PRATT & WHITNEY ENGINES USED
IN VOUGHT F4U "CORSAIR"

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According to our information, all models of the F4U Corsair type airplane have been powered by Pratt & Whitney engines. All of these aircraft have had Double Wasp engines installed with the exception of the F2G which was powered by the Wasp Major engine. Several successively improved versions of the Double Wasp engine were used in the Corsair, indicating a progressive development of the engine parallel to that of the airplane. Each improved version evolved as a result of experience accrued on the previous models and from the emergence of new military requirements.

The following basic Pratt & Whitney Double Wasp engine models were used in the "Corsair": Series "A", "B", "C", "CE", and "E". The Double Wasp engine is an 18 cylinder twin-row radial air cooled type engine with two rows of nine cylinders. Piston displacement is 2804 cubic inches. R-2800 is the basic military designation of the engine. The following physical description will apply to the "A & B" Series two-stage supercharged engines as used in the Corsair. Normally, Pratt & Whitney engines have a single-stage supercharger which contains a single impeller driven at either one or at two different speeds. However, the principal difference between the two-stage engine and the single-stage engine is in the design of the accessory section, which incorporates two blower units (main and auxiliary), together with their driving mechanisms. The main blower has only one ratio to engine crankshaft speed, whereas the auxiliary blower has two. The latter is used to pressurize the air entering the carburetor at high altitudes, thereby greatly increasing the altitude performance of the engine, as compared with an engine incorporating only one stage of supercharging. The auxiliary impeller may be disengaged (Neutral), or may be shifted to either one of the two gear ratios (Low or High), by a manually operated selector valve which controls the function of oil-operated clutches. A schematic diagram of the two-stage control arrangement is shown in Fig. 24.

For descriptive purposes the engine may be divided into seven major assembly groups: the front (nose) section, main crankcase section, cylinders, main stage blower section, auxiliary stage blower section, intermediate rear section, and rear section. A combination of the main crankcase section and cylinders is generally regarded as the power section, whereas the main blower, auxiliary blower, intermediate rear, and rear section, when combined, are termed the accessory section.

The following information should be kept in mind when reading the ensuing description:

The cylinders are numbered consecutively in the direction of crankshaft rotation (anti-clockwise when viewing the engine from the propeller end), beginning with the top cylinder in the rear row which is called No. 1. Reference to right and left sides of the engine will apply as viewed from the rear.

GROUP I -- FRONT (NOSE) SECTION

The front section consists of the reduction gear housing, which is of cast magnesium alloy the propeller shaft and reduction gearing. External integral pads on the housing provide mounts for a dual magneto, twin distributors, propeller governor and a scavenge oil pump. A support sleeve, bolted to the inside front face of the nose section, carries a propeller oil transfer bearing, and acts as a support for the front oil scavenge pump drive shaft, the propeller governor drive intermediate gear and an oil transfer pipe from the propeller governor pump which provides oil for the operation of a hydro-controllable propeller. The housing also has provision for a deep-groove ball bearing which transmits the thrust of the propeller from the propeller shaft to the engine mounting via the crankcase.

Magneto, Distributor and Propeller Governor Drives -- The magneto is driven through a train of gears by a gear on the upper cam reduction gear shaft. This gear train is supported by the front support plate, commonly called the anchor plate. Each of the two distributors is driven through a separate train of gears by the same gear on the upper cam reduction gear shaft. These gear trains are supported by the front support plate and the reduction gear housing. The governor is driven by a bevel ring gear on the reduction gear cage through an intermediate gear.

Reduction Gearing -- The reduction gearing has a ratio of .500:1 (2:1) and is of the compound spur planetary type. The driving gear is splined to a coupling on the front of the crankshaft and meshes with six compound pinion gears. The pinion gears are of composite construction, having a 30 tooth large pinion internally splined to fit over a portion of the small 15 tooth pinion. The small pinions mesh with the driving gear and the large pinions mesh with the fixed gear. The fixed gear is an internal spur ring and has splines which fit into mating splines machined in the reduction gear housing. The pinion gears are supported in a cage bolted to a flange which is integral with the propeller shaft. A bevel ring gear is mounted on the cage flange to drive the nose section oil scavenge pump and the intermediate gear of the propeller governor drive.

With all types of gearing, the propeller shaft is supported at the forward end by the main thrust bearing and at the rear end in two steel-backed bronze bushings fitted inside the front end of the crankshaft.

GROUP II -- MAIN CRANKCASE SECTION

The main crankcase is composed of three forged aluminum alloy sections: front, center and rear, held together by through bolts. The front and rear sections are one-piece, whereas the center section consists of two halves bolted together along the horizontal diameter. A front support plate is fastened to the front face of the main crankcase assembly and a rear support plate is fastened to the rear face of this assembly. Around the outer circumference of the crankcase assembly two rows of cylinder mounting pads are arranged. Fifteen studs hold each cylinder to its pad.

One-piece steel-backed lead bronze bearings are pressed into place and locked in the front and rear sections of the main crankcase to support the front and rear main crankshaft journals. The center main crankshaft journal is supported by a two-piece bearing of the same type, locked in position in the center main crankcase. The cams and cam bearings are supported on integral circular shelves on the main crankcase front and rear sections. The valve tappets and tappet guides for each row of cylinders are also housed in the main crankcase front and rear sections respectively.

Front and Rear Support Plate -- The front section of the main crankcase and the front support plate house and support the cam reduction gears, cam and tappets which are part of the valve operating mechanism for the front bank of cylinders. The rear section of the main crankcase and the rear support plate house similar units of the valve operating mechanism for the rear bank of cylinders.

The support plates are aluminum castings and provide support for the trains of gears which drive the cams and two counterbalances; and also, in the case of the front support plate, the gear trains for driving the magneto and the twin distributors.

Valve Timing Mechanism -- A double-track, four-lobe cam actuates the valves in each row of cylinders. The front cam rotates on a bronze bearing with processed bearing surface which fits over a circular shelf forged integral with the forward face of the front main crankcase section. The rear cam is similarly mounted on the rear face of the rear main crankcase section. Both cams are driven opposite to crankshaft rotation at 1/8 crankshaft speed by two cam reduction gears, one above and one below the crankshaft. The cam reduction gears mesh with the cam drive gears on the crankshaft and with the internal gears of the cams. The front cam drive gear is splined to the front of the crankshaft and the rear cam drive gear is secured to the rear of the crankshaft by cap screws. The cam reduction gears are supported by and turn in bronze bushings pressed into the support plates and the main crankcase.

The tappet guides are of aluminum alloy and are shrunk into the front and rear sections of the main crankcase. The outer ends of the tappet guides are supported in the outer wall of the crankcase and the inner ends are anchored in bosses forged integral with the crankcase section. Steel valve tappets with roller type cam followers are mounted in the tappet guides, actuating the valve operating mechanism in each cylinder through tubular push rods.

Crankshaft -- The crankshaft is machined from three steel forgings having two throws which divide at the center of the crankpins where it is splined and bolted together. The crankshaft assembly is supported by steel-backed bronze bearings mounted in the front, center and rear main crankcase sections.

The weights of the reciprocating and rotating parts connected to the crankpin are counterbalanced by weights riveted to the outer cheeks of the crankshaft. The rear counterweight incorporates two removable torsional vibration dampers.

Secondary counterbalances are provided at each end of the crankshaft to dampen second-order vibrations caused by the eccentric masses of the master rod assemblies. The counterbalances turn on sleeve bearings mounted on the crankshaft and are driven at twice crankshaft speed by spring drive gears attached to the crankshaft through intermediate gears mounted on the support plates.

The hollow front end of the crankshaft has two steel-backed bronze bushings, pressed in to support the rear of the propeller shaft, and is splined externally to accommodate the reduction drive gear coupling and the front cam drive gear. The reduction drive gear coupling also supports the front secondary counterbalance spring drive gear. The rear end of the crankshaft assembly has an internal spline to accommodate the main accessory splined drive sleeve. The rear secondary counterbalance spring drive gear and the rear cam drive gear are secured to the rear end of the crankshaft assembly by cap screws.

Master and Articulated Rods -- The master rods are of the one-piece type and are located in cylinders No. 8 and 13. The master rod bearings are one-piece steel shells covered on the inside and outside with leaded silver. Each bearing is held in place by two spider retainer plates which fit between the shoulders of the crankpins and master rods. The plates have fingers which fit over bosses at each end of the full-floating type knuckle pins. Eight "I" section articulated rods are attached to each master rod by knuckle pins. The articulated rods have bronze bushings for the piston and knuckle pins.

Oil Sumps -- The main oil sump, attached to the bottom of the main crankcase, between cylinders No. 9 and 11, collects drain oil from the power and intermediate rear sections of the engine.

A small sump, located between the rocker housings of No. 10 cylinder, collects the drain oil from the rocker boxes through a series of inter-cylinder drain pipes. This sump is scavenged by one section of the nose scavenge oil pump.

GROUP III -- CYLINDERS

Cylinders -- The cylinders are of steel and aluminum construction. The cylinder barrels are machines from steel forgings, after which forged aluminum sleeves, in which deep-cut cooling fins have been machines, are shrunk over the central portion. The heads are aluminum alloy castings having closely spaced cooling fins and integral rocker housings. The aluminum heads are screwed and shrunk onto the cylinder barrels, forming permanent joints. Each cylinder has one inlet and one exhaust valve, the inlet seating on a bronze insert and the exhaust on a steel insert, both of which are shrunk into the head. The cylinder head also incorporates bronze inlet and exhaust valve guides, aluminum bronze bushings for two spark plugs, and four steel inserts for supporting the two rocker arm shafts. The cylinders are provided with mounting flanges and are secured by studs and nuts to the crankcase.

Pistons -- The pistons are machines from aluminum alloy forgings and are of the full skirt type with domed tops. Each piston has five ring grooves and is fitted with wedge type compression rings in the first three grooves, dual oil control rings in the fourth groove, and an oil scraper ring in the bottom groove. The top compression ring is chromium plated on the face which bears against the cylinder wall.

Cylinder Deflectors -- Pressure type deflectors, between the rocker housings on each cylinder head and between adjacent cylinders, force a high velocity flow of cooling air through and around the finning on both rows of cylinders. This air flow is induced by the forward speed of the airplane which produces a pressure differential between the front and rear of the cylinders.

Valve Mechanism -- All valve operating parts are enclosed. The rocker arms are supported on double-row ball bearings in housings cast integral with the cylinder heads. Tappets located in the front and rear main crankcase sections actuate the rocker arms through tubular steel push rods which have steel ball-end caps. The push rods are protected by removable two-piece oil tight push rod cover tubes held in place by a packing nut at each end. The push rod cover tubes telescope together at the center, the joints being covered with short rubber sleeves. Rocker box covers are secured by studs and elastic stop nuts. The rocker arms are equipped with valve clearance adjusting screws and lock nuts, the action of the rocker being transmitted to the end of the valve stem through a half-ball and socket in the lower end of each adjusting screw.

There is one intake valve and one exhaust valve in each cylinder. The exhaust valves are of hollow head and stem design and are sodium cooled with the seating face stellited. Two concentric valve springs, secured to the stems by split cone locks and washers, are used at each valve. The inlet and exhaust valve springs are not interchangeable.

GROUP IV -- MAIN STAGE BLOWER SECTION

The main stage blower section, or what might be called the mounting section, supports the engine in the airplane and is attached to the rear of the main crankcase section. Engine mounting bracket pads are machined on the outer circumference to accommodate six mounting pedestals which are secured by studs. The case is a magnesium alloy casting and it houses the main impeller drive mechanism. A splined drive sleeve couples the main impeller spring drive gear to the rear of the crankshaft. The spring drive gear meshes with two pinion gears, which form the hubs of two intermediate spring drive gears incorporating friction damping plates. These two intermediate spring drive gears mesh with and drive the main impeller pinion gear, which is an integral part of the impeller shaft. The main stage impeller is splined to the hollow impeller shaft which is supported on the main accessory shaft through steel-backed bronze bearings. A main blower drive support plate is fitted into a circular shelf machined inside the inner wall of the blower annulus. This plate is fitted with five steel bushings and a steel-backed bronze bearing. The steel-backed bronze bearing is in the center and supports the main impeller splined drive sleeve and the main impeller spring drive gear. Two of the steel bushings support the forward ends of two fixed shafts which carry the two intermediate pinion and spring drive gears. Two similar bushings support the forward ends of two dummy shafts. The fifth bushing supports the rear end of the fixed shaft of the rear counter-balance intermediate gear. A steel liner is provided in the center of this section to accommodate the main impeller front oil seal rings, and the main impeller thrust bearing plates are attached to this liner.

The annulus formed at the outer portion of the case receives the mixture from the impeller and delivers it to nine outlet ports. Attached to each outlet port is a Y-shaped intake pipe, each pipe directing the mixture to one front and one rear row cylinder. An automatic blower drain valve is provided in this section to drain fuel which may collect at the bottom of the blower annulus when the engine is not running. Breather and oil scavenge passages, which connect with similar passages in the power and auxiliary blower sections, are provided in this section.

GROUP V -- AUXILIARY STAGE BLOWER SECTION

The auxiliary stage blower section is a magnesium alloy casting which houses the auxiliary impeller and incorporates inlet passages for the main and auxiliary blowers. It is attached to the rear of the main stage blower section by studs. Two rectangular inlet ports are provided at the bottom of the auxiliary blower section to conduct air to the auxiliary impeller. In each inlet port a butterfly valve, mounted on a single shaft connected by linkage to the auxiliary supercharger regulator, controls the amount of air required by the auxiliary impeller to maintain a constant pressure at the carburetor entrance.

The main stage diffuser is attached to the forward face of the auxiliary stage blower section. An insert is fitted on the forward face of the auxiliary stage blower section forming the inlet throat of the main stage blower. The insert has a vertical web which forms a boss around the main impeller shaft. The vertical web is drilled to accommodate a fuel feed valve which carries fuel to be injected into the air stream at the main impeller entrance. The main and auxiliary impeller shafts are hollow. They are equipped with steel-backed bronze bearings and turn on the main accessory drive shaft, which is supported at its central portion by a steel-backed bronze bearing fitted in the steel liner in the center of the auxiliary blower section. The steel liner accommodates the front and rear oil seal rings of the auxiliary and main impellers, respectively. Breather and scavenge oil passages are provided in this section, connecting similar passages in the main stage blower and intermediate rear sections.

This section may be assembled so that its carburetor mounting flange is on top, for a down-draft carburetor, or on the bottom, for an up-draft carburetor.

GROUP VI -- INTERMEDIATE REAR SECTION

The intermediate rear section is a magnesium alloy casting attached to the rear of the auxiliary blower section and contains the diffuser and annulus for the auxiliary impeller. This annulus has two outlet ports, one on each side, which are connected by ducts and inter-coolers to the carburetor inlet.

A steel liner is provided in the center of this section to accommodate the rear oil seal rings, and the thrust bearing plates of the auxiliary impeller attach to this liner. This section, together with the rear section, houses and supports the gear train for driving the two-speed auxiliary impeller clutches and the accessory drives of the rear section. The arrangement of the gear train is shown in Fig. 10. A scavenge oil screen is provided in the lower right side and the engine breather connection is in the center at the upper rear face of this section.

GROUP VII -- REAR SECTION

The rear case is a magnesium alloy casting fastened to the intermediate rear section by studs and nuts. This case provides accessory mounting pads and, together with the intermediate rear case, houses and supports the gear train for driving the accessories and the two-speed auxiliary impeller driving mechanism. The gear train is supported in steel-backed bronze bushings pressed into the forward face of the rear section. The pressure and main scavenge pumps are installed in the rear face of this section. An oil pressure chamber containing two cylindrical oil screens and a check valve is located in the bottom central portion of the rear section. The auxiliary impeller ratio selector valve is mounted on top.

Main Accessory Drive Shaft -- This shaft is supported at the forward end by the previously described drive sleeve which is splined into the rear end of the crankshaft, and at its central portion by a bearing fitted in the steel liner of the auxiliary blower section. The rear end of the shaft is splined to, and supported by, the hub of the main accessory drive gear, which is in turn supported in steel-backed bronze bushings in the rear section. The starter jaw is splined to the rear end of the main accessory gear hub.

Auxiliary Impeller Shaft -- The auxiliary impeller shaft is hollow and is supported concentrically by the main accessory shaft, on two pressed-in steel-backed bronze bearings. The auxiliary impeller is splined to the auxiliary impeller shaft. Two spur gears, integral with the rear part of the auxiliary impeller shaft, mesh with the gears of the internally coned (driven) members of the high and low ratio impeller clutches.

Selector Valve and Auxiliary Dual Ratio Clutches -- The selector valve is mounted on top of the rear section and incorporates a pilot valve, a time delay cylinder and piston (dashpot), two actuating pistons, a thermostat, and a cylindrical distributor valve. The time delay piston and the pilot valve are integral. The actuating pistons transmit their motion to the time delay piston and pilot valve by a piston rod. The distributor valve, controlled from the cockpit, directs the engine pressure oil to the actuating pistons which move the pilot valve. The pilot valve directs engine pressure oil through drilled passages to a chamber between the driving and driven cones of the two clutches for the particular gear ratio selected. The thermostat is proved to circulate oil through the time dealy cylinder, thereby maintaining a predetermined temperature and insuring uniform operation of the time delay jet in the time delay piston. The function of this jet is to delay the movement of the pilot valve long enough to permit oil to reach the accelerators.

