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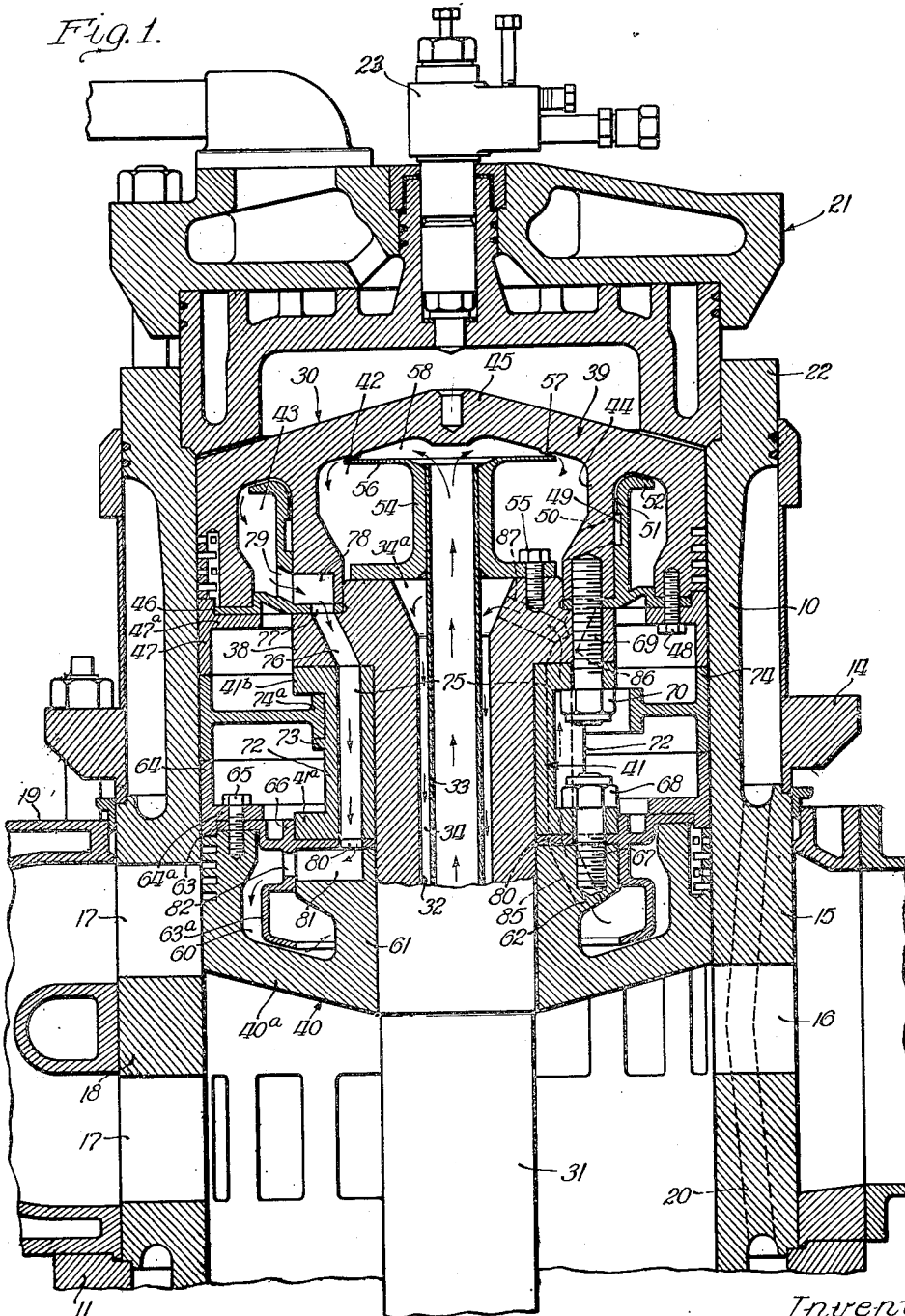
E. S. DENNISON

2,109,060

CROSS HEAD AND PISTON ROD AND PISTON CONSTRUCTION

Filed Feb. 25, 1937

4 Sheets-Sheet 1



Inventor:

Edward S. Dennison

By:

