HANDBOOK

OF

SERVICE AND OVERHAUL INSTRUCTIONS

FOR THE

CONSTANT SPEED PROPELLER AND CONTROLS

MANUFACTURED BY

HAMILTON STANDARD PROPELLER CO.

EAST HARTFORD, CONN.

NOTE: Reference to periodic inspections specified in Section IV, will be entered where applicable, on A.A.F. Forms 41-A.

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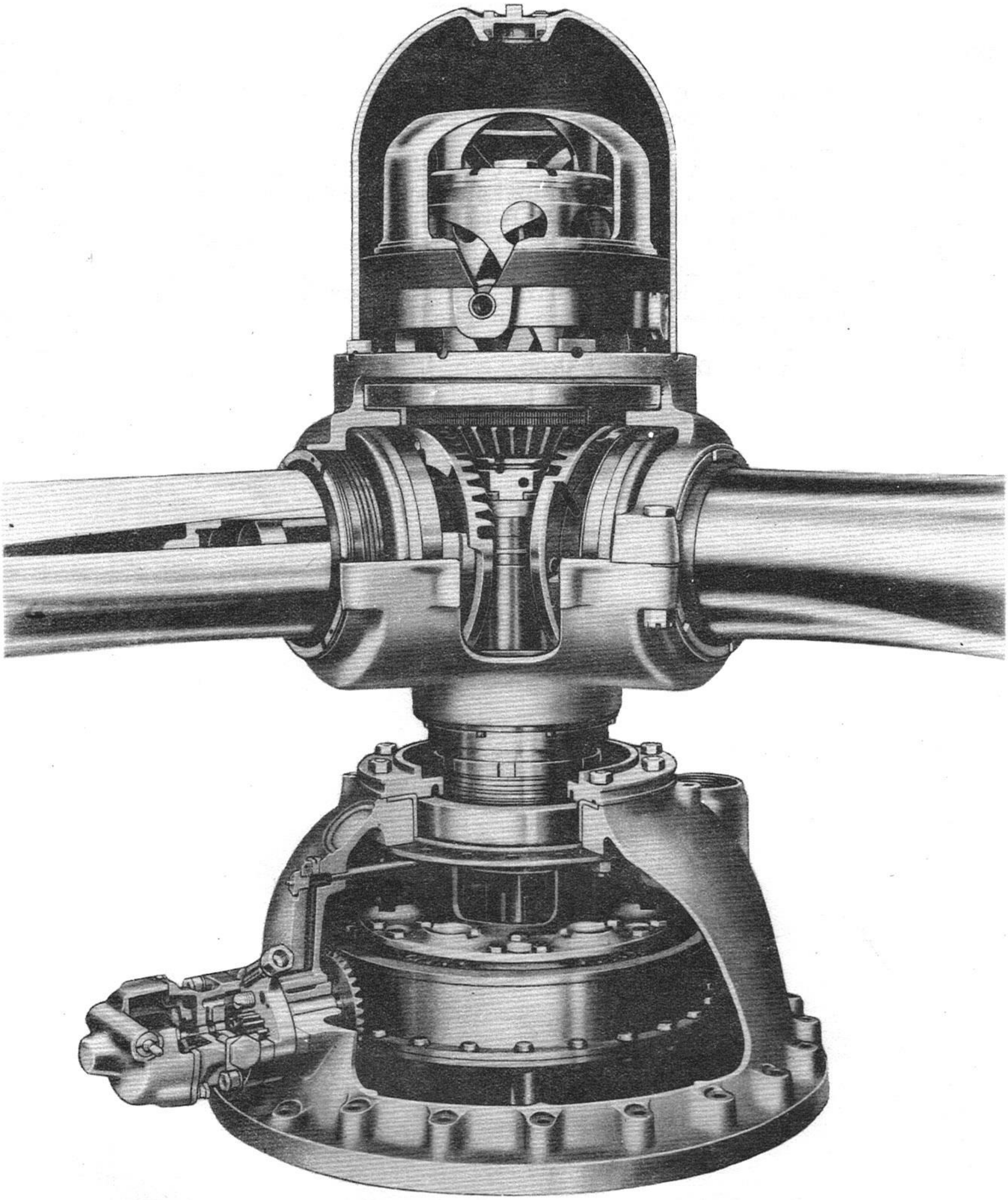

FIG. I - HYDROMATIC PROPELLER CUTAWAY

SECTION I

INTRODUCTION

1. This Handbook is the basic Technical Order for the maintenance and overhaul of the equipment involved.

2. This Handbook is intended to supply necessary information for installation, operation, maintenance, inspection and assembly of Hamilton Standard Hydromatic Full-Feathering Constant-Speed Propeller and Constant-Speed Control Units for use with the propeller.

3. Reference has been made in this Handbook to the following Technical Orders which contain applicable data and instructions:

	T. O. No.	
	00-20A	The Visual Inspection System for Airplanes.
*	03-20-5	Overhaul Period for Propellers. *
	03-20A-1	Airplane Propellers - General Instructions.
*	03-20CC-1	Operation & Flight Instructions - Hydromatic Controllable Propeller. *

NOTE: An asterisk * denotes that portion of a paragraph or page which has been revised. The asterisk will not be used when the entire page is revised.

SECTION II

GENERAL DESCRIPTION

1. Feathering.

a. Many of the principles of construction and operation of the Hydromatic Propeller are similar to those of the counterweight type constant-speed propellers. In addition, the Hydromatic Propellers incorporate the full-feathering feature which permits movement of the blades to a high angle sufficient to stop engine rotation and reduce propeller drag to a minimum.

b. Feathering is the term applied when the blades of a propeller are turned to such a high angle that they lie in the direction of flight. In this position they act as powerful brakes to stop the engine rotation and at the same time offer the least possible drag on the airplane. To return from feathering to normal operation (commonly called unfeathering) the blades are turned from the feathering position to a lower angle where the pressure of the air flow due to the forward speed of the airplane causes the propeller to windmill and crank the engine.

c. The ability to stop an engine from rotating in case of an engine failure on multi-engine airplanes is, from the safety standpoint, the greatest asset of the full-feathering propeller. In addition, flight tests with bi-motored airplanes equipped with feathering propellers have shown a definite improvement in all phases of single engine performance as well as freedom from vibration which may be due to windmilling of a damaged engine. An additional characteristic observed in single-engine flight with propeller feathered is the improved handling quality and ease of control.

d. The utility of the feathering propeller should be considered from its value as an efficient brake which permits an engine to be stopped with minimum loss of performance, and not as a device which leads to any improvement over the take-off or flight performance with the conventional constant-speed propeller. The feathering feature should be used as a safety device designed to protect the aircraft from damage due to vibration resulting from power plant failure, or to stop an engine while minor repairs are made on power plants which are accessible in flight.

2. Principle of Operation.

a. The pitch control mechanism of the Hydromatic Propeller retains the rugged hydraulic type control whereby the angle of the propeller blades is controlled by a precision type governor to obtain constant engine speed and synchronization of the propellers of a multi-engine airplane.