Both a high and a low ratio clutch are mounted on each of two shafts. These clutch shafts, one one each side of the auxiliary impeller shaft, are driven by the main accessory drive gear through pinion gears on the clutch shafts. The high clutch has a built-in accelerator which is used to bring the auxiliary impeller up to speed when first engaging the low clutch (shifting from Neutral to Low), and to synchronize the speeds of the impeller shaft and the clutch shafts when shifting from Low to High. The clutches are cone type, with the externally coned (driving) member splined to the clutch shaft, and the internally coned (driven) member having an integral gear meshing with the gears on the auxiliary impeller shaft. Pressure oil, directed by the pilot valve in the selector unit to the two clutches for the particular gear ratio selected, causes the driving cones to engage the driven cones. The two clutches for each gear ratio operate in parallel, and drive the auxiliary impeller. The selector valve and clutch operation is illustrated in Fig.. 11.

Generator Drive -- The generator is driven by a shaft having 16 internal involute splines and is mounted on a circular pad with a 5 in. diameter bolt circle. The generator shaft is driven from the main accessory spring drive gear through an intermediate gear and rotates in a clockwise direction at 1.4 crankshaft speed.

Power Take-off -- The generator drive may be converted to a power take-off by removing an adapter in the end of the generator drive shaft, which leaves a 24 internal involute spline.

Starter Drive -- The starter drive consists of a twelve tooth starter jaw which turns the main accessory drive shaft through the main accessory spring drive gear. The main accessory drive shaft is coupled to the rear of the crankshaft by a splined drive sleeve and turns the crankshaft directly. A pad with a 5-3/4 in. diameter bolt circle is provided on the rear section for mounting the starter.

Fuel Pump Drive -- The fuel pump is driven by a shaft having 11 internal involute splines. This shaft is driven at .864 crankshaft speed in a counterclockwise direction by an integral gear meshing with the main oil scavenge pump drive gear. The fuel pump is mounted on a square pad with stud centers 2 in. x 2 in.

Dual Tachometer Drives -- Two tachometer drives are provided, one on the left and one on the right side of the rear section. These drives have square holes in the ends to accommodate the square shaft of an electric tachometer. The drives are driven by helical gears on the intermediate accessory gear shaft at.5 crankshaft speed. The left drive rotates in a clockwise direction and the right drive in a counterclockwise direction. The mounting pads for the tachometer are square with stud centers 1-7/8 in. x 1-7/8 in.

Mounting pad and drive shaft adapters may be installed to convert the dual electric tachometer drives to flexible shaft connections (7/8 in. -- 18NS-3) for mechanical tachometers.

Dual Side Angular Auxiliary Drives -- These drives have shafts with 12 internal involute splines and square mounting pads with stud centers on a 5 in. diameter circle. Bevel gears on the accessory gear shafts drive these auxiliary drive shafts at 1.4 crankshaft speed, in a clockwise direction.

Mounting pad adapters change the mounting pads to small square pads with stud centers at 1-7/8 in. x 1-7/8 in.

Dual Gun Synchronizer Drives -- The dual side angular auxiliary drives may be converted to dual gun synchronizer drives. The conversion is made by replacing the angular auxiliary drive bevel gear and integral shaft with another identical bevel gear, its integral shaft having a spur pinion gear to drive the gun synchronizer adapter shaft. The synchronizer adapter shaft has an integral internal gear meshing with the spur pinion gear which drives it at propeller shaft speed. The synchronizer adapter has a round mounting pad with a 2-13/32 in. bolt circle and its shaft has 16 external rectangular splines.

Vacuum Pump Drive -- The vacuum pump has a mount and drive similar to the side angular auxiliary drives. This drive is driven from the rear end of the accessory gear shaft.

A mounting pad adapter changes the pad to a small square pad with stud centers at 1-7/8 in. x 1-7/8 in.

LUBRICATION

Oil from the tank is circulated through the engine by a gear type pressure pump which is situated in the left rear face of the rear section. The oil pressure pump provides mounting bosses for the inlet oil connection, the temperature compensating high pressure relief valve, the low pressure relief valve, the oil screen by-pass valve and the thermostat, together with their connecting cored passages. The oil, after passing through the pressure pump, flows to the oil pressure screen chamber. The oil pressure screen chamber, located in the lower central portion of the rear section, has two cylindrical oil screens with a check valve at the top. The check valve prevents the oil in the main oil tank from flowing into the engine when the engine is stopped. The oil screen by-pass valve is provided to allow oil to by-pass the oil screens, thus preventing stoppage of oil to the engine should the screens become clogged. The oil from the pressure chamber passes through the check valve to a chamber directly above, from which a passage connects with an annulus around a bushing in the center of the rear section. A passage from this annulus runs to the main piston of the temperature compensating high pressure relief valve. Oil from this passage is circulated over the thermostat which controls the compensating action of the relief valve. The thermostat opens and causes oil to flow to the compensating piston of the relief valve, when the oil temperature rises to 40°C. (104°F.). The temperature of the engine and oil at the time of starting influences the cold starting oil pressure developed and the length of time before normal operating oil pressure is established. Under cold starting conditions oil pressure may momentarily reach as high as 400 lbs./sq. in. (28 kg./sq. cm.), whereas under starting conditions when the engine and/or oil are warm, high starting oil pressure will not be developed.

The high pressure oil system, for clarity of description, will be divided into three branches.

First Branch -- The oil for this branch is received from the annulus around the bushing in the center of the rear section and is directed through a passage to an annulus around the rear end of the main accessory drive shaft. From this annulus, oil is directed to the selector valve for the operation of the two speed auxiliary impeller drive mechanism, to the main oil pressure gage connections and through the hollow accessory drive shaft to the forward part of the engine. The main quantity of oil is then transferred by means of a pipe from the accessory drive shaft into the rear of the crankshaft. The thrust and two support bearings of each impeller shaft are lubricated by oil carried through drilled holes in the hollow accessory drive shaft.

A series of drilled passages in the crankshaft direct the oil through both crankpins and to the master rod bearings. A retainer plate at each end of the master rod bearings distributes oil to the hollow floating knuckle pins through lugs which fit over bosses at each end of the knuckle pins. The knuckle pins are drilled to allow passage of oil to the knuckle pin bushings in the articulated rods.

Drilled passages from the crankshaft bearing journals direct oil to the three crankshaft main bearings. Spray lubrication is afforded to the cylinder walls and piston pins by oil thrown from the master rod bearings and knuckle pin bushings.

From the crankshaft, the oil continues into the propeller shaft where two oil pipes extending across the diameter of the rear portion of the propeller shaft conduct oil to the two propeller shaft support bearings in the crankshaft.

The reduction gearing is lubricated by oil carried through drilled passages in the reduction gear pinion cage flange of the propeller shaft from where the oil is directed to the front end of each hollow pinion shaft, and thence through drilled holes in the pinion shafts to the pinion gear bushings. A spray of oil is played on the fixed gear from oil holes in the pinion cage of the reduction gear.

High pressure engine oil is carried to the front end of the propeller shaft by a central tube, for use in operation of a hydromatic propeller.

Second Branch -- The oil for this branch is taken from the main accessory drive shaft at its center bearing in the auxiliary blower section. This bearing has an annulus connected to drilled passages which carry the oil to the top outer wall of the case. The oil is then transferred to the main blower section and carried to the front of this section through a drilled passage, where an oil transfer pipe, bent in a semi-circle conducts the oil to the bottom of the case and divides into two routes. One route supplies oil to the main blower drive support plate by means of a short connecting pipe; a drilled passage then leads the oil to a distributing groove in the periphery of the support plate from which it is led to the five bushings and the central bearing for the splined drive sleeve. A jet of oil lubricates each of the two main impeller intermediate gears. The other route transfers oil to the rear main crankcase and thence through drilled passages and connecting oil pipes to the valve operating mechanism for the rear row of cylinders. The rear secondary counterbalance intermediate gear bearing is lubricated by the oil from its hollow shaft supplied through drilled passages connecting with both routes.

The entire valve operating mechanism is lubricated by engine oil which is metered as it enters the tappets and passes through the hollow tubular push rods into drilled passages in the rocker arms to lubricate the rocker bearings, the half-ball and socket of the clearance adjusting screws, and the valve stems.

Third Branch -- The oil for this branch is taken from the propeller shaft through an oil pipe fitted across the diameter of the propeller shaft, forward of the reduction gearing. This oil pipe supplies oil to an annulus in the oil transfer bearing from which it is carried by another pipe to two series of drilled passages in the front (nose) section. One series of drilled passages carries oil to the magneto and distributor gear train bearings, the front counterbalance intermediate gear bearing and the front valve operating mechanism. The other series of drilled passages conducts oil to the propeller governor where it passes through the governor pump and is returned to the propeller shaft for operation of a hydromatic propeller.

Low Pressure Oil -- High pressure oil enters the hollow fuel pump drive shaft from the chamber above the oil pressure chamber check valve and is metered out as low pressure oil through two holes which register alternately, as the shaft rotates, with two holes in its bushing. The low pressure relief valve located in the pressure pump cover is connected with the metered oil by a drilled passage. The bypassed oil from the low pressure and the temperature compensated high pressure relief valves is returned through a common passage to the inlet side of the pressure pump. The low pressure oil is carried through a series of drilled passages to the bearings of the accessory gear train in the intermediate rear and rear sections.

Scavenge Oil -- The engine drain oil is scavenged by two separate gear type pumps. A two-section main scavenge pump is located in the right rear face of the rear section and a three-section scavenge pump is located in the bottom of the front (nose) section.

The drain oil from the power, main blower, auxiliary blower, and intermediate rear sections is collected in the main sump located below the crankcase between cylinders No. 9 and 11. This sump is scavenged by the large section of the main scavenge pump through connecting cored passages in the main sump, main blower, auxiliary blower, intermediate rear, and rear sections with a removable screen in the intermediate rear section passage. The drain oil in the rear section collects at the bottom of the section and is scavenged through a cored passage, containing a removable screen, by the small section of the main scavenge pump. Both sections of the main scavenge pump discharge into the oil outlet passage which is part of the main scavenge pump.

The front cam compartment drain oil is scavenged through a connecting pipe by the top section of the nose scavenge pump. The drain oil from the reduction gearing, which collects at the bottom of the front (nose) section is removed by the middle section of the nose scavenge pump. The rocker drain sump, located between the rocker boxes of No. 10 cylinder, collects the drain oil from the rocker boxes of cylinders below the horizontal centerline of the engine through a series of inter-cylinder drain pipes. The drain oil in this sump is scavenged by the bottom section of the nose scavenge pump through an external suction pipe.

The scavenged oil from the three sections of the nose scavenge pump is forced through an external pipe connecting with a cored passage in the main blower section. An external cast duct carries the scavenged oil from the main blower section to the intermediate rear section which is provided with a cored passage connected by an internal pipe to the passage at the discharge side of the main scavenge pump.

IGNITION

Ignition is furnished by a dual Scintilla magneto, designated as DF18RN, and two distributors separately mounted on the front (nose) section. The magneto has two contact breaker assemblies. The breaker assembly on the left (Name Plate) side of the magneto is connected to ground and high tension connections GR2 and HT2 and controls the current to the right distributor, and the breaker assembly on the right side of the magneto is connected to ground and high tension connections GR1 and HT1 and controls the current to the left distributor.

The left distributor supplies current to the rear spark plugs in all cylinders and the right distributor supplies current to the front spark plugs. The two distributors and the ignition harness form a completely shielded unit to carry the current to the shielded spark plugs. The distributors are provided with a vent and drain system to prevent an accumulation of moisture which might impair their operation.

The early type ignition harnesses were composed of rigid steel and flexible braided metal conduits with rewireable wiring. The ignition harness and distributors were vented to atmosphere with a pressure differential system of venting. Later ignition systems on "B" series engines were redesigned for improved performance at high altitudes and under humid atmospheric conditions. A Bosch DF18LU dual magneto with large air space between parts in the breaker compartment was provided to minimize electrical flashover at altitude. The distributors incorporated air pumps to provide pressurized air in the distributor and magneto to help prevent electrical flashover at altitude. The ignition harness was a "cast type" wherein ignition wires were submerged in a special plastic filled moisture proof magnesium cast manifold ring. Similar plastic filled detachable ignition leads connect the manifold to the spark plugs.

CARBURETOR

The "B" Series two stage engine is equipped with an updraft PT-13D4 Bendix Stromberg injection carburetor. The carburetor meters fuel in proportion to the mass flow of air to the engine. Operation will be clarified by describing the following units separately: throttle unit, automatic mixture control unit, regulator unit, fuel control unit and accelerating pump.

The throttle unit has three barrels, each barrel having a throttle valve, a large venturi, a boost venturi and a group of impact tubes around the top of the large venturi. The throttle valve controls the amount of air entering the engine. The pressure difference between the impact tubes and the boost venturi throat is a measure of the volume of air entering the engine. This pressure difference, when corrected by the automatic mixture control unit for changes of air density, becomes a measure of the mass air flow and is applied to the regulator unit to control the metering pressure across the fixed jets in the fuel control unit. A by-pass valve for the automatic mixture control unit is incorporated in the throttle unit.

The automatic mixture control unit is mounted on the throttle unit and vented to the throat of the large venturi. This unit contains a metallic bellows, responsive to pressure and temperature changes, actuating a contoured needle valve which regulates the pressure from the impact tubes, thus regulating the differential pressure applied to the regulator unit in accordance with the density of the air. The by-pass valve for the automatic mixture control, when open, allows the pressure of the impact tubes to pass directly to the regulator unit. This by-pass valve is operated by linkage with the mixture control selector valve on the fuel control unit.

The regulator unit has two sections; an air section and a fuel section. The air section is divided into two chambers by an air diaphragm and the fuel section is similarly divided by a fuel diaphragm. The diaphragms are mounted on the stem of the fuel valve. The pressure differences between the impact tubes and the boost venturi throat act on the air section diaphragm producing an air metering force which controls the fuel valve and therebyproduces a corresponding fuel metering force. The fuel metering force causes a fuel differential pressure across the metering jets in the fuel control unit, thus causing fuel to be metered in proportion to the mass air flow through the throttle unit.

The fuel control unit contains metering jets, the idle valve, a power enrichment valve, and a four position mixture control selector valve. The idle valve is mechanically connected to the throttle and controls the fuel flow in the idle range of speed. The power enrichment valve richens the mixture throughout the upper power range of operation. The four positions of the mixture control selector valve are: full rich, automatic rich, automatic lean and idle cut-off positions.

The accelerating pump on these carburetors is operated by the fuel pressure in the carburetor and the discharge of fuel is controlled by the operation of the throttle. Hence, when there is fuel pressure, whether the engine is running or not fuel is momentarily discharged into the engine if the throttle is opened rapidly.

The metered fuel from the fuel control unit is delivered to the supercharger entrance through a spring loaded discharge nozzle in the auxiliary blower section.

The throttle of the carburetor is provided with a spring loaded anti-creep device to prevent change of throttle position during flight.

SUPERCHARGER REGULATOR

This unit is mounted on the left side of the auxiliary blower case of engines having up-draft carburetors. It operates independently of the carburetor throttle and affects the engine operation by maintaining, within the physical limits of the engine, an absolute pressure of approximately 28 inches Hg. at the auxiliary blower annulus. At high altitudes the auxiliary supercharger is thus controlled, and the carburetor inlet air pressure is automatically held to within close limits. Power control is accordingly greatly simplified.

The air pressure in the auxiliary blower annulus, in the intermediate rear section, is vented through internal passages to the regulator bellows. These, in turn, operate a balanced valve which directs high pressure engine oil to a servo-piston. Through external linkage, this piston operates the air throttle valves in the auxiliary blower inlet passages. The valves, obviously, control the amount of air admitted to the blower, and consequently control the pressure at the blower annulus.

DIFFERENCE BETWEEN "A" AND "B" SERIES ENGINES

The general configuration between the "A" and "B" Series engines is the same. To obtain the additional one hundred and fifty horsepower for the "B" Series engine certain parts of increased strength and new cams were incorporated. It is difficult to distinguish apart the two engines by a casual inspection.

INTRODUCTION OF THE DOUBLE WASP "C" SERIES ENGINES

As World War II progressed, the need for a more rugged and powerful engine became evident to meet the increasingly arduous demands of combat flying. Consequently, the Double Wasp was completely redesigned to permit an additional one hundred horsepower for take-off, increased strength to accommodate the War Emergency Powers through use of water injection and to incorporate later developments and features. This redesigned engine became known as the Double Wasp "C" Series. Following is a general description of this engine.

FRONT SECTION

FRONT CASE - The front case is made from a magnesium casting and houses the propeller shaft reduction gearing. A recessed liner at the front end of the case supports the propeller shaft thrust bearing, which is a ball bearing with a split inner race. The bearing supports the front end of the propeller shaft and transmits the thrust of the propeller from the propeller shaft to the engine mounting brackets by way of the front cases and crankcase section. A boss is provided in the front case for installation and support of the governor oil transfer tube, and a mounting pad is provided for a torquemeter oil pressure transfer diaphragm. Six circular steel lined recesses in the rear of the front case house the torquemeter pistons. A bracket secured to the inside of the front of the case positions the propeller shaft oil transfer bearing.

REDUCTION GEARING - The reduction gearing is of the spur planetary type and provides a propeller reduction ratio of 20:9. The reduction drive fixed gear is an internal spur ring gear with diagonal splines on its outside diameter, and these splines mesh with splines in the reduction drive fixed gear support, which is secured to the rear face of the front case. Six reduction drive fixed gear retainers are bolted to the support to hold the fixed gear in place. A splined coupling on the front end of the crankshaft mates with internal splines in the reduction drive gear and transmits power from the crankshaft to the drive gear. Teeth on the inside diameter of the drive gear mesh with 15 reduction drive pinions housed in the reduction drive pinion cage, which is integral with the propeller shaft. The reduction drive pinions incorporate tri-metal bearings as a bearing surface for the reduction drive pinion races, which are supported in the cage by individual pinion shafts. Each pinion mates with the teeth on the inside of the fixed gear.