Brown, Jackson, Butler & Quinn

Attys

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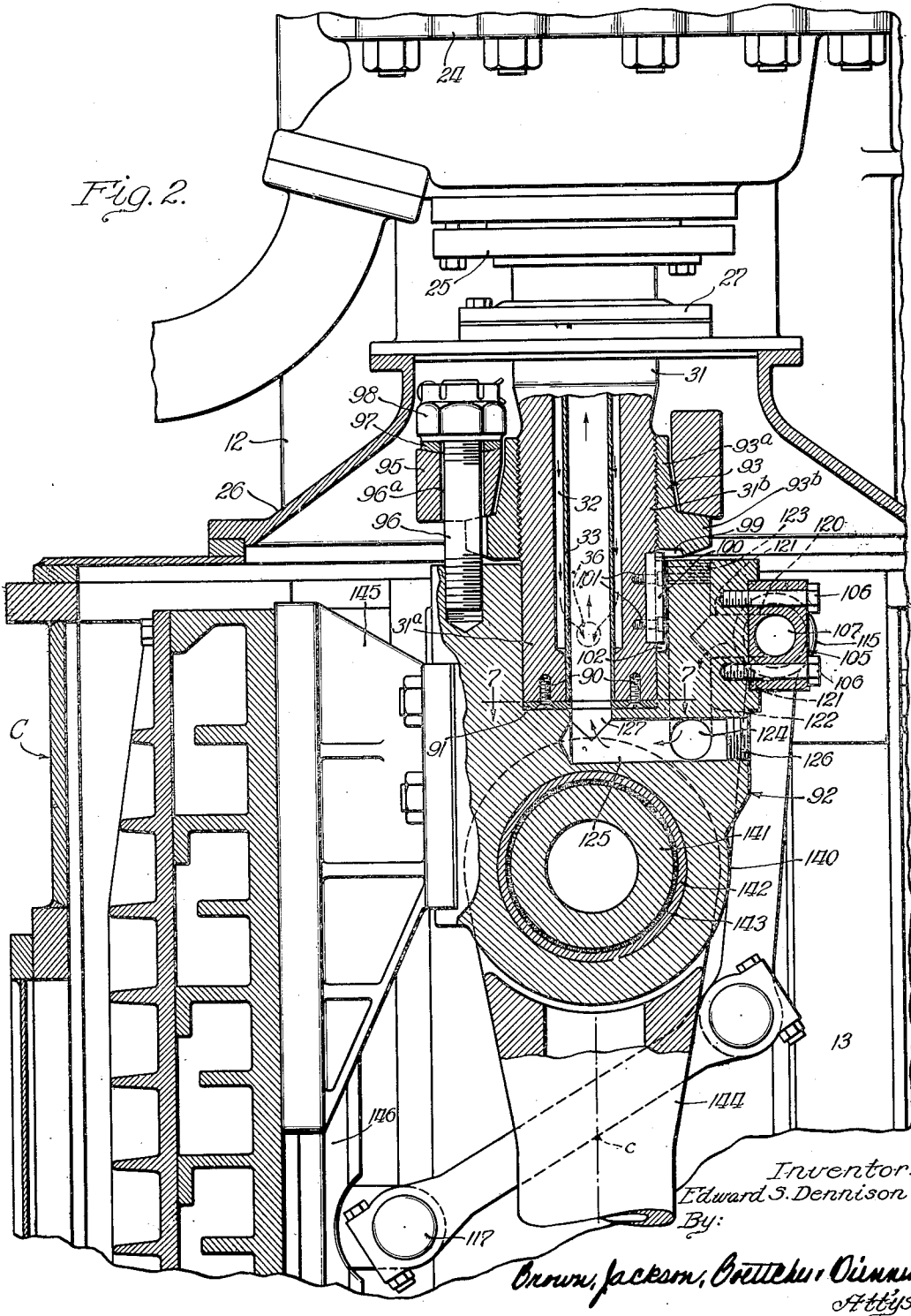
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CROSS HEAD AND PISTON ROD AND PISTON CONSTRUCTION

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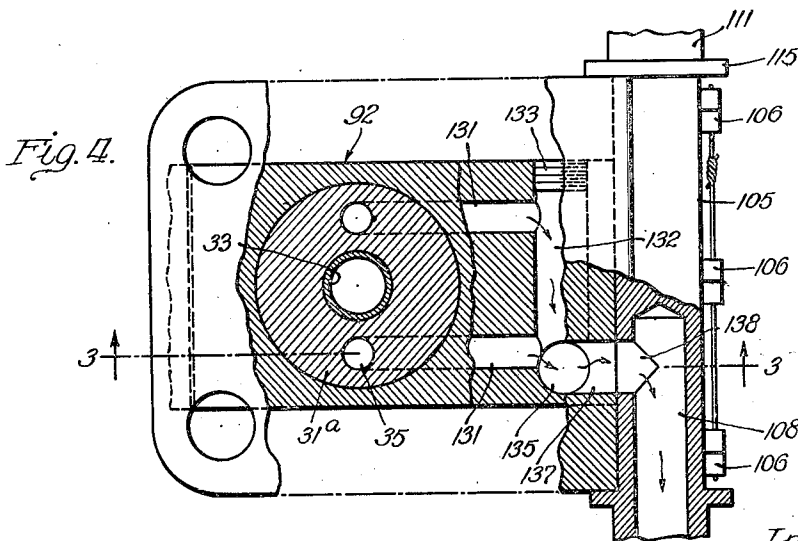
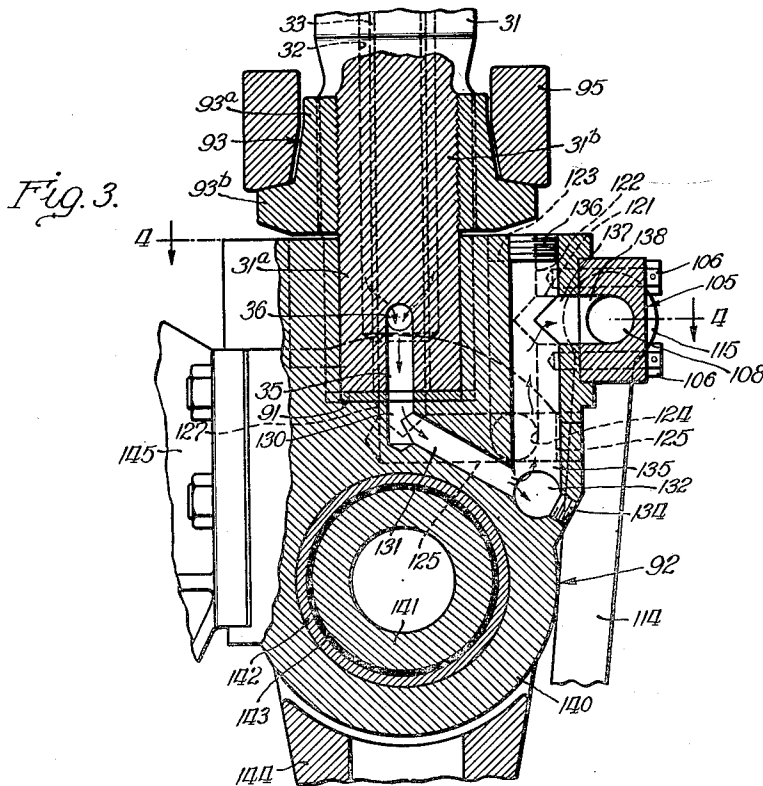
E. S. DENNISON

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CROSS HEAD AND PISTON ROD AND PISTON CONSTRUCTION

Filed Feb. 25, 1937

4 Sheets-Sheet 3



Inventor:
Edward S. Dennison

By: *Brown, Jackson, Bottel & Quinn*
Attys.

Feb. 22, 1938.

