May 8, 1956 O. H. BANKER 2,744,509

HYDRAULIC TAPPET

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Fig. 1

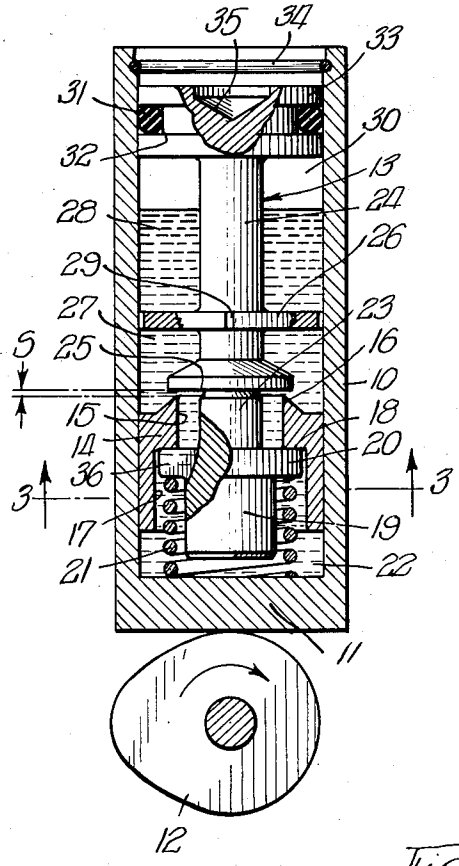


Fig. 2

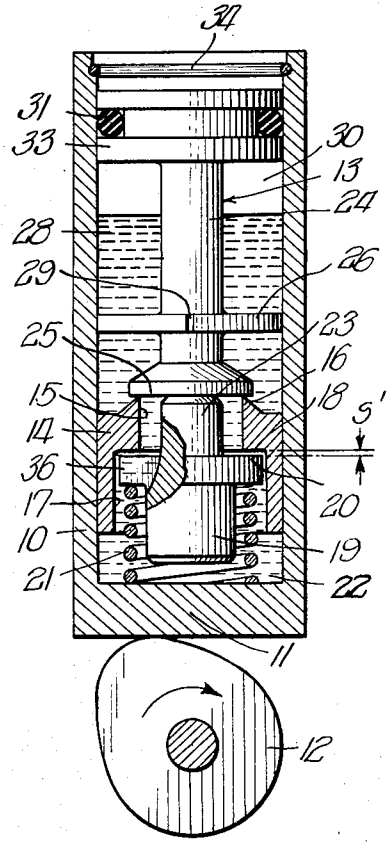
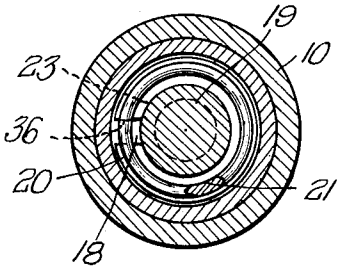


Fig 3.



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HYDRAULIC TAPPET

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5 Claims. (Cl. 123—90)

The present invention relates to improvements in a hydraulic tappet. Such tappets are employed in transmitting thrust between an automotive engine valve and its actuating cam during a valve opening and closing cycle, insuring quiet operation by maintaining a constant contact of the tappet with the valve stem and cam.

It is a general object of the invention to provide improvements which provide a built-in "back lash" in a constantly engaged tappet of this type. Thus a predetermined upward shifting of the body of the tappet by the cam is ineffective to lift the valve, due to relative lost motion action within the tappet, in general accordance with the action shown and described in my Patent No. 2,580,382 of January 1, 1952. The time interval determined by the lost motion portion of the stroke can be easily selected and set by changing the relative dimension of certain portions of the improved tappet, enabling the tappet to commence lifting of the valve at any desired time after the valve starts to lift the tappet body, yet without losing contact with the cam and valve stem. This is an important feature in a tappet which is adapted for use both as an initial component of an engine and also as a replacement or conversion part to be substituted for a mechanical tappet.