TORQUEMETER SYSTEM - The torquemeter system makes possible the accurate measurement of the actual power delivered to the propeller when the airplane is in flight. The reduction drive fixed gear thrusts forward on its diagonal outside splines because of the torque applied to the propeller shaft by the crankshaft through the reduction drive gear coupling. This forward thrust of the reduction drive fixed gear is transferred through the slipper bearings of the torquemeter pistons to the pistons themselves, which are held in their respective recesses by a retaining cover. Each piston is fitted with two oil seal rings, and pressure oil is supplied to the front side of the pistons through the master piston by the booster section of the front oil scavenge and booster pump. The pressure oil from the pump is received by the master piston, located at the bottom of the front case, which, by its own movement, meters oil to itself and to the five other pistons in direct proportion to the varying load of the fixed gear thrust. Therefore the thrust of the reduction drive fixed gear is always balanced by oil pressure acting against the front face of the pistons. The oil pressure also acts on a pressure diaphragm mounted on the front case, and this diaphragm transmits the pressure through a tube line filled with a low viscosity fluid to a pressure gage in the airplane. By calculating the oil pressure acting on the torquemeter pistons together with the engine rpm and a previously determined torque constant, the horsepower being delivered to the propeller can be readily determined.

FRONT ACCESSORY SECTION AND FRONT SUPPORT PLATE

FRONT ACCESSORY CASE - The front accessory case is provided with external pads for mounting a dual magneto, two distributors, an automatic spark advance operating unit, a propeller governor, and the oil scavenge and booster pump. Two distributor drive gears and the distributor intermediate drive spur and bevel gears are supported on the inside of the case.

FRONT SUPPORT PLATE - The front support plate is secured to the crankcase section and supports the intermediate gears for driving the front accessories, the front cam, and the front crankshaft counterweight. It also houses the spark advance piston.

MAGNETO DRIVE GEAR TRAIN - The magneto is driven by a train of gears which starts with the crankshaft front gear and runs through the spark advance gear system and the magneto intermediate drive gears, which are mounted on the front support plate, to the magneto drive gear mounted in an adapter on the front accessory case.

DISTRIBUTOR DRIVE GEAR TRAINS - Each distributor is driven by a train of gears which starts with the crankshaft front gear and runs through the spark advance gear system and the distributor intermediate drive gears, which are mounted on the front support plate and on the side of the front accessory case, to the distributor drive gear mounted in the front accessory case.

SPARK ADVANCE OPERATING UNIT AND SPARK ADVANCE PISTON - The spark advance operating unit is mounted on the front accessory case and is connected by a system of tubing to the supercharger rim, to the supercharger throat, and to the spark advance control unit on the carburetor. Pressure differential between the supercharger rim and throat acts through the tube lines on a diaphragm in a selector valve. The movement of this selector valve allows presssure oil to pass to either the cruising advance or the normal advance side of the spark advance piston mounted in the front support plate. The spark advance piston acts on the spark advance gear system through a yoke on the spark advance pinion bracket. As the position of the piston changes, the position of the spark advance pinions changes with respect to their driving gear; but the position of their driving gear is fixed with respect to the crankshaft. Therefore, the change of position of the piston, acting through the pinions, the pinion driven gears, and the magneto and distributor intermediate drive gears, advances or retards the timing of the magneto and distributors with respect to the crankshaft.

GOVERNOR DRIVE GEAR TRAIN - The governor is driven by a train of gears which starts with the crankshaft front gear and runs through four intermediate gears on the front support plate to the governor drive gear, which is mounted in the front accessory case.

OIL SCAVENGE AND BOOSTER PUMP DRIVE GEAR TRAIN - The oil scavenge and booster pump is driven by a train of gears which starts with the crankshaft front gear and runs through the lower cam reduction gear and the oil scavenge and booster pump intermediate drive gear, both of which are mounted on the front support plate, to the drive gear in the pump, which is mounted in the front accessory case.

CRANKCASE

CRANKCASE FRONT, CENTER AND REAR SECTIONS - The crankcase consists of three one piece sections held together by studs and special bolts. Two rows of cylinder mounting pads are located around the outer circumference of the crankcase assembly. Steel backed, prefitted bearings with leaded bearing surfaces are shrunk into the bore of the crankcase front and rear sections to support the front and rear sections of the crankshaft. The center section of the crankshaft is supported by a two piece bearing of the same type, which seats in a liner shrunk into the crankcase center section and is held in position by retaining plates. The front and rear main bearings are rolled over into the crankcase as the rear and front ends respectively, and are held from turning by four lock tabs on the flanged end of each bearing. Integral, circular bosses on the crankcase front and rear sections support the cams and cam bearings. The rear ends of the front cam reduction gears and the front ends of the rear cam reduction gears are supported in the crankcase front and rear sections respectively, and the valve tappet guides and tappets for each row of cylinders are supported in the crankcase front and rear sections. Four engine lifting links are secured to the crankcase, two on the crankcase front section and two on the crankcase rear section.

REAR SUPPORT PLATE - The rear support plate is secured to the crankcase rear section and supports the rear end of each rear cam reduction gear and the front end of the rear counterweight intermediate drive gear shaft.

CRANKSHAFT - The crankshaft is machined from three steel forgings. The front and rear sections are held to the center section by bolts which are threaded at both ends and pass through the crankpins. The end of each crankpin and its mating face on the crankshaft center section are face-splined. Each crankpin is equipped with a special sludge retainer. The crankshaft assembly is supported by the bearings in the crankcase front, center, and rear sections. The front and rear crankcheeks each support a dynamic damper counterweight to counterbalance the weights of the reciprocating and rotating parts connected to the crankpins. Each counterweight is of the pendulum type and is supported on two floating roller pins which pass through both the counterweight and the crankcheek. The counterweight and crankcheeks have steel bushings in the roller pin holes. The pendulum travel of the counterweight assemblies is controlled by stops which are bolted to the crankcheeks.

A secondary counterweight is provided at each end of the crankshaft to dampen second order vibrations caused by the eccentric masses of the masterod assemblies. The front counterweight turns on a leaded sleeve bearing which is splined to the front crankshaft section. A counterweight spring drive gear, splined to the reduction drive gear coupling, drives the counterweight intermediate drive gear, which is mounted on the front support plate. The rear counterweight turns on a leaded bearing surface on the outside diameter of the crankshaft rear gear, which is secured to the end of the crankshaft. A counterweight spring drive gear, splined to an adapter secured to the end of the crankshaft, drives the counterweight intermediate drive gear, which is mounted on the rear support plate. Each counterweight intermediate drive gear drives its counterbalance at twice crankshaft speed.

The hollow front section of the crankshaft contains two steel backed bronze bearings which support the rear of the propeller shaft. The reduction drive gear coupling, which supports the crankshaft oil transfer bearing and the front counterweight spring drive gear, and the crankshaft front gear are splined to the front end of the crankshaft. The rear end of the crankshaft has internal splines to accommodate the main accessory splined drive sleeve.

MASTEROD AND LINKRODS - The one piece masterods are located in cylinders Nos. 8 and 9. The masterod bearings are one piece steel shells having a special leaded inside surface. Each bearing is held in place by two masterod bearing and linkpin retaining plates which fit on the faces of the masterod. The retaining plates have fingers which fit over bosses at each end of the full-floating type linkpins. Eight I-section linkrods are attached to each masterod by the linkpins, and a piston is attached to each masterod and linkrod by a pistonpin.

CAM GEAR TRAINS - The double track, four lobe cams which actuate the valves in each row of cylinders, rotate on bronze bearings with leaded surfaces, and are mounted in the front and rear crankcases. The front cam is driven by a train of gears which starts with the front crankshaft gear and runs through two cam reduction gears which are supported by the front support plate and crankcase front section. The rear cam is driven by a similar train of gears, and both cams are driven opposite to crankshaft rotation at 1/8 crankshaft speed.

VALVE TAPPETS AND TAPPET GUIDES - The tappet guides are shrunk into the crankcase front and rear sections. The outer ends of the tappet guides are supported in the crankcase wall, and the inner ends are anchored in bosses forged integral with the crankcase. Steel valve tappets with roller type cam followers operate within the tappet guides. These tappets actuate the valve operating mechanism in the cylinders through tubular pushrods which have ballends.

CYLINDERS - The cylinder barrels are machined from steel forgings. An aluminum muff with cooling fins is shrunk over the central portion of each barrel. The heads are of forged aluminum with machined cooling fins and integral valve rockerboxes. The cylinder heads are screwed and shrunk onto the barrels. Each cylinder has one inlet and one exhaust valve, and corresponding valve seats which are shrunk into the cylinder head. The cylinder head also incorporates bronze inlet and exhaust valve guides, inserts for two sparkplugs and four steel backed bronze rocker shaft bushings. The cylinder barrels are provided with mounting flanges and secured by studs and nuts to the crankcase section.

PISTONS - The aluminum pistons are of the full skirt type. Each piston has five ring grooves and is fitted with wedge-type compression rings in the first three grooves, dual oil control rings in the fourth groove, and a rectangular compression ring in the fifth groove. The top compression ring is chromium plated on the side which bears against the cylinder wall.

CYLINDER DEFLECTORS - Cylinder deflectors are located between the rockerboxes on each cylinder and between adjacent cylinders to direct a high velocity flow of cooling air between and around the cylinder fins.

VALVE MECHANISM - All valve operating parts are enclosed. The rockers are supported by shafts which are, in turn, supported by bushings in the rockerboxes. Cams and tappets in the crankcase front and rear sections actuate the rockers through tubular steel pushrods which have steel ballend caps. The rockers are equipped with valve clearance adjusting screws and locknuts, the action of the rocker being transmitted to the end of the valve stem through a half-ball and socket in the lower end of each valve adjusting screw. There is one inlet and one exhaust valve in each cylinder. The exhaust valve is hollow and is partially filled with sodium for cooling. To insure long life, the seating surface of the exhaust valve is stellite faced. The inlet valve is hollow and has a smaller diameter stem than the exhaust valve. Both the inlet and exhaust valves are fitted with two concentric coil springs. These springs are secured to the valve stems by washers and split cone locks.

MAIN SUPERCHARGER SECTION

MAIN SUPERCHARGER CASE - The main supercharger case is attached to the crankcase rear section by studs, washers, and nuts. This section supports the engine in the airplane through six integral, angular bosses which incorporate steel liners to accommodate the engine mounting flexible bracket assemblies. Nine outlet ports are located around the periphery of the case, and Y-shaped cylinder intake pipes are attached to these ports. A bowl shaped center section divides the interior of the case, forming an annulus inside the outlet ports and a recess which houses the main impeller drive gear train at the front of the case. Bushings in the front face of the center wall support the shafts for the main impeller intermediate spring drive gears, and a steel liner in the center accommodate the four main impeller front oil seal rings and the thrust plate. The main impeller diffuser is supported on studs from the rear face of the center wall.

MAIN IMPELLER DRIVE SUPPORT - The main impeller drive support plate attaches to studs in the front recess of the main supercharger case. Four steel bushings in the plate support the ends of the four shafts in the front face of the supercharger case, and another steel bushing supports the rear end of the rear counterweight intermediate drive gear shaft. A steel backed bearing pinned in the center of this plate supports the accessory splined drive sleeve, which mates with the internal spline in the rear of the crankshaft. The main impeller spring drive gear locks onto an external spline at the rear of the sleeve, and an internal spline in the center of the sleeve accommodates the front end of the accessory drive shaft.

MAIN IMPELLER AND ASSEMBLY - The main impeller assembly is housed between the main supercharger and the supercharger inlet case. The main impeller shaft is hollow, with two bronze bearings pinned in the inside diameter. These bearings support the main impeller shaft on the accessory drive shaft. The impeller shaft incorporates splines for the main impeller and the impeller drive gear, as well as lands for the four front oil seal rings. The main impeller drive gear is locked onto the front splines, and the main impeller, fuel slinger, rear oil seal ring carrier, and two locknuts are installed on the rear of the shaft. Power is supplied from the crankshaft through the accessory splined drive sleeve, the main impeller spring drive gear, and the two main impeller intermediate spring drive gears to the main impeller shaftgear.

SUPERCHARGER INLET SECTION

The supercharger inlet case attaches to the studs at the rear of the main supercharger case and incorporates inlet passages for both the main and auxiliary impellers. One inlet passage, incorporating a rectangular mounting flange for the carburetor, conducts air to the front of the case for the main impeller; while two smaller passages with rectangular parts conduct the air to the rear of the case for the auxiliary impeller.

Two gate valves on a single shaft, one in each auxiliary inlet passage, are connected by linkage to the auxiliary supercharger control and control the amount of air to the auxiliary impeller so that a constant pressure exists at the carburetor entrance.

An insert is fitted into the front face of the supercharger inlet case, forming the throat for the main impeller air passage. A steel fuel nozzle is pressed into the center web of this insert, and a drilled passage, from the outside of the case through the web of the insert to the fuel nozzle houses the fuel feed valve.

At the lowest point in the intake duct, a drain passage leads to an automatic fuel drain valve which discharges any gasoline that may accumulate while the engine is being started. A steel liner, pinned in the bore of the case, accommodates the front and rear oil seal rings for the auxiliary and main impeller shafts respectively, and incorporates a steel backed bronze center bearing for the accessory drive shaft.

A pad for the supercharger control is at the center of the right side of the supercharger inlet case.

AUXILIARY SUPERCHARGER SECTION

AUXILIARY SUPERCHARGER CASE - The auxiliary supercharger case attaches by studs, washers, and nuts to the rear of the supercharger inlet case. A mounting pad for the water control unit of the combat power system is provided on the left side of the case, and the main breather outlet is located at the top right side. A bowl shaped interior wall divides the case from top to bottom and forms an annulus which collects the superchargered air from the auxiliary impeller and directs it to an air outlet port on each side of the case. The auxiliary diffuser is attached to studs on the front face of the center wall of the case, and bosses on the rear face of the wall support the auxiliary impeller thrust plate oil transfer shaft and the hydraulic coupling front bushing. A web in the lower rear half of the case supports the front bushings for the vacuum pump, high speed generator drive, and accessory intermediate drive gears as well as the shafts for the three high speed generator drive pinions. A steel liner in the bore of the center wall accommodates the four auxiliary impeller shaft rear oil seal rings and the thrust plate.

AUXILIARY IMPELLER AND ASSEMBLY - The auxiliary impeller assembly is housed between the supercharger inlet and auxiliary supercharger cases. The auxiliary impeller shaft is hollow steel. Two bronze bearings pinned in the inside diameter support the assembly on the accessory drive shaft. The impeller drive gear is splined to the outside diameter of the shaft, and lands are machined on the shaft for the four rear oil seal rings. The auxiliary impeller drive gear is locked on the rear of the shaft, and the auxiliary impeller and front oil seal ring carrier are installed on the front of the shaft with a locknut.

HYDRAULIC COUPLINGS - High and low ratio hydraulic couplings are mounted on each of the two shafts which are supported on either side of the impeller shaft between the rear and auxiliary supercharger cases. The two coupling shafts are driven by the accessory drive gear through a pinion splined on the rear of each shaft. The impellers of each coupling are splined to the shaft, and the runners, or driven impellers, are splined to the respective coupling gears which are free running on the coupling shaft and mesh with the auxiliary impeller shaft gear. When oil is directed into the high or low ratio couplings by the selector valve, the selected couplings fill with oil. Power is transmitted from the impeller to the runner, causing the coupling gear, which drives the auxiliary impeller shaftgear, to accelerate as the coupling fills until the coupling gear travels at the same rpm as the coupling shaft. In shifting from the high ratio to the low ratio coupling, a circular sleeve valve, located on the hydraulic coupling shaft between the low ratio runner and impeller, prevents the low ratio coupling from filling with oil until the auxiliary impeller has slowed to a point at which the low ratio runner is traveling at a slightly lower rpm than the low ratio impeller. The low ratio coupling valve will rotate on the coupling shaft when the rpm of the low ratio impeller equals or exceeds the rpm of the low ratio runner. The distance that the valve can rotate is controlled by a stop, and when the valve rotates to the stop, the oil holes in the valve will line up with the oil holes in the shaft, allowing pressure oil from the shaft to enter the low ratio coupling. When the shift is made from low to high, the rpm of the low ratio runner will exceed that of the impeller, which will cause the valve to rotate to the stop in the opposite direction. With the valve in this position, oil from the shaft will be blocked off and prevented from entering the low ratio coupling.

REAR SECTION

REAR CASE - The rear case is secured to the auxiliary supercharger case studs and has mounting pads on its exterior surface for various accessories. Together with the auxiliary supercharger case, it supports the gear trains for driving the auxiliary impeller and the various accessories. The oil pressure and main oil scavenge pump are installed in the rear face of this case. The main oil screen chamber, containing two cylindrical oil screens and an oil return check valve, is located in the bottom center of the case. A mounting pad for the hydraulic coupling selector valve is located at the top center of the case.

SELECTOR VALVE - The selector valve is a manually operated three position valve. In neutral position, both sets of couplings are connected to the drain passage and no power is transmitted by the couplings. When the control lever is moved to low position, pressure oil is directed to the low ratio couplings while the high ratio coupling lines are left connected to drain. In the high position of the control lever, pressure oil is directed only to the high ratio couplings while the low ratio couplings are switched to drain. The pressure oil fills the couplings to which it is directed and forms a fluid drive through these couplings to the auxiliary impeller.