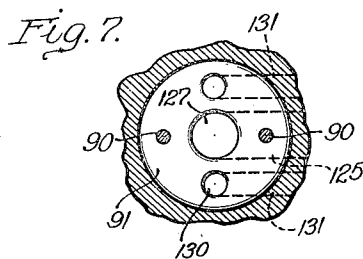
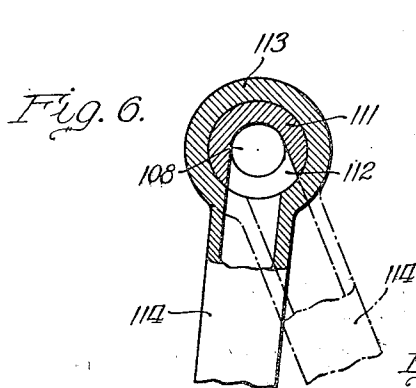
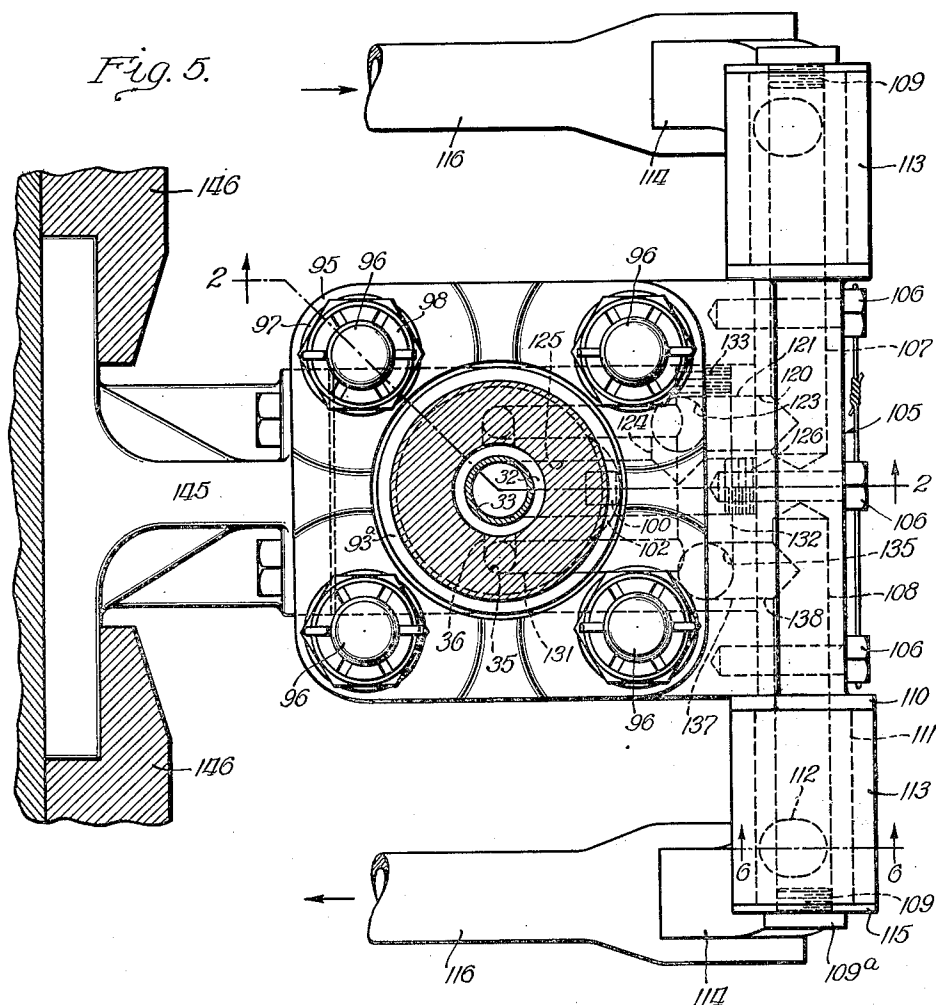
E. S. DENNISON

2,109,060

CROSS HEAD AND PISTON ROD AND PISTON CONSTRUCTION

Filed Feb. 25, 1937

4 Sheets-Sheet 4



Inventor:
Edward S. Dennison
By: *Brown, Jackson, Bottel & Dierker*
Attys.

UNITED STATES PATENT OFFICE

2,109,060

CROSS HEAD AND PISTON ROD AND PISTON
CONSTRUCTIONEdward S. Dennison, New London, Conn., assignor
to Electric Boat Company, Groton, Conn., a
corporation of New Jersey

Application February 25, 1937, Serial No. 127,670

13 Claims. (Cl. 123—176)

This invention relates to internal combustion engines, and has to do with a cross-head and piston rod and piston construction particularly suitable for use in two-cycle double acting injection engines.

My invention is directed to improved means for connecting the cross-head to the piston rod of an internal combustion engine and supplying cooling oil to the piston through the rod, while assuring adequate strength of the latter, the prevention of rocking or tilting of the piston rod relative to the cross-head at its connection to the latter, ready accessibility for assembling and disassembling the piston rod and the cross-head, and assuring that the oil passages of the cross-head are properly disposed relative to those of the piston rod in the assembling of these parts. It is also an object of my invention to provide a piston of improved construction, assuring adequate cooling thereof. Further objects and advantages will appear from the detailed description.

In the drawings:

Figure 1 is an axial sectional view through a cylinder and a piston of an engine embodying my invention, parts being broken away and certain parts being shown in elevation;

Figure 2 is a transverse vertical sectional view through the crank case and associated parts of the engine of Figure 1, the piston rod and cross-head being sectioned substantially on the line 2—2 of Figure 5, and the upper portion of the connecting rod being shown in section, parts being broken away and certain parts being shown in elevation;

Figure 3 is a sectional view taken substantially on line 3—3 of Figure 4;

Figure 4 is a sectional view taken substantially on line 4—4 of Figure 3, parts being broken away and shown in section in different planes for showing the oil passages, certain parts being shown in plan;

Figure 5 is a plan view, on an enlarged scale, of the cross-head and associated parts, the piston rod being shown in transverse section, and the guide means for the cross-head shoe being shown fragmentarily and in section, certain parts being broken away;

Figure 6 is a sectional view taken substantially on line 6—6 of Figure 5; and

Figure 7 is a sectional view taken substantially on line 7—7 of Figure 2.