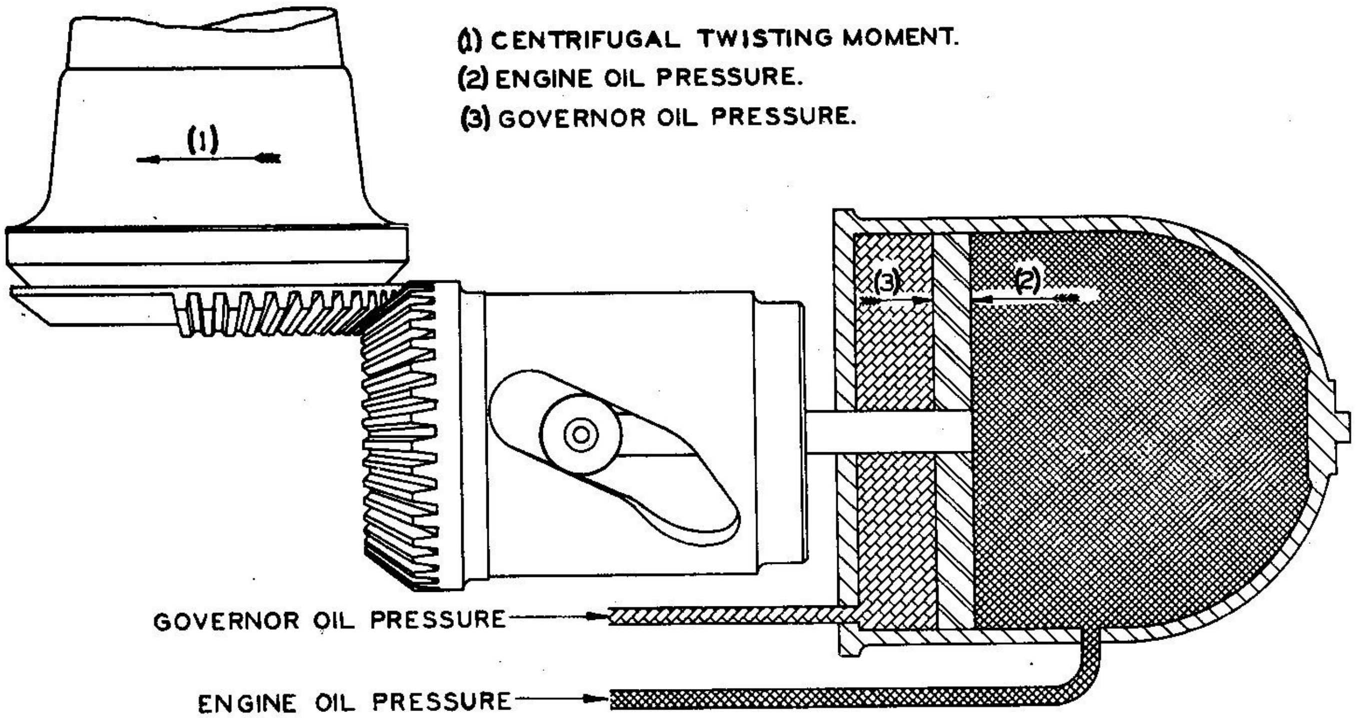

Fig. 2 - Propeller Control Forces

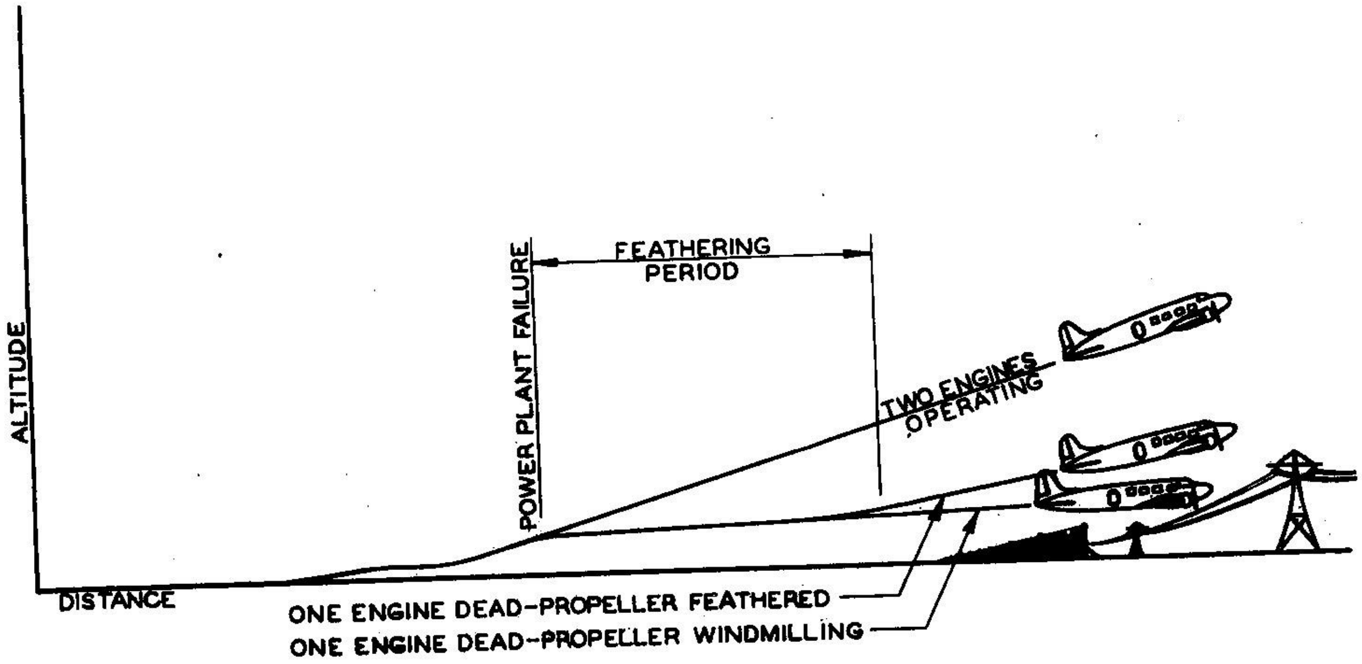

Fig. 3 - Take-Off - Propeller Feathered

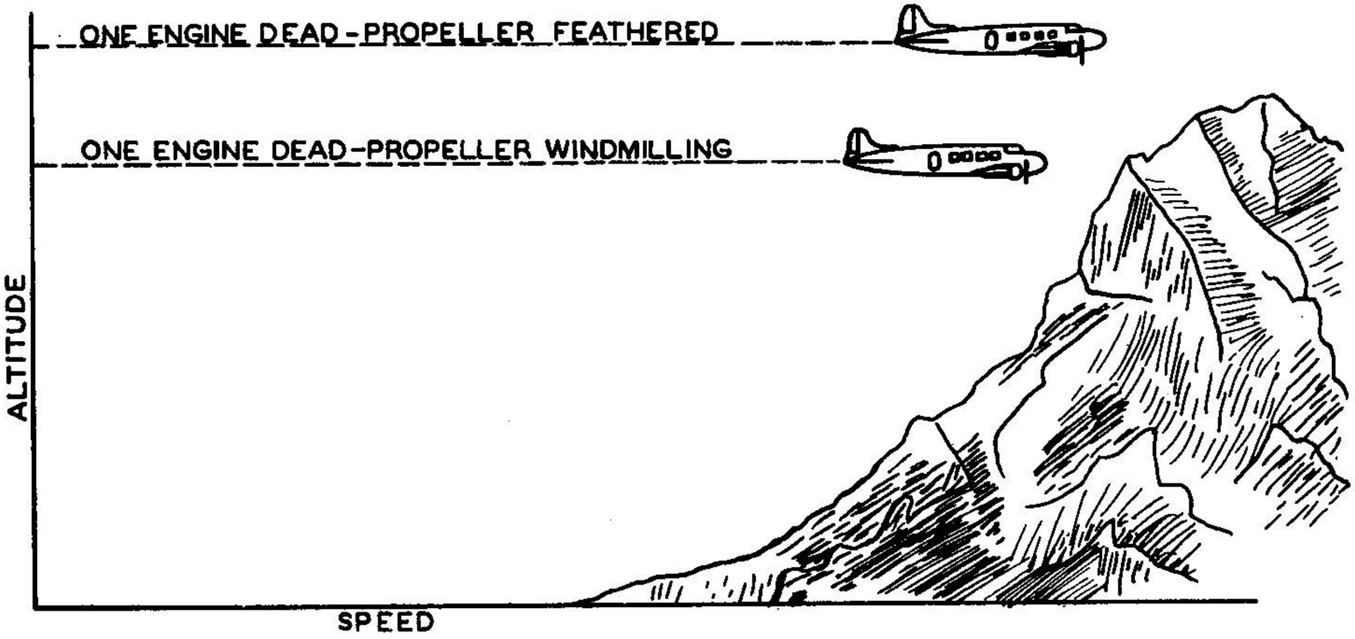

Fig. 4 - Level Flight Propeller Feathered

b. Three fundamental forces are used to control the blade angle. They are: (1) Centrifugal twisting movement of the blades toward low angle which is utilized to decrease the blade angle. (2) Engine oil under normal engine pressure which supplements the centrifugal movement, thus insuring adequate control force toward low angle at low propeller speeds. (3) Engine oil under boosted pressure from the governor which moves the blades toward high angle. These forces are indicated on the diagram of Fig. 2.

c. The necessary balance between these control forces is maintained by the propeller governor which, in addition to boosting the engine oil pressure, meters to, or drains from the propeller the quantity of oil required to maintain the proper blade angle for constant speed operation.

d. When it is desired to feather the blades an auxiliary pressure supply system is necessary. This consists essentially of an independent oil supply with a provision for manual control by the pilot to provide up to four hundred pounds pressure for feathering and six hundred pounds pressure for unfeathering. When, during the unfeathering operation the propeller blades have been moved into the flight operating range, normal constant-speed control automatically becomes available.