ACCESSORY DRIVE GEAR AND SHAFT - The hollow accessory drive shaft supports the two impeller shafts, and transmits power from the accessory splined drive sleeve through the accessory drive shaft to the accessory drive gear in the rear section. It is supported at the front, center, and rear respectively by the accessory splined drive sleeve into which it splines, by the steel backed bronze bearing in the auxiliary supercharger case liner, and by the hub of the accessory drive gear which splines onto the rear of the shaft. The hub of the accessory drive gear is supported in steel backed bronze bushings in the rear case. The starter jaw is splined to the rear of the accessory drive gear hub and locked in place with a stud and nut on the rear of the accessory drive shaft.

HIGH SPEED GENERATOR DRIVE GEAR TRAIN - The high speed generator is driven by a train of gears which starts with the accessory drive gear and runs through the right accessory intermediate drive gear, the generator intermediate drive gear, and three high speed generator drive pinions, to the high speed generator drive gear.

SIDE AUXILIARY DRIVE GEAR TRAINS - The side auxiliary drive gears on the upper right and left sides of the rear case are driven by a train of gears which starts with the accessory drive gear and runs through the respective accessory intermediate drive gears and the vacuum pump drive gear or the high speed generator intermediate drive gear to the side auxiliary drive gear.

TACHOMETER DRIVE GEAR TRAINS - The tachometers are mounted on the lower right and left sides of the rear case and are driven by a train of gears which starts with the accessory drive gear and runs through the right and left accessory intermediate drive gears to the respective tachometer drive gear.

VACUUM PUMP DRIVE GEAR TRAIN - The vacuum pump mounting pad is an adapter located on the left rear face of the rear case. The vacuum pump is driven by a train of gears which starts with the accessory drive gear and runs through the left accessory intermediate drive gear to the vacuum pump drive gear.

OIL SCAVENGE PUMP DRIVE GEAR TRAIN - The oil scavenge pump drive gear train starts with the accessory drive gear and runs through the right accessory intermediate drive gear to the oil scavenge pump drive gear.

FUEL PUMP DRIVE GEAR TRAIN - The fuel pump is mounted on a pad on the oil scavenge pump cover and is driven by a train of gears which starts with the accessory drive gear and runs through the right accessory intermediate drive gear and the oil scavenge pump drive gear to the fuel pump drive gear.

OIL PRESSURE PUMP DRIVE GEAR TRAIN - The oil pressure pump is driven by a train of gears from the accessory drive gear through the left accessory intermediate drive gear to the oil pressure pump drive gear.

LUBRICATION SYSTEM

The lubrication system of the "C" Series engine is very similar to the "B" Series engine and will not be repeated. One feature peculiar to this engine is the addition of an oil booster pump to supply high pressure oil at 200 psi to the torquemeter.

IGNITION SYSTEM

Ignition is furnished by a dual magneto and two distributors which are separately mounted on the front accessory case. The magneto has two breaker assemblies, each of which controls the current to one distributor. The left distributor supplies current to the rear sparkplugs in all cylinders, and the right distributor supplies current to the front sparkplugs in all cylinders. The two distributors and the ignition manifold and cable assembly, which is of the filled cast type, form a completely shielded unit to carry the current to the sparkplugs. Each distributor incorporates an air pump and is provided with a tubing system to pressurize the magneto and the distributors.

CARBURETION

The basic carburetion system has not changed in principal but many improved details have been incorporated including an improved Bendix carburetor (PR-58E2) with a rectangular venturi.

COMBAT POWER

These engines are rated for combat power, which is a rating representing the maximum power that can be obtained for short periods within the structural limitations of the engine. With the fuel/air ratio leaned to best power mixture, water is injected with the fuel, thereby cooling the intake charge and slowing the speed of the flame travel in the combustion chamber. In this way, detonation is suppressed, and increased manifold pressures are made possible. When the water injection system is brought into operation, water pressure, through connecting tubing to the supercharger control, automatically adjusts the control so that higher manifold pressures may be obtained. Advancing the throttles past full open position causes this system to function. The system is fully automatic after it is activated. When the throttle is retarded or the water is expended, engine operation returns to normal. The Army and Navy have approved the higher rating designated as combat power and indicate that its use should be confined to combat emergencies.

Toward the end of World War II a new engine type evolved known as the "CE" Series. This engine was basically a strengthened "C" Series engine with improved water injection and carburetion. Outwardly, the engine appearance was little changed.

ADVENT OF THE DOUBLE WASP
"E" SERIES ENGINE

As World War II came to a close a new Double Wasp engine known as the "E" Series was brought forth. The principle purpose of this engine was to provide a new improved supercharging system for improved fighter aircraft performance. Since the Front and Power Sections of the "E" Series engine are identical to the "C" and "CE" Series engine, the general description will be confined to supercharger section of the two-stage version used in the "Corsair".

SUPERCHARGER COLLECTOR CASE SECTION - The supercharger collector case is attached to the crankcase rear section. The collector case supports the engine in the airplane through six integral steel lined, angular bosses which accommodates six engine mounting bracket assemblies. Nine outlet ports are located around the periphery of the case, and the "Y" shaped cylinder intake pipes attach to these ports. The intake pipe leading to the No. 10 cylinder incorporates a float type fuel drain valve for discharging any excess fuel or oil which may accumulate while the engine is idle or being started. The center wall of the collector case is bowl shaped and forms an annulus under the outlet ports. A steel liner in the center of the case provides a seating surface for the impeller shaft front oil seal rings. The impeller diffuser is attached by studs to the rear face of the center wall. A primer manifold is attached by clamps around the outside of the supercharger collector. Primer lines, attached to the manifold, are connected to the top eight cylinder intake port bosses. The primer manifold is connected to the carburetor by tubing.

ACCESSORY DRIVE CASE SECTION

ACCESSORY DRIVE CASE - The accessory drive case attaches to the rear of the supercharger collector case. The case, which houses the impeller, incorporates an air inlet passage which extends from the carburetor mounting pad to the supercharger intake insert. The supercharger intake insert, which is fitted into the front face of the case, forms the throat for the air inlet passage. A passage, extending from the outside of the case through the web of the insert, houses the fuel feed valve. Fuel is carried from the carburetor to the fuel feed valve by an internal passage. A steel liner, pinned in the center bore of the supercharger intake insert, provides a seating surface for the rear oil seal rings on the impeller shaft. The outside diameter of the liner is grooved, and this groove together with the web of the insert forms an annulus from which fuel is fed to a slinger on the impeller shaft. A bronze support bearing is pressed into the center wall of the case to restrict any possible deflections of the impeller shaft. The rear scavenge oil pump and strainer assembly is mounted on the bottom of the case. Bosses in the rear face of the wall support the front bushings for the main impeller intermediate drive gear and the generator drive gear and the starter intermediate drive gear shaft and the center and bottom bushings for the rear scavenge oil pump intermediate drive shaft. The case is vented by an external breather which may be connected on either the left or right side or the top of the case. The supercharger collector rim and throat pressures are transmitted by means of cored passages and transfer tubes to the engine control unit.

ACCESSORY DRIVE SUPPORT - The accessory drive support is mounted in the inner rear of the accessory drive case and supports the auxiliary impeller drive pinion shafts at their inner ends. The support also incorporates bushings to support the rear bushings for the accessory drive shaft, the upper bushing for the rear scavenge oil pump intermediate drive shaft, the rear bushing for the main impeller intermediate drive gear, the front bushings for the accessory intermediate drive gear shaft and the pressure oil pump intermediate drive gear shaft.

REAR COVER - The rear cover is fastened to the rear of the accessory drive case. This cover is provided with mount pads for various accessories and, together with the accessory drive case, houses and supports gear trains for driving the accessories and the supercharger assembly. The pressure oil pump, in which the pressure oil relief valve is mounted, is installed in the bottom left rear face of the cover. The oil strainer chamber, containing the oil strainer assembly and an oil return check valve, is located just above the pressure oil pump. The by-pass relief valve, the low pressure oil regulating valve, the high pressure oil gage connection, and the oil temperature bulb boss are located to the right of the oil strainer chamber. The mounting pad for the tachometer is located in the center of the rear cover. The mount pad for the three-way vacuum pump adapter is located at the top right of the cover. The two pads on the lower right side of the cover are designed for either two fuel pumps or a fuel pump and a water pump. The fuel pump drive gear bracket which supports the fuel pump intermediate drive gear, two fuel pump drive gears, and the tachometer intermediate drive gear is mounted on the inside face of the rear cover. The tachometer drive gear is mounted in the rear cover and is retained in position by a retaining plate. The automatic engine control unit is located on the mounting pad on the upper left side of the rear face. A single vacuum pump adapter is mounted on the power take-off mounting pad.

AUXILIARY SUPERCHARGER COLLECTOR SUPPORTS - The left and right auxiliary supercharger collector supports are mounted on the left and right sides of the accessory drive case and mount the low and high ratio couplings and the left and right auxiliary impeller assemblies respectively.

AUXILIARY SUPERCHARGER COLLECTORS - The collectors are mounted on the auxiliary supercharger collector supports, and house the auxiliary impellers. A diffuser is mounted on the inside face of each collector.

IMPELLER ASSEMBLY - The impeller assembly is housed between the supercharger collector and the accessory drive cases. The impeller shaft is hollow and incorporates three bronze bearings in the I.D. These bearings support the impeller hub and the impeller shaft drive pinion, as well as lands for the five rear oil seal rings are machined on the O.D. of the shaft. The impeller shaft drive pinion is mounted on the rear of the shaft, and the fuel slinger, impeller, impeller hub, impeller thrust bearing, and impeller thrust plate are installed on the front of the shaft. The power is supplied to the main impeller from the accessory drive shaft through the supercharger drive gear, the main impeller intermediate drive gear and the main impeller shaft pinion.

AUXILIARY IMPELLER ASSEMBLIES - A hub is shrunk on each auxiliary impeller and, each hub and impeller are shrunk on the end of a hollow shaft and locked with a nut and pin. Each auxiliary impeller shaft is splined into and supported by a hollow auxiliary impeller drive pinion shaft. Each pinion shaft is supported at its outer end by a liner in an auxiliary supercharger collector support and on its inner end by a separate bushing in the accessory drive support. A thrust washer is mounted toward the outside end of the pinion shaft directly on the outside of the pinion and bears against a self-centering thrust bearing which is seated in a concave recess in the inner end of the collector liner. The outer end of the liner is sealed by a face plate and a face oil seal. The inner end of the auxiliary impeller shaft which projects beyond the pinion shaft is splined into the I.D. of the auxiliary impeller shaft quill, which is located between the pinion shaft bushing bosses in the accessory drive support. The entire assembly is locked together by the auxiliary impeller connecting shaft which extends through the auxiliary impeller shafts and the quill.

HYDRAULIC COUPLINGS - The high and low ratio hydraulic couplings are mounted on the left and right auxiliary supercharger collector supports respectively. Each coupling pinion is driven by the supercharger drive gear. The coupling impellers are free running on the coupling shafts and the coupling runners are splined to the respective coupling shafts. Each coupling drive bevel gear is splined on the coupling shaft and meshes with the auxiliary supercharger impeller drive shaft pinion.

When oil is directed into the low or high ratio coupling, power is transmitted through the oil from the coupling impeller to the runner. The runner of the selected coupling accelerates as the coupling fills with oil, until it travels at the same rpm as the coupling impeller and drives the auxiliary supercharger impellers.

A sleeve type valve is installed on the coupling shaft of the low ratio coupling between the impeller and runner. A spacer instead of the valve occupies a similar position in the high ratio coupling.

While the speed of the low ratio coupling impeller is greater than the speed of its runner, the valve turns with the impeller coupling and its oil holes are aligned with the oil holes in the coupling shaft. Then the oil flows from the shaft into the coupling, and the low ratio runner, hydraulically engaged by the low ratio impeller drives the auxiliary supercharger impellers.

When oil is directed to the high ratio coupling, the high ratio runner, hydraulically engaged by the high ratio coupling impeller, drives the auxiliary supercharger impellers. When the low ratio coupling runner, which is meshing with the auxiliary supercharger impeller drive gear, rotates faster than the low ratio coupling impeller, the friction between the low ratio coupling valve and runner causes the valve to turn on the coupling shaft in the direction of the coupling rotation. When the valve turns, its oil holes move out of alignment with the oil holes in the coupling shaft, thereby shutting off the flow of oil into the low ratio coupling and preventing low ratio coupling operation from interfering with high ratio coupling operation.

When the oil is cut off from the high ratio coupling, to such extent that the speed of the low ratio coupling runner becomes less than the speed of the low ratio coupling impeller, the friction between the low ratio coupling valve and runner will then cause the valve to turn on the coupling shaft in a direction opposite to that of coupling rotation. When the valve turns, its oil holes will line up with the oil holes in the coupling shaft, and oil will again fill the low ratio coupling and the coupling will become operative.

FUEL FEED VALVE - Fuel is conducted into the fuel feed valve housing through a passage in the accessory drive case which connects with the internal fuel feed passage in the carburetor. While the pressure of the fuel exerted outwardly against the valve diaphragm is less than the pressure exerted by the valve spring inwardly against the valve diaphragm, the valve remains seated against the discharge end of the valve housing, thereby shutting off the fuel flow. When the fuel pressure exceeds the valve spring pressure, the diaphragm lifts the valve off its seat and fuel flows to the fuel slinger through small holes in the front face of the supercharger intake insert liner. Fuel is distributed from drilled passages in the impeller which connect with the fuel slinger.

ACCESSORY DRIVE SHAFT ASSEMBLY - The front end of the accessory drive shaft is supported by a bushing in the hub of the accessory drive pinion cage. The rear bearing journal of the accessory drive shaft is supported by bearings in the accessory drive support. The accessory drive shaft drive gear, which is integral with the front end of the accessory drive shaft, is driven by the pinions of the accessory drive pinion assembly. Three gears are splined on the rear end of the accessory drive shaft. The front gear (supercharger drive gear) drives the hydraulic couplings. The center gear (rear scavenge oil pump drive gear) drives the intermediate drive shaft which in turn drives the rear scavenge oil pump. The rear gear (accessory drive gear) drives the accessory intermediate drive gear and the pressure oil pump intermediate drive gear. A power take-off sleeve is splined on the rear end of the accessory drive shaft. This sleeve is supported in the rear cover of the accessory drive case.

GENERATOR DRIVE GEAR TRAIN - The generator is driven through a train of gears which starts with the accessory drive gear and runs through the accessory intermediate and the large gear of the starter intermediate, to the generator drive gear.

STARTER JAW DRIVE GEAR TRAIN - The starter turns the engine through a train of gears which starts with the starter jaw and runs through the starter intermediate drive gear, the accessory intermediate drive gear, the accessory drive gear (splined to the rear of the accessory drive shaft), the accessory drive shaft gear (integral with the forward end of the accessory drive shaft) and the accessory drive pinion assembly which is splined and secured to the rear of the crankshaft.

VACUUM PUMP DRIVE GEAR TRAIN - The vacuum pump is driven through a train of gears which starts with the accessory drive gear and runs through the accessory intermediate and the small gear of the starter intermediate, to the vacuum pump drive gear.

SINGLE VACUUM PUMP DRIVE ADAPTER - The single vacuum pump drive gearing is housed within an adapter which is mounted on the power take-off pad located on the rear cover of the accessory drive case. The single vacuum pump drive gear is driven by the smaller gears of three compound pinions. The larger gears of the pinions are in turn driven by the single vacuum pump intermediate drive gear, the outer end of which rotates in a bearing in the bore of the drive gear. The inner end of the single vacuum pump intermediate drive gear is splined into and driven by the power take-off coupling.

TACHOMETER DRIVE GEAR TRAIN - The tachometer is driven through a train of gears which starts with the accessory drive gear and runs through the small gear of the accessory intermediate and tachometer intermediate, to the tachometer drive gear.

FUEL PUMPS DRIVE GEAR TRAIN - The two fuel pumps (or fuel and water pumps) are driven through a train of gears which starts with the accessory drive gear and runs through the accessory intermediate drive gear, the fuel pump intermediate drive gear to the two fuel pump drive gears.

PRESSURE OIL PUMP INTERMEDIATE DRIVE GEAR - The pressure oil pump intermediate drive gear is driven by the accessory drive gear. The front end of the gear is supported by a bushing in the accessory drive support and the rear end is supported by a bushing in the rear cover of the accessory drive case. The rear end of the pressure oil pump intermediate drive gear splines onto the pressure oil pump drive gear shaft and drives the pressure oil pump.

PRESSURE OIL PUMP - The pressure oil pump is mounted on the lower left side of the rear cover of the accessory drive case. A pressure relief valve is screwed into the pump body. The pump body has a square mounting pad for the oil inlet connection. The splined pressure oil pump drive gear shaft which protrudes outside the pump body is driven by the pressure oil pump intermediate drive gear. This gear and an additional drive gear are keyed to the shaft and mesh with the two idler gears to force oil under high pressure to the oil screen chamber.

PRESSURE OIL STRAINER - The pressure oil strainer assembly consists of a body assembly which includes an oil return check valve and a perforated central tube. A series of screens in disc form, separated alternately by stamped brass inlet and outlet spacers are assembled around the perforated tube. The screens and spacers are secured in place by a support assembly and plug. The oil strainer is retained in a chamber in the middle left side of the rear cover of the accessory drive case by a cover which includes an oil drain plug.