The engine herein disclosed is, in general, similar in construction to the engine disclosed in my copending applications, Serial No. 114,568, for

Exhaust valve means, filed December 7, 1936, and Serial No. 119,422, for Internal combustion engine, filed January 7, 1937. The construction of my invention has been illustrated, by way of example, as applied to a two-cycle double acting injection engine, for which it is particularly suitable. In certain aspects, however, my invention may be applied to advantage to other types of internal combustion engines.

I have illustrated my invention as applied to an engine comprising a crank case C of suitable construction within the lower portion of which the engine crank shaft (not shown) is mounted in a known manner. A cylinder 10 is suitably mounted in an entablature 11 supported by brackets, one of which is shown at 12 in Figure 2, which brackets are mounted upon U frames, one of which is shown at 13 in Figure 2, within the crank case C. The brackets and the entablature are suitably bolted to the U frame, and the cylinder is secured to the entablature by a clamping ring 14, which ring is bolted to the entablature. Cylinder 10 is provided with a central port boss 15 having, at one side, a series of inlet ports 16 and, at its other side, two series of exhaust ports 17 separated by a bridge element 18. A port belt member 19, in part water-jacketed, is mounted about boss 15 and defines inlet and exhaust passages. The cylinder is suitably water-jacketed, and boss 15 is provided with passages 20 for flow therethrough of cooling water from the lower to the upper cylinder water-jacket. The upper end of cylinder 10 is closed by a sectional water-cooled head 21 bolted to a thickened element or boss 22 at the upper end of the cylinder. An injection nozzle 23 is mounted in head 21 centrally thereof for injecting fuel into the cylinder. The lower end of the cylinder is closed by a head 24 bolted to a thickened element or boss at the lower end of the cylinder, said latter head also being sectional and water-cooled. Suitably disposed injection nozzles (not shown) are mounted in head 24 for injecting fuel into the lower end of the cylinder substantially chordally thereof. The construction of the head 24 and the mounting of the injection nozzle associated therewith may be the same as in my above identified copending application for internal combustion engine, filed January 7, 1937, Serial No. 119,422. Head 24 has associated therewith a stuffing box 25 of known type, and a dome member 26 is appropriately mounted upon the top of crank case C and has associated therewith a stuffing box 27 aligned with the stuffing box 25. The engine so far described is similar in construction to that of my

two above identified depending applications, and need not be illustrated nor described in greater detail, it sufficing to note that the engine may be of any desired construction suitable for the purposes intended.

A piston 30 operates in cylinder 10, and has associated therewith a piston rod 31 which operates through the stuffing boxes 25 and 27. Rod 31 is provided with an axial bore 32 which is reduced in diameter at the lower end of the rod, as shown in Figure 2. A tube 33, of less exterior diameter than the interior diameter of bore 32, has a close sliding fit in the lower end of rod 31 and extends upwardly through bore 32, in concentric spaced relation thereto, to a short distance above the upper end of rod 31. Tube 33 thus defines, with bore 32, an annular passage 34 for cooling oil, the upper end portion of this passage being flared upward at 34a. The tube 33 also defines an oil passage, and opens, at its lower end, through the lower end of rod 31. The latter is also bored from its lower end to provide two supplemental passages 35 opening at their upper ends, by ports 36, into passage 34 adjacent the lower end thereof. The passage defined by tube 33 is an oil inlet passage, and the passage 34 is an outlet passage, suitable means to be later described being provided for supplying oil to the tube and for conducting oil away from the passage 34.

Piston rod 31 is provided, at its upper end, with a relatively thick outwardly projecting flange 38. The piston 30 comprises an upper head 39, a lower head 40, and a spacing member 41 disposed about rod 31 below and in contact with flange 38. Head 39 defines an interior central chamber 42 and a channel 43 extending about this chamber and separated therefrom by a wall 44 depending from top wall 45 of head 39. Wall 44, at the lower end of chamber 42, fits snugly about the upper end of rod 31, appropriately formed for that purpose as shown.

The lower end of channel 43 is closed by a flanged deflector 46 seating, in part, against the underface of head 39. The lower or base element of deflector 46 is clamped between the underface of head 39 and web element 47a of a ring member 47 of angle cross-section, the upper end of which seats in a rabbet formed in the lower end of head 39. Ring member 47 is secured to head 39 by cap screws, one of which is shown at 48, passing through web 47a and screwing into head 39.

Deflector 46 fits snugly about the lower portion of wall 44, at the outer face thereof, and is provided, in its inner face, with a groove 49 which receives oil from chamber 42 through short passages or ducts 50 in wall 44. Above groove 49 the deflector 46 is decreased in thickness to provide a slight space 51 between the deflector and the outer face of wall 44, at the upper portion thereof, it being noted that the deflector is provided, at its upper end, with an outwardly projecting element 52 which extends along the roof of channel 43 in proximity thereto and towards the outer wall of this channel. Oil supplied to groove 49 from chamber 42 is thus caused to flow upward along the outer face of wall 44, then along the roof of channel 43, and thence downward along the outer wall of this channel, the latter being provided with appropriately located outlets, to be referred to more in detail presently. A spool member 54, disposed within chamber 42, is suitably secured upon the upper end of piston rod 31, as by means of cap screws, one of which is shown

at 55. Member 54 fits snugly about the upper end of tube 33, to which it is suitably secured as by welding, and serves to close the upper end of passage 34. At its upper end, spool member 54 is provided with a relatively thin flange 56 disposed adjacent the underface of the center of top wall 45 of head 39. The outer portion of this flange is spaced a slight distance from an annular surface 57 provided on the underface of wall 45 and disposed parallel to flange 56. The clearance between surface 57 and flange 56 retards the escape of oil from above flange 56 sufficiently to assure that the space 58 above spool member 54 will be at all times maintained filled with oil, and positive flow of oil over the underface of wall 45, above flange 56, is assured. The oil entering space 58 from tube 33 flows outward from the latter along the underface of wall 45, at the central portion thereof, escapes between flange 56 and surface 57, flowing outward along the remainder of the roof of chamber 42, and then flows downward in chamber 42 along wall 44, escaping through the ducts 50 to groove 49 of the deflector 46. The central portion of top wall 45 of head 39 is effectively cooled, thus eliminating danger of cracking or other injury to this wall due to overheating. The flow of the cooling oil along the inner and the outer faces of the depending wall 44 and the roof and the outer wall of channel 43 serves to cool the head 39, as a whole, in a highly efficient manner. This oil flow, as well as the flow of the oil in the chamber 42, is indicated by the arrows in Figure 1.

