring.

The beveled passage 65 facilitates escape of air from the reserve chamber provided by this beveled passage and the enlarged bore 63. The air can flow upwardly through the beveled passage 65 and the clearance between the periphery of the separate cylinder 75, and the wall of bore 66, and escape between the supporting shoulder 72 and flange 76 particularly during the period when the cam 22 is not elevating an engine valve 28.

When initiating operation of a new engine or conditioning an engine for operation after a long idle period, it is desirable to expel all air from the tappet and fill the reserve chamber provided by the enlarged bore 63 and beveled passages 65 as well as the compression chambers 91 of the tappets with oil which is free from air.

Referring also to Fig. 1, oil under a pressure of above eighty pounds per square inch for tappets equipped with a seven to ten pound plunger spring may be injected into the lubricating system of the engine by means of the conduit and check valve 51 provided in conjunction with the pump 38 as indicated in Fig. 1. Injection of oil at a pressure above eighty pounds per square inch would lift the self compensating unit relative to the tappet body to break the seal between the shoulder 72 and flange 76 permitting the escape of air from the reservoir 63 and insuring that all of such reservoirs would be filled in order to condition the engine for operation. Once the tappets have been filled with oil, the plungers 78 under the influence of their plunger springs 80 will function in conjunction with the check valve 88 to pump oil into the hydraulic compression chambers 91 and the reservoir 63 will be supplied with oil from the conventional lubricating system of the engine. During the injection of such oil under high pressure into the lubricating system for the purpose of filling the tappet, it is noted that the inspection plate 60 would be removed and that either the vent 57 of pressure relief valve 52 could be closed or a solid piece or heavier spring substituted for the spring 56 thereof. This would insure delivery of oil under high pressure to all of the tappets of the system. Once the tappets have been supplied with oil, the pressure relief valve 52 is conditioned to act under the influence of its spring 56 which may be so adjusted as to such tension that it will relieve at a predetermined pressure and insure flow of lubricant to all of the tappets 35 and throughout the longitudinally extending passage 36. The bearings 24 and 18 will be supplied with oil under pressure, the maximum pressure of which will be approximately that predetermined

pressure at which the pressure relief valve 52 is set to open. As previously indicated, the cap 53 of the pressure relief valve 52 may be employed for adjusting the pressure at which this valve will afford relief. It is noted that the flow of oil through the cam shaft bearing 23 and passage 36 is ordinarily sufficient to supply the reservoirs of all tappets, but, as an added precaution, the provision of pressure relief valve 52 insures adequate flow to all of the tappets.

As many changes could be made in the above construction, and many apparently widely different embodiments of this invention could be had without departing from the spirit thereof, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

20 1. In an internal combustion engine, the combination with a plurality of hydraulic valve tappets, of an engine block provided with a like number of cylindrical tappet guide bores through a wall of said block and receiving said tappets, 25 said tappet guide bores having their axes extending in substantially the same direction and lying in a common plane, a straight line passage extending through all of said bores, a source of liquid supply, a pump arranged between and communicating with said source of liquid supply and one end of said straight line passage for furnishing liquid to said tappets, and a pressure relief valve communicating with the other end of said straight line passage.

35 2. In an internal combustion engine, the combination with a plurality of hydraulic valve tappets, of an engine block provided with a like number of cylindrical tappet guide bores through a wall of said block and receiving said tappets, 40 said tappet guide bores having their axes extending in substantially the same direction and lying in a common plane, a straight line passage extending through all of said bores, a source of liquid supply, a pump arranged between and communicating with said source of liquid supply and one end of said straight line passage for furnishing liquid to said tappets, and an adjustable pressure relief valve communicating with the other end of said straight line passage.

50 3. In an internal combustion engine, the combination with a plurality of hydraulic valve tappets, of an engine block provided with a like number of cylindrical guide bores through a wall of said block and receiving said tappets, said 55 tappet guide bores having their axes extending in substantially the same direction and lying in a common plane, a straight line passage extending through all of said bores, a source of liquid supply, a pump arranged between and communicating with said source of liquid supply and one end of said straight line passage for furnishing liquid to said tappets, a pressure relief valve communicating with the other end of said straight

line passage, and an admission means adjacent said pump for supplying liquid at a higher pressure to said straight line passage than the pressure at which liquid is normally delivered to said passage by said pump.

4. In a valve tappet of the hydraulic type comprising a tappet body having a bore closed at its lower end, a self compensating unit including a separate cylinder, plunger, and plunger spring, said unit being insertable into said bore, the bore of said tappet body being enlarged at its upper end to provide a shoulder adjacent the upper end of said separate cylinder, and an outwardly extending portion of the upper end of said separate cylinder adapted to engage the shoulder for supporting the self compensating unit.

5. In a valve tappet of the hydraulic type comprising a tappet body having a bore closed at its lower end, a self compensating unit including a separate cylinder, plunger, and plunger spring, said unit being insertable into said bore, the bore of said body being enlarged at its upper end to provide a shoulder adjacent the upper end of said separate cylinder, and an outwardly extending portion of the upper end of said separate cylinder spaced from the walls of said enlarged portion of the bore of the tappet body and adapted to engage said shoulder for supporting the self compensating unit.

6. In a valve tappet of the hydraulic type comprising a tappet body having a bore closed at its lower end, a self compensating unit including a separate cylinder, plunger, and plunger spring, said unit being insertable into said bore, the bore of said tappet body being enlarged at its upper end to provide a shoulder adjacent the upper end of said separate cylinder, and an outwardly extending annular flange on the upper end of said separate cylinder engageable with the shoulder of said tappet body for supporting the self compensating unit, said flange being spaced from the wall of the enlarged portion of the bore at the upper end of said tappet body.

7. In a valve tappet of the hydraulic type comprising a tappet body having a bore closed at its lower end, a self compensating unit including a separate cylinder, plunger, and plunger spring, said unit being insertable into said bore and terminating in a reduced tubular portion at its lower end, the bore of said tappet being enlarged at its upper end to provide a shoulder adjacent the upper end of said separate cylinder, an annular flange portion on the upper end of said cylinder engageable with the shoulder of said tappet body for supporting the self compensating unit, said flange having its outer peripheral surface spaced from the wall of the enlarged portion of the bore and the upper end of said tappet body to prevent a sealing effect therebetween, and the bore of said tappet body being enlarged at its lower end to provide a liquid reservoir within the tappet body.

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