3. Performance

a. The Hydromatic Propeller is furnished with an operating angle range of thirty-five degrees for constant-speed control which is considered ample for all present-day, high-performance aircraft.

b. The feathering feature makes it possible to stop rotation of an engine in approximately 15 seconds. In an emergency where quick feathering is essential the propeller may be feathered immediately without first reducing engine power or speed. This ability to stop rotation of an engine in an emergency, such as power plant failure, assures greater flight safety.

c. The increase in single engine performance for the feathered over that for the windmilling or braked propeller is demonstrated by increased ceiling, increased rate of climb, and increased speed during level flight. Due to lower drag and decreased disturbance of the air flow, there also results a freedom from vibration, improvement in stability and better control in single engine flight.

d. For single engine ceiling, climb and high-speed of multi-engine planes, the order of merit of performance is as follows:

(1) Full-feathered.
(2) Windmill (in high blade angle).
(3) Braked (in high blade angle).
(4) Windmill (in low blade angle).

e. The gain in single engined performance for the feathered propeller over the windmilling propeller increases for airplanes of high performance. Flight tests on representative airplanes have indicated increases in single engine ceiling up to thirteen hundred feet for the feathered propeller as compared to ~~high angle~~ C.P. windmilling.

f. The ceilings for the braked propeller in high angle range from twelve hundred to thirty-five hundred feet under the high angle windmilling ceilings. The ceilings for windmilling in ~~low angle~~ F.P. were found to be about two thousand feet under the braked ceilings.

g. An increased windmilling drag will be found as engine oil temperatures drop from normal operating temperature toward the prevailing atmospheric temperature. This additional drag causes an increased yaw in single engine flight, which in turn results in additional body and tail surface drag.

4. Model Designation--Hub

a. A system of model designation has been adopted which is intended to simplify the designation of propeller assemblies. By selecting the Parts List, whose heading includes the same dash number as that etched or stamped on the propeller barrel, it is possible to determine exactly the parts (both names and numbers) composing the complete Hub assembly.

Example: Model 23E50-31 is a typical Hydromatic Propeller assembly number. In this case the "three of the twenty-three indicates the propeller has three blades; the "E" is the blade shank size; the "50" is the propeller shaft size; the "dash" number "31" indicates right-hand rotation, and a specific parts list. Right-hand propellers are indicated by the odd "dash" numbers and left-hand propellers by even numbers. In each case an even "dash" number indicates that the propeller is identical, with the exception of direction of rotation, with the propeller bearing the next lower (odd) "dash" number.

b. Major changes that may be incorporated in the basic design are identified by a change in the first digit of the model number.

Example: The first major change of a 23E50- propeller would be identified as 33E50-, second change as 43E50-, etc.

c. Minor changes are indicated by and alteration of the "dash" number.

Example: A minor change in a 23E50-31 propeller would be indicated thus, 23E50-33; a second minor change 23E50-35 series.

5. Model Designation--Blade

a. In addition to the hub designation, the blades are identified by design numbers stamped on the circumference of the butt end of each blade.

b. The method of blade identification is as follows:

(1) Blade only

Design number only, example: 6139.

(2) Blade Assembly--(Including Thrust Bearing, Balancing Plug, and Bushing)

Design number with suffix "A", example: 6139A. Right-hand blades are indicated by odd design numbers and left-hand blades of identical design by the next higher even number.

6. Propeller Diameter.

a. Dash Number. - (1) The dash number following the blade design number indicates the number of inches that the propeller diameter is reduced from that provided by the basic blade design. Example: 6139-6("dash 6" indicates that the diameter is reduced 6 inches from basic 6139-0 design).

(2) The foregoing applies to production of standard blades. Occasionally, however, to meet special requirements, the standard designs may be modified by telescoping or by special pitch distribution. Blades so modified are identified by special lettering as follows:

b. Telescope from Cut-Off to Widest Station. - Letter "T" immediately following the diameter dash number. Example: 6139-18T.

c. Combination of Straight Cut-Off and Telescope Cut-Off.

(1) Dash number following blade design number indicates reduction of diameter made by straight cut-off; second dash number followed by letter "T" indicates additional reduction of diameter made by telescope cut-off. Example: 6139-6-12T. This means diameter is reduced a total of 18 inches, telescoped from the 6-inch straight cut-off.

d. Combination of Telescope Cut-Off and Straight Cut-Off.

(1) First dash number followed by letter "T" indicates reduction of diameter made by telescoping; second dash number indicates additional reduction of diameter made by straight cut-off. Example: 6139-12T-6. This means diameter is reduced a total of