REAR SCAVENGE OIL PUMP - The rear scavenge oil pump is located on the bottom of the accessory drive case. The drain oil from the accessory drive case and from the oil sump, which is connected to the scavenge oil pump by an external line, is collected in the scavenge oil pump and discharged through an internal passage in the accessory drive case to the oil outlet connection. The scavenge oil pump drive and idler gears are supported in the pump body and surrounded by a screen.

REAR SCAVENGE OIL PUMP DRIVE GEAR TRAIN - The rear scavenge oil pump is driven through a train of gears which starts with the rear scavenge oil pump drive gear (splined to the accessory drive shaft) and runs through the rear scavenge oil pump intermediate drive shaft gear. This gear is splined and secured to the rear end of the rear scavenge oil pump intermediate drive shaft. The rear scavenge oil pump intermediate drive shaft pinion at the lower end of the shaft, drives the rear scavenge oil pump intermediate drive bevel gear, which inturn is splined to the rear scavenge oil pump gear drive shaft.

CARBURETION - The engine is equipped with a Bendix PR-64B2 updraft pressure injection carburetor with an integral water injection regulator. This carburetor operates by the same principle as previously described carburetors.

ENGINE CONTROL - The automatic engine control unit is attached to a pad on the upper left side of the rear cover of the accessory drive case. It is essentially a manifold pressure regulator and operates and correlates the carburetor throttle with the supercharger impeller drive coupling selector valve which is a part of the control unit. It maintains constant manifold pressure regardless of change in altitude by means of an aneroid bellows arrangement which regulates the throttle in conjunction with the supercharger impeller speed as required.

THE WASP MAJOR ENGINE IN THE CORSAIR

Late in World War II the Wasp Major Series "B" engine became available and was installed experimentally in a Vought F4U-1 by Pratt & Whitney at Pratt & Whitney's Installation Development Department. During the development of this high-powered engine, there existed considerable controversy concerning the suitability of this engine for a relatively small fighter airplane. It was thought by some that the high torque produced by the Wasp Major would create serious controllability problems. In an effort to prove or disprove this contention and to further the acceptability of the Wasp Major engine for fighter aircraft, Pratt & Whitney took a standard F4U-1 and modified it to accommodate this engine. (Photographs of this aircraft are included.) Performance and flight characteristics of this aircraft were exceptionally good. The torque problem proved to be inconsequential and the development of a dual rotation reduction gear and propeller for this airplane was abandoned. The U. S. Navy was so impressed with the Wasp Major powered F4U that Goodyear Aircraft was ordered to further develop and produce it under the designation of F2G-1. A limited quantity of F2G-1's were produced before the end of the war. As a result of the success of this airplane the Wasp Major engine was accepted for fighter aircraft and new designs by Republic and Boeing were flying when the end of the war and the advent of the jet engine terminated these aircraft and the extension of the Wasp Major engine into the fighter aircraft field.

A general description of the Wasp Major engine used in the F2G-1 follows. The engine used in P&WA's converted F4U-1 was a similar experimental engine.

GENERAL

The Wasp Major engines are four row, radial, air cooled engines with single stage, variable speed superchargers.

From front to rear, the five major sections of the engine case are the propeller shaft case, the magneto drive case, the crankcase, the supercharger case, and the accessory drive case.

The 28 cylinders are helically arranged around the crankcase in four rows of seven banks.

The five section crankcase houses a five cam system and supports a one piece crankshaft incorporating four crankpins.

Ignition is furnished by seven magnetos whose timing is controlled by a three position spark advance system.

PROPELLER SHAFT CASE SECTION

PROPELLER SHAFT CASE - The propeller shaft case supports the propeller shaft and its thrust bearing, the propeller governor and front oil pump drives, and the front oil pump. Bosses with bearings for supporting two gun drives project internally from each side of the case. No drives are installed, however, since there is no requirement for them on these engines.

PROPELLER SHAFT - The propeller shaft, which incorporates a No. 60A spline at its front end for mounting the propeller, supports an oil transfer bearing and the reduction drive pinion cage. The pilot end of the shaft is supported by two steel backed bronze bearings in the front end of the crankshaft, and the main body of the shaft is supported by the thrust bearing.

The bore of the propeller shaft is separated into two compartments by a propeller shaft plug. Various oil holes and pipes transfer oil from the rear compartment to lubricate the reduction gearing, and other holes and pipes direct boosted oil into the front compartment.

REDUCTION DRIVE PINIONS - Sixteen reduction drive pinions of spur planetary type are provided. Each pinion incorporates a prefitted tri-metal bearing which rotates around a steel race. The steel backed bronze bearing is internally coated with babbitt. A slot in each bearing race engages the pinion shaft dowel pin, thereby preventing the race from spinning. The ends of each pinion shaft are supported by the pinion shaft front and rear supports.

REDUCTION DRIVE PINION SHAFT SUPPORTS - The pinion cage consists of the pinion shaft front and rear supports. A split, lead plated, cast iron oil seal ring is incorporated in the groove at the front end of the propeller shaft rear splines, and the hub end of the front support is pressed onto the splines over the oil seal ring and locked in place by a spanner nut. The rear support is bolted to the front support and is secured to the rear ends of the pinion shafts. The front accessory drive gear, a bevel ring gear attached to the front of the front support, drives the propeller governor and front oil pump drive gears.

PROPELLER GOVERNOR DRIVE - The propeller governor drive gear is supported by a flanged bushing in each end of a boss projecting internally from the upper part of the case. End movement of the gear is limited by a snap ring in the groove at the other end of the gear shaft. The propeller governor drive gear is driven by the front accessory drive gear.

FRONT OIL PUMP DRIVE - The front oil pump extension shaft rotates within its support which is attached to studs in the bottom inside wall of the case. The front oil pump drive gear is splined to the inner end of the extension shaft and is driven by the front accessory drive gear. The outer end of the extension shaft is coupled to the front oil pump drive shaft.

FRONT OIL PUMP - The front oil pump housing consists of four sections bolted together to form three scavenge chambers. The pump is mounted in the bottom of the case and is secured to the studs in the mounting pad which project through the pump cover. The housing supports the oil pump drive shaft and the idler shaft.

The three gears which are keyed to the drive shaft mesh with the three gears mounted on the idler shaft. The top idler gear is pinned to its shaft. Each pair of gears operates within one of the scavenge chambers of the pump. The top chamber scavenges oil from the propeller shaft case and magneto drive case sections, the center chamber scavenges oil from the front rocker box sump, and the bottom chamber scavenges oil from the front cam compartment.

PROPELLER SHAFT OIL TRANSFER BEARING - After the reduction driven pinion shaft front support has been installed on the propeller shaft, the hub of the support and the adjacent grooved surface of the shaft are jointly ground to the same dimension. The resulting ground surface, indicated by the absence of flash tin plate, acts as a seat for the babbitt bearing surface in the propeller shaft oil transfer bearing.

The transfer bearing, which floats on the propeller shaft, is held in position by the two governor oil transfer pipes, the rear pipe being rigidly supported by one of the internally projecting bosses of the case. Engine high pressure oil is boosted by a dual action governor and then transmitted through the two transfer pipes and the transfer bearing into the propeller shaft and thence to the propeller where it is used for hydromatic propeller control.

PROPELLER SHAFT THRUST BEARING - The thrust bearing is a ball bearing which has a split inner race. The outer race of the bearing seats in the propeller shaft case liner. The thrust bearing cover retains the outer race of the bearing against the rear flange of the liner, and the thrust bearing nut retains the inner race against a spacer which seats against a shoulder on the propeller shaft.

The thrust bearing nut carries two oil seal rings which contact the liner in the thrust bearing cover. The thrust bearing cover spacer is installed between the thrust bearing cover and the outer race of the bearing. An oil slinger is held between the thrust bearing nut and the bearing inner race. The bearing supports the front of the propeller shaft and transmits propeller thrust from the shaft to the case.

MAGNETO DRIVE CASE SECTION

MAGNETO DRIVE CASE - The magneto drive case is mounted on the front crankcase over the long studs which project forward from the crankcase. The propeller shaft case is secured to the front ends of those studs which pass completely through the holes in the outer wall of the magneto drive case. The magneto drive case is secured to the three shorter studs, which do not project completely through the holes.

Arranged radially around the outside of the case are seven pads for mounting the magnetos, the drive shafts of which are supported in the web of the case. The magneto drive case houses the propeller shaft reduction gears and the spark advance system.

The helical splines in the wall of the magneto drive case are for engaging a fixed gear equipped with torquemeter pistons, and the case is provided with pads for mounting a torquemeter transmitter and a torquemeter booster pump. Torquemeter equipment is not installed on engines used in the F2G airplane.

PROPELLER SHAFT REUDCTION GEARS - The reduction drive gear is splined onto the reduction drive gear coupling and locked in place by two snap rings. The coupling in turn, is splined onto the front end of the crankshaft. The fixed gear is attached by its flange to the front rim of the magneto drive case web. The reduction drive pinions are driven by the reduction drive gear and, as they rotate within the fixed gear, they turn the pinion supports and hence the propeller shaft at .425 times crankshaft speed.

CRANKSHAFT OIL TRANSFER BEARING - The crankshaft oil transfer bearing, which is lined with babbitt, floats on the reduction drive gear coupling just behind the reduction drive gear. The chromium plated end of a boss, integral with the top of the bearing, fits into an elbow which is attached to the front face of the magneto drive case web, thus limiting any movement of the floating bearing.

A telescoping pipe, consisting of an inner pipe and an outer pipe mounted on opposite ends of a small spring, is installed between the elbow and the pipe boss on the transfer bearing. The spring holds the inner pipe against its seat in the pipe boss and the outer pipe against its seat in the elbow.

Oil flows into the elbow through a hole in the web of the magneto drive case and then passes through the telescoping pipe and into the oil transfer bearing. The oil then flows through holes in the coupling, crankshaft, and propeller shaft into the bore of the propeller shaft where it joins the oil conducted to the propeller shaft by the crankshaft, thereby maintaining sufficient oil pressure in the front of the engine.

MAGNETO DRIVES - The magneto drive pinion cage, which is splined onto the front end of the crankshaft just behind the reduction drive gear coupling, supports the six magneto drive compound pinions. Each pinion rotates on the leaded silver bearing surface of its race. A pin in each pinion shaft engages the groove in the pinion race, thereby preventing the race from spinning on the shaft. The front and larger gear of each compound pinion meshes with the spark advance gear while the smaller gear of each compound pinion drives the spur gear teeth of the magneto intermediate drive gear.

The crankshaft drives the pinion cage, causing the pinions to rotate within the spark advance gear and to drive the magneto intermediate drive gear, which is supported on the leaded silver bearing surface on the front end of the crankshaft front bearing. The bevel gear teeth of the magneto intermediate drive gear drives the magneto drive gears which rotate within the slots in the spark advance gear. The magneto drive gears are splined onto the inner ends of the magneto drive shafts, the outer ends of which are internally splined for driving the magnetos.

SPARK ADVANCE SYSTEM - The four spark advance cylinders, each of which houses a spring loaded piston, are numbered right to left from 1 through 4. Special oil transfer studs secure the pairs of cylinders to the rear face of the magneto drive case web. The spark advance gear, which regulates the timing of the magneto drive system, has two arms, each of which is attached to a pair of pistons by two piston links.

When there is no pressure oil in the cylinders, as in the case before the engine is started, the spark advance gear will be in the starting (5 degrees) spark advance position. After the engine starts, high pressure oil from the annular groove behind the flange of the reduction drive fixed gear is diverted to the No. 1 and No. 4 cylinders through their special studs. The pressure oil, counteracting the spring pressure, forces the pistons to turn the spark advance gear to the normal (20 degrees) spark advance position.

Improved fuel economy during cruising operation is obtained by opening the spark advance valve, a simple shut-off valve with manually operated pulley wheel control, which is attached to the outside of the magneto drive case between the No. 1 and No. 2 magneto mounting pads.

When the pulley wheel is turned so that the valve is in the open position, pressure oil is diverted by the valve from the annular groove to a drilled passage in the web of the case. This passage conducts oil to the No. 2 cylinder through its special stud. Simultaneously, the spark advance cylinder oil feed pipe carries oil from this passage to another web passage which conducts oil to the No. 3 cylinder through its special stud. This pressure oil forces the No. 2 and No. 3 pistons to turn the spark advance gear still further to the cruising (35 degrees) spark advance position.

The travel of each piston outward from its cylinder is limited by the inner end of an adjustable stop which is supported by a boss integral with the web of the case. The four stops are so adjusted that they prevent any movement of the No. 1 and No. 4 pistons beyond the 20 degree spark advance position and any movement of the No. 2 and No. 3 pistons beyond the 35 degree spark advance position.

When the pulley wheel is turned sotthat the valve is in the closed position, the pressure oil is cut off from the No. 2 and No. 3 cylinders. The oil from these cylinders drains back through the valve into the magneto drive case, and the No. 2 and No. 3 spring loaded pistons return the spark advance gear to the 20 degree spark advance position. When the oil drains from the No. laand No. 4 cylinders after the engine stops, the No. 1 and No. 4 spring loaded pistons return the spark advance gear to the 5 degree spark advance position.

TORQUEMETER BOOSTER PUMP - A small gear type pump, driven by a shaft and splined coupling extended back to the top front cam reduction gear, boosts engine oil pressure sufficiently to operate the torquemeter under the greatest engine driving torque.

TORQUEMETER - The splines in the magneto drive case engage similar splines on the reduction drive fixed gear and are cut at an angle so that engine driving torque produces a component thrust toward the rear on the fixed gear. To counteract this thrust there are 40 small pistons placed in holes in the rear face of the gear. The piston heads rest on a steel ring attached to the case. Engine oil, under high pressure from the booster pump, is admitted to the piston through drilled passages in the fixed gear. Two of the pistons have small holes in their sides to control the oil flow in such way that, as the fixed gear moves toward the front, the oil flow is decreased; and as the fixed gear moves toward the rear, the oil is increased. Thus the fixed gear is balanced between the thrust component of the engine torque and the thrust caused by the oil pressure on the pistons. The piston oil pressure is directly proportional to the engine driving torque and is transferred to the inner side of the transmitter diaphragm. A low viscosity oil is used between the outer side of the diaphragm and a pressure gage; the gage provides a direct indication of the propeller driving torque.

TORQUEMETER TRANSMITTER - The torquemeter transmitter is a diaphragm contained between a cover and the magneto drive case. It prevents the engine oil from mixing with the low viscosity oil used in the torquemeter pressure gage line, thus preventing congealing in the line with resultant sluggish operation of the pressure gage.

CRANKCASE SECTION

CRANKCASE - The five sections of the crankcase are identified as the front, front intermediate, center, rear intermediate, and rear crankcases are externally bolted together. Each section of the crankcas supports a journal of the crankshaft and a part of the valve actuating mechanism.

ENGINE LIFTING LINKS AND MOUNTING BRACKETS - Two engine lifting links are screwed into the upper part of the rear crankcase, and one lifting link is secured to the front end of the bolt which joins the front and front intermediate crankcases between the No. 7 and No. 1 cylinder banks. The threaded inserts in the machined pads around the rear and rear intermediate crankcases are for attaching the engine mounting brackets.

CRANKCASE OIL PUMPS - Drain oil is scavenged from the front intermediate, center, rear intermediate, and rear cam compartments by the four crankcase oil pumps and is transmitted toward the rear through pipes and drilled passages in the lower part of the crankcase. Each of the pumps is mounted on the front wall of one of these compartments.

VALVE TAPPET GUIDES AND TAPPETS - The 56 valve tappet guides are supported in the holes provided for them in the crankcase. The front and rear crankcases each support seven radially positioned guides, and the center crankcase and front and rear intermediate crankcases each support 14 radially positioned guides. Each guide houses and provides a bearing surface for a valve tappet. A cam roller is secured to the inner end of each tappet by a silver plated roller pin.

TAPPET OIL MANIFOLDS - Each of the five tappet oil manifolds consists of a series of pipes and connections joined together to form a circuit. The pipes of each manifold fit snugly in the connections which are attached by special oil transfer screws to the tappet guide bosses and a feeding oil passage. Part of the pressure oil which passes forward through drilled passages and transfer pipes in the upper part of the crankcase enters each manifold through the feeding oil passage. This oil is then transmitted to the rocker boxes via the valve tappets and push rods.

CAM DRIVES - Each of the five identical cams has an internal gear and two external tracks, each track having three lobes. The cam rollers, which are attached to the valve tappets, contact the cam tracks and, as the cams rotate around their bearings, the rollers and tappets are actuated by the cam track lobes. The cam bearings are aluminum alloy rings, one of which is attached to the shelf integral with the front of the web of each crankcase section.

The two retainers for each cam are located diametrically opposite each other on the front face of the cam bearing and are secured by the bolts which secure the cam bearing and the crankshaft bearing support retainers. Each cam retainer is copper plated on the face which contacts the cam. The retainers for the front intermediate, center, and rear intermediate cams have cutouts for clearing the cam reduction pinions and slots for engaging the front ends of the crankshaft bearing support spacers. These slots function jointly with the slots in the crankshaft bearing support retainers to prevent the supports from turning.

Each cam is driven by two cam reduction gear and pinion assemblies at 1/6 the speed of, and opposite in direction to, the crankshaft. Each of the 10 cam reduction gears is splined to the shaft of its pinion, which is supported by two leaded bearings. The bearings for the front and rear pinions are located in the front and rear crankcase webs, whereas the bearings for the front intermediate, center, and rear intermediate pinions are located in the corresponding crankshaft bearing supports. Except for the lower rear cam reduction gear, each lower cam reduction gear drives a crankcase oil pump.