The lower head 40 defines an interior channel 60 extending about a hub 61 which fits snugly about piston rod 31 and is provided at its upper end with an outwardly projecting flange 62. A deflector 63, flanged at its upper end, closes the upper end of channel 60 and is clamped between the upper face of head 40 and a ring 64 of angle cross section, the lower end of which seats in a rabbet formed in head 40, web 64a of this ring being secured to head 40 by cap screws, one of which is shown at 65, these cap screws also passing through the flange of deflector 63, which is clamped between web 64a and the upper end of head 40. Deflector 63 is provided with a depending portion 63a of approximately C shape in cross-section spaced away from the outer wall of channel 60 and extending inward along and a slight distance above the inner face of bottom wall 40a of head 40. The upper or base portion of deflector 63 is depressed and provided with an upwardly projecting rib 66 defining, with piston rod 31, an annular depression in which flange 41a, at the lower end of spacer 41 seats. This flange 41a is bolted to flange 62 of hub 61 of the lower head 40 by means of studs and cooperating nuts, one of these studs and its nut being shown at 67 and 68, respectively, it being noted that the stud also passes through the base or depressed portion of deflector 63. Spacer 41 is provided, at its upper end, with a flange 41b which seats against the underface of flange 38 of piston rod 31 and is secured thereto by bolting studs and cooperating nuts, one of these studs and its nut being shown at 69 and 70, respectively. It will be noted that the stud 69 passes through the base element of deflector 46 which is thus clamped between flange 38 and wall 44 in the same manner as the base element of deflector 63 is clamped between flanges 41a and 62.

Spacer 41 is provided with a plurality of lengthwise extending ribs 72, certain of these ribs be-

ing each provided, a short distance below flange 41b, with an outwardly projecting lug 73. A ring 74 of T cross-section fits tightly between the rings 47 and 64, and is provided with suitably disposed elements 74a seating between lugs 73 of ribs 72 and flange 41b. This ring, which is split in a known manner, completes the sectional construction of the piston, and it is provided with suitable openings for accommodating the nuts 10, as will be clear from Figure 1, it being noted that the ribs 72 of spacer 41 are suitably disposed to accommodate the nuts 88 of the bolting stud 67. While the piston 39 is preferably of the sectional construction shown and described, it may be of any other suitable construction, it being noted that each of the piston heads is provided with suitable grooves which receive piston rings, in a known manner.

Each of the ribs 72 of spacer 41 is provided with a lengthwise bore forming an oil passage 75. In Figure 1, the left hand passage 75 is in register, at its upper end, with the lower end of an inclined duct 76 extending through flange 38 and in register, at its upper end, with a port 77 opening through the base portion of deflector 46. Port 77 opens into a groove 78 formed in the lower end of wall 44, extending from the outer face thereof and terminating short of the inner face of this wall. The outer end of groove 78 is in register with a port 79 extending through the lower portion of deflector 46, which fits about wall 44. The lower end of passage 75 is in register with a port 80 through the base or web element of deflector 63, this port opening into a groove 81 in the upper face of flange 62, extending from the outer face of this flange and terminating short of the inner face thereof. The outer end of groove 81 is aligned with a port 82 in the portion of deflector 63 extending about flange 62. It will be clear that oil from channel 43 flows therefrom downward through the passages and ports shown and described, into channel 60 between the outer wall thereof and portion 63a of deflector 63. This oil then flows along the bottom wall 40a of head 40 toward hub 61, it being noted that the oil entering channel 60 is caused, by the deflector 63, including portion 63a thereof, to flow downward along the outer wall of channel 60.

Passage 75 of the right hand rib 72 shown in Figure 1 is in register, at its lower end, with a port 80 through the base or web element of the deflector 63. This latter port 80 is in register with the upper end of an inclined duct 85 extending through flange 62 and opening, at its lower end, into channel 60 adjacent hub 61, and between the latter and portion 63a of deflector 63. The upper end of passage 75 at the right hand of Figure 1 is in register with the lower end of a short duct 86 extending through flange 38 of piston rod 31, and closed at its upper end by the base portion of deflector 46. Flange 38 is further provided with a duct 87 intersecting duct 86 and opening into the flared upper portion 34a of outlet passage 34. It will be understood that, in practice, certain of the ribs are provided with passages which permit downflow of the oil from channel 43 of head 39 to channel 60 of head 40, others of the ribs 72 defining, with the associated ducts, upflow passages for discharge of the oil from channel 60 to the outlet passage 34. The number of the downflow passages and the number of the upflow passages, as well as the cross area thereof, will depend upon the pressure, rate of oil flow, and other factors, and may be

varied as desired to suit conditions. The flow of the oil from the upper piston head to the lower piston head, and from the latter to the outlet passage 34 of the piston rod 31, is indicated by the arrows in Figure 1 and will be clear therefrom and from the above description.

Lower end portion 31a of piston rod 31 is accurately turned and finished to a slightly reduced uniform diameter, for a suitable length, equal to approximately the reduced diameter of the rod. The lower end of piston rod 31 is flat and normal to the axis thereof, and may have secured thereon, as by means of screws 90, a spacing ring 91 provided with openings disposed to register with the lower end of tube 33 and the lower ends of the supplemental outlet passages 35, as will be clear from Figure 7. Portion 31a of piston rod 31 fits snugly into a corresponding socket formed in the upper end of a cross-head 92, the bottom of this socket being flat and normal to the axis of the piston rod. Rod 31 is further provided, above portion 31a, with an exteriorly threaded portion 31b. A securing nut 93, comprising an upwardly tapering body 93a and an outwardly projecting flange 93b at the lower end of the body, screws upon portion 31b of the rod. The upper surface of flange 93b is convex and of spherical curvature about a center c located on the axis of piston rod 31 and below the latter, as in Figure 2. A clamping member 95 is disposed about body 93a of nut 93 and is provided, at its lower end, with a base curved conformably to and seating upon the upper face of flange 93b. Bolting studs 96, suitably anchored in cross-head 92, pass through member 95 with suitable clearance 96a about each stud. Member 95 is provided, in its upper face, with depressions of spherical curvature extending about the studs 96, these depressions receiving washers 97, the underfaces of which are of spherical curvature and seat in the depressions. Securing nuts 98 screw upon the studs 96 and bear upon washers 97 for securing the clamping member 95 to and forcing it toward cross-head 92. The lower end of nut 93 is spaced a slight distance above the cross-head 92, and is provided with a slot 99 which receives the upper end of a key 100 secured by screws 101 in a groove in rod 31, this key projecting into a keyway 102 opening into and extending from the upper end of the socket in cross-head 92. Key 100 serves to assure proper positioning of portion 31a of piston rod 31 in the socket of cross-head 92, as will be explained more fully hereinafter, and also assures proper positioning of nut 93 upon portion 31b of piston rod 31, while also holding this nut against turning movement. The annular plate 91 serves as a spacer for compensating for any slight inaccuracies in machining of the parts, it being understood that the thickness of this plate may be varied as required.