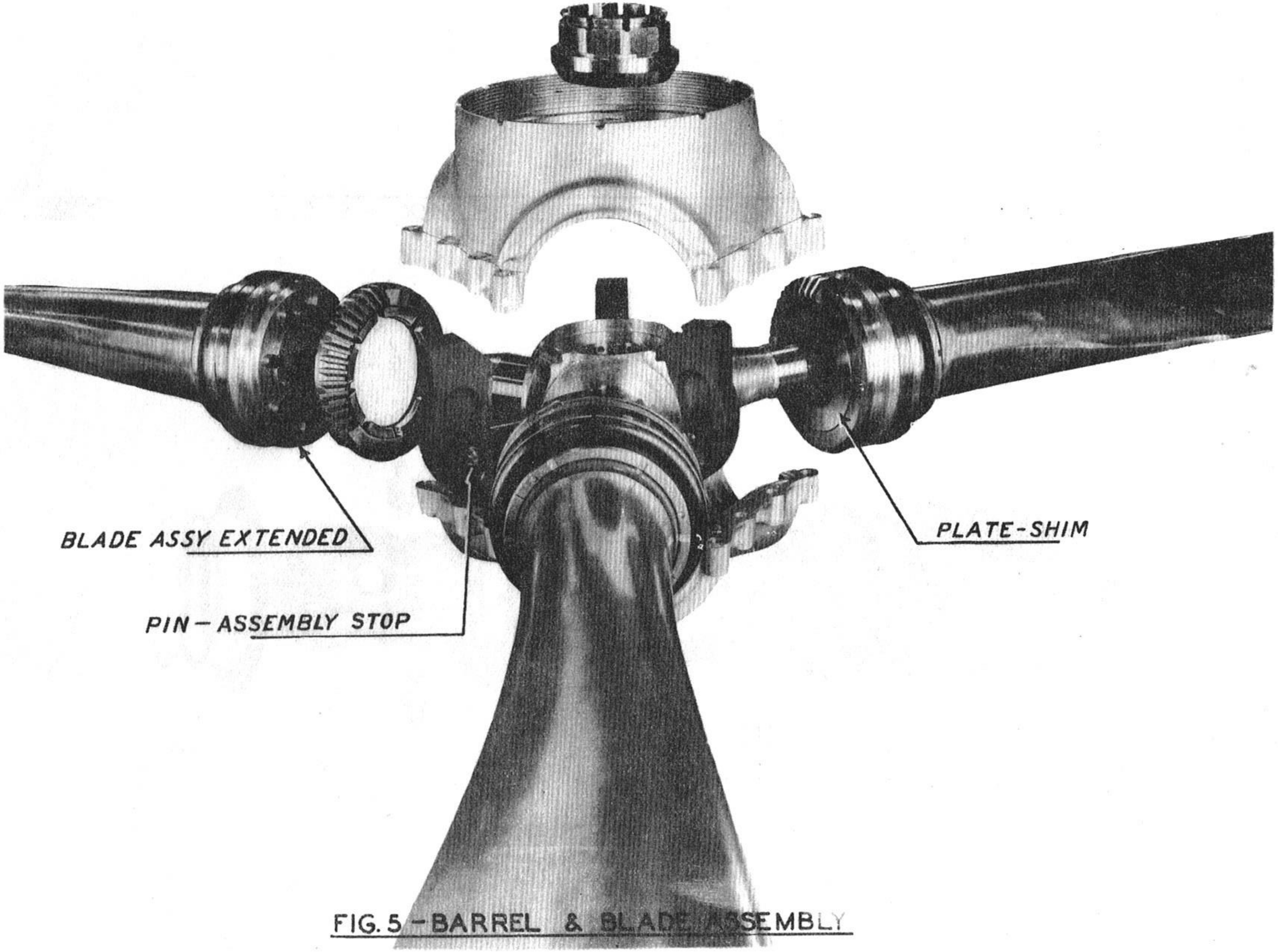

FIG. 5 - BARREL & BLADE ASSEMBLY

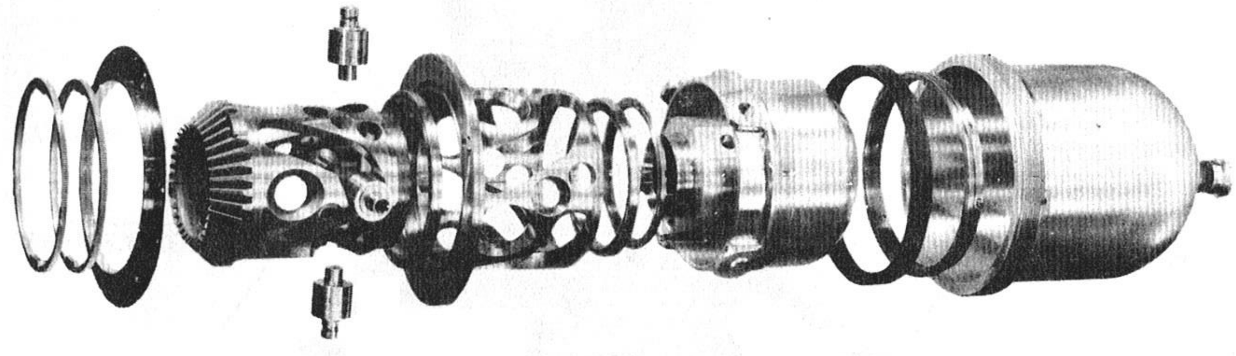

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FIG 6 - *DOME ASSEMBLY EXTENDED*

18 inches, telescoped from the 12-inch cut-off and then reduced 6 inches more by straight cut-off.

e. Special Pitch Distribution. - Letter "A" immediately following the diameter dash number. Example: 6139-12A. If blade is also telescoped the designation would be 6139-12TA; if the diameter were reduced 6 inches more by straight cut-off the designation would be 6139-12TA-6.

SECTION III

DETAILED DESCRIPTION

1. Major Assemblies.

a. The propeller consists of three major subassemblies, the Hub and Blade Assembly, the Dome Assembly, and the Distributor Valve Assembly.

b. All individual major parts of the hub and dome assemblies are statically balanced during manufacture.

2. Hub and Blade Assembly.

a. The hub and blade assembly consists of three major parts which are the spider, the barrel and the blades.

b. The spider may be considered as the foundation for the entire propeller. Its central bore is splined to fit the engine shaft and it is through these splines that the engine torque is transmitted to the propeller. It is equipped at either end with an accurately ground cone seat and at its outer end provision is made for the propeller retaining nut and front cone by means of which the spider is attached rigidly to the engine shaft. Integral spider arms with two bearings on each arm support the blades, taking the greater part of the thrust and torque loads from the blades.

c. The barrel is supported on the spider by means of phenolic blocks located between the spider arms. Shoulders machined in the barrel take the centrifugal loads from the blades which are transmitted to the barrel through heavy duty roller bearings.

d. Blades used with the Hydromatic propeller are identical in basic design with those in the Hamilton controllable type propeller. They differ in slight detail at the inner end and are not interchangeable between the two propeller types.

e. Chevron type oil seals are used between the blades and the barrel and between the spider and the barrel. The barrel thus forms an oil tight casing which houses the entire hub mechanism and provides support for the attachment of the dome unit.

3. Dome Assembly.

a. The dome assembly comprises the pitch changing mechanism by means of which oil forces on a double acting piston are translated into blade twisting moments.

b. It consists of four major parts, namely: two cylindrical coaxial cams forged from high strength alloy steel, a double walled

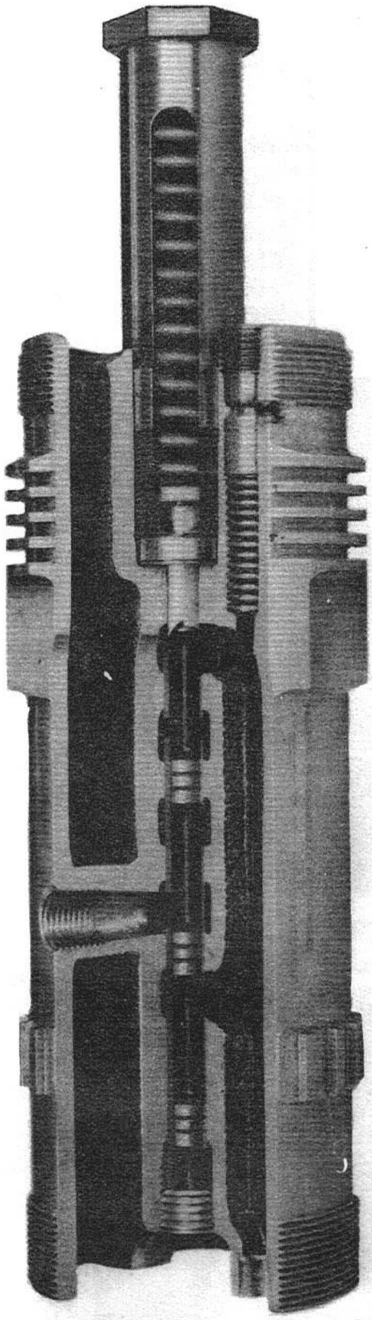

FIG. 7 - DISTRIBUTOR VALVE POSITION CONSTANT SPEED & UNFEATHERING

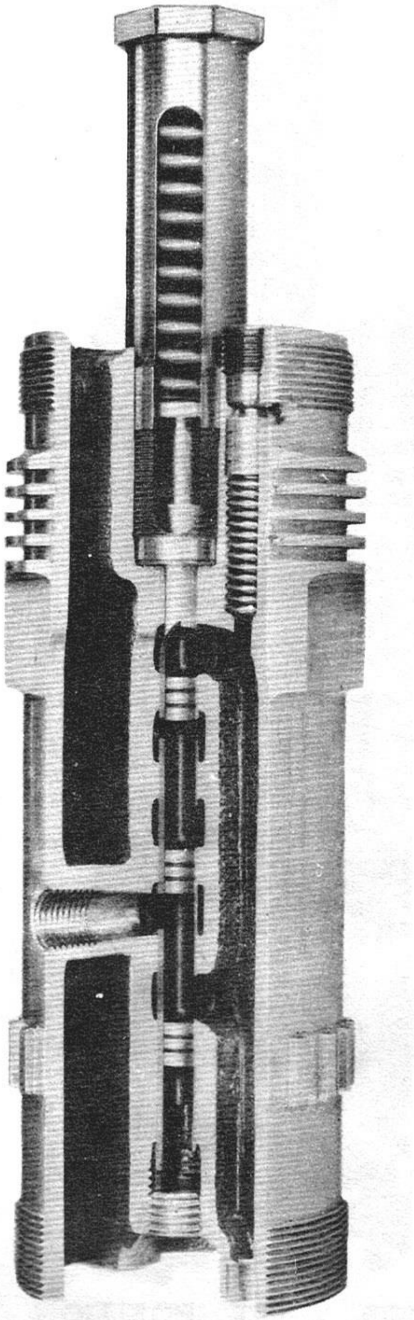

FIG. 8 - DISTRIBUTOR VALVE POSITION (UNFEATHERING)

piston and a dome cylinder which serves also as a housing for the entire unit. The piston and cylinder are machined from aluminum alloy forgings.

c. When the dome unit is installed in the hub assembly, the outer or stationary cam becomes rigidly fixed in the barrel and provides support for the remaining parts of the dome unit. The inner or rotating cam, with which the main drive gear is integral, is supported within the stationary cam by means of ball bearings which take the gear reactions and piston oil forces. The piston motion is transmitted to the rotating cam by means of four sets of cam rollers carried on shafts supported by the inner and outer walls of the piston.

d. The construction provides a rugged, simple, pressure lubricated mechanism which is quickly assembled and disassembled and which is readily attached to the propeller by a single retaining nut.

