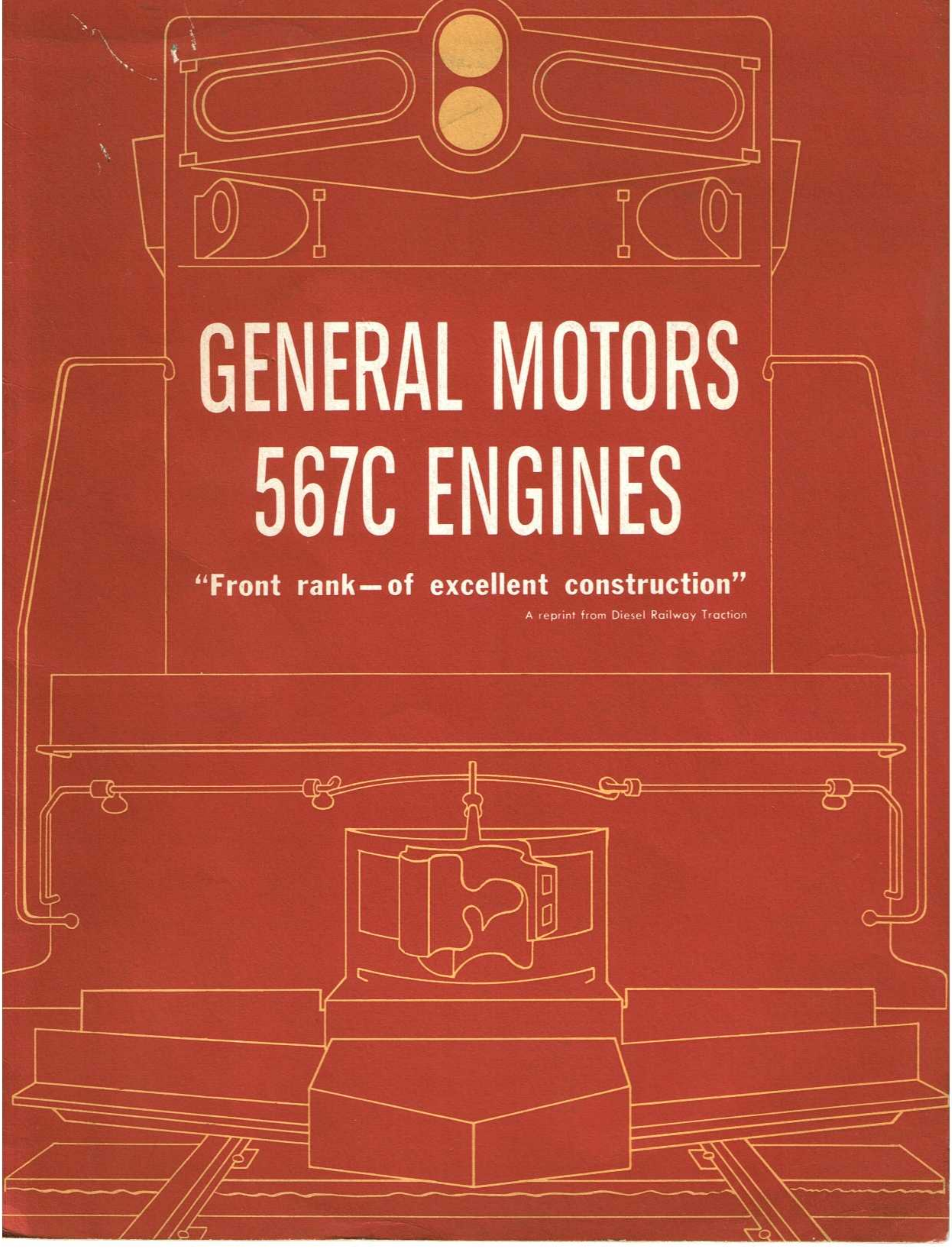
GENERAL MOTORS 567C ENGINES

"Front rank—of excellent construction"

A reprint from Diesel Railway Traction



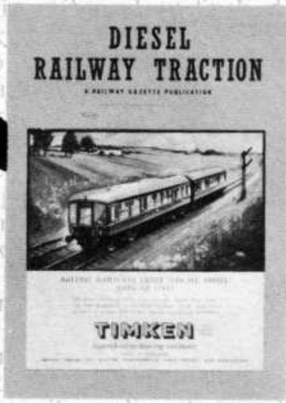
REPRINTED BY PERMISSION OF DIESEL RAILWAY TRACTION

main-line power, a beginning is being made in the use of diesel shunting power, and a characteristic of one of the orders recently placed is that hydraulic transmission is being incorporated. First, the Gold Coast Railways have ordered 13 400-h.p. diesel-electric units with Paxman engines from the Birmingham Carriage & Wagon Co. Secondly, the Nigerian Port Authority has ordered eight six-wheel 400-b.h.p. shunters from H.A.K., to include that company's own oil engine and form of rod drive, along with Voith hydraulic transmission. Things in British West Africa, an early cradle for British industrial locomotives such as built by Hunslet and Bagnall 20 years ago, are thus now tending to follow the large [illegible] where [illegible] electric and diesel-hydraulic [illegible] more or less ousted steam working from line service and shunting, though in these territories a considerable use is made also of diesel railcars. To make this brief record complete, mention should also be made of the two General Motors diesel-electric locomotives of four-figure power operating on an important mineral railway in Liberia. Though these [illegible] now making use of diesels.

Detergency Tests

When all contaminating particles in an oil engine lubricati[illegible] divided and suspended in micr[illegible] of adding a detergent [illegible] the o[illegible]. It does not matter [illegible] how much of it was [illegible] are micro-size the dete[illegible]nt.

These [illegible] of a U.S. specialist in deter[illegible] thousands [illegible] activity tests co[illegible] contaminating particles from ox[illegible] into gr[illegible] by size and [illegible] coag[illegible] and fro[illegible] gent co[illegible] of re[illegible] gent co[illegible] to be a relia[illegible] cation [illegible] kers in this [illegible] detergent oils realise that each make [illegible] of engine is different in its detergent-[illegible] but it appears, also, that each engine is [illegible], for it is quite likely that each may have different rates of creating oxidised oil and oxidised fuel contamination, even in the new condition. For example, an oil with little detergent but with a light contamination burden can have something closely approaching 100 per cent detergency activity, whereas an oil with a large detergent content will have a low activity if there is much contamination. The important thing is to know what the engine conditions are doing to the detergent, not how much compound remains.