Forming the upper face of flange 93b of nut 93 and the cooperating face of clamping member 95 in the manner stated, with provision for clearances between the studs 96 and member 95 and between the latter member and the body 93a of the nut, in conjunction with the provision of the washers 97 and the spherical depressions about the studs 96, permits of slight movement of clamping member 95, relative to nut 93, about the center c. This is advantageous in that it prevents or greatly reduces unequal tensioning of the studs 96 and also prevents subjecting the piston rod, at its connection to the cross-head 92, to objectionable transverse stresses. The lower end of rod 31, or

plate 91, seats upon the bottom of the socket in cross-head 92, and is maintained in sealing contact therewith by the pressure exerted through the stud 96 and clamping member 95, it being noted that portions 31a and 31b of the piston rod are maintained under compression at all times. The clamping member 95 is substantially square in plan, and of somewhat greater width than the body of cross-head 92, the latter being provided, at its upper end, with lateral projections or flanges for reception of the studs 96, as will be clear from Figures 2 and 4. Since the studs 96 are spaced from the piston rod 31 a distance somewhat less than the width of flange 93b of nut 93, this flange is suitably notched to accommodate studs 96, as in Figure 2.

Cross-head 92 is provided, at one side and adjacent its upper end, with a rectangular channel or groove of considerable width in which seats the inner portion of an elongated block 105 secured to the cross-head by cap screws 106. Block 105 is bored out from its ends to provide oil inlet and outlet passages 107 and 108, respectively, the inner ends of which are spaced apart and the outer ends of which are closed by screw plugs 109. The block 105 is provided with integral flanges 110, of circular outline, which abut the ends of cross-head 92, the portions of the block extending outward beyond flanges 110 being of cylindrical shape and accurately finished to provide bearing sleeves 111. Each of these sleeves is provided with an opening 112 a short distance from its outer end, this opening being of considerable extent circumferentially of the sleeve. Each sleeve 111 receives thereon a sleeve 113 at the upper end of a tubular link 114, conveniently formed integrally with the link. Sleeve 113 is confined between flange 110 and a washer 115 through which passes screw plug 109, the latter being provided with a head 109a which seats upon the outer face of washer 115. Link 114 is pivoted, at its lower end, to a tubular link 116, the lower end of the latter link being pivoted to a fitting 117 suitably mounted within the crank case C. It will be understood that, in practice, there are two fittings 117, oil being supplied under pressure to one of such fittings and the other fitting constituting a return member through which the oil is returned to the source of supply. Linkage arrangements of this character for supplying cooling fluid to a piston are well known in the art and need not be illustrated or described in greater detail. If desired, any other suitable known means, such as telescoping tubes, may be provided for supplying oil to passage 107 and delivering oil from passage 108. Suffice it to state that suitable means is provided whereby cooling fluid, such as oil, is supplied to the passage 107 and delivered from the passage 108.

Block 105 and the cross-head 92 are bored to provide suitably disposed passageways for delivering oil to tube 33 and conducting oil from outlet passage 34 of the piston rod 31. Referring to Figures 2 and 5, block 105 is provided with an outlet port 120, adjacent the inner end of passage 107, which port is in register with the outer end of a horizontal passage 121 in the cross-head. Passage 121 intersects a vertical passage 122 in the cross-head, closed at its upper end by a screw plug 123. Passage 122 opens, at its lower end, into a short passage 124 extending lengthwise of cross-head 92 and opening into a passage 125 extending transversely of cross-head 92 and closed at its outer end by a screw plug 126. At its inner end passage 125 opens into a short vertical passage 127 which opens into the socket of cross head

92 centrally of the bottom of the socket and is in register with the central opening of plate 91, which central opening is in register with the lower end of tube 33. In this manner, I provide a passageway whereby oil is conducted from passage 107 to the inlet tube 33 at the lower end thereof.

Referring to Figures 3, 4 and 5, cross-head 92 is provided with two short vertical passages 130 opening through the bottom of the socket in the cross-head and disposed in register with the two eccentric openings in plate 91, such openings being in register with the lower ends of the supplemental outlet passages 35. The latter passages, in effect, open directly into the upper ends of the passages 130. The latter passages open, at their lower ends, into inclined passages 131 bored in the cross-head 92, and passages 131 open, at their lower ends, into a passage 132 of greater diameter bored in the cross-head 92 from one end thereof and closed at such end by a screw plug 133. The outer end of each passage 131 is closed by a screw plug 134, and passage 132 is intersected, adjacent its other end, by a vertical passage 135 of equal diameter bored from the upper end of cross-head 92 and closed, at its upper end, by a screw plug 136. A short passage 137 opens, at its inner end, into vertical passage 135, and is in register, at its outer end, with a port 138 opening through the inner wall of block 105 into passage 108 adjacent the inner end thereof. It will be seen that the outlet passage 34 of the piston rod 31 is thus connected to passage 108 of block 105 for conducting oil from the piston rod. In this manner oil is conducted to the piston through tube 33 and, after circulating through the piston heads and associated parts in the manner previously described, is conducted from the piston through passage 34 of the piston rod. It will be noted that the proper oil connections are assured by the act of assembling the cross-head and the piston rod, due to the provision of the key 100 and keyway 102 previously referred to. Since the portion 31a of the piston rod has a snug fit in the socket of cross-head 92, and the lower end of this rod is held in sealing contact with the bottom of the socket, in the manner previously explained, no appreciable or objectionable leakage of oil about the lower portion of the piston rod occurs.