4. Distributor Valve Assembly.

The purpose of the distributor valve assembly is twofold:

a. Constant Speed and Feathering. - (1) During constant speed operation of the propeller it provides a passage through which engine oil, boosted in pressure and metered by the governor, is led to or from the inboard side of the propeller piston and a passage through which oil under engine pressure is conducted to or from the outboard end of the cylinder.

(2) During feathering, the same two passages provide means for deliverying high pressure oil (from the auxiliary pressure system) to the inboard side of the piston, and a means of conducting oil from the outboard end of the cylinder to the engine lubricating system. The pressure differential which exists across the piston moves it toward the outboard end of the cylinder and feathers the blades.

(3) Thus during constant speed operation or feathering, there is no movement of the distributor valve and the assembly merely provides passages through which oil may flow to and from the cylinder.

b. Unfeathering. - In unfeathering, the function of the distributor valve is to reverse the above mentioned passages. The high pressure oil from the auxiliary system is then led to the outboard side of the piston and the inboard end is connected to the engine lubricating system thus reversing the pressure differential and moving the piston toward the inboard end of the cylinder in order to unfeather the blades.

5. Description of Hub Parts.

a. Dome. - (1) The dome is machined from an aluminum alloy forging. It acts as a case for the cam operating mechanism, and as a cylinder for the piston. The outer surface of the dome also serves as a spinner.

b. Piston. - (1) The piston is an aluminum forging machined to close tolerances and independently balanced. It is the medium by which the oil pressure forces actuate the cams which in turn rotate the blades.

(2) The piston is supported by the rotating cam and its motion is transmitted to this cam by four sets of steel rollers operating on bronze bushings supported on steel shafts.

(3) The inner bore of the piston is fitted with a steel sleeve permanently pressed in place. A large, double acting piston gasket held firmly in place by means of a ring nut forms an oil-tight seal between the pressure surfaces of the piston.

c. Cams. - (1) The stationary and rotating cams are made from steel forgings machined and ground to close tolerances to insure smooth, accurate operation of the assembly.

(2) At the inboard end of the rotating cam and integral with it, is a bevel gear which engages the gear segments attached to each blade butt.

(3) Each cam has four slots; those of the rotating cam slope in the opposite direction from those of the stationary cam.

(4) The four sets of rollers located on shafts at the inboard end of the piston operate in the cam slots of the rotating and stationary cams.

d. Blade Angle Stop Rings. - (1) At the inboard end of the stationary cam the stop locating plate is secured by three unequally spaced dowels and six screws. The inner diameter of the plate has a series of fine teeth which mesh with similar teeth on the outside diameter of the angle range limit stop rings.

(2) Three dowel holes equally spaced in the inboard flange of the stationary cam and in the stop locating plate are used to align the dome assembly in the barrel.

(3) The stop rings are machined from steel forgings. Included in the Dome Assembly are two of these rings, which are identical, except for markings which indicate the blade angle range setting.