The improvements particularly deal with structural simplification of the parts which function in combination to these ends, permitting more economical manufacture and assembly of the tappet without sacrifice of operating efficiency. The number of relatively moving parts is also reduced to a minimum.

Specifically, it is an object to provide a hydraulic tappet made up of a three part plunger structure mounted in a cam actuated external body, and a spring which acts between the plunger structure and body in a direction to urge parts of the former for engagement with one another in opposition to the force of a conventional valve spring. The proportioning of the axial length of a first part of the plunger structure, in the axial space between its surfaces which engage the second and third parts, is so related to the axial space between the points so engaged as to produce the optionally variable lost motion delay referred to; and this involves the use of simple metal components which are easily and quickly machined in quantity production and individually involve no assembly time.

Another object of the invention is to provide a built-in back lash type of tappet as described in the preceding paragraph, which features an internal liquid storage and supply chamber subdivided by a portion of the plunger structure into vertically spaced primary and secondary reservoirs. These have the effect of maintaining in a purely liquid condition, without entrained air, a volume of compression liquid in the primary reservoir to replenish the hydraulic column employed on each upward stroke of the tappet. The secondary reservoir contains a further volume of relatively turbulent liquid in downward communication with the primary reservoir and provide an

expansion air space above the liquid level therein to accommodate a rise in the level under certain operating contingencies.

Still more specifically, it is an object of the invention to provide a structurally simple and compact hydraulic tappet made up of a cam-actuated hollow cylindrical body member, and a composite lost motion plunger structure shiftable axially therein to control opening and closing of a member such as an automotive tappet valve. This structure merely comprises a unitary hollow tubular plunger member frictionally engaging the internal wall of the body and a two-piece plug-plunger unit having relative lost motion travel in relation to the tubular plunger member to permit valved flow of liquid through the latter in certain parts of the operating cycle and seal off flow in other parts of the cycle. One part of this unit is equipped with a radial flange slidably engaging the internal wall of the body and subdividing the space in the latter above the tubular plunger member into primary and secondary reservoirs of the sort referred to above.

The plunger member of the plug-plunger unit is also equipped with an annular non-metallic O-ring frictionally engaging the body wall to seal the same from atmosphere, preferably at the top of the secondary reservoir, this O-ring at the same time acting as a frictional brake to prevent "toss up" of the plunger structure under extremely high speed operation of the tappet. The plug member of the unit applies the force of a tappet spring to the plunger structure as a whole, opening its valve space during the desired lost motion phase of operation.

The foregoing statements are indicative in a general way of the nature of the invention. Other and more specific objects will be apparent to those skilled in the art upon a full understanding of the construction and operation of the tappet.

A single embodiment of the invention is presented herein for purpose of illustration. It will be appreciated that the invention may be incorporated in other modified forms coming equally within the scope of the appended claims.

In the drawings:

Fig. 1 is a view in vertical axial section through the tappet in one phase of its operating cycle, the view being partially broken away to more clearly illustrate structural details and relationships;

Fig. 2 is a view in section similar to Fig. 1, illustrating the tappet in another phase of operation; and

Fig. 3 is a view in horizontal section along a line corresponding to line 3—3 of Fig. 1.

Referring to Figs. 1 and 2 of the drawings, the improved tappet comprises a hollow cylindrical body **10** which is suitably guided by appropriate provisions (not shown) in an automotive engine block. Its closed bottom plate **11** rides an engine driven cam **12** in the usual manner. The tappet illustrated is a self-contained type, in that the body **10** is prefilled with a hydraulic liquid, such as a suitable grade of lubricating oil, and operates thereafter as a sealed unit; however, the tappet liquid may also be engine supplied through suitable communicating provisions in the tappet body guide, which are well known in character. In either of these adaptations, the tappet will preferably include its illustrated divided reservoir feature, to be described, to prevent aeration of its hydraulic operating column.