The lower portion of the cross-head 92 is appropriately formed to provide a bearing sleeve 140 which receives a wrist pin 141 and associated bushings 142 and anti-friction bearings 143, providing a pivotal connection between sleeve 140 and the upper end of a connecting rod 144, the lower end of which is connected, in a known manner, to the engine crank shaft. The connecting rod 144 and associated parts may be provided with suitable passages for supplying oil to the wrist pin bearings in a known manner.

A guide shoe 145, of known type, is suitably secured to the other side of cross-head 92, conveniently by bolting. This shoe 145 operates in suitable guideways 146 of known type, appropriately mounted within the crank case C in a known manner. The cross-head guide shoe is of conventional type, as are the guideways and associated parts, and none of these parts need be illustrated or described in greater detail. It is sufficient to note that the crosshead has associated therewith suitable guide means, such as the guide shoe and the associated guides, referred to.

It will be noted that the greater portion of the cross section of the piston rod is available to

transmit both tension and compression to the cross-head, which assures adequate mechanical strength. The piston rod 31 is not drilled laterally in a region subject to tension during operation, which further contributes to strength of the piston rod. It is recognized that holes drilled laterally in the piston rod in a region subjected to tension during operation are objectionable and frequently cause failures of the piston rod, such holes being known as stress raisers. A further advantage of my construction is that no attachments to the piston rod are necessary in effecting the cooling oil connections, such connections being made automatically in assembling the piston rod and the cross-head. All operations in assembling and disassembling the piston rod and the cross-head are performed at the upper end of the latter, which is readily accessible, this being conducive to expedition and facility in effecting the assembling and disassembling operations. The use of the studs 96 and associated nuts 98 of standard size, in securing the piston rod to the cross-head, is advantageous in that these nuts can readily be tightened or adjusted to any desired extent within limits. Suitable locking means for preventing loosening or displacement of the nuts, particularly the nuts 98, and of the cap screws 106 for securing the block 105, may be provided, as is well known in the art.

What I claim is:

1. In a double acting internal combustion engine, a cylinder, a piston operating therein and provided with passages for circulation of cooling fluid, a cross-head having a socket in its upper end, a piston rod operatively connecting said piston and said cross-head and seating in said socket with its lower end in sealing contact with the bottom of said socket, said piston rod being provided with lengthwise inlet and outlet passages opening through its lower end and communicating with said piston passages, a securing member secured upon said piston rod adjacent and spaced from the upper end of said cross-head, said member being provided with an outwardly projecting flange having its upper face convex and of a spherical curvature, a clamping member having its lower face curved conformably to and seating upon the upper face of said flange, said clamping member being movable relative to said securing member about the common center of curvature of said surfaces, means securing said clamping member to and forcing it toward said cross-head effective for maintaining the lower end of said piston rod in sealing contact with the bottom of said socket, said cross-head having inlet and outlet passages opening through the bottom of said socket respectively in register with said piston rod inlet and outlet passages, means for conducting cooling fluid to and from said inlet and outlet passages of said cross-head, and a connecting rod operatively connected to said cross-head.

2. In a double acting internal combustion engine, a cylinder, a piston operating therein and provided with passages for circulation of cooling fluid, a cross-head having a socket in its upper end, a piston rod operatively connecting said piston and said cross-head and seating in said socket, said piston rod having lengthwise inlet and outlet passages opening through its lower end and communicating with said piston passages, a nut screwed upon said piston rod adjacent and spaced from the upper end of said cross-head, said nut comprising an upwardly tapering body and an outwardly projecting flange having

its upper face of convex spherical curvature about a center on the axis of said piston rod, a clamping member having its lower face curved conformably to and seating upon the upper face of said flange, said member being spaced outwardly from the body of said nut, bolts securing said clamping member to and forcing it toward said cross-head effective for maintaining the lower end of said piston rod in sealing contact with the bottom of said socket, said cross-head having inlet and outlet passages opening through the bottom of said socket respectively in register with said piston rod inlet and outlet passages, means for conducting cooling fluid to and from said inlet and outlet passages of said cross-head, and a connecting rod operatively connected to said cross head.

3. In a double acting internal combustion engine, a cylinder, a piston operating therein and provided with passages for circulation of cooling fluid, a cross-head having a socket in its upper end, a piston rod operatively connecting said piston and said cross-head and seating in said socket, said piston rod having lengthwise inlet and outlet passages opening through its lower end and communicating with said piston passages, a nut screwed upon said piston rod adjacent and spaced from the upper end of said cross-head, a clamping member seating upon said nut, bolts securing said clamping member to and forcing it toward said cross-head effective for maintaining the lower end of said piston rod in sealing contact with the bottom of said socket, said cross-head having inlet and outlet passages opening through the bottom of said socket respectively in register with said piston rod inlet and outlet passages, means holding said piston rod against turning in said socket and also holding said nut against turning on said piston rod, means for conducting cooling fluid to and from said inlet and outlet passages of said cross-head, and a connecting rod operatively connected to said cross-head.

4. In a double acting internal combustion engine, a cylinder and a piston operating therein, a cross-head having a socket in its upper end, a piston rod operatively connected to said piston and seating in said socket, a securing member secured upon said piston rod adjacent and spaced from the upper end of said cross-head, and a clamping member seating upon said securing member and bolted to said cross-head, said members cooperating for securing said piston rod to said cross-head with its lower end in contact with the bottom of said socket.

5. In a double acting internal combustion engine, a cylinder and a piston operating therein, a cross-head having a socket in its upper end, a piston rod operatively connected to said piston and seating in said socket, a securing member secured upon said piston rod adjacent and spaced from the upper end of said cross-head, and a clamping member seating upon said securing member and bolted to said cross-head, said clamping member being capable of movement relative to said securing member about a center on the axis of and below said piston rod, said members cooperating for securing said piston rod to said cross-head with its lower end in contact with the bottom of said socket.