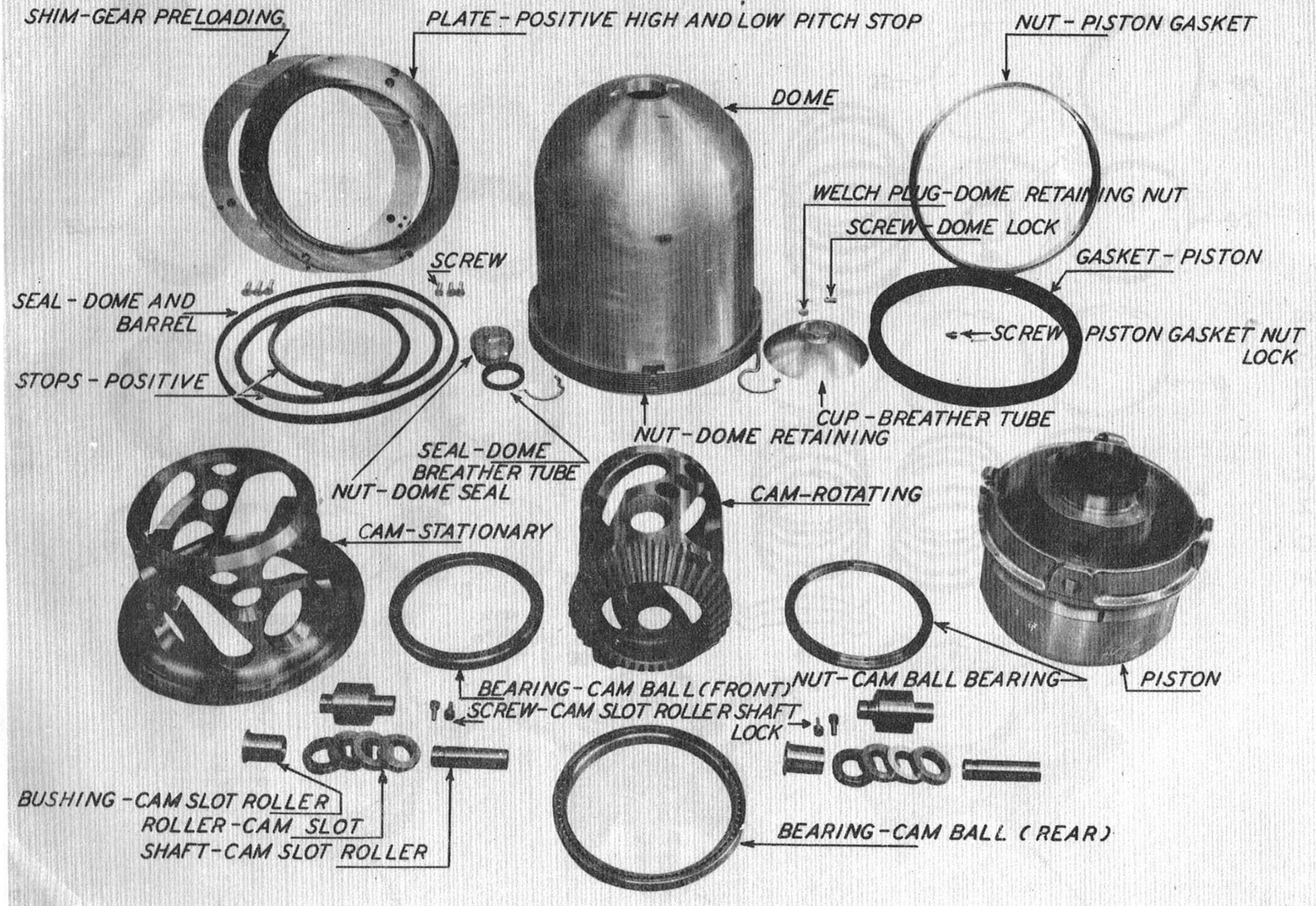

FIG. 9 - DOME ASSEMBLY PARTS

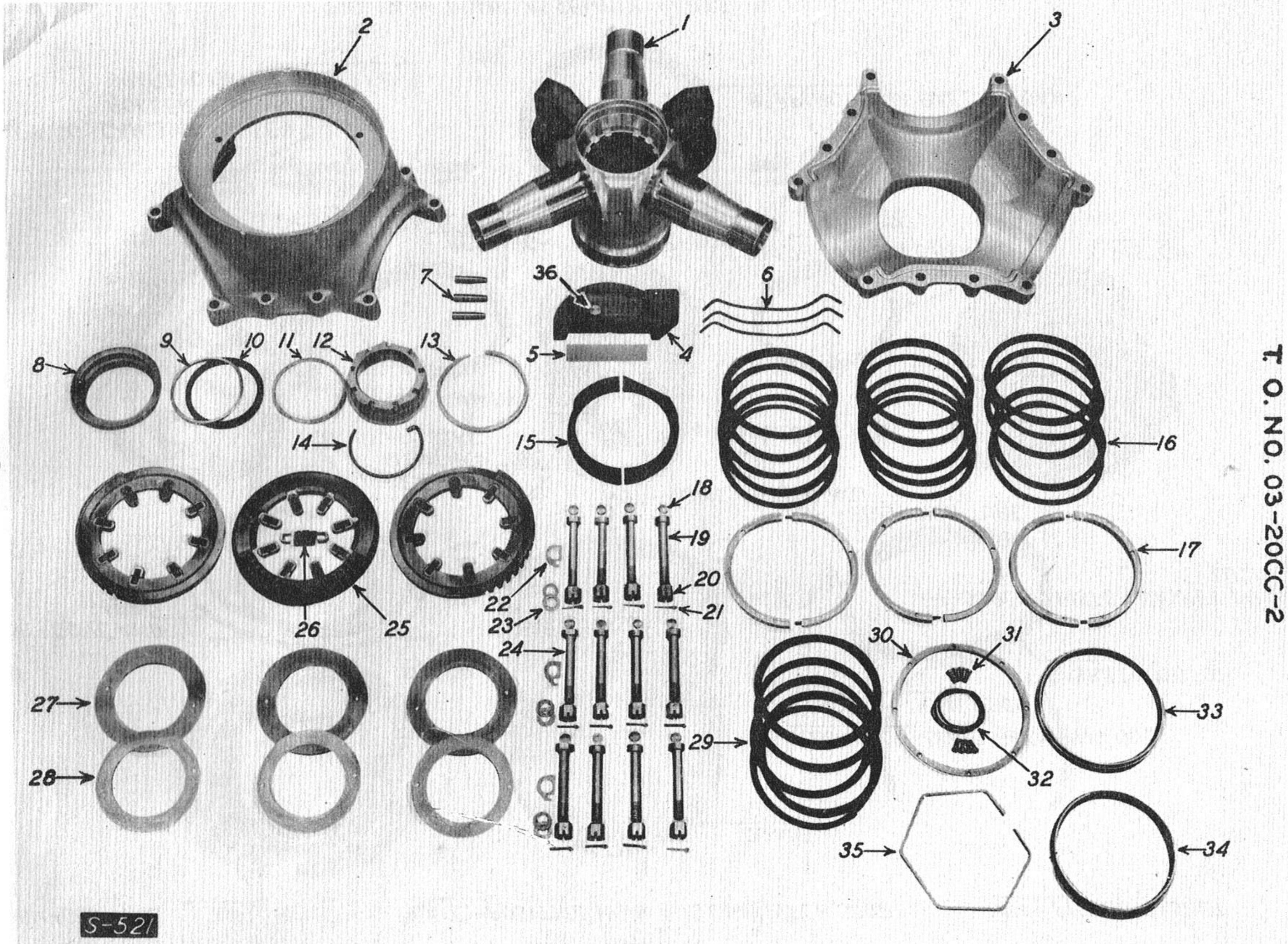

FIG. 10 - *HUB PARTS*

(4) Due to a 5:4 gear reduction between the rotating cam and blades, the stop plate and stop rings have 288 teeth each, so that indexing one tooth of the stops changes the blade angle one degree. Two lugs located 180° apart on each stop ring engage with the stops on the rotating cam. The rotating cam movement is limited to the desired range by adjusting the position of the stop rings in the stop plate.

e. Barrel. - The barrel is made from steel forgings which have been carefully heat treated. The halves of the barrel are machined in pairs to insure perfect matching. The shoulders of the barrel blade bores carry the centrifugal blade loads and provision is made for chevron type packings for oil tightness. The barrel is balanced as a unit to facilitate balance of the complete propeller assembly.

f. Spider. - The spider is machined from a steel forging, heat treated, and with all dimensions held to close tolerances. The splines and cone seats are finished to standards which insure satisfactory installation on appropriate engine shafts. Each spider arm has two ground bearing surfaces which carry the thrust and torque loads.

g. Barrel Supporting Blocks. - Phenolic blocks are provided for alignment and support of the barrel on the spider. Solid brass shims are used for adjustment of the spider and barrel concentricity during assembly.

h. Shim Plates and Shims. - Shim plates and solid brass shims are installed between the face of the blade bushings and spider arm shoulder. The shim plates are installed on shim plate drive pins mounted in the blade bushings. Solid brass shims are placed between the shim plate and face of the blade bushing for adjustment of the blade torque during assembly. These shims are available in thicknesses .008" to .020" by increments of .001".

i. Oil Packings. - Oil packings are provided to insure oil tightness between the barrel and blades, and between the barrel and spider. The sealing assembly consists of three V-shaped rings constructed of synthetic rubber material which is resistant to oil. These rings are supported at each end by split header and follower rings. The oil packings are held in place by packing retainers. The barrel halves are provided with grooves in the parting surfaces which carry synthetic rubber oil seals.

j. Distributor Valve. - (1) The distributor valve housing is an aluminum alloy casting provided with cored passages for the operating pressures. A steel sleeve, shrunk into the central bore of the housing, contains ports which align with oil passages in the housing. In order to unfeather, the normal flow of oil through these ports is redirected by a change in the position of the distributor valve which operates within the sleeve. Change in position of the distributor valve is accomplished by applying to it a higher pressure than that required for normal constant-speed operation or feathering.

(2) The valve is equipped with oil seal rings on its outboard end which provide a seal between the valve assembly and the inner bore of the propeller piston. Cored breather passages are incorporated in some housings for those engines which still breathe through the propeller shaft.

6. Blade Assembly Parts.

a. Blade. - (1) The blades are manufactured from aluminum forgings, heat treated for high tensil strength. The blade butt is provided with a tapered hole for the bushing and a shoulder to carry the thrust bearing loads.

(2) A phenolic material is moulded to the blade between the inner bearing race and the blade butt. The purpose of this phenolic sleeve is to reduce stress concentration in the blade and eliminate chafing between the aluminum blade material and the steel bearing race. In addition, the sleeve extends far enough onto the blade shank to furnish an excellent sealing surface for the barrel and blade packing.

b. Thrust Bearing. - The thrust bearing consists of two thrust races which are not removable from the blade, and a split bearing retainer. The centrifugal blade loads are transmitted from the shoulders on the blade butt to the inner or beveled thrust washer through a phenolic sleeve moulded on the blade. The outer, or flat thrust washer, transmits the bearing loads to the shoulder on the barrel blade bore. The roller thrust bearings are designed for low frictional torque under high thrust loads.

c. Blade Bushing. - Blade bushings are made of an aluminum-bronze alloy. The bushings are shrunk into the tapered holes in the blade ends and secured by two drive pins and two lock screws. The bearing surfaces of the bushings are machined to close tolerances to produce perfect alignment of the blade assembly on the spider arms. Each blade bushing is provided with eight slots which carry the spring packs for attachment of the gear segment. Two of the spring pack slots are offset to give an initial preload to the gear teeth. There is but one angular position which is correct for assembly of the gear segment on the blade bushing for right-hand tractor propellers.

d. Spring Pack. - Each spring pack assembly consists of two spring retainers and approximately 34 spring leaves. The purpose of the spring packs is to provide a flexible coupling between the gear segment and blade bushing. The spring packs also permit preloading of the gears to prevent backlash.