Locomotives for Refineries

Not unnaturally oil companies favour diesel locomotives for their own shunting requirements, and have been doing so on a rising scale for 24 or 25 years. As a rule, makers' standard designs are sufficient for the duties, but usually with flameproofing equipment added, or exhaust-cooling adopted as an extra, to suit them to operation in refineries or similar locations where oil mist and leaking oil are not uncommon. On occasion, something akin to transfer traffic may necessitate a variation in the locomotive design compared with what would have met purely shunting requirements; and this came to the fore in the design of two locomotives which have been operating for nearly two years in a refinery outside of Rotterdam, and which are illustrated and described elsewhere in this issue. In appearance they scarcely justify the line of the poet Keats that "A thing of beauty is a joy for ever," though the performance so far may give rise to the hope that they will fulfil the second [illegible], and "never pass into nothingness." To [illegible] rather do they justify the description of the poe[illegible] in possessing "a monstrous beauty, not unlike [illegible] quarters of an elephant." But these defects in [illegible] be traced to the onerous requirements of hig[illegible] power on a short wheelbase, and to the [illegible] of flameproofing equipment in the exhaust [illegible]. Considerable [illegible] to a nu[illegible] of the controls and [illegible] to give foot-proof and co[illegible] driving, and some idea of these can be gained [illegible] from the [illegible] illust[illegible] of the cab [illegible] shows t[illegible] desk and its appurtenances.

The G.M. Two-Stroke

The world's best-known railway two-stroke engine has a technical development history of a most interesting character. Assured of a market of several thousand engines, at least, of four-figure power, money could be literally poured into the development. It was; and the results have been good, for though American diesel traction progress and application have been on lines which cannot be duplicated elsewhere, there is no doubt that the G.M. type 567C engine as made by Electro-Motive at La Grange is not only in the front rank of two-strokes in regard to ratings and so on, but is also of excellent construction. The article elsewhere in this issue which describes the engine can do no more than touch on certain aspects of development; but the way in which the inherent problems of the original 201-A engine were tackled—and the way in which the designs of that engine were more or less thrown overboard in favour of an entirely new design without forgetting the hair-greying experiences—needed courage and skill. But always to the fore was the production aspect, in which good design from a performance viewpoint was subject to the closest scrutiny by the shop managers and the time-and-motion study experts, so that production costs could be closely estimated and controlled, and could remain at a low level despite what might seem complications in the engine design. The maximum production of eight to ten locomotives a day in the peak periods, and the total of well over 20,000 large oil engines, shows how critical were the production methods down to the last detail. The 567C is a production man's engine just as much as a designer's, and the collaboration between the two categories has brought good results.

General Motors 567-C Engines

A detailed description of the world's best-known two-stroke railway oil engine

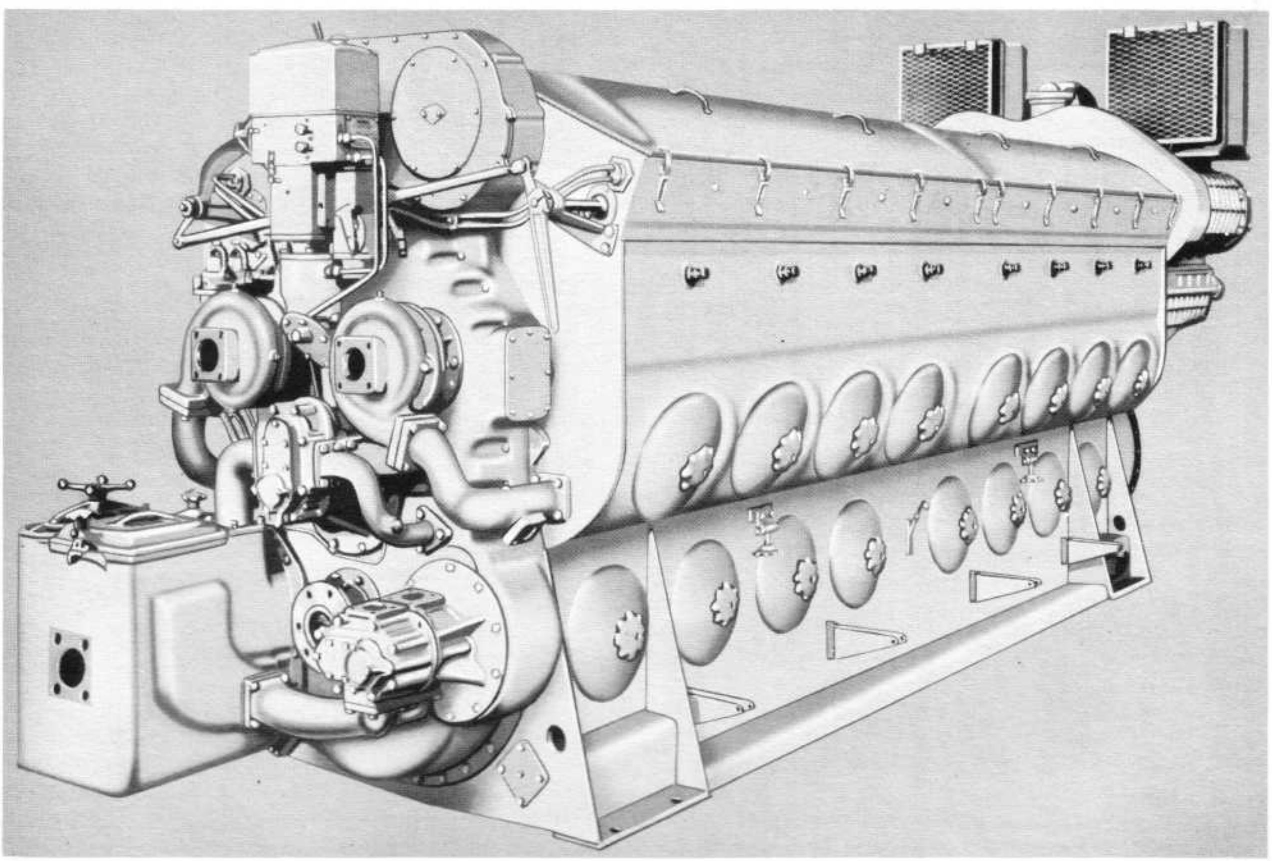
THIS current engine of the Electro-Motive Division of General Motors has a history of over 20 years. It is a direct descendant of the 567A and 567B engines; but the A engine itself followed the 201A model which was the original applied to the Zephyrs and certain locomotives; and although the 567A was a complete re-design, nevertheless it incorporated the valuable experiences gained with the 201A, some of which were detailed in our issue of September, 1936. A leading G.M. executive has said that by the end of 1935 they "believed this 201A engine was not good enough for railway service—but in all due respect it was good enough to prove the diesel locomotive and to thoroughly launch the revolution of American railroad operation."