The rear cam drive gear is a one piece gear splined onto the accessory drive shaft coupling and held in place by a spanner nut which is secured by a spring loaded screw. The remaining four cam drive gears are of two piece construction, being split along the centerline of diametrically opposite tooth spaces, and are attached directly to the crankshaft by screws and bolts. Each of these gears drives two cam reduction gears.

CRANKSHAFT - The one piece crankshaft is dynamically bala nced and has four crankpins and five supporting bearing journals. The center journal has flanged ends which locate the crankshaft axially. Each crankpin is angularly positioned 192-6/7 degrees clockwise around the longitudinal axis of the shaft with reference to the crankpin behind it.

The hollow crankshaft is fitted with plugs and pipes for conducting pressure oil to the master rod bearings and crankshaft bearings. Small drilled holes adjacent to the crankpins provide oil squirts for improved cylinder wall lubrication. The accessory drive shaft coupling is splined into the rear end of the crankshaft and anchored to the crankshaft rear plug.

The crankshaft is equipped with two large counterweights, one suspended from the crankshaft front cheek and one from the rear cheek. In addition, two small fixed counterweights are bolted to the crankshaft. Bifilar suspension of the large counterweights is effected by a system of floating bushings and rollers. Movement of each large counterweight assembly is limited by a stop which is supported by and attached to a counterweight adapter riveted to the corresponding crankshaft cheek.

CRANKSHAFT BEARINGS - The crankshaft is supported at each of its bearing journals by a prefitted, steel blacked, leaded silver bearing. The front and rear bearings are of one piece construction and are located in the small bores of the corresponding crankcase sections. The front end of the front bearing supports the magneto intermediate drive gear.

The front intermediate, center, and rear intermediate crankshaft bearings are of two piece construction. The flanged center bearing transmits thrust from the crankshaft to its center bearing support. Each split bearing is held together by a similarly split crankshaft bearing support, the halves of which are bolted together by studs and serrated locknuts. Each of the bearing supports is supported by the liner in the large bore of the corresponding crankcase section and by two scalloped retainers attached to the crankcase at the rear of the bore. Dowel located spacers are provided between the parting faces of the bearing support halves. The bearings are keyed to their supports to prevent the bearings from turning.

MASTER AND LINK ROD ASSEMBLIES - Four master and link rod assemblies, each basically consisting of a master rod and six link rods, drive the crankshaft. Each of the four master rods and master rod bearings are of the split type. Each bearing, prefitted and keyed to its master rod, is a steel backed leaded silver bearing. The component parts of each master rod assembly, the master rod and cap, are bolted together around the corresponding crankpin. Silver plated shims are provided between the parting faces of the master rod and its cap to prevent galling.

Each link rod is of the "I" section type. A bronze bushing in the larger or piston end of the rod accommodates the piston pin. The smaller end of each link rod is attached to the master rod by a knuckle pin. Two link rods are anchored to each master rod and four are anchored to each master rod and four are anchored to its cap.

The knuckle pins are classified as fully intersected, partially intersected, and non-intersected according to the extent of absence of the cut-outs which provide clearance for the master rod bolts. Of the four knuckle pins in the master rod cap, the two nearest the parting face of the cap are fully intersected. The remaining two pins in the cap are non-intersected and are prevented from turning by a lock. The two knuckle pins in the master rod are of the partially intersected type. All outside diameter surfaces of the pins are silver plated, with the exception of the copper flash plated surfaces on the non-intersected knuckle pins, which contact the master rod.

CYLINDERS

CYLINDER HEADS AND BARRELS - An aluminum muff in which barrel cooling fins have been machined and an aluminum head with integral braced cooling fins are shrunk onto each of the 28 cylinder barrels. The choke in the bore of the steel barrel resulting from shrinking on the muff is removed when the bore is ground, but the grinding of the bore does not remove the taper at the top of the barrel resulting from the shrinking on of the head. This taper exists when the parts are cold, but at operating temperatures the bore is practically straight because of greater head expansion at the top of the barrel.

Each of the 28 identical cylinders is secured to the 16 studs in the corresponding cylinder mounting pad on the crankcase. These studs project from the mounting pad through the holes in the flange integral with and near the base of the cylinder barrel.

Two valve rocker boxes are integral with each cylinder head and are located diametrically opposite each other in the top of the head. The rocker box covers are secured by washers and self locking nuts to their studs in the rocker boxes. Each rocker box is equipped with a push rod cover nut union.

The exhaust pipe coupling in the exhaust port of each cylinder is equipped with a steel liner and four studs for securing the exhaust pipe. The intake port is located between the rocker boxes and has four studs for intake manifold attachment.

Two stainless steel helicoil spark plug inserts are screwed and staked into the spark plug openings, located in the left and right sides of each cylinder head. The insert in the recess at the top of the cylinder head, between the intake port and the exhaust rocker box is for a cylinder head thermocouple attachment.

A bronze inlet valve seat, a steel exhaust valve seat, and two bronze valve guides are installed in each cylinder head.

PUSH RODS AND COVERS - The tubular push rods have hardened steel ball ends which seat in the valve tappet ball sockets at the crankcase end of the rods and in the valve rocker ball sockets at the cylinder end of the rods. Single piece tubular covers enclose the push rods and are secured to the tappet guides in the crankcase and the unions in the rocker boxes by special nuts. The push rods and covers connected to the inlet rocker boxes are slightly shorter than those connected to the exhaust rocker boxes, and the nuts securing the push rod covers to the unions in the rocker boxes are slightly larger than those securing the push rod covers to the tappet guides. The push rods transmit valve tappet motion to the valve rockers.

VALVE ROCKERS - Each valve rocker is supported on its rocker shaft by the bronze bearing in its bore and by a removable steel sleeve which fits around the shaft. The solid steel rocker shaft, which extends through the rocker box, is supported at each end by a flanged steel bushing and is secured by a nut. A valve clearance adjusting screw and lock nut are provided in the valve end of each rocker. The rockers transmit push rod motion to the valves.

VALVES - Each cylinder has an inlet and an exhaust valve. The solid inlet valve is partially filled with sodium for improved cooling characteristics and has a stellite coated seating surface to prolong its life. Each valve is seated by the action of two concentric springs which operate between two washers, the upper of which is secured to the valve stem by conical locks.

PISTONS - Each of the 28 pistons has a domed head in which there is a clearance cut-out for each valve of its cylinder. The piston travels through a 6 inch stroke to afford a 7 to 1 compression ratio. The internal faces of the piston are provided with cooling fins.

Cast iron piston rings with butt type gaps are installed in the five grooves in the piston skirt. The rings in the top three grooves are wedge type compression rings. The top compression ring is chromium plated on the face which bears against the cylinder wall. The two bottom grooves are provided with oil drain holes. Two oil control rings are installed in the fourth ring groove and an oil scraper ring is installed in the bottom groove.

A piston pin anchors each piston to its link rod. The dural plug in each end of the hollow steel, full floating piston pin contacts the cylinder barrel bore.

ROCKER SUMPS - All the lower rocker boxes drain through interconnecting external pipes into two rocker sumps. The front sump is suspended from the lower front inner cowl deflector, between D3 and D4 cylinders, and is scavenged by the center chamber of the front oil pump. The rear sump, which is attached directly to A5 cylinder inlet rocker box in place of a rocker box cover, is scavenged by the smaller scavenge chamber of the rear oil pump. The removable basin in the rocker box end of the rear sump provides a pool of oil for improved A5 inlet valve guide lubrication.

CYLINDER DEFLECTORS - The pressure type deflectors are so arranged that each of the seven cylinder banks is cooled by a separate unit. Each unit has four outlets one for each cylinder of its bank, and each cylinder has two tight fitting side plates. Top plates almost completely enclose the cooling system.

SUPERCHARGER CASE SECTION

SUPERCHARGER CASE - The outer of two concentric rings of studs in the front of the supercharger case provides for the attachment of the case to the rear of the crankcase. The hydraulic coupling support is secured to the inner ring of studs.

The hydraulic coupling compartment houses the impeller drive which consists of the hydraulic coupling spring drive gear, two high and two low ratio hydraulic couplings, and the impeller drive gear. The drive gear is splined onto the front end of the impeller shaft. This compartment is vented by two large external breathers with brass screened ports, which are attached to the upper sides of the case. The breathers are connected by cored passages to recesses in the web of the supercharger case.

Around the outside of the case and between the outlet ports are seven pairs of bosses, each boss having two inserts. The machined faces of these bosses provide the pads to which, in conjunction with the pads on the rear and rear intermediate crankcases, the engine mounting brackets are secured.

The impeller compartment, to the rear of the supercharger case web, houses the diffuser and the impeller.

HYDRAULIC COUPLING SUPPORT - The hydraulic coupling support secures the front ends of the hydraulic coupling shafts and supports an oil manifold, an oil pump, and an oil check valve. Drilled passages in the support conduct oil to the hydraulic coupling shafts for lubrication of the hydraulic coupling bearing surfaces. A spring loaded oil pressure reducing valve, which is screwed into the supercharger case, reduces the pressure of this oil which is diverted to the support from the high pressure oil passage in the upper part of the supercharger case.

HYDRAULIC COUPLING OIL MANIFOLD - The hydraulic coupling manifold, a brazed assembly of curved pipes and circular brackets attached to the front of the hydraulic coupling support, connects with the high and low ratio coupling oil passages from the hydraulic coupling selector valve and directs high pressure oil into the couplings through the coupling shafts. The outer of the three pipes receives oil from the bracket which connects with the low ratio coupling oil passage and directs the oil to the top and bottom brackets which feed oil to the low ratio coupling shafts.

The inner pipe receives oil from the bracket which connects with the high ratio coupling oil passage and directs part of the oil to the bracket which feeds the right side high ratio coupling shaft. The remainder of the oil which the inner pipe receives is diverted through an adapter into the short middle pipe which connects with the bracket feeding the left side high ratio coupling shaft.

The middle pipe increases the distance the oil must travel from the inlet bracket to the bracket feeding the left side high ratio coupling shaft so that it approximates the distance the oil must travel from the inlet bracket to the right side high ratio coupling shaft.

HYDRAULIC COUPLING SUPPORT OIL PUMP - The hydraulic coupling support oil pump drive gear is driven by the lower rear cam reduction gear. The front and rear chambers of the pump scavenge oil from the sections of the hydraulic coupling compartment at the front and rear, respectively, of the hydraulic coupling support. The oil discharged by the pump and the oil in the adjoining rear end of the crankcase scavenge line is carried by an external pipe from the supercharger case to the rear oil pump outlet.

HYDRAULIC COUPLING SUPPORT CHECK VALVE - The bronze flapper hinged to the front of the support and adjacent to the pump is a check valve which opens to permit oil to flow from the rear to the front section of the coupling compartment. The flapper is gravity closed to prevent free crankcase oil from flowing back into the rear section of the coupling compartment when the engine is in climb position.

HYDRAULIC COUPLING SPRING DRIVE GEAR - The spider, splined onto the accessory drive shaft coupling, is housed within the gear and the retaining plates. The retaining plates are secured to each en of the gear by bolts which pass through the holes in the gear web. Button seated springs reduce shock loading as they transmit rotational movement from the spider legs to the spokes of the gear web. The chambers between the spider legs and the gear spokes are filled with high pressure oil admitted by check valves in the spider hub, which do not permit the oil to flow out of the chambers. This oil dampens torsional vibration.

HYDRAULIC COUPLINGS - Each of the four hydraulic coupling shafts is a stationary shaft supported at its rear end by a flanged bushing in the web of the supercharger case. The front end of each coupling shaft is secured in the coupling support by a lock screw. The two low ratio couplings are supported by the top and bottom coupling shafts, and the two high ratio couplings are supported by the left and right coupling shafts.

The hydraulic coupling spring drive gear drives the four coupling pinions, each of which is supported by and rotates around the leaded silver bearing surface on its coupling shaft. Each of the four hydraulic coupling impellers is splined onto the rear end of its pinion shaft. Each of the four hydraulic coupling turbines is mounted between the hydraulic coupling impeller and cover, is equipped with a steel backed bronze bearing, and turns on the shaft of the pinion. The hydraulic coupling cover is secured to the impeller casing by screws.

The hydraulic coupling gear is splined onto the front end of the turbine and, when the turbine of each coupling is hydraulically engaged by its impeller, the coupling gear drives the supercharger impeller drive gear at a speed which is infinitely and selectively variable with the volume of oil in the coupling.

HYDRAULIC COUPLING OPERATION - A sleeve type valve with leaded silver bearing surfaces on the outside diameter and front face is installed on the shaft of each low ratio coupling pinion between the impeller and turbine. Two bronze friction ring segments which contact the bore of the turbine are installed in the ring groove in the outside diameter of each valve. Two pins in the bottom of the groove prevent the ring segments from turning with respect to the valve. Pins in the hub of the impeller engage slots in the rear face of the valve, thereby limiting movements of the valve with respect to the impeller.

While the speed of the impeller is greater than the speed of the turbine, the valve turns with the impeller and its oil holes are aligned with the oil holes in the shaft of the pinion. Under these conditions and while the selector valve is directing oil into the low ratio hydraulic coupling shafts, oil flows from the shafts into the couplings, and the low ratio turbines, hydraulically engaged by the low ratio impellers, drive the supercharger impeller drive gear at the desired low ratio speed.

When the high pressure oil is diverted by the selector valve from the low ratio couplings to the high ratio couplings, the high ratio turbines, hydraulically engaged by the high ratio coupling impellers, drive the supercharger impeller drive gear at the desired high ratio speed. Under these conditions and when the low ratio turbines, which are meshing with the supercharger impeller drive gear, rotate faster than the low ratio impellers, the friction between each low ratio coupling valve and turbine causes the valve to turn on the shaft of the pinion in the direction of coupling rotation. When the valve turns, its oil holes move out of alignment with the oil holes in the shaft of the pinion, thereby shutting off any remaining flow of high pressure oil into the low ratio coupling and preventing low ratio coupling operation from interfering with high ratio coupling operation.

When the high pressure oil is diverted by the selector valve from the high ratio couplings to the low ratio couplings, the speed of the low ratio turbines will become less than the speed of the low ratio impellers and the friction between each low ratio coupling valve and turbine will then cause the valve to turn on the shaft of the pinion in a direction opposite to that of coupling rotation. When the valves turn, their oil holes will line up with the oil holes in the shafts of the pinions and oil will again enter the low ratio couplings.

IMPELLER AND SHAFT ASSEMBLY - The supercharger impeller drive gear which is splined onto the front end of the impeller shaft and secured by a spanner nut, meshes with the four hydraulic coupling gears. The impeller shaft is internally supported on its two steel backed bronze bearings by the accessory drive shaft.

The impeller drive gear front and rear spacers and the impeller shaft front ring carrier are splined onto the impeller shaft between the drive and the impeller. The impeller shaft thrust plate, with leaded silver bearing surfaces on its front and rear faces, transmits impeller shaft thrust to the supercharger case. The supercharger case liner, the thrust plate, and the dual thrust plate oil baffle are secured by screws to the inserts in the hub of the supercharger case.

The oil seal rings in the grooves of the impeller shaft front ring carrier bear against the liner in the bore of the supercharger case. The space between the front two and rear three rings in the carrier is vented by two elbow breathers in the web of the supercharger case just above the liner flange to prevent excess seepage of oil into the induction system.

The impeller is splined onto the impeller shaft between the front ring carrier and the impeller retainers, two ring segments which fit into a groove in the impeller shaft. The inducer, which functions as a supplementary impeller, has integral vanes enclosed in an integral hoop. It is splined onto the impeller shaft behind the impeller so that its vanes blend with those of the impeller. The impeller and inducer are shrunk onto the impeller shaft to form a semipermanent dynamically balanced assembly.

The fuel slinger is splined onto the impeller shaft and seats against the rear end of the inducer. Fuel is transmitted from the slinger to the impeller vanes by drilled passages in the inducer and the impeller which connect with the holes in the front face of the slinger.

DIFFUSER - The 28 equally spaced vanes projecting from the front face of the diffuser are so arranged that the 14 thicker vanes alternate with the 14 thinner vanes. The holes in the thicker vanes provide for the screw attachment of the diffuser to the web of the supercharger case. The studs in the supercharger case for securing the accessory drive case pass through holes in the flange of the diffuser. The diffuser directs the fuel air mixture from the impeller to the annulus in the rim of the supercharger case which is provided with seven outlet ports.

INTAKE MANIFOLDS - Attached to each of the seven supercharger case outlet ports is a sectional intake manifold which carries the fuel and air mixture to a bank of four cylinders. Each of the four pipe sections of each manifold is coupled to its adjacent section by a clamped hose and is secured by an integral flanged outlet to the inlet port of the cylinder which it serves.

The three bottom manifolds serve the No. 3, No. 4, and No. 5 cylinder banks and are provided with automatic drain valves for discharging any excess fuel or oil which may accumulate while the engine is idle or being started. The number and location of the valves on each of these manifolds may vary with installational requirements.

PRIMING SYSTEM - A primer line is clamped to each of the top three intake manifolds, which serve the cylinders in the No. 7, No. 1, and No. 2 banks. The cone ends of the primer line tubings are connected to jet tees and elbows screwed into the intake manifold bosses adjacent to the inlet ports of the cylinders. The rear ends of the three primer lines are connected by union nipples to the distributor outlets. The distributor is attached to the rear section of the No. 1 intake manifold and has eight outlets, the unused ones being plugged. The distributor inlet port is connected to the primer line from the electric primer on the carburetor.