A composite plunger structure generally designated **13** is coaxially mounted in the interior of body **10**. It includes a hollow, tubular, barrel-like plunger member **14** of cylindrical cross sectional outline, being closely fitted to the interior of body **10** and normally partaking of but slight movement therein in the operation of the plunger,

other than that following leak-by, or due to elongation of the plunger structure.

Plunger member **14** has a central axial bore **15** of substantial diameter, this bore terminating at its top in a sharpened annular valve seat **16** immediately surrounding the same. The lower portion of plunger member **14** is internally counterbored at **17**, providing a radially inwardly extending, annular shoulder **18** which defines the bottom limit of bore **15**.

A solid plug member **19** is a second component of plunger structure **13**. It is disposed in part in the counterbore **17** of member **14**, and has a radially extending, annular, flange-like shoulder **20** which extends outwardly beneath the shoulder **18**, the upper surface of shoulder **20** being adapted to axially abut the surface **18** of member **14** under the upward force of a coil compression spring **21**. This spring is disposed in an internal compression chamber **22** of the tappet body defined by the plunger member **14**, to which counterbore **17** of the latter is exposed, the spring **21** acting between the body bottom plate **11** and shoulder **20** of plug member **19**.

An integral reduced diameter upper neck portion **23** of plug member **19** is received in the bore **15** with a wide radial clearance; and the axial length of neck **23** is slightly greater than the axial length of bore **15**. Hence when the plug shoulder **20** engages plunger member shoulder **18**, as illustrated in Fig. 1 of the drawings, the upper surface of plug neck **23** is at a level slightly above the knife-edged valve seat **16**.

The third component of plunger structure **13** is an upper plunger member **24** which has at its bottom a radially outwardly flanged valve sealing foot **25** riding on plug neck portion **23**. The result is that the lower surface of foot **25** is axially spaced above valve seat **16** when the parts are as shown in Fig. 1, affording an annular liquid flow port in the intervening zone.

Plunger portion **24** is provided, in upwardly spaced relation to foot **25**, with an intermediate circular, radially extending flange **26**, which has sliding engagement at its circumference with the internal wall of body **10**. Flange **26** subdivides the space in body **10** above plunger member **14** into lower primary and upper secondary liquid reservoirs, designated **27** and **28**, respectively. Primary reservoir **27** is completely filled with hydraulic operating liquid when the tappet is in operation, and one or more small passages **29** milled in the periphery of flanges **26** adequately communicate the primary with secondary reservoir for gravity replenishment of the former. Flange **26** protects reservoir **27** from liquid turbulence and aeration in high speed operation. Upper reservoir **28** is but partially filled, leaving an air space **30** above the liquid level for expansion. The plunger structure is sealed at its top, preventing escape of liquid from the secondary reservoir, by means of an annular non-metallic O-ring **31**. This is applied to an annular groove **32** in an enlarged integral head portion **33** of upper plunger member **24**. A split snap ring **34** in an internal groove at the top of the tappet body **10** prevents separation of the plunger parts from the body. Head **33** is provided with a seat **35** in which a valve stem is received.

The reference character *s* in Fig. 1 represents an axial valve clearance space between valve seat **16** and the lower surface of enlarged valve sealing foot **25** of plunger member **24** when the shoulders **20**, **18** are axially engaged. This is due to the proportioning of the length of the reduced diameter plunger neck **23** in relation to the length of bore **15** receiving the same. Foot **25** engages and seals seat **16** when the tappet parts are in the condition illustrated in Fig. 2 of the drawings, an axial clearance space *s'* existing in this case between the shoulders **18**, **20** which is equal to the clearance *s*. Plug shoulder **20** is radially milled at **36** to provide a relatively large axial passage communicating compression chamber **22** upwardly with the bore **15** of plunger member **14**, thus opening the compression chamber to the primary reservoir **27** when valve clearance *s* is in effect.