In design the 567C engine dates back to 1951, but the present 6–, 8–, 12–, and 16–cylinder models, all of the V type, were not offered commercially until January 1, 1954. They have been installed in all G.M. locomotives ordered since that time; and also a number of 567B engines then at work have been rebuilt into the C type, for many details are interchangeable in regard to mounting. For example, the regular C-type top deck covers and frames, modified water and oil drain piping, water jumper liner, water jumpers, water inlet manifold, and the machining of the lower pilot bores of the crankcase to accommodate a permanent pilot ring and a replaceable wear ring, can all be incorporated in the B engine, the rebuilt model being known as the 567 B-C.

Early Development

Development and problems of the 567A and B engines were dealt with at length by E. W. Kettering in a paper to the American Society of Mechanical Engineers on November 29, 1951, one of the best oil engine papers ever presented to a technical institution. But at that time only certain features of the 567C engine had been definitely finalised, though two prototype engines were then undergoing tests at La Grange.

Of the development to that time, Kettering said: "from the first 567 engine in 1938 through to the 567B engine in 1951, we have not only increased durability and reliability, but to a great degree have maintained interchangeability. All the pieces from a given model of 567B design can be used in any 567 engine that was ever built with the exception of the camshaft-blower drive gear, a change in which was made in 1941. This means that current items such as crankshafts, camshafts, main bearings, connecting rod bearings, wrist pins, pistons, cylinder heads,



General Motors 16-567C engine of 1,900 h.h.p. from the forward end

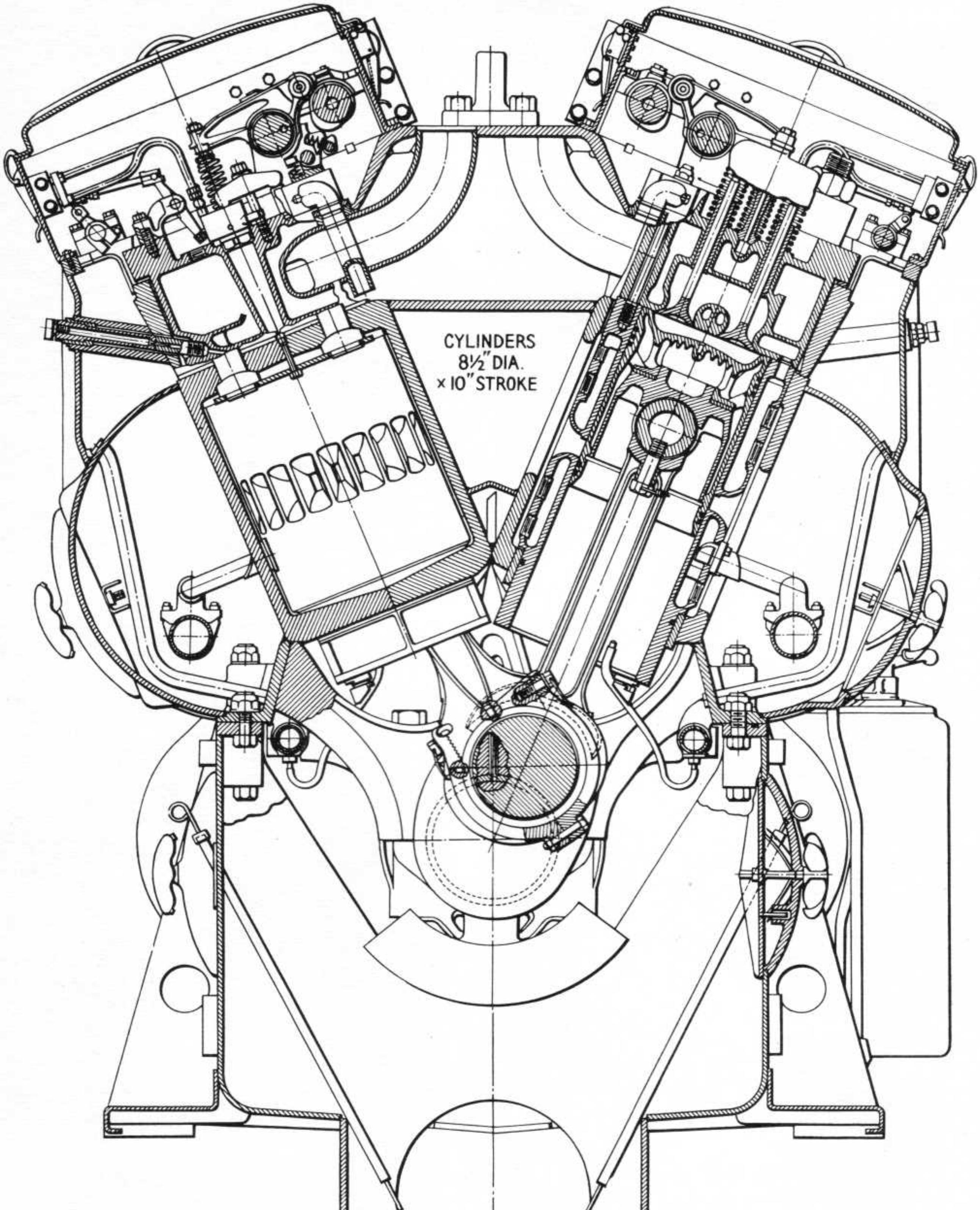


Fig. 1—Cross section of 567-C two-stroke railway oil engine as built on production-line methods by the Electro-Motive Division of General Motors at the La Grange works. Output per cylinder is about 120 b.h.p. at a speed of 800 to 835 r.p.m. The special liner construction is to keep cooling water away from the welds in the steel framing. Engine weight is borne through the welded steel oil pan or engine base

liners, connecting rods, water pumps and oil pumps can be used in any model of crankcase. Further than this, any current engine including the new C engine can be used in any 567 locomotive model that was ever built."

Kettering's use of the word interchangeability here does not mean that the detail design of no part was ever changed, but that the new details could be mounted in place of the old without extraneous change to other parts of the engine. Within the 567C range itself there is interchangeability, in that all four models have the same cylinder head assembly, pistons, connecting rods and bearings, external accessories and other details; and, of course, all parts are made to interchangeable limits and fits.