ACCESSORY DRIVE CASE SECTION

ACCESSORY DRIVE CASE - The accessory drive case, which is attached to the studs in the rear face of the supercharger case, supports the main sump assembly, the rear oil pump, the rear accessories, and the rear accessory drives. The supercharger intake insert is secured by screws to the front face of the case in the air intake duct. A cover is attached to the rear of the accessory drive case by studs and bolts.

An oil pressurereducing valve in the bottom of the case reduces the pressure of the accessory drive lubricating oil, which is directed to the various accessory drives by the oil distributor secured in the rear face of the case.

The accessory drive case is vented by a large external breather attached to the top of the case in front of the carburetor mounting flange. The flange for mounting an injection type, down draft carburetor is located around the outer end of the intake duct, which carries air to the inducer and impeller via the supercharger intake insert.'

SUPERCHARGER INTAKE INSERT - The supercharger intake insert is installed in the accessory drive case so that a machined passage in the case joins a similar passage in the insert to form the recess which houses the fuel feed valve.

Fuel is conducted into the fuel feed valve housing through a passage in the accessory drive case which connects with the external fuel feed pipe from the carburetor. While the pressure of the fuel exerted outwardly against the valve diaphragm is less than approximately 4 pounds per square inch, which is the pressure exerted by the valve spring inwardly against the diaphragm, the valve remains seated against the discharge end of the valve housing, thereby shutting off the fuel flow. When the fuel pressure exceeds 4 pounds per square inch, the diaphragm lifts the valve off its seat and fuel flows to the fuel slinger through small holes in the front face of the supercharger intake insert liner.

The liner in the bore of the supercharger intake insert provides a seating surface for the rings on the impeller shaft rear ring carrier. The space between the front three and rear two rings is vented by a drilled passage and a breather, which is screwed into the rear of the web of the accessory drive case, to prevent excessive oil seepage into the induction system.

MAIN SUMP ASSEMBLY - The main sump, which collects drain oil from the rear crankcase, the supercharger case, and the accessory drive case sections, is mounted on a pad at the bottom of the accessory drive case and houses an oil strainer, an oil screen assembly, and the supercharger fuel drain valve.

The oil screen assembly consists of two concentric, cylindrical oil screens which are installed in the center chamber of the sump. This chamber is continuous with a cavity in the sump mounting pad into which the oil return check valve is screwed. The oil screens are retained within the sump by a cover and oil drain plug assembly which is attached to the outer end of the screen chamber.

SUPERCHARGER FUEL DRAIN VALVE - The supercharger fuel drain valve is contained within, but is functionally independent of, the main sump. This valve drains excess fuel which may accumulate in the intake duct and diffuser when the engine is being started. The valve closes automatically after the engine starts.

ACCESSORY DRIVE SHAFT AND GEAR - The front end of the accessory drive shaft is supported by an splined into the accessory drive shaft coupling, and the grooved bearing journal at the rear end of the shaft is supported by the steel backed bronze bearing in the bore of the accessory drive case.

The rear accessory drive gear, which is splined onto the accessory drive shaft, drives the fuel pump intermediate drive, the vacuum pump intermediate drive, the bottom generator drive, the rear oil pump intermediate drive, the side generator drive, and the magneto pump intermediate drive.

FUEL PUMP AND MAGNETO PUMP INTERMEDIATE DRIVES - The fuel pump and magneto pump intermediate drives are supported in brackets secured to studs in the upper right and left sides, respectively, of the accessory drive case web. The inner gears, which are splined onto the shafts of the outer gears, are driven by the rear accessory drive gear; and the right and left outer gears drive the fuel pump drive gear and the magneto pump drive gear, respectively.

FUEL PUMP AND MAGNETO PUMP DRIVE GEARS - The fuel pump and magneto pump drive gears are splined to the inner ends of the fuel pump and magneto pump drive shafts, which are located just above the corresponding intermediate drives in the accessory drive case. The drive shafts are supported at their outer and inner ends by bronze bearings. Each shaft has an integral spiral gear which drives a tachometer drive shaft. The internal splines in the outer ends of the drive shafts drive the fuel pump and the magneto pressurizing pump.

TACHOMETER DRIVE GEARS - The two tachometer drive gears, one in the left and one in the right side of the accessory drive case, are driven by the spiral gears of the fuel pump and magneto pump drive shafts. Each tachometer drive gear is enclosed in a housing which is pinned in the accessory drive case. The housing, which has a cut-out to permit engagement of the spiral gear, retains a pool of oil for improved spiral gear lubrication. Square holes are provided in the ends of the gears for the square shafts of electric tachometers. Mounting pad and drive shaft adapters are also provided to accommodate flexible shaft connections for mechanical tachometers.

STARTER GEAR - The starter gear meshes with the rear accessory drive gear and is splined onto the shaft of the starter jaw. The three tooth starter jaw, which provides for starter engagement, is held in a housing secured in the right side of the accessory drive case by nuts.

VACUUM PUMP INTERMEDIATE DRIVE GEAR - The vacuum pump intermediate drive gear is held in a housing secured in the lower right side of the accessory drive case by nuts. The bevel gear at the inner end of the shaft is driven by the rear accessory drive gear, and the spur gear at the outer end of the shaft drives the vacuum pump drive bell gear.

VACUUM PUMP DRIVES - The vacuum pump drives are contained in the vacuum pump three way adapter, which is mounted on the lower right side of the accessory drive case. The inner end of the vacuum pump drive bell gear is supported by two bronze bearings in a bearing support attached to the inner face of the three way adapter, and the outer end of the gear is splined into the center vacuum pump drive gear. The vacuum pump drive bell gear drives the center vacuum pump drive gear, which is supported by a bronze bearing in a housing held in the three way adapter by four screws. The center vacuum pump drive gear drives the two side vacuum pump drive gears, each of which is supported by a bronze bearing in the three way adapter.

GENERATOR DRIVE GEARS - The bottom generator drive gear is held in a bronze bearing in a housing secured in the bottom of the accessory drive case by nuts, and the side generator drive gear is held in a housing secured in the left side of the accessory drive case by nuts. The gears are driven by the rear accessory drive gear, and the internal splines in the outer end of each gear may be used to drive a generator.

REAR OIL PUMP INTERMEDIATE DRIVE GEAR - The rear oil pump intermediate drive gear is held in a housing secured in the lower left side of the accessory drive case by nuts. The bevel gear at the inner end of the shaft is driven by the accessory drive gear, and the spur gear at the outer end of the shaft drives the rear oil pump drive gears.

REAR OIL PUMP - The rear oil pump, having a single chamber pressure section and a two chamber scavenge section, is mounted on the lower left side of the accessory drive case. A pressure relief valve and an oil screen by-pass valve are screwed into the pump body. The pump has square mounting pads for the oil inlet and outlet connections, a pad above the outlet for the connection of the oil line from the supercharger case, and a fitting for the connection of the oil line from the rear rocker sump.

The two oil pump drive gears outside the pump body, which are driven by the spur gear at the outer end of the rear oil pump intermediate drive gear, are splined onto the pressure section and scavenge section drive shafts. The gears integral with these shafts mesh with the corresponding pressure and scavenge idler gears. These idler gears are mounted on the bronze idler shafts, each of which is pinned to its section of the pump body. The larger scavenge gears scavenge the main sump and are housed within the scavenge section body, which separates the scavenge section of the pump into two chambers. The smaller of the two chambers, located between the scavenge section body and the pump body, houses the smaller scavenge gears which scavenge the rear rocker sump. One of the smaller scavenge gears is keyed to the outer end of the scavenge section drive shaft and meshes with the idler gear which is mounted on the outer end of the scavenge section idler shaft. The inner ends of all the pump shafts are supported by the rear oil pump body cover.

IGNITION

MAGNETO UNITS - The radio shielded ignition system consists of seven separate Scintilla D4RN-2 magneto units, one complete magneto unit for the four cylinders in each of the seven banks. Each magneto unit consists of a magneto to which is attached a spark plug cable and distributor block assembly. Each cable assembly directs the high tension impulses generated by its magneto to the eight spark plugs in the bank of four cylinders just behind the magneto.

MAGNETOS - Each of the seven magnetos is flange mounted on one of the pads radiating from the magneto drive case and is of the four pole rotating magnet type. Each magneto has a compensated cam with two tracks of four lobes each, two sets of breaker points, and a distributor rotor with four jump gap pickup electrodes and two distributing electrodes. With the exception of the cams, which are timed to the front cylinders of the corresponding banks, all seven magneto units are identical and interchangeable. A coupling on the engine end of each magneto shaft is splined into the outer end of the corresponding magneto drive shaft in the magneto drive case. A ratchet ring between the coupling and the magneto shaft provides a vernier adjustment of the shaft provides a vernier adjustment of the shaft when timing the magneto to the engine.

SPARK PLUG CABLE ASSEMBLY - The distributor block end of each of the seven high tension cable assemblies is attached to the side of the magneto which opens into the distributor rotor compartment. Each distributor block carries eight electrodes, a pair of electrodes for the two spark plugs in each of the four cylinders fired by the magneto to which the spark plug cable assembly is attached. The cables from the electrodes to the spark plugs are housed in a metallic conduit filled with moistureproof sealing compound.

BOOSTER AND GROUND WIRE MANIFOLD - The ground wire manifold is the only common connection between the seven magneto units. The ground wires run from the magneto ground wire connectors to a circular conduit attached to the front end of the crankcase. A trunk line conduit, which extends longitudinally to the rear of the engine between the No. 2 and No. 3 cylinder banks, carries the 14 ground wires from the circular conduit to a special plug at the fire wall end of the manifold. By means of a selector type magneto switch in the instrument panel, the pilot can selectively check either the right or left spark plugs fired by any one of the seven magnetos. Three booster coils, connected to the ground wires from No. 7, No. 1, and No. 2 magnetos, increase the high tension voltage for starting the engine at speeds below the coming in speed of the magnetos. The spark plugs affected by the booster may be either all in the right or all in the left sides of their cylinders, depending upon installation requirements.

PRESSURIZING - The magnetos are pressurized to prevent the flash-over which tends to occur in unpressurized ignition systems operating in the rarefied atmosphere of high altitudes. The rotary vane type pump that pressurizes the magnetos is mounted on the upper left side of the accessory drive case and is driven by the magneto pump drive shaft. Air is drawn into the pump through a screened intake, pressurized by the rotor vanes, and forced into a tubing assembly which joins the pump outlet to a connection at the rear end of the ground wire manifold. The airtight conduits of the ground wire manifold carry the pressurized air into the magnetos through holes in the ground wire connectors. By permitting a predetermined amount of air leakage, the altitude valve in each magneto housing maintains a delicate balance between the air pressure for flash-over prevention and the air flow for magneto ventilation.

DESCRIPTION OF SPECIFIC ENGINE TYPES USED IN
VOUGHT F4U "CORSAIR" TYPE AIRCRAFT

neral Notes:

1. "W" (as in -8W) indicates a water injection equipped engine.

2. Ratings: Explanation of the ratings is as follows:-

<u>2000/2700/1500</u>

2000 brake horsepower (engines power delivered to the propeller shaft)
2700 revolutions/minute (engine speed at that power)
1500 feet in altitude (critical altitude or maximum altitude to which this power may be maintained)

<u>2100/2800/28.5</u>

2100 BHP
2800 RPM
28.5 inches of mercury absolute static pressure at the carburetor inlet (corresponds to critical altitude for turbo supercharged engines)

3. WEP War Emergency Power (usually by aid of water injection)

ENGINE MODEL	TYPE	R-2800	R-2800
	Military	X-2	X-4
	P&WA	A2-G	SSA5-G
	Basic Series	A	A
AIRCRAFT	Type	XF4U-1	XF4U-1
RATINGS	Take-off Military	1800/2600	1850/2600 (Main)
	Normal	1500/2400/17500	1600/2400/3500 (Main) 1540/2400/13500 (Low) 1460/2400/21500 (High)
FUEL	Grade	100	100
OIL	Grade	1100 or 1120	1100 or 1200
WEIGHT DRY	Pounds	2429	2500
PROP. SHAFT	Gear Ratio	2:1	2:1
	Spline SAE	50	50
CYLINDERS	Comp. Ratio	6.65:1	6.66:1
	Bore (ins.)	5.75	5.75
	Stroke (ins.)	6.00	6.00
	Volume (cu. in.)	2804	2804
SUPERCHARGER	Type	Two Stage - Two Speed	Two Stage - Two Speed
	Impeller Ratio	6.8:1 (main, 6.46:1 (Low), 8.64:1 (High)	7.80:1 (Main), 6.46:1 (Low), 8.64:1 (High)
ENGINE POWER CONTROL OR REGULATOR		Eclipse 581-3A	Eclipse 581-3A

RBURETOR	Model	Stromberg PT13D2-101	Stromberg PT13D2-5
	Type	Pressure Injection	Pressure Injection
	Airflow	Up-draft	Up-draft
MAGNETOS	Model	Scintilla DF18RN	Scintilla DF18RN
	Type	Ventilated High Tension	Ventilated High Tension
DIMENSIONS	Diameter (in.)	52.00	52.00
	Length (in.)	85.80	88.81
NOTES		1) Three engines were built but subsequent development indicated means of increasing the horsepower by providing a new supercharger housing. Since Vought had already completed their engine installation design and parts, they desired to flight test the aircraft with the X-2 engine while the X-4 engines were being constructed and a new engine installation developed. One X-2 Serial No. 3 was installed in the XF4U-1 and first flight was reported to have occurred on June 13, 1940. The flight was cut short after 22 minutes because of a malfunctioning magneto condensor. On July 11, 1940 the XF4U-1 is reported to have crashed. Engine #3 was removed and returned to P&WA where it was converted to an X-4 engine. Meanwhile the XF4U-1 was repaired. 2) Engine #3 included a two-piston type test torquemeter and P&WA supplied intercoolers. 3) Engine weight included front extension exhaust pipes, expansion joints and clamps but did not include intercoolers and supercharger regulator. 4) Design work on X-2 and XF4U-1 was begun early in 1938.	1) Two of the three X-2 engines were converted to X-4 engines prior to delivery. Conversion consisted of adding a new supercharger housing incorporating larger passages which allowed an increase of power ratings. New housings increased length of engine 3 inches. 2) Torquemeter on #3 X-2 engine was installed on X-4 Serial No. 4 which was installed in the repaired and revised XF4U-1. Meanwhile X-2 Serial No. 3 was converted to X-4 configuration and eventually replaced No. 4 engine in the XF4U-1. X-4 Serial No. 5 was delivered to Navy for a type test engine. 3) Engine weight did not include front exhaust pipes, expansion joints and clamps. 4) Policy of supplying intercoolers was eliminated by Navy agreement and responsibility for selection and procurement was shifted to aircraft manufacturer.

ENGINE MODEL	TYPE	R-2800	R-2800
	Military	-8, -8W	-14W
	P&WA	SSB2-G	TSC2-G
	Basic Series	B	C
AIRCRAFT	Type	(-8) F4U-1, F4U-1D, F4U-2, FG-1, FG-1A, FG-1D, F3A-1, (-8W) F4U-1, F4U-1C, F4U-1D, F4U-1P, FG-1A, FG-1D, FG-1K	XF4U-3, F4U-3, FG-3
RATINGS	Take-off	2000/2700 (Main)	2100/2800/SL
	Military	2000/2700/1000 (Main) 1800/2700/15500 (Low) 1650/2700/22500 (High)	2100/2800/28.5
	Normal	1675/2550/5500 (Main) 1625/2550/17000 (Low) 1550/2550/21500 (High)	1700/2600/26.0
FUEL	Grade	100	100/130
OIL	Grade	1100 or 1120	1100 or 1120
WEIGHT DRY	Pounds	2480	2315
PROP. SHAFT	Gear Ratio	2:1	.450:1
	Spline SAE	50	60-A
CYLINDERS	Comp. Ratio	6.65:1	6.75:1
	Bore (in.)	5.75	5.75
	Stroke (in.)	6.00	6.00
	Volume (cu. in.)	2804	2804
SUPERCHARGER	Type	Two Stage - Two Speed	Single Stage - Single Speed for Turbo
	Impeller Ratio	7.8:1 (Main) 6.46:1 (Low) 7.93:1 (High)	7.29:1
ENGINE POWER CONTROL OR REGULATOR		Eclipse 581-5A, -9A	Supplied by Aircraft Manufacturer
CARBURETOR	Model	(-8) Stromberg PT13D4-6 (-8W) Stromberg PT13D6-6	Stromberg PR58E2-2
	Type	Pressure Injection	Pressure Injection
	Airflow	Up-draft	Down-draft
MAGNETOS	Model	Scintilla DF18RN Bosch DF18RU	Scintilla DF18LN
	Type	Pressurized High Tension	Pressurized High Tension
DIMENSIONS	Diameter (in.)	52.44	52.80
	Length (in.)	88.24	78.22
NOTES		1) -8 engines were readily convertible to -8W engines by minor modification to carburetor plus addition of water regulator and piping. In service use airplanes and engines were converted back and forth for water injection as tactical requirements dictated.	1) Built by P&WA of Missouri at Kansas City. 2) These aircraft used a TT13-18 turbosupercharger manufactured by Turbo Engineering Corp., Trenton, N.J. controlled by an Eclipse 827-6 regulator and an Eclipse 1462-2A WEP reset control.

2) PT13D6-6 carburetor differed from PT13D4-6 carburetor by incorporating a derichment valve and different jets for water injection.
3) Both engine models were built under license by Nash-Kelvinator Corp.
4) Early -8 engines had unpressurized, ventilated tubular ignition system (as shown in photo D-8190) while later -8 engines had pressurized cast manifold and air pumps (as shown in photo D-7116).