As indicated above, it is intended that the improved tappet serve optionally as a unit for initial factory installation or as a replacement when conversion from mechanical to hydraulic tappet operation is desired. In the case of a replacement installation, inasmuch as standard mechanical tappets are designed for a cam shaft requiring .012–.015 inch back lash for proper valve action, and since the hydraulic replacement tappet must operate in conjunction with the standard cam shaft, neck **23** and bore **15** will be proportioned so that the axial clearance *s* will be .012–.015 inch. The operation of the engine is thus unaltered when the hydraulic tappet is installed. On the other hand, if the tappet is intended for factory installation with a cam shaft specially designed therefor, the parts will be related so as to provide almost instantaneous hydraulic column action, with a minimum clearance *s* of, for example, .002–.005 inch. In all other respects the two designs will be identical, and it is seen that the change over is very simply made.

In operation, assuming the cam **12** engages bottom plate **11** of tappet body **10** in a position of zero rise (Fig. 1) and that a poppet valve actuated by the tappet is closed on its seat, tappet spring **21** urges plug **19** upwardly for engagement of its shoulder **20** with the shoulder **18** of tubular plunger member **14**. Accordingly, the upper reduced neck **23** of the plug holds valve seating foot **25** of member **24** upwardly out of engagement with valve seat **16**. Compression chamber **22** is in open communication with primary reservoir **27** through the milled passage **36** in the plug, the bore **15** and the annular clearance space *s*.

As cam **12** continues clockwise rotation, it forces body **10** upwardly, however the superior force of the poppet valve spring (not shown) acting downwardly on plunger structure **13**, overcomes the upward force of spring **21** on plug **19**; accordingly, spring **21** is compressed, plug shoulder **20** progressively separates from shoulder **18**, and valve seating foot **25** approaches seat **16**. Compression chamber **22** remains in communication with the primary reservoir **27** until valve seat **16** is sealed off by the foot.

In this condition of the parts, illustrated in Fig. 2 of the drawings, the compression chamber **22** is tightly sealed; a hydraulic column in the chamber supports closely fitted plunger member **14** and upper plunger member **24** as the cam continues to rotate and body **10** to rise and lift the tappet actuated valve in opposition to its control spring. A small leak-by of liquid between the outer diameter of plunger **14** and the wall of body **10** may occur, accompanied by a slight depression of the plunger in relation to the body and plug **19**.

When cam **12** has fully elevated the tappet and passes its high, the valve spring starts to push the tappet assembly downwardly, keeping tappet bottom plate **11** in contact with the cam. As this spring load is progressively decreased, then removed, during tappet lowering movement, the tappet spring **21** urges plug **19** upwardly, the plug elevating upper plunger member **24** and opening the clearance *s* at the valve seat. This continues until plug shoulder **20** engages upwardly against the plunger member shoulder **18**, whereupon further movement of the plug by spring **21** elevates tubular plunger member **14** to restore the same to its position before leak-by, maintaining the clearance *s* the while. The restorative movement of plunger member **14** is effected without difficulty because there is free passage for return flow of liquid from primary chamber **27** through the clearance space, bore **15** and passage **36** to compression chamber **20**. This replenishes the lost fluid as plunger member **14** is returned to its original position in reference to the compression chamber.

After an extended period of operation of the tappet, the valve stem, push rod, tappet structure, etc. will become heated and expand. The result is simply that

plunger member **14** will be depressed further in the bore of body **10** than when cold, thus compensating for heat expansion and keeping the actuated valve always in proper closed and open position. Accompanying heating of the hydraulic liquid in the tappet only results in further compression of air in the upper reservoir space **30**.

Another advantage of the tappet in reference to its operation at extremely high engine speed is its ability to forestall "toss-up." At extreme speeds the force of inertia causes the engine valve to move upwardly beyond the push of the cam, in which case, an ordinary hydraulic tappet will follow, expanding its plunger relative to its body. Accordingly, at the next cycle of operation the actuated valve will remain open, a condition which will obtain until such time as the engine is decelerated and the plunger again is subject to leak-by, whereupon reseating of the valve will occur. If the high speed operation is a prolonged one, there is a danger of burning valves.