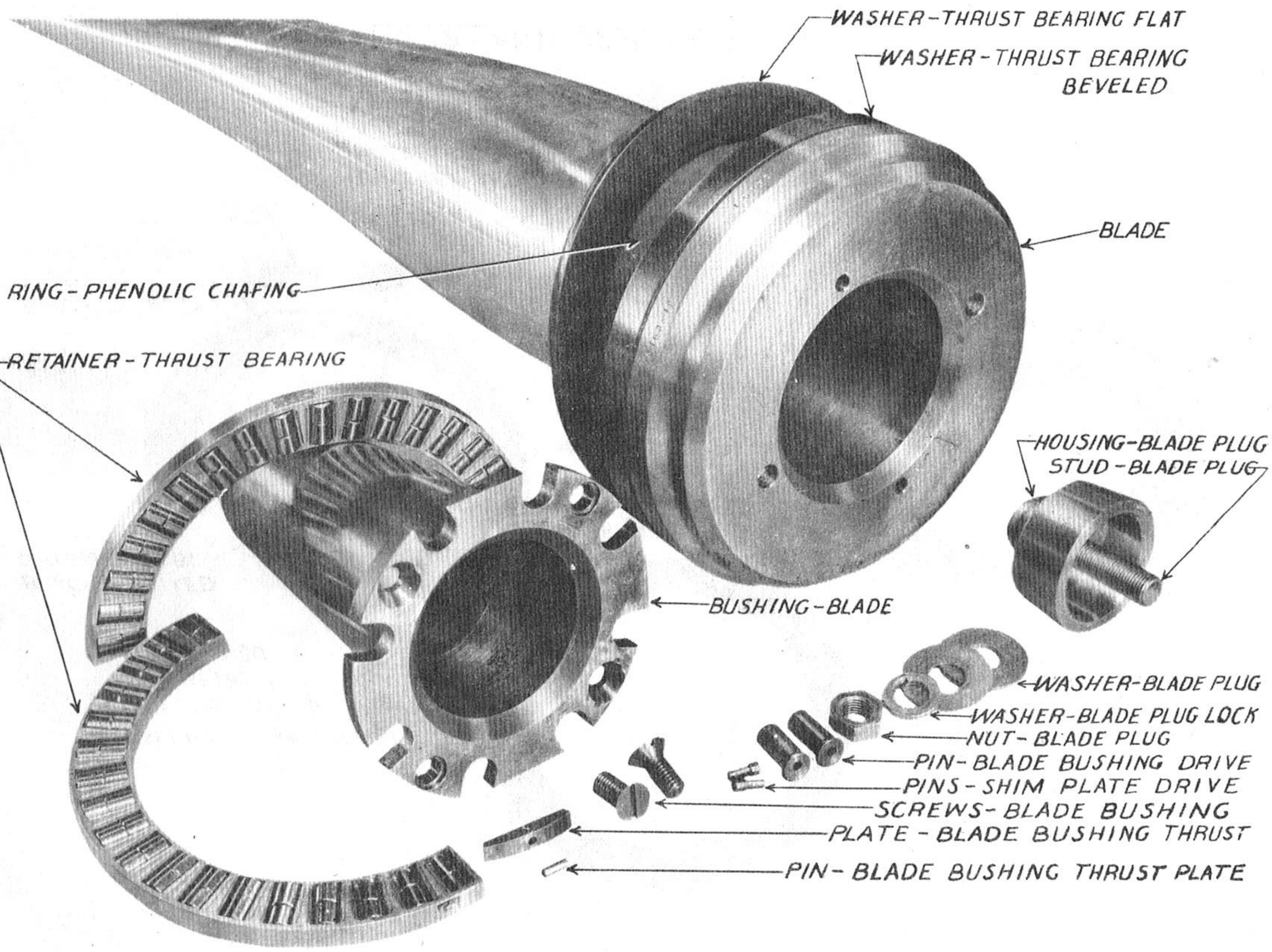

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FIG. 11 - BLADE ASSEMBLY

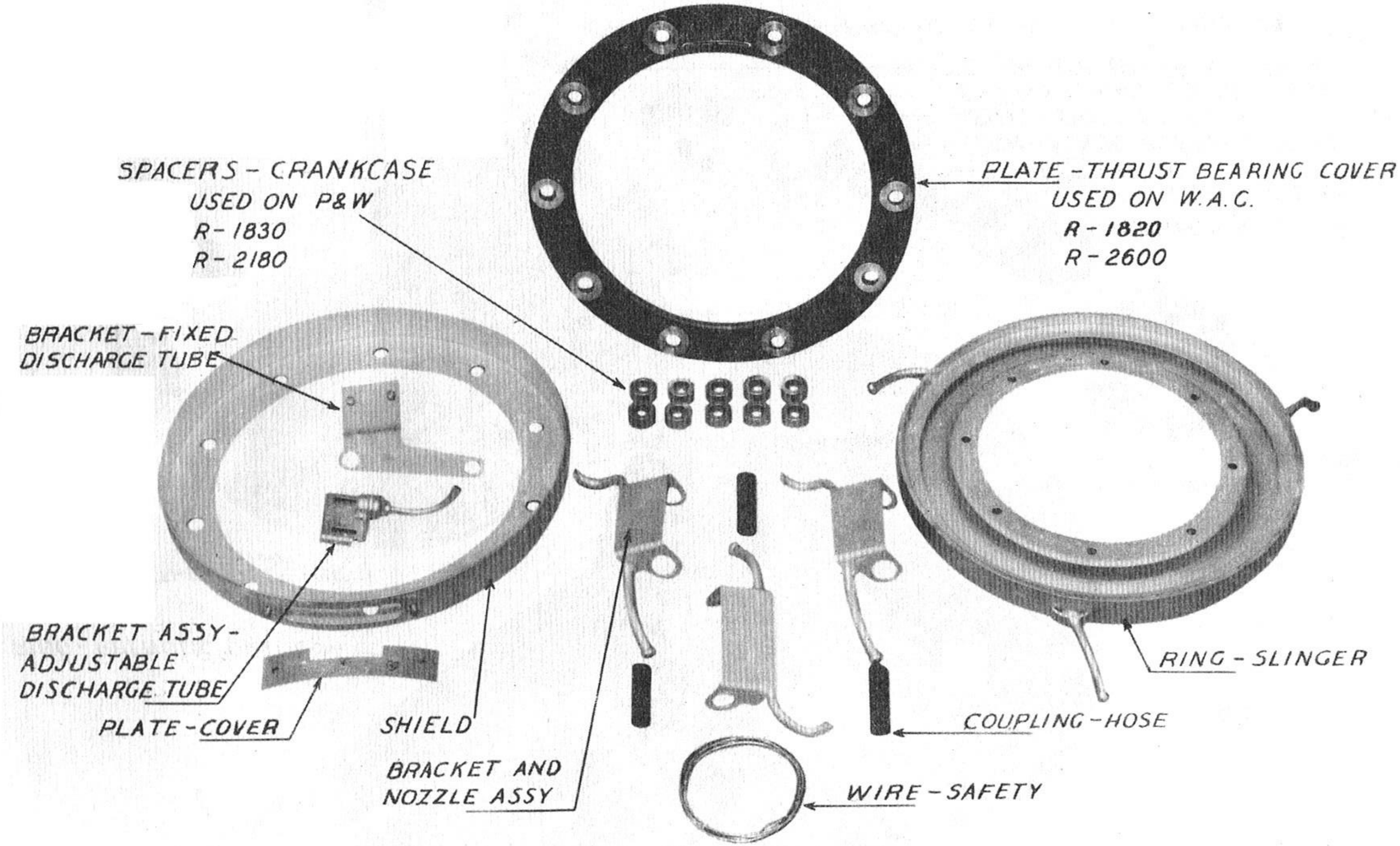

FIG. 12 - ANTI-ICER PARTS

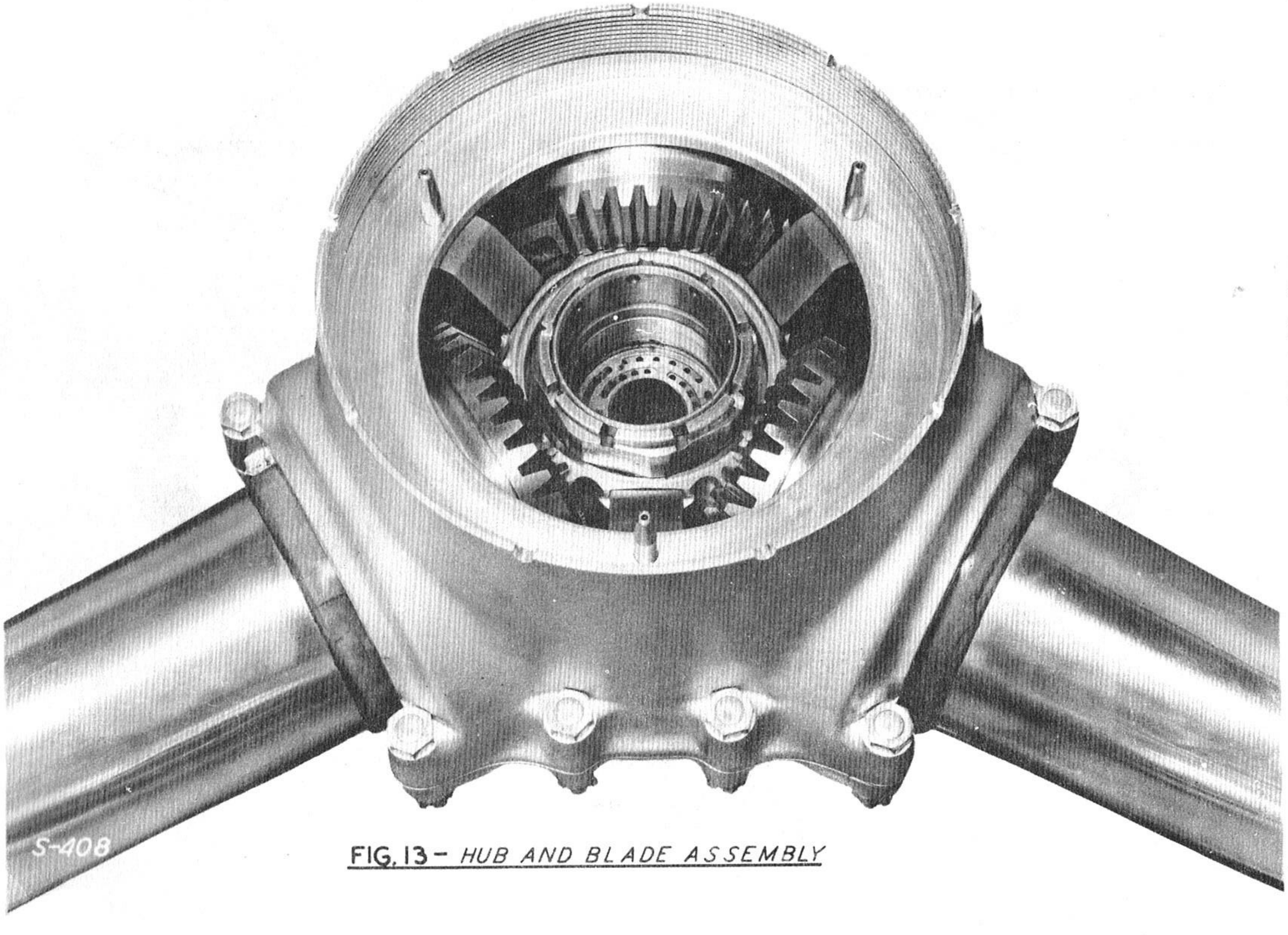

FIG. 13 - HUB AND BLADE ASSEMBLY

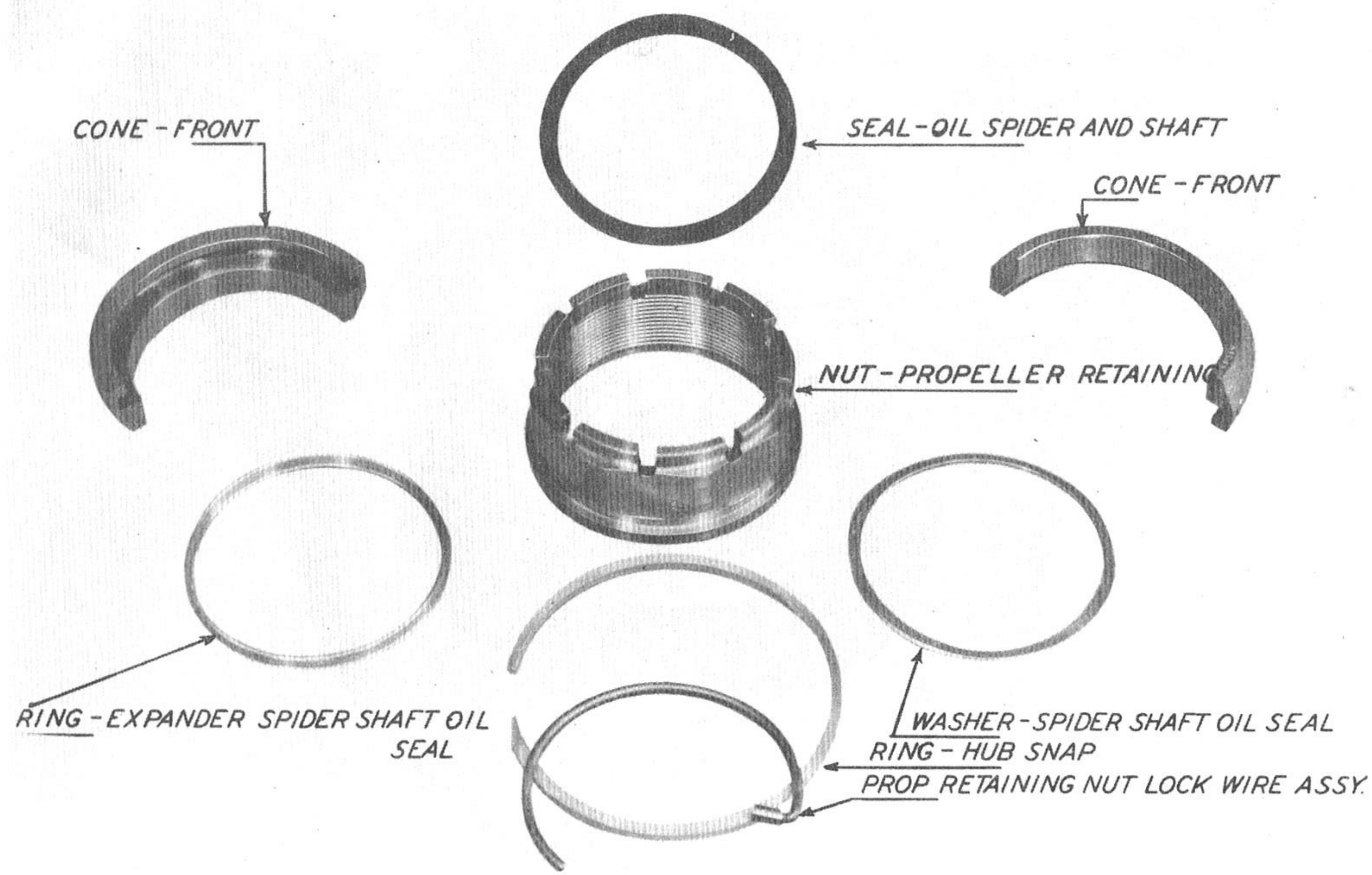

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FIG 14 - PROPELLER RETAINING NUT AND FRONT CONE

e. Gear Segment. - (1) The blade gear segments are made from steel forgings.

(2) Attachment of the gear segment to the blade bushing is accomplished by eight spring pack slots equally spaced.

(3) Each segment contains 15 teeth which engage with the teeth of the rotating cam. In this manner, the actuating forces are utilized for movement of the blades within the operating range.

f. Balancing Plug. - Each blade is fitted with an aluminum plug which is wedged into the hollow shank at a point just beyond the inner end of the blade bushing. This plug prevents oil from escaping into the extreme end of the taper. The blade plug is provided with a stud on which washers may be installed for balancing purposes.

7. Anti-Icer Parts.

The de-icer slinger ring is attached to the rear barrel half by means of eight screws. Bracket and nozzle assemblies are provided for distribution of de-icer fluid from the slinger ring to each blade. A shield is included for attachment to the thrust bearing cover plate of the engine which carries an adjustable discharge tube. The discharge tube is connected to the de-icer fluid supply by suitable piping.

SECTION IV

INSTALLATION

1. Preparation.

a. Hydromatic Propellers, as prepared for installation on the engine shaft, consist of three sub-assemblies: The hub and blade assembly, (which includes the hub retaining nut and front cone) the distributor valve assembly, and the dome assembly.