The 567C Characteristics

The present 567C engine is a V type with an angle of 45 deg. between cylinder banks; and as in previous 567 engines the bore is $8\frac{1}{2}$ in. and the stroke 10 in.; but there has been some slight change in speed. The two-stroke uniflow-scavenge system is retained. The number 567 denotes simply the cubic inches of piston-swept volume of each cylinder. Basic particulars of all models are given in Table I, and attention is drawn to the two columns of outputs included, for general American practice is to denote the engine by the traction input to the main generator, whereas for comparison with all non-American makes the b.h.p. figure is necessary. For correct appraisal of the firing order, mention should be made that the cylinders are numbered from the front of the engine to the back in each bank, with 1 to 6 in the left-hand bank and 7 to 12 in the right-hand bank, taking the 12-cylinder engine as an example.

Values included in Table I show that the engines are very highly rated as two-strokes, and have power-weight ratios of excelled calibre judged by the standards of modern medium-speed four-strokes. Also it is obvious that a fair degree of pressure-charging must actually be provided by the gear-driven Roots scavenging blowers. Indeed, blower pressure at normal top engine speed is said to be 6·0 in. to 8·5 in. of mercury; and the blower capacity is 2,000 cub. ft. per min. at $7\frac{1}{2}$ in. Hg. in the six- and 12-cylinder engines and 2,900 cub. ft. per min. in the eight- and 16-cylinder models. These are the capacities per blower, and there are two blowers mounted on the 12- and 16-cylinder engines.

Frame Structure

Main structural part of the 567C engine is the fabricated steel crankcase, supporting the cylinder assemblies and engine-mounted accessories. Below the crankcase is the welded steel oil pan, supporting the crankcase and also acting as the engine base through which the weight is transferred to the locomotive frame. Principal parts of the crankcase are the top deck, the A frames supporting the main bearings, the side panels and the end plates. The two cylinder banks form the backbone of the crankcase, and each bank is made up of two steel channels welded together, with holes at top and bottom to take the liners, and with circular holes in the side stress plates to provide for the air supply to the intake ports and for liner inspection. These circular holes in the crankcase sides, and corresponding ones in the oil pan, form the readiest external means of distinguishing a 567C engine from a 567B, for the latter has rectangular doors.

The A frames are welded to the cylinder-bank stress plates and the base rail, and form the bottom part of the crankcase. They are line bored to take the main bearings, which are of the underslung type. When production methods for the 567C engine were being drawn up recognition was made that a properly-designed automatic weld is much stronger than many multi-pass welds. Therefore, when the new production line for crankcase and oil pan was brought into operation, nine special automatic welding fixtures were built into the line. They make a total of 32 separate welds totalling over 350 ft. in length in the 16-567 engine. Into the crankcase production was also put a new 18-position conveyor line for manual welding operations. Crankcase skeletons start at the head end, and the main-bearing carrier forgings, cylinder head retainer sub-assemblies, and seals are fed into the line from the machine operations alongside. These methods were introduced to help in reducing crane lifts and minimising material handling.

Air Box

Returning to the design of the crankcase, the air box is the area surrounding the liners and formed by the cylinder banks and enclosed by the crankcase end plates and side panels. Two air inlet holes in the rear end plate permit air supply to the air box from the engine blowers to provide air for the cylinder-liner intake ports.

Separation of the air box from the upper exposed part of the crankcase is by means of the upper deck of the cylinder banks. Located on this bank are the cylinder-head retainers of each bank, joined at their inward sides by the water outlet manifold. Exhaust elbows extend from each cylinder retainer through the water discharge manifold to the top deck of the crankcase. Forged camshaft supports, with lined keyways, are integral with the top deck. Two removable water-inlet manifolds, one on each side of the crankcase for the adjacent cylinder bank, are located at the outer bottom of the air box. Lubricating oil and piston-cooling oil manifolds are incorporated as part of the crankcase.

Incorporated in the oil pan is the sump, which is located centrally in the pan. The sealing arrangement between crankcase and the oil-pan mounting flanges consists of a silicone rubber cord placed in a groove outside the bolt line.

Cylinder Heads

Cylinder heads are of alloy cast iron, but the assembly is not interchangeable with those of 567A and B engines. The whole assembly includes three rocker arms, four exhaust valves and their springs, valve bridges with springs, valve guides, overspeed trip pawl, and fuel injection unit. The cylinder head is bolted to the liner by a dozen $1\frac{3}{4}$-in. crab-bolts as shown in Fig. 2. These bolts extend through the cylinder bank upper deck plate adjacent to each cylinder retainer. The bottom heads of the bolts have a spherical seating surface which seats in a like surface, and the bolts are held in position by a separate plate and cap-screw for each pair of bolts. The square bolt head fits into a corresponding hole in the plate, so that turning is prevented. Lower crabs are not used; the upper crabs each contact two cylinder heads except at the ends, and at the centre of the 16–567 engine.

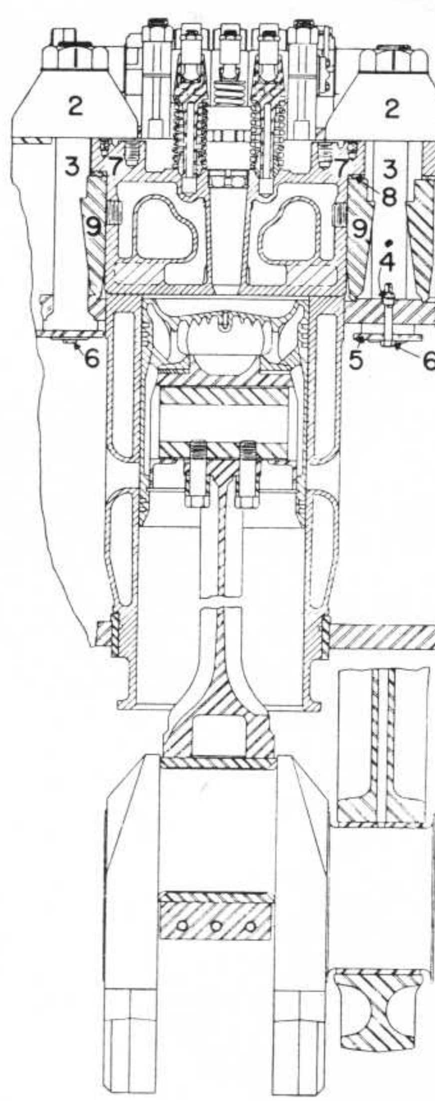
Liner

Another distinctive feature of the engine is the cylinder liner. To keep cooling water away from the stressed fabricated parts of the engine frame, the cast-iron liner comprises also an integral water jacket, formed by a cored annular space between inner and outer walls. This liner is secured to the cylinder head by eight studs and the entire assembly is held in place in the crankcase by the cylinder head crabs. A pilot stud locates the liner in proper angular relation to the head, and assures alignment with the piston cooling-oil pipe. The scavenging air inlet ports encircle the liner; and, as the water space extends below the port openings, the port struts are water cooled. Water discharge to the cylinder head is through 12 water tubes which extend into the head, and around each tube in a counterbore is a synthetic rubber sealing ring. A thin copper-clad steel gasket is used between head and liner. General shape of the liner casting is shown in Fig. 2.

