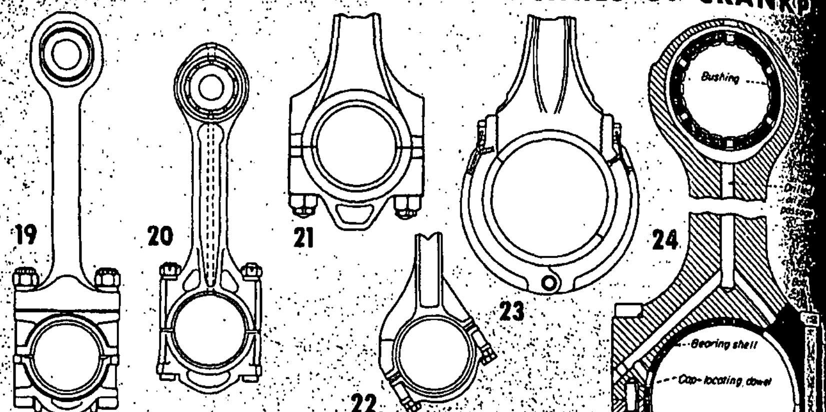
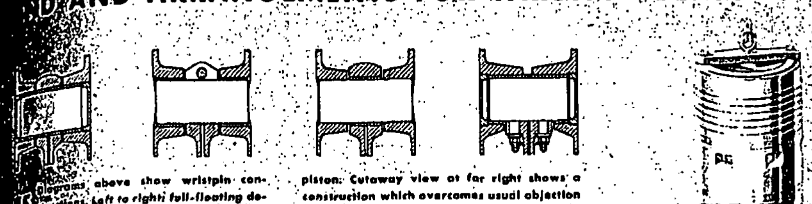
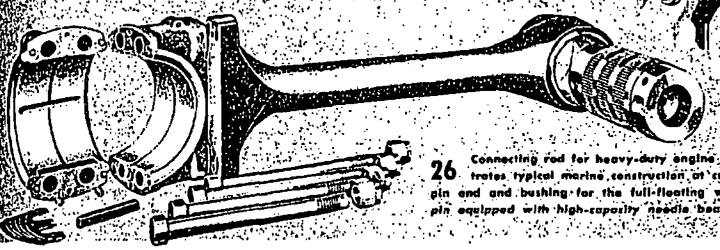
CONNECTING RODS DIFFER IN DETAILS OF CRANKPIN AND ARRANGEMENTS FOR WRISTPIN BEARING



19-24 Typical connecting-rod designs: rod with foot and separate crankpin box or so called "marine" big end (19); common design has upper half of crankpin bearing integral with rod (20); studs are used in place of bolts for compactness (21); angle-split crankpin box makes it easier to withdraw through cylinder (22); a hinged-strap construction is also compact (23); section of typical rod shows lubrication path (24)



25 Diagrams above show wristpin constructions. *Left to right:* full-floating design with pin bearing in both rod and piston; pin tight in rod, bearing in piston; pin tight in piston, bearing in rod; and pin bolted to saddle at top of rod and bearing in the piston. Cutaway view at far right shows a construction which overcomes usual objection to fastening pin in piston. Pin bolts to internal supporting structure in piston. There is no distortion of piston such as results from a press fit, and disassembly is facilitated



26 Connecting rod for heavy-duty engine illustrates typical marine construction at crankpin end and bushing for the full-floating wristpin equipped with high-capacity needle bearings

Skirt length in a trunk piston acts as a crosshead; it also carries one or more rings. Below the upper ring band, where most heat flows, wall thickness falls off rapidly. Clearance between skirt and wall must be small, hence skirt must be truly round. Interior ribs stiffen skirt.

Piston Cooling. Large engines, and units operated at high ratings, usually require piston cooling. Both water and oil have been used but although water has greater heat-absorbing ability, oil is almost universally used because of convenience and freedom from contamination hazard.

In one simple system, Fig. 14, part of wristpin lubricating oil jets out through nozzles in the rod end and sprays against underside of piston crown. The oil drips down the piston and into the crankcase.

In many cooled pistons, the oil circulates in a space under the crown. Pump forces an excess of oil to the wristpin and thence through passages, Fig. 15, to the crown. Oil returns to the sump by gravity. In the piston of Fig. 16, circulation is intermittent. Oil enters the crown space from the hollow wristpin and is retained there until the piston descends. At stroke end, a release passage in the piston skirt mates with a slot in the liner and oil discharges into the crankcase. In the large piston of Fig. 17, oil from wristpin bearing is forced through labyrinth passages in crown space, returns from the crown through a telescopic tube.

Piston Rings. The typical piston carries a wide band of rings at the top (usually four to six) and a few rings on the skirt. Rings have three basic jobs: (1) to seal gas pressure (2) to provide path for heat flow from piston to cylinder walls, and (3) to control cylinder-wall lubrication.