6. In a double acting internal combustion engine, a cylinder and a piston operating therein, a cross-head having a socket in its upper end, a piston rod operatively connected to said piston and seating in said socket, a nut screwed upon

said piston rod adjacent and spaced from the upper end of said cross-head, said nut comprising a body and an outwardly projecting flange having its upper face of spherical curvature about a center on the axis of and below said piston rod, a clamping member having a face curved conformably to and seating upon the upper face of said flange, said member being spaced from the body of said nut, and means securing said member to and forcing it toward said cross-head while permitting movement of said member relative to said nut about said center.

7. In a piston and piston-rod assembly for double acting internal combustion engines, a piston, a tubular piston rod secured in said piston, an inlet tube secured in said rod in spaced relation to the inner face thereof and defining therewith an annular outlet passage, and a spool member fitting about the upper end of said tube and closing the upper end of said outlet passage, said spool member having at its upper end a flange in proximity to the under face of the top wall of the piston head, said piston being provided with interior intercommunicating spaces and passages leading from the upper end of said spool member to said outlet passage, the latter and said tube being respectively provided with outlet and inlet openings exterior of said piston.

8. In a piston and piston-rod assembly for double acting internal combustion engines, a piston, a tubular piston rod secured in said piston, an inlet tube secured in said rod in spaced relation to the inner face thereof and defining therewith an annular outlet passage, said piston comprising upper and lower heads and an intermediate member secured together and to said piston rod, said upper head defining a central chamber and a channel extending about said chamber and separated therefrom by a wall depending from the top wall of said upper head, a deflector closing the lower end of said channel fitting snugly about the lower portion of the outer face of said depending wall and extending upward therealong and along said top wall, said deflector having its upper portion spaced from said top wall and depending wall and the latter having passages therethrough from said chamber to the space between said deflector and said depending wall, a spool member in said chamber secured to the upper end of said piston rod fitting about the upper end of said tube and closing the upper end of said outlet passage, said spool member having at its upper end a flange in proximity to the underface of the top wall of said upper head, said lower head defining a hub and a channel extending thereabout, and a deflector closing the upper end of said channel fitting snugly about said hub and extending downward into the channel in spaced relation to the sides thereof with its lower portion extending along and spaced a short distance from the upper face of the bottom wall of said lower head, said heads and deflectors and said piston rod and intermediate member being provided with passages establishing communication between the channel of said upper head and the channel of said lower head at the outer side of said lower deflector and between the channel of said lower head at the inner side of said lower deflector and said outlet passage.

9. In a piston and piston-rod assembly for double acting internal combustion engines, a piston, a tubular piston rod secured in said piston, an inlet tube secured in said rod in spaced relation to the inner face thereof and defining therewith an annular outlet passage, said piston rod having

an outwardly extending flange at its upper end, said piston comprising upper and lower heads and a spacer secured together and to said flange, said upper head defining a central chamber and a channel extending about said chamber and separated therefrom by a wall depending from the top wall of said upper head, said depending wall having passages therethrough from said chamber to said channel, deflector means for directing cooling fluid entering said channel from said chamber upward along said depending wall, then along the roof of the channel and thence downward, a spool member in said chamber secured to said flange fitting about the upper end of said tube and closing the upper end of said outlet passage, said spool member having at its upper end a flange disposed in proximity to the roof of said chamber, said lower head defining a hub and a channel extending therearound, said heads, flange, rod, and spacer having passages establishing communication between the channels of said heads and between the channel of said lower head and said outlet passage, and deflector means for directing cooling fluid outward and downward in the channel of said lower head and then inward along the upper face of the bottom wall of said lower head to said hub.

10. In a piston and piston rod assembly for double acting internal combustion engines, a piston, a piston-rod secured in said piston and provided with inlet and outlet passages for cooling fluid, said piston comprising upper and lower heads, said upper head defining a central chamber and a channel extending around said chamber separated therefrom by a wall depending from the top wall of said head and provided with openings from the lower portion of said chamber into said channel, said lower head defining a hub and a channel extending therearound, said piston and rod having passages establishing communication between said channels and between said lower channel and said outlet passage, said inlet passage opening into said chamber, deflector means for directing cooling fluid along the roof of said chamber downward along said depending wall, then upward along the outer face of said depending wall, and thence along the roof and downward along the outer wall of the channel of said upper head, and deflector means for directing cooling fluid downward along the outer wall of the channel of said lower head and then along the bottom wall of said lower head to said hub.

11. In a piston and piston rod assembly for double acting internal combustion engines, a piston, a piston rod secured in said piston and provided with inlet and outlet passages for cooling fluid, said piston comprising upper and lower heads each having an interior concentric channel, said upper head also having a central chamber communicating at its lower portion with the channel of said upper head, said piston rod having an inlet passage opening into said chamber and an outlet passage, said piston and rod having passages establishing communication between said channels and between the channel of said lower head and said outlet passage, deflector means for directing cooling fluid along the roof and downward along the surrounding wall of said chamber, then along the surrounding walls and the roof of the channel of said upper head, and deflector means for directing cooling fluid along the outer and the bottom walls of the channel of said lower head.

12. In a piston and piston rod assembly for

double acting internal combustion engines, a piston, a piston rod secured in said piston and provided with inlet and outlet passages for cooling fluid, said piston comprising upper and lower heads each having an interior concentric channel, said piston rod having an inlet passage communicating with the channel of said upper head and an outlet passage, said piston and rod having passages establishing communication between said channels and between the channel of said lower head and said outlet passage, deflector means for directing cooling fluid along the surrounding walls and the roof of the channel of said upper head, and deflector means for directing cooling

fluid along the outer and the bottom walls of the channel of said lower head.

13. In a double-acting internal combustion engine, a cylinder and a piston operating therein, a cross-head having a socket in its upper end, a piston rod operatively connected to said piston and seating in said socket, a securing member secured upon said piston rod adjacent and spaced from the upper end of said cross-head, and bolting means attaching said securing member to said cross-head, said members cooperating for securing said piston rod to said cross-head with its lower end in contact with the bottom of said socket.

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