Valve and Timing Gear

Four 2½-in. exhaust valves are fitted in each cylinder head. They are actuated from two gear-driven camshafts one for each cylinder bank, and the gear-train for the drive is located at the back end of the engine. This train is of straight-tooth spur gears and comprises the crankshaft wheel, two idlers, right- and left-hand bank camshaft wheels, and (in the 12- and 16-cylinder engines) two blower drive wheels. Off No. 2 idler is also taken a spur-gear drive to the auxiliary generator. The idlers and blower-drive gears rotate on stub shafts mounted on the end plate, and are provided with floating bushes and thrust bearings.

The camshafts are at top cylinder head level, so that no push rods or tappets are needed, and they operate direct on the roller-followers at the fork ends of the rocker arms. The opposite end of each rocker has an adjusting screw and locknut for setting the injector timing or adjusting the lash adjusters. The camshafts are in sections bolted together; in the six- and 12-cylinder engines each section covers three cylinders, and in the 16-567C each section covers four cylinders; but the 8-567C has an individual section for each cylinder. At each cylinder location there are two camshaft bearing journals, two exhaust-valve cams, and one fuel injection cam. Each camshaft has a counterweight, and embodied in the right-hand weight is the engine overspeed trip release mechanism.



1—Crab nut
2—Crab
3—Crab bolt
4—Retainer bolt nut
5—Retainer plate
6—Retainer bolt
7—Cylinder head
8—Cylinder head seat ring
9—Cylinder head retainer

Fig. 2—Cylinder head and crab bolt assembly, showing also the piston and rod assembly

Exhaust valves of engines set to high power out-

TABLE I—DATA OF GENERAL MOTORS 567C TWO-STROKE ENGINES

Model	No. of cyls.	R.P.M.	B.H.P.	Traction Input to Main Generator H.P.	B.H.P. per cyl.	Brake mean pressure lb. per sq. in.	Piston speed ft. per min.	Dry-weight lb.	Dry per b.h.p. lb.	No. of gear-driven blowers
6–567C ..	6	800	730	650	121½	106	1,335	15,700	21·5	One
8–567C ..	8	835	975	875	122	102½	1,395	18,000	18·5	One
12–567C ..	12	800	1,425	1,310	119	104	1,335	24,700	17·4	Two
16–567C ..	16	835	1,900	1,750	119½	100½	1,395	32,100	17·0	Two

All models are uniflow-scavenge, 45-deg. V., 8½-in. by 10-in. cylinders, 16 to 1 compression ratio, and 275 r.p.m. idling speed put have Stellite faces; otherwise not. Valve stem guides are of precision type. A valve bridge is used to operate the exhaust valves from one rocker arm; and there is a long-travel hydraulic lash adjuster to maintain zero lash between valve stem end and the valve bridge. In this, lubricating oil flows from the rocker arm through a drilled passage in the valve bridge to the top of the lash adjuster, past a ball check valve, and into the body. When the rocker arm depresses the valve bridge, a slight movement of the plunger in the lash adjuster seats the ball check, trapping the oil. As oil is almost incompressible, further movement of the rocker arm causes the lash adjuster plunger to force open the exhaust valve.

TABLE II—FIRING SEQUENCE OF V TWO-STROKES

Model	Firing Order
6–567C	1–4–3–6–2–5
8–567C	1–5–3–7–2–6–4–8
12–567C	1–12–7–4–3–10–9–5–2–11–8–6
16–567C	1–8–9–16–3–6–11–14–4–5–12–13–2–7–10–15

Injection and Fuel Systems

A leading detail of the G.M. engines is the unit injector and fuel pump. This assembly, located in the centre of the cylinder head, comprises a high-pressure fuel metering pump and a spray valve in one housing. Each is supplied with a continuous flow of low-pressure fuel delivered by a separate transfer pump. The injection-pump plunger is given a constant-stroke reciprocating motion by the injector cam acting through the rocker arm and plunger follower. Timing of the injection period during the plunger stroke is set by an adjusting screw at the end of the rocker arm. Rotation of the plunger by means of the rack and gear controls the amount of fuel injected, and rack position is controlled by the hydraulic governor through the injector layshaft and linkage. Proper atomisation of the fuel is maintained by the high pressure created by the downward stroke of the plunger, which forces fuel past the injector spherical valve and out through six spray holes in the injector lip. High pressure is confined to a short length of passage at the lower end of the pump-injector unit.

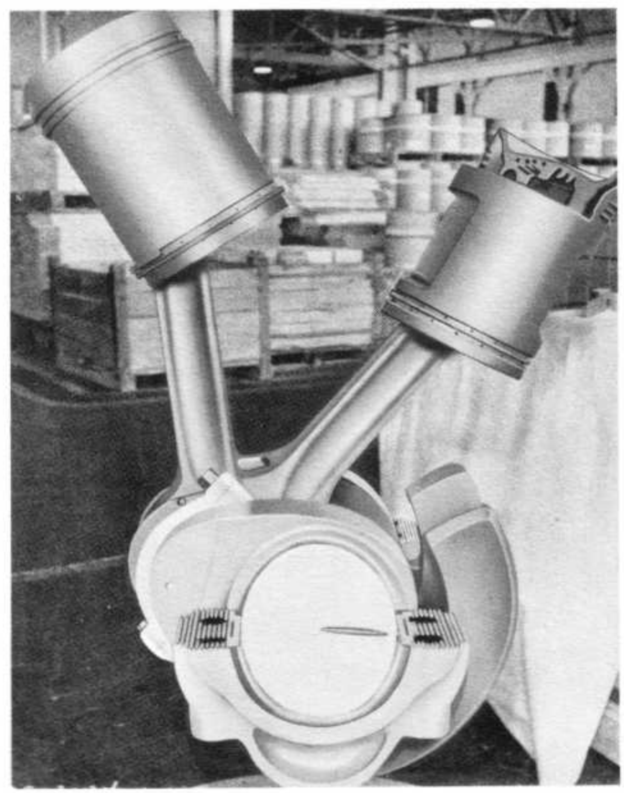
Filters are inserted in the fuel system in the suction line between the fuel tank and the low-pressure transfer pump, and in the pump discharge line to the injector units, and also at the injector fuel inlet and outlet openings. Cartridge filters are used in the suction and discharge lines, but a sintered bronze filter is used as a discharge filter additional to the cartridge units.