3) Production aircraft were all FG-3, converted from FG-1 by NAMU, Johnsonville, Pa. It is reported that 13 aircraft were converted using -14W engines and P-47N exhaust stacks.

ENGINE MODEL	Type	R-2800	R-2800
	Military	X-16	-18W
	P&WA	TSB1-G	SSC22-G
	Basic Series	B	C
AIRCRAFT	Type	XF4U-3	F4U-4, F4U-4E, F4U-4N, F4U-4P, F4U-4K, XF4U-4, XF4U-4B, F4U-7, FG-4
RATINGS	Take-off	2000/2700	2100/2800 (Main)
	Military	2000/2700/1500 2000/2700/25000 with turbo	2100/2800/1000 (Main) 1900/2800/14000 (Low) 1800/2800/23000 (High)
	Normal	1625/2700/6500 1625/2700/25000 with turbo	1700/2600/7000 (Main) 1630/2600/18000 (Low) 1550/2600/26000 (High)
FUEL	Grade	125	100/130
OIL	Grade	1100 or 1120	1100 or 1120
WEIGHT DRY	Pounds	2265	2560
PROP. SHAFT	Gear Ratio	2:1	.450:1
	Spline SAE	50	60-A
CYLINDERS	Comp. Ratio	6.65:1	6.75:1
	Bore (in.)	5.75	5.75
	Stroke (in.)	6.00	6.00
	Volume (cu. in.)	2804	2804
SUPERCHARGER	Type	Single Stage - Single Speed For Turbo	Two Stage - Two Speed
	Impeller Ratio	7.60:1	7.50:1 (Main), 6.30:1 (Low) 7.80:1 (High)
ENGINE POWER CONTROL OR REGULATOR		Supplied by Aircraft Manufacturer	Eclipse 581-20C
CARBURETOR	Model	Stromberg PT13G1-9	Stromberg PR58E2-3
	Type	Pressure Injection	Pressure Injection
	Airflow	Down-draft	Down-draft
MAGNETOS	Model	Scintilla DF18RN	Bosch DF18LU
	Type	Unpressurized High Tension	Pressurized High Tension
DIMENSIONS	Diameter (in.)	52.50	52.80
	Length (in.)	75.72	93.84

NOTES

1) Replaced by -14W in F4U-3.
2) These aircraft used a TT13-18 turbosupercharger manufactured by Turbo Engineering Corp., Trenton, N.J. controlled by an Eclipse 827-6 regulator and an Eclipse 1462-2A WEP reset control.
3) Production aircraft were all FG-3, converted from FG-1 by NAMU, Johnsville, Pa. It is reported that 13 aircraft were converted using -14W engines and P-47N exhaust stacks.

GINE MODEL	Type		
	Military	Y-32W Semi-production	-32W Production
	P&WA	VSSE21-G	E-22
	Basic Series	E	E
AIRCRAFT	Type	XF4U-5, F4U-5	F4U-5, F4U-5N, F4U-5P
RATINGS	Take-off	2300/2800 (Main)	2300/2800/SL (Main)
	Military	2300/2800 (Main)	2300/2800/SL (Main)
		1800/2800/30000 (Dual)	1800/2800/30000 (Dual)
	Normal	1900/2600 (Main)	1900/2600/S.L. (Main)
		1500/2600/30000 (Dual)	1500/2600/30000 (Dual)
FUEL	Grade	115/145	115/145
OIL	Grade	1100	1100
WEIGHT DRY	Pounds	2715	2705
PROP. SHAFT	Gear Ratio	.450:1	.450:1
	Spline SAE	60-A	60-A
CYLINDERS	Comp. Ratio	6.75:1	6.75:1
	Bore (in.)	5.75	5.75
	Stroke (in.)	6.00	6.00
	Volume (cu. in.)	2804	2804
SUPERCHARGER	Type	Two Stage - Dual Auxiliary Impellers - Variable Speed	Two Stage - Dual Auxiliar Impellers - Variable Spee
	Impeller Ratio	6.70:1 (Main), up to 9.65:1 Dual-Variable	6.70:1 (Main) to 9.65:1 Dual-Variable up
GINE POWER CON-ROL OR REGULATOR		Bendix CO-3F	Bendix CO-3F
CARBURETOR	Model	Ceco 64-CPC8-2	Stromberg PR64B2-2
	Type	Hydro-metering	Pressure Injection
	Airflow	Up-draft	Up-draft
MAGNETOS	Model	Scintilla DF-18LN	Scintilla DF-18LN
	Type	Pressurized High Tension	Pressurized High Tension
DIMENSIONS	Diameter (in.)	52.80	52.80
	Length (in.)	98.40	98.40

GINE MODEL	Type	R-2800	R-2800
	Military	-42W	-83WA
	P&WA	CE21	2SC14-G
	Basic Series	CE	C
AIRCRAFT	Type	F4U-4B	AU-1 (F4U-6)
RATINGS	Take-off	2300/2800 (Main)	2100/2800 (Low)
	Military	2300/2800/1000 (Main) 2000/2800/17500 (Low) 1850/2800/24000 (High)	2100/2800/3000 (Low) 1700/2800/16000 (High)
	Normal	1800/2600/5500 (Main) 1700/2600/19000 (Low) 1600/2600/25500 (High)	1700/2600/7300 (Low) 1500/2600/17500 (High)
FUEL	Grade	115/145	115/145
OIL	Grade	1100	1100 or 1120
WEIGHT DRY	Pounds	2543	2385
PROP. SHAFT	Gear Ratio	.450:1	.450:1
	Spline SAE	60-A	60-A
CYLINDERS	Comp. Ratio	6.75:1	6.75:1
	Bore (in.)	5.75	5.75
	Stroke (in.)	6.00	6.00
	Volume (cu. in.)	2804	2804
SUPERCHARGER	Type	Two Stage - Two Speed	Single Stage - Two Speed
	Impeller Ratio	7.5:1 (Main), 6.3:1 (Low), 7.8:1 (High)	7.29:1 (Low), 9.45:1 (High
NGINE POWER CON- ROL OR REGULATOR		Eclipse 581-20C - 581-22C	Eclipse 1483-13B
ARBURETOR	Model	Stromberg PR-58E5-5	Stromberg PR-58E2-3
	Type	Pressure Injection	Pressure Injection
	Airflow	Down-draft	Down-draft
MAGNETOS	Model	Bosch, DF-18LU-4	Scintilla DF18LN
	Type	Pressurized High Tension	Pressurized High Tension
DIMENSIONS	Diameter (in.)	52.80	52.80
	Length (in.)	94.00	78.4
NOTES			1) These engines were purchased by the Navy from Capital Airlines who had converted them from -83 to -83A by adding a Scintilla ignition system. Navy gave them a top overhaul and added water injection and a power control and redesignated to -83WA. 2) Built under license by Chevrolet for the Air Forc 3) F4U-6 was redesignated AU-1. It is reported that as many F4U-5 aircraft parts were used as possibl in this aircraft.

ENGINE MODEL	TYPE	R-4360	R-4360
	Military	None	-2
	P&WA	TSB1-G	VSB11-G
	Basic Series	B	B
AIRCRAFT	Type	F4U-1-M P&WA Test	XF2G-1, F2G-1, F2G-2
RATINGS	Take-off	3000/2700	3000/2700
	Military	3000/2700/1500	3000/2700/1500 2400/2700/13500
	Normal	2500/2550/6500	2500/2550/5000 2200/2550/14500
FUEL	Grade	100/130	100/130
OIL	Grade		1100 or 1120
WEIGHT DRY	Pounds	3325	3325
PROP. SHAFT	Gear Ratio	.381:1	.425:1
	Spline SAE	60-A	60-A
CYLINDERS	Comp. Ratio	7.00:1	7.00:1
	Bore (in.)	5.75	5.75
	Stroke (in.)	6.00	6.00
	Volume (cu. in.)	4363	4363
SUPERCHARGER	Type	Single Stage - Single Speed	Single Stage - Variable Speed
	Impeller Ratio	6.08:1	6.08:1 (low min.) 7.52:1 (high max.)
NGINE POWER CON-ROL OR REGULATOR		None	Eclipse 1359-4B
ARBURETOR	Model	Stromberg PR-100A3-1	Stromberg PR100B2-3
	Type	Pressure Injection	Pressure Injection
	Airflow	Down-draft	Down-draft
MAGNETOS	Model	Scintilla D4RN-1	Scintilla DF-4RN-2
	Type	Pressurized High Tension	Pressurized High Tension
DIMENSIONS	Diameter (in.)	53.50	52.50
	Length (in.)	96.75	96.50
NOTES		1) This was an experimental engine installed in a specially modified F4U-1 at P&WA's test facility. 2) The F4U-1-M (Bu #02460) served as a "flying test bed" for the Wasp Major engine and a demonstration airplane for the successful use of Wasp Majors in fighter type aircraft. After serving its purpose and completing extensive test work the airplane was converted back to its R-2800-8 installation and returned to the Navy. 3) The F4U-1-M served as the inspiration for the placement of a Navy contract with Goodyear Acft. for the development of a similar fighter to be known as the F2G.	1) -2 and -2A engines were the YR-4360-4 engines redesignated to eliminate confusion between YR-4 and -4 engines. After completion of the F2G contract these engines were used during Navy evaluation tests of the E2G so as to release -4 engines for other aircraft projects.

NGINE MODEL	Type		
	Military	-2A	X-4 (semi-production)
	P&WA	VSB11-G	VSB11-G
	Basic Series	B	B
AIRCRAFT	Type	XF2G-1, F2G-1, F2G-2	XF2G-1
RATINGS	Take-off	3000/2700	3000/2700
	Military	3000/2700/1500 2400/2700/13500	3000/2700/1500 2400/2700/13500
	Normal	2500/2550/5000 2200/2550/14500	2500/2550/5000 2200/2550/14500
FUEL	Grade	100/130	100/130
OIL	Grade	1100 or 1120	1100 or 1120
WEIGHT DRY	Pounds	3325	3325
PROP. SHAFT	Gear Ratio	.425:1	.425:1
	Spline SAE	60-A	60-A
CYLINDERS	Comp. Ratio	7.00:1	7.00:1
	Bore (in.)	5.75	5.75
	Stroke (in.)	6.00	6.00
	Volume (cu. in.)	4363	4363
SUPERCHARGER	Type	Single Stage - Variable Speed	Single Stage - Variable Speed
	Impeller Ratio	6.08:1 (low min.) 7.52:1 (high max.)	6.08:1 (low min.) 7.52:1 (high max.)
NGINE POWER CON- ROL OR REGULATOR	Eclipse	Eclipse 1359-4B	P&WA Mechanical Control
CARBURETOR	Model	Ceco 100PB7-1	Stromberg PR-100A3-1
	Type	Hydro-metering	Pressure Injection
	Airflow	Down-draft	Down-draft
MAGNETOS	Model	Scintilla DF-4RN-2	Scintilla DF-4RN-1
	Type	Pressurized High Tension	Pressurized High Tension
DIMENSIONS	Diameter (in.)	52.50	52.50
	Length (in.)	96.05	96.50
NOTES		1) -2 and -2A engines were the YR-4360-4 engines redesignated to eliminate confusion between YR-4 and -4 engines. After completion of the F2G contract these engines were used during Navy evaluation tests of the F2G so as to release -4 engines for other aircraft projects.	1) Four X-4 engines were assigned to the F2G project and were used in the first four XF2G-1 aircraft. Extensive installation differences existed between these engines and the production engines. During the development of the F2G these four engines were extensively modified to improve engine performance and reliability, though they never equaled the production -4 configuration.

NGINE MODEL	TYPE	
	Military	-4 (production)
	P&WA	VSB11-G
	Basic Series	B
AIRCRAFT	Type	XF2G-1, XF2G-2, F2G-1, F2G-2
RATINGS	Take-off	3000/2700
	Military	3000/2700/1500 2400/2700/13500
	Normal	2500/2550/5000 2200/2550/14500
FUEL	Grade	100/130
OIL	Grade	1100 or 1120
WEIGHT DRY	Pounds	3400
PROP. SHAFT	Gear Ratio	.425:1
	Spline SAE	60-A
CYLINDERS	Comp. Ratio	7.00:1
	Bore (in.)	5.75
	Stroke (in.)	6.00
	Volume (cu. in.)	4363
SUPERCHARGER	Type	Single Stage - Variable Speed
	Impeller Ratio	6.08:1 (low min.) 7.52:1 (high max.)
ENGINE POWER CON-'ROL OR REGULATOR		Eclipse 1359-4B
NOTES		1) Certain early production -4 engines were known as YR-4360-4. These engines differed from later -4 production engines by having a different rear accessory drive housing which made them noninterchangeable in the aircraft without installation modifications to the aircraft. To eliminate confusion these YR engines were redesignated -2 and -2A. 2) On some engines the variable speed supercharger drive was converted to a fixed speed drive. 3) Not all engines incorporated the automatic engine power control. Early engines incorporated mechanical power control as shown on left side of attached engine photographs and were eventually converted to automatic power controls. 4) Stromberg PR-100B1-1 carburetors were originally used and replaced by PR-100B2-3 carburetors incorporating water injection provisions. Stromberg carburetors were eventually replaced with Ceco carburetors which provided smoother engine operation. Engines retaining Stromberg carburetors were redesignated -4A.

Though large scale production of 418 F2G's was planned only 17 aircraft were produced because of continued delays resulting from development difficulties and the tactical change of the Corsair from offensive fighter to fighter-bomber during the latter part of the war. Fighter-bomber work did not require the high performance of the F2G and the need for aircraft was great. Consequently the FG-4 (F4U-4) was put into production and the F2G cut back to a pilot production line for future procurement. Termination of World War II ended further consideration of the aircraft. Seven XF2G-1 aircraft were hand built, of which the first two were modified FG-1 aircraft to incorporate Wasp Major engines similar to P&WA's F4U-1M. Of the 10 production aircraft, 5 were F2G-1's for Marine service with manual folding wings and certain aircraft carrier equipment removed while 5 were F2G-2 with hydraulically folded wings and all carrier equipment included for Navy service. Certain test aircraft had water injection installed. All aircraft had water tank and plumbing installed. Cook Cleland purchased surplus F2G-1 (Bu #88456) and one F2G-2 (Bu #88463) and modified them into racers and eventually won the Thompson Trophy Race at the National Air Races in 1949 at an average speed of 397 miles per hour in one of them. Cleland is reported to have used special grade 145/175 gasoline and to have obtained powers of 3800 BHP without water injection and 4000 BHP with water injection. These racers are reported to have had the military equipment removed, wing flaps locked and taped over, special P&W designed airscoop and the aircraft surfaces smoothed.

LIST OF ILLUSTRATIONS

R-4360

LIST OF ILLUSTRATIONS

R-2800, E Series

LIST OF ILLUSTRATIONS

R-2800, C Series

LIST OF ILLUSTRATIONS

R-2800, A and B Series

LIST OF ILLUSTRATIONS

R-2800, C Series

INSTALLATION DRAWINGS

*R-44839	R-2800-4
*R-50425	R-2800-8, -8W
*R-87101	R-2800-14W
*R-78401	R-2800-18W
R-98501	R-2800-32W
R-107101	R-2800-42W
***R-93101	R-2800-83, -85
*R-86301	R-4360-4, -4A, 4W, -24
***R-270-1	R-4360 TSB1-G Installation in F4U-1-M
***R-270A-1	Three View Drawing of F4U-1-M

*Obsolete as of 8-27-53

**For -83WA magneto details see magneto details on -14W drawing R-87101.

***Installation Development Drawing

NOTE: Photographs and drawings are to be found in the files of Pratt & Whitney Aircraft.

LIST OF PHOTOGRAPHS AND DRAWINGS TO ACCOMPANY REPORT NO. PWA. INST. 434, "PRATT & WHITNEY AIRCRAFT ENGINES USED IN VOUGHT F4U CORSAIR"

PHOTOGRAPHS

R-2800-8W

D-7110	1/16 Left Rear
D-7111	Front
D-7112	Rear
D-7116	1/16 Left Front
D-7117	Left Side
D-7118	Right Side

R-2800-42W

D-11963	1/16 Right Front
D-11964	Right Side
D-11965	1/16 Right Rear
D-11966	Rear
D-11967	1/16 Left Rear
D-11968	Left Side

R-2800-14W

D-8091	1/16 Left Front
D-8095	Right Side
D-8096	Left Side

R-2800-83WA (-83)

D-11542	1/16 Left Rear
**D-11554	Left Side
D-11558	Rear

R-4360-4

D-10429	3/4 Right Front
D-10433	3/4 Left Rear
D-10435	Front
D-10436	Right Side
D-10437	Left Side

R-2800-18W

D-8662	1/16 Left Front
D-8663	Front
D-8664	Rear
D-8666	Left Side
D-8668	1/16 Right Rear
D-8671	Right Side

R-2800-32W

D-13489	1/4 Right Front
D-13490	1/4 Left Rear
D-13491	1/4 Right Rear
D-13492	Rear
D-13493	Right Side
D-13494	1/4 Left Front

R-2800-16

D-8190	3/4 Right Front
*P-3508	Left Side

R-2800-4

D-2139	Left Rear
D-2142	3/4 Right Rear

F4U-1-M

C-958
C-959
X-47
X-49

*P-3508 illustrates the -11 engine. Externally this engine is identical to the -16 engine. Also illustrated is the torque nose for measuring engine power such as was used on the -4 engine and also used for a time on the -16 engine. The bulge below the distributor accommodates one of the hydraulic pistons of the torque balancing mechanism.

**D-11554 shows -83 front section with GE magnetos. Front section of -83WA would be same shown in D-8091 for -14W engine. Power section and rear section are correct for -83WA.