The present tappet will not follow valve toss-up. O-ring **31** on plunger **24** acts as a brake on the plunger structure in regard to movement relative to body **10**, also preventing the plunger components from quickly and readily moving relative to one another during the split second interval at the extreme upward thrust of the cam.

Due to rapid reciprocating action of the tappet there is a tendency of air in space **30** to mix with the liquid in secondary reservoir **28**, however air bubbles thus entrained in the liquid in this reservoir never reach the tranquil body of liquid in primary chamber **27**. Liquid bypass, by leak-by from compression chamber **22** past plunger member **14**, rejoins the pure liquid supply in primary reservoir **27**, so that no matter how fast the engine is operating, it is impossible for air bubbles to enter compression chamber **22**.

It is evident that if the liquid in the tappet should somehow be lost or the tappet should not be properly filled, the plug **19** will ride the bottom **11** of body **10** and, since it positively engages the upper plunger portion **24**, provide a positive mechanical thrust transmission which will operate the engine valve temporarily, even if more noisily, until an opportunity is had to correct the condition.

Another advantage of the construction is that the back lash clearance *s*, even if held to a minimum of .002 inch, reduces over-all cost of engine production because the base circle of cam **12** need not require absolute concentricity. Present day engine fed hydraulic tappets of the so called "zero lash" type require almost absolute concentricity in order to prevent pump-up and holding of the valve in partially open condition.

I claim:

1. A hydraulic tappet comprising a hollow cylindrical body, a plunger structure in said body coacting therewith in defining a compression chamber in the body beneath said structure, said structure comprising a rigid tubular plunger member frictionally engaging the inner wall of said body and having an axial bore surrounded at its top by an annular valve seat and at its bottom by a downwardly facing annular shoulder, a plug member received in said bore and provided with a radially extending shoulder, a spring acting between said body and plug member to urge the shoulder of the latter for axial engagement with the shoulder of said plunger member, the axial length of the plug member in said plunger member bore exceeding the axial length of the bore and the upper extremity of said plug member being predeterminedly spaced above said valve seat when said shoulders are axially engaged, a further separate plunger member disposed above and resting on the top of said plug member, said further member engaging and sealing said valve seat when said shoulders are axially separated, and an annular non-metallic sealing ring on said further plunger member in frictional sealing and braking engagement with the wall of said body to prevent upward overthrow of said further plunger member relative to said plug member and said rigid tubular plunger member, said plug member shoulder having an axial passage communicating said compression chamber through said bore with the space above said tubular plunger member when said shoulders are engaged.

2. A hydraulic tappet comprising a hollow cylindrical body, a plunger structure in said body coacting therewith in defining a compression chamber in the body beneath said structure, said structure comprising a rigid tubular plunger member frictionally engaging the inner wall of said body and having an axial bore surrounded at its top by an annular valve seat and at its bottom by a downwardly facing annular shoulder, a plug member received in said bore and provided with a radially extending shoulder, a spring acting between said body and plug member to urge the shoulder of the latter for axial engagement with the shoulder of said plunger member, the axial length of the plug member in said plunger member bore exceeding the axial length of the bore and the upper extremity of said plug member being predeterminedly spaced above said valve seat when said shoulders are axially engaged, a further plunger member extending above said plug member, said further member engaging and sealing said valve seat when said shoulders are axially separated, an annular non-metallic sealing ring on said further plunger member in frictional sealing and braking engagement with the wall of said body to prevent upward overthrow of said further plunger member relative to said plug member and said rigid tubular plunger member, said plug member shoulder having an axial passage communicating said compression chamber through said bore with the space above said tubular plunger member when said shoulders are engaged, and a liquid reservoir in said body above said tubular plunger and beneath said sealing ring to which the bore of the former is directly exposed when said valve seat is unsealed.