From the sump of the main tank fuel is drawn by the transfer pump through the suction strainer and discharges the fuel through the discharge filters. It then passes through the elements to the fuel manifold supply line from where it flows through a jumper line at each cylinder into the injector unit through the inlet filter. A small portion of this fuel supply is pumped into the cylinder at high pressure through the spherical check valve and the injector nozzle; the remainder of the fuel flows through the injector unit and serves to lubricate and cool the working parts. This fuel oil then leaves the injector through the return fuel filter, which protects the injector in the event of a backward flow of fuel from the return fuel line. From the return fuel filter on the injector unit the excess fuel returns through the fuel return line in the manifold to the orifice inlet of the return sight glass. This orifice restricts the return fuel to the extent of maintaining a back pressure of about 5 lb. per sq. in. The fuel continues into the return sight glass, filling the glass, and down through the stand-pipe under the glass through the return line to the fuel supply tank.

Pistons

The alloy cast iron pistons are two-piece, or floating, units, comprising an integral piston body and a trunnion-type forged steel oil hardened piston carrier. This is a completely new design compared with the 567A and B engines; nevertheless, the piston and connecting rod assembly is interchangeable with that of the two older 567 engines. This carrier supports the piston body at an internal piston platform, and is held in position by an internal snap ring in the piston body. A thrust washer is used between the carrier platform and piston platform. This design allows freedom of rotation to the piston body during engine operation; and it is considered that this feature distributes piston skirt wear, reduces liner wear, and improves the ring performance.

Certain details of piston construction can be seen in Fig. 2. The carrier in the trunnion piston assembly has a circular boss located centrally on its upper platform, which pilots in a bore in the centre of the



Connecting rod and piston assembly showing section of crankshaft and underslung main bearing cap

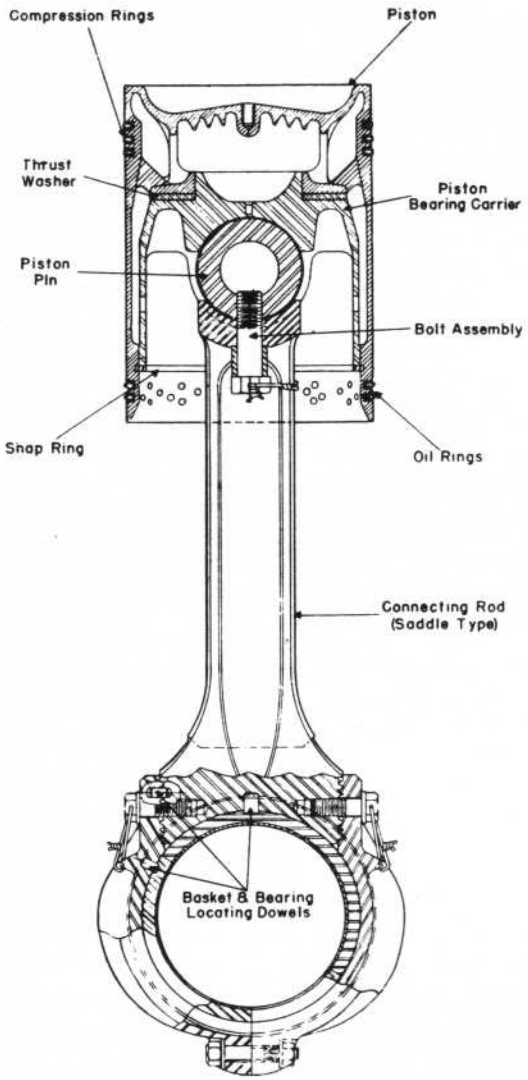


Fig. 3—Cross section through cast iron oil-cooled $8\frac{1}{2}$-*in. dia. piston and the forked connecting rod*

piston platform, and is also piloted in the piston at the carrier bottom outside diameter. No gudgeon pin bushings are used in the carrier, as the gudgeon pin bearing area extends over the diameter of the carrier and is formed to the contour of the piston pin. The bearing surface of the pin oscillates in the carrier.

Internal parts of the piston, and the under-side of the crown, are lubricated and cooled by a forced circulation of piston pooling oil, which is directed through a drilled passage in the piston carrier, circulates over the under-side of the crown, lubricates the gudgeon pin, and drains through two holes in the carrier at right angles to the pin. The pistons in the 567C engine are given Parco Lubrite treatment to aid skirt lubrication; this process etches the surface to a dark dense porosity which gives better oil retention. Each piston carries three compression rings above the pin and two double-hook oil-control rings below.

The alloy steel gudgeon pin is mounted directly on the circular contour at the top of the connecting rod, and two bolts pass through the upper end of the rod and screw into the hollow-bored gudgeon pin as shown in Fig. 2. The top surface of the pin, which is the bearing area, is provided with lubricating oil grooves. A silver bearing material about 15 thou's thick is provided all over the outer surface of the pin, and this surface is also given a thin lead flash.

Rods

Connecting rods, with a length to crank-radius ratio of 4·6 to 1, are of the fork-and-blade type as in previous 567 engines, but compared with conventional practice the big ends are of unusual type. Two-stroke operation, to begin with, eliminates load reversal and makes possible a fork rod cap design which allows, if desired, the connecting rod to be removed through the cylinder despite the large crankpin diameter.

Both fork-and-blade rods are drop-forged I-section and the fork rods are on the left bank of the engine looking forward. The blade rod moves back and forth on the back of the upper crankpin bearing and is held in place by a counter-bore in the fork rod. One side of the blade rod bearing surface is longer than the other and is known as the long toe.

A serrated basket type of big-end is used, and its construction is illustrated in Figs. 2 and 3. Serrations on the *sides* of the rod foot match others on the bearing caps, which are in quarter circles bolted together below the crankpin. These bottom bolts have self-locking nuts; the serrated tops are bolted and dowelled to the fork rod. The fork rods and their basket ends are assembled and line bored.