Commonest are *snap* rings with angle or step joints. To reduce compression loss by leakage through the gap in plain rings, special *seal* rings may be used. *Oil-control* rings are designed to scrape excess oil from cylinder walls on the down stroke; ride over the film on the way up. Ring groove may be connected to inside of piston by channels *or ports to carry away excess oil.* Most rings are made of cast iron; some bimetallic constructions (phosphor-bronze wear strips, for example) have been used. Chromium plating and other surface treatments have also been employed.

Connecting Rod. In essence a strut with a bearing at each end, the connecting rod transmits piston thrust to the crankshaft. It must be strong, yet because of inertia forces must be without excessive weight, especially in high-speed engines. The rod is usually forged from alloy steel, frequently with an "I" or channel section.

In large engines, the crankpin end may consist of a separate bearing box (in two parts) bolted to a "foot" on the rod. Shims between foot and box permit adjusting compression. This so-called "marine" design has largely given way to the construction of Fig. 20, in which upper half of crankpin box is integral with the rod.

Need for large crankpin bearings in highly loaded engines makes it difficult to keep crankpin end small enough to withdraw through the cylinder. More compact construction results from: (1) use of four bolts instead of two (2) use of studs instead of bolts, Fig. 21, (3) splitting box at an angle, Fig. 22, and (4) employing hinged-strap construction, *Fig.* 23.

Rod Bolts. Connecting-rod bolts are made from heat-treated carbon steel or alloy steel in some cases; the fine threads used for strength are carefully cut and finished to avoid surface defects which might start fatigue cracks. To assist bolts in resisting side-inertia forces many designers put a step or tongue-and-groove at the joint between rod foot and upper bearing half, or between bearing halves.

Wristpin Construction. The wristpin links connecting rod and piston. Of the three possible arrangements — (1) wristpin secured in piston, bearing in rod (2) wristpin fastened to rod, bearing in piston or (3) wristpin bearing in both piston and rod — the latter, or *full floating*, design is now most common. Piston bosses usually carry bushings for the pin; either snap rings or end caps hold the pin against longitudinal movement. End caps keep wristpin-bearing lube oil from leaking into cylinder.

Full-floating design makes almost full area of wristpin available as bearing surface. The "fastened in the rod" construction may be used in such a way as to secure maximum bearing surface on top of pin, where it is most needed. The pin bolts to a saddle or pad at the rod end, freeing entire top pin surface for bearing.

Principal objection to fastening the pin in the piston comes from use of press fits to hold pin in bosses. This almost always resulted in distortion of the piston, and made disassembly difficult. In large pistons, the wristpin can be bolted to an internal supporting structure, Fig. 25, avoiding these drawbacks.

The connecting-rod wristpin bearing is usually a solid bushing. It receives lubrication from the crankpin bearing through rifle-drilled passages in the rod, Fig. 24. The wristpin itself is usually steel and hollow. Fig. 26 shows a wristpin fitted with small-diameter cageless rollers in what is called a *needle bearing.* This design permits extremely small clearance and hence less tendency to "pound". It also offers high load-carrying capacity.

Crankshafts. The principal force a diesel crankshaft must resist is the bending action of connecting-rod thrust when piston is at top center. *Then* maximum gas pressure acts straight down on the crankpin, tending to bend the shaft between supporting bearings. The crankshaft must also withstand twisting or *torsional* forces from connecting-rod angular thrust.

Most modern engines have one-piece crankshafts forged from carbon steel or steel alloyed with nickel, chromium and molybdenum. In extremely large engines, crankshaft may be two forgings, bolted together. In some engines, crankshafts too large to be made as single forgings are built up. Webs are forged and journals turned; journals are shrunk and keyed into web forgings. Some modern engines have crankshafts cast from chrome-nickel-moly iron.

It is customary to heat-treat forged shafts to relieve any internal stresses. Induction hardening is often applied to give journals a hard skin over a tough inner core. In addition, journal surfaces may be *superfinished* to make them extremely smooth. These steps greatly increase life.

Counterweighting. Crankshafts are sometimes counterweighted to relieve loads on main bearings by offsetting inertia forces. It may also improve balance, especially in 1-, 2-, and 3-cylinder units. In crankcase-scavenging engines, counterweights help fill crankcase space *and hence improve pumping* action. Major disadvantage lies in fact that counterweights lower crankshaft critical speed and may bring it into the engine's operating range.

Bearings. With the exception of needle-bearing wristpins previously mentioned and occasional use of ball and roller bearings, diesels use sleeve bearings almost exclusively. Main and crankpin bearings are split and, where load conditions permit, lined with tin- or lead-base babbitts. Current practice leans heavily to *precision* bearings, consisting of a thin back or shell and an extremely thin lining, machined to be interchangeable without hand fitting. For a comprehensive discussion of bearing construction, lining materials, and applications *in diesels, see* POWER, Jan 1948, pp 84-87; Feb, pp 74-77.