3. A hydraulic tappet comprising a hollow cylindrical body, a plunger structure in said body coacting therewith in defining a compression chamber in the body beneath said structure, said structure comprising a rigid tubular plunger member frictionally engaging the inner wall of said body and having an axial bore surrounded at its top by an annular valve seat and at its bottom by a downwardly facing annular shoulder, a plug member received in said bore and provided with a radially extending shoulder, a spring acting between said body and plug member to urge the shoulder of the latter for axial engagement with the shoulder of said plunger member, the axial length of the plug member in said plunger member bore exceeding the axial length of the bore and the upper extremity of said plug member being predeterminedly spaced above said valve seat when said shoulders are axially engaged, a further separate thrust transmitting plunger member disposed above and resting on the top of said plug member, said further member engaging and sealing said valve seat when said shoulders are axially separated, an annular non-metallic sealing ring on said further plunger member in frictional sealing and braking engagement with the wall of said body to prevent upward overthrow of said further plunger member relative to said plug member and said rigid tubular plunger member, said plug member shoulder having an axial passage communicating said compression chamber through said bore with the space above said tubular plunger member when said shoulders are engaged, and a liquid reservoir in said body above said tubular plunger and beneath said sealing ring to which the bore of the former is directly exposed when said valve seat is unsealed.

4. A hydraulic tappet comprising a hollow cylindrical body, a plunger structure in said body coacting therewith in defining a compression chamber in the body beneath said structure, said structure comprising a rigid

tubular plunger member frictionally engaging the inner wall of said body and having an axial bore surrounded at its top by an annular valve seat and at its bottom by a downwardly facing annular shoulder, a plug member received in said bore and provided with a radially extending shoulder, a spring acting between said body and plug members to urge the shoulder of the latter for axial engagement with the shoulder of said plunger member, the axial length of the plug member in said plunger member bore exceeding the axial length of the bore and the upper extremity of said plug member being predeterminedly spaced above said valve seat when said shoulders are axially engaged, a further plunger member extending above said plug member, said further member engaging and sealing said valve seat when said shoulders are axially separated, an annular non-metallic sealing ring on said further plunger member in frictional sealing and braking engagement with the wall of said body to prevent upward overthrow of said further plunger member relative to said plug member and said rigid tubular plunger member, said plug member shoulder having an axial passage communicating said compression chamber through said bore with the space above said tubular member when said shoulders are engaged, a primary liquid reservoir in said body above said tubular plunger to which the bore of the latter is directly exposed when said valve seat is unsealed, and a radially extending flange on said further plunger member slidably engaging the wall of said body and separating said primary reservoir from a secondary reservoir in the body sealed at its top by said sealing ring, said flange having one or more apertures of small size communicating said reservoirs with one another.

5. A hydraulic tappet comprising a hollow cylindrical body, a plunger structure in said body coacting therewith in defining a compression chamber in the body beneath said structure, said structure comprising a rigid tubular plunger member frictionally engaging the inner wall of said body and having an axial bore surrounded

at its top by an annular valve seat and at its bottom by a downwardly facing annular shoulder, a plug member received in said bore and provided with a radially extending shoulder, a spring acting between said body and plug member to urge the shoulder of the latter for axial engagement with the shoulder of said plunger member, the axial length of the plug member in said plunger member bore exceeding the axial length of the bore and the upper extremity of said plug member being predeterminedly spaced above said valve seat when said shoulders are axially engaged, a further separate thrust transmitting plunger member disposed above and resting on the top of said plug member, said further member engaging and sealing said valve seat when said shoulders are axially separated, an annular non-metallic sealing ring on said further plunger member in frictional sealing and braking engagement with the wall of said body to prevent upward overthrow of said further plunger member relative to said plug member and said rigid tubular plunger member, said plug member shoulder having an axial passage communicating said compression chamber through said bore with the space above said tubular plunger member when said shoulders are engaged, a primary liquid reservoir in said body above said tubular plunger to which the bore of the latter is directly exposed when said valve seat is unsealed, and a radially extending flange on said further plunger member slidably engaging the wall of said body and separating said primary reservoir from a secondary reservoir in the body sealed at its top by said sealing ring, said flange having one or more apertures of small size communicating said reservoirs with one another.

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