Big-end bearings comprise upper and lower shells of semi-circular steel, having a layer of lead-bronze with a lead-tin overlay on the inside diameter. The centre part of the outer diameter of the upper half of the bearing has a lead-bronze layer, but no lead-tin flash, to form the bearing for the slipper-type blade rod. Dowels in the fork rod and basket hold the bearing shells in proper position. Shells are of the precision type, and no adjustment of connecting-rod bearings is provided.

Crankshaft

Drop-forged carbon steel with journals induction hardened is used for the crankshaft. The 16-cylinder engines have crankshafts made up of two sections joined by bolted flanges at the centre; all the other models have single piece shafts, and all are dynamically balanced. There are four bearings in the six-cylinder engine, five in the eight-cylinder, seven in the 12-cylinder, and 10 in the 16-cylinder models.

A design problem was the calculation of torsional vibrations and overall balance between the four engines in the range, plus the development of a firing order which would give the best conditions in each engine. One result is that exactly the same harmonic balancer is applied to the 8-, 12-, and 16-cylinder engines; the six-cylinder engine does not need a balancer. Maximum order of vibration for each engine—i.e., the number of twists per crankshaft revolution—is the same as the number of crank throws. In no case does maximum amplitude occur at or near a governed load speed. In the 16-cylinder engine, for example, the 8th order critical occurs at about 375 r.p.m., that is between the idling speed of 275 r.p.m. and the lowest normal load-carrying speed.

At the back end the main shaft is joined to the main generator shaft by a flexible coupling comprised of an engine half disc and an armature half disc. Arrangement of the junction of the two discs round the periphery is on a serrated principle; and bolted into the assembly round the shaft is the first timing-gear wheel. At the front end of the shaft is the torsional vibration damper or harmonic balancer; and just outside this again is the accessory drive gear, of the flexible type. The balancer is of the laminated spring type, and the springs receive oil through radial passages in the spring housing from the crankshaft.

The accessory gear transmits the drive from the main shaft to the pump gears and governor drive gear. As shown in Fig. 4 the hub is assembled in the gear with spring packs in each of eight mating spring slots in both pieces. Gear, spring packs and hub are located between two discs, with two dowels through to secure the assembly plus two safety dowels.

Main bearings of the crankshaft are precision-type steel-backed lead-bronze lined with a lead-tin overlay; and tangs in the bearings locate them in the proper axial position and prevent turning. The upper and lower halves are not interchangeable, and the lower shells have two tangs which fit into the underslung main bearing cap. Front and intermediate bearings are the same for all engines in the 567C range, as are the rear main bearings; but centre bearings are different; though in the eight-cylinder engine the centre bearing is the same as an intermediate bearing. The thrust bearings are of solid bronze and are in a counter-bored seat on each side of the centre bearing A frame except in the six-cylinder model, where they are on each side of No. 3 bearing. These thrust surfaces are lubricated by main bearing leak-off oil.

Blower Characteristics

A most vital engine constituent in maintaining the high rating is the blower. Much development work was done in the days of the old 201-A engine, and since then there has been no major change in design. But when production of the 567 engines was being planned, the course chosen was to use the same blower for all engine models, but to provide a change in gear ratio and to use either one or two blowers. This greatly reduced production cost. In the six- and eight-cylinder engines one blower is used and is attached to the end of the right-hand cylinder bank. In the 12- and 16-cylinder engines two blowers are used. To gain the increased air delivery needed by the eight- and 16-cylinder engines compared with the six- and 12-cylinder models, the driving gear ratio is varied. With top engine speed of 800 r.p.m. in the "six" and the "12," the blower speed is 1,540 r.p.m.; in the "eight" and the "16," running at 835 r.p.m., the blower speed is 2,200 r.p.m.

At full engine throttle and speed the delivery air pressure in the air box is equal to about 8½ in. of mercury, and the volumetric efficiency of a blower is about 75 per cent. At the full throttle and speed output, excess air through the engine is about 27 per cent in the six- and 12-cylinder engines and 30 to 31 per cent in the 8-567C and 16-567C models. Blower capacity is about 5,800 cub. ft. per min at 7½ in. of water for the 16-cylinder engine with the engine running at 835 r.p.m. This figure being the combined capacity of the two blowers fitted.

Blower Construction

The blower itself consists of a pair of helical three-lobed rotors revolving in a close-fitting aluminium housing. Each rotor is pressed on a tubular steel shaft. The engine ends of these shafts are journals supported in the rear end plate bearing blocks. The front, or gear, ends of the shafts are serrated; flanged hubs having serrated bores are pressed on to the serrated tubular shaft ends, and serve as bearing journals and drive flanges for a matched pair of helical rotor gears. Thrust bearings are included in the front end bearing blocks. Blower rotor bearings have a high tin babbit content, and are pressure lubricated by engine oil supplied from the auxiliary-generator drive housing. Each blower is driven off the timing train as already explained. Mounted on

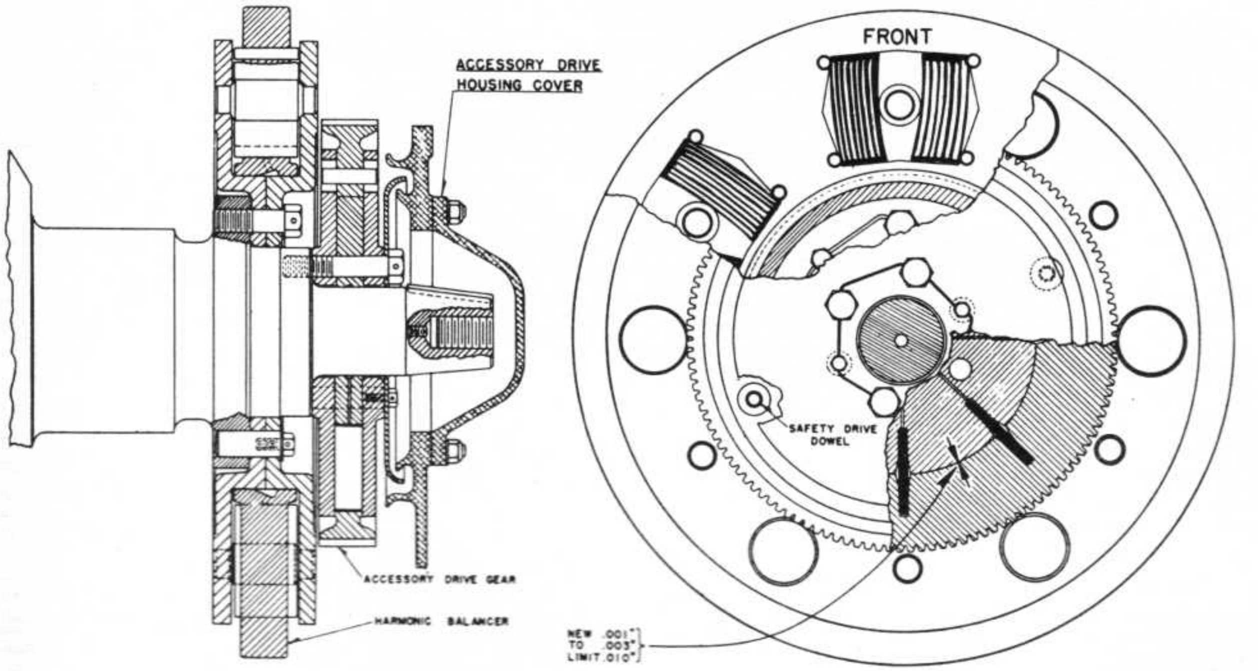


Fig. 4—General arrangement of harmonic balancer and the flexible gear drive to accessories

each blower is an oil-wetted intake air filter and an air-intake silencer to eliminate blower scream.

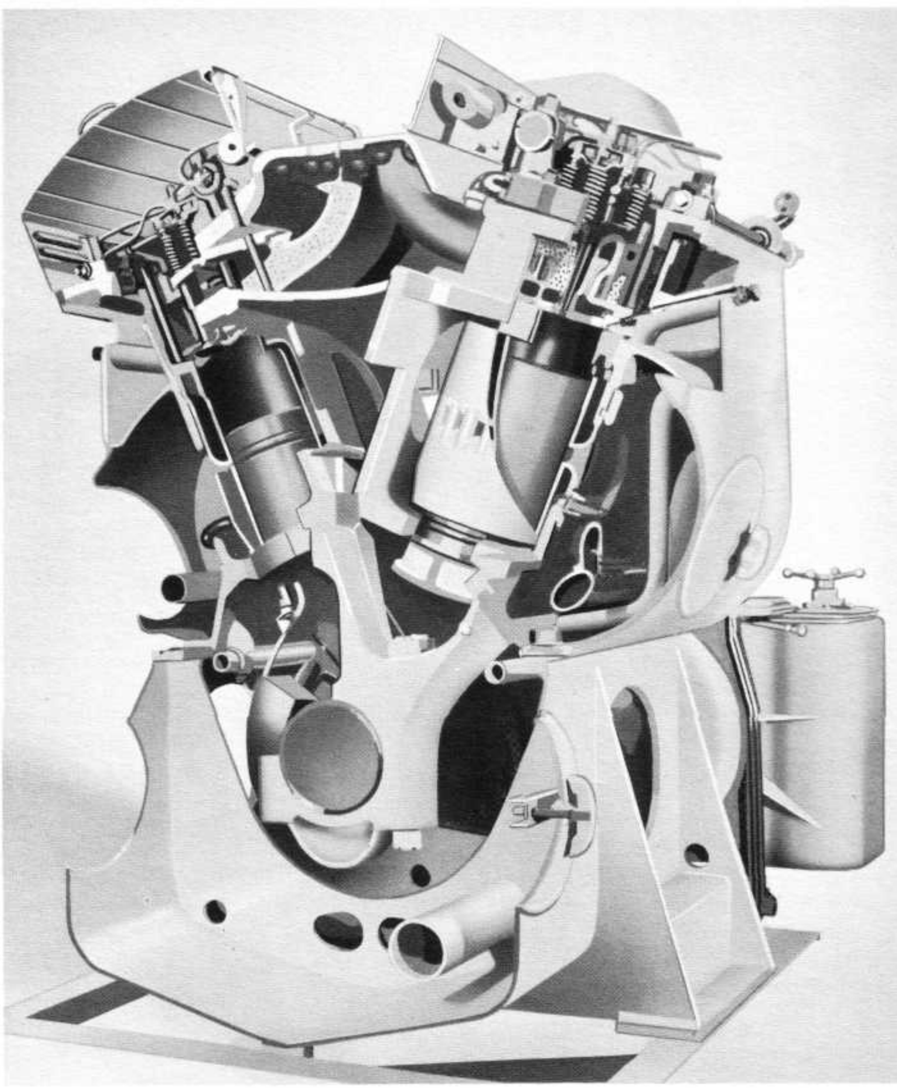
Lubrication

In principle, engine lubrication is a combination of three separate systems, viz.: the engine system, the piston cooling system, and the scavenging system. The first two are for the direct supply to the two parts named; the scavenging system serves the purpose of supplying the other two systems with cooled and filtered oil, by taking the oil which has drained into the sump and forcing it through the filter and coolers, from where it flows to the suction strainer housing, and supplies the lubricating and piston cooling pumps.

The scavenging oil pump suction line is built in to the engine sump. The oil strainer housing is a large cast-aluminium box mounted on the front end of the engine at engine-base level; it has independent strainers for the main oil pump supply and the scavenging pump. The scavenging oil pump is mounted on the accessory gear cover at the front end of the engine, and is a positive displacement helical gear-type pump. Lubricating oil and piston cooling pumps are contained in one housing and are separated by a division plate; their general construction is similar to that of the scavenging pump, and they, also, are carried on the cover of the accessory drive gear. Oil capacity in the 16-cylinder engine is about 167 gal.; at 835 r.p.m. engine speed the oil pump capacities per min. are approximately 217 gal. (scavenging), 51 gal. (piston cooling), and 122 gal. (lubricating oil). General level of the oil pressure is 30 to 50 lb. per sq. in at full speed and 16 to 20 lb. at the idling speed, but the shut-down pressure is 20 lb. at full speed and 6 lb. at idling. Piston cooling oil pressure at full speed is 15 or 16 lb. per sq. in.

Cooling

The cooling system comprises gear-driven centrifugal water pumps (one in the six- and eight-cylinder engines and two in the 12- and 16-cylinder models), replaceable inlet water manifolds with individual jumper line to each liner, a deflector plate at each liner inlet, the 12 water discharge tubes between each liner and the corresponding cylinder head, cylinder head discharge elbows and outlet manifold, and the radiators and fans. Pump speeds are 2,440 r.p.m. at 800 r.p.m. engine speed and 2,546 r.p.m. at 835 r.p.m. engine speed. Individual pump capacity at 800 r.p.m. engine speed is about 200 gal. per min. A design requisite laid down was good hot-water pumping characteristics.



Cut-away section of General Motors 567C two-stroke engine, showing liner construction, main bearings, cylinder head arrangement and other details

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