b. Before installing a propeller, all parts will be examined for defects and damage, and checked for proper fitting. All corrosion and all raised points of nicks, burrs, galls, scores, etc., on joining surfaces of the attaching parts, hubs and crankshaft end, will be carefully dressed off and the parts thoroughly cleaned before the propeller is installed on the shaft. In addition, the splines, cones, cone seats, etc., will be coated with clean engine oil to provide lubrication and prevent corrosion. Cup grease or semi-fluid oils will not be used for this purpose. The threads in the propeller hub dome, breather tube, will be thoroughly coated with compound, thread, aircraft instrument, AC Specification 3590.

2. Attaching Parts.

a. To insure proper fit, balance, etc., the sub-assemblies and hub attaching parts for each propeller will be kept together as a complete assembly.

b. The distributor valve assemblies of the same type are interchangeable.

c. Dome assemblies are interchangeable if previously checked with the hub assembly for balance and gear preload.

3. Procedure.

a. Coat the engine shaft and cones with engine oil and install the propeller hub and blade assembly on the propeller shaft, sliding it back only far enough at first to engage the threads of the propeller retaining nut with those of the shaft. Start the propeller retaining nut on by hand.

b. Check to be sure that the 1/32" copper gasket (provided by the engine manufacturer) is in place against the adapter flange inside the propeller shaft.

c. Check the valve housing oil transfer plate on the base of the distributor valve assembly to be sure that it is properly in place with the 1/32" copper gasket between it and the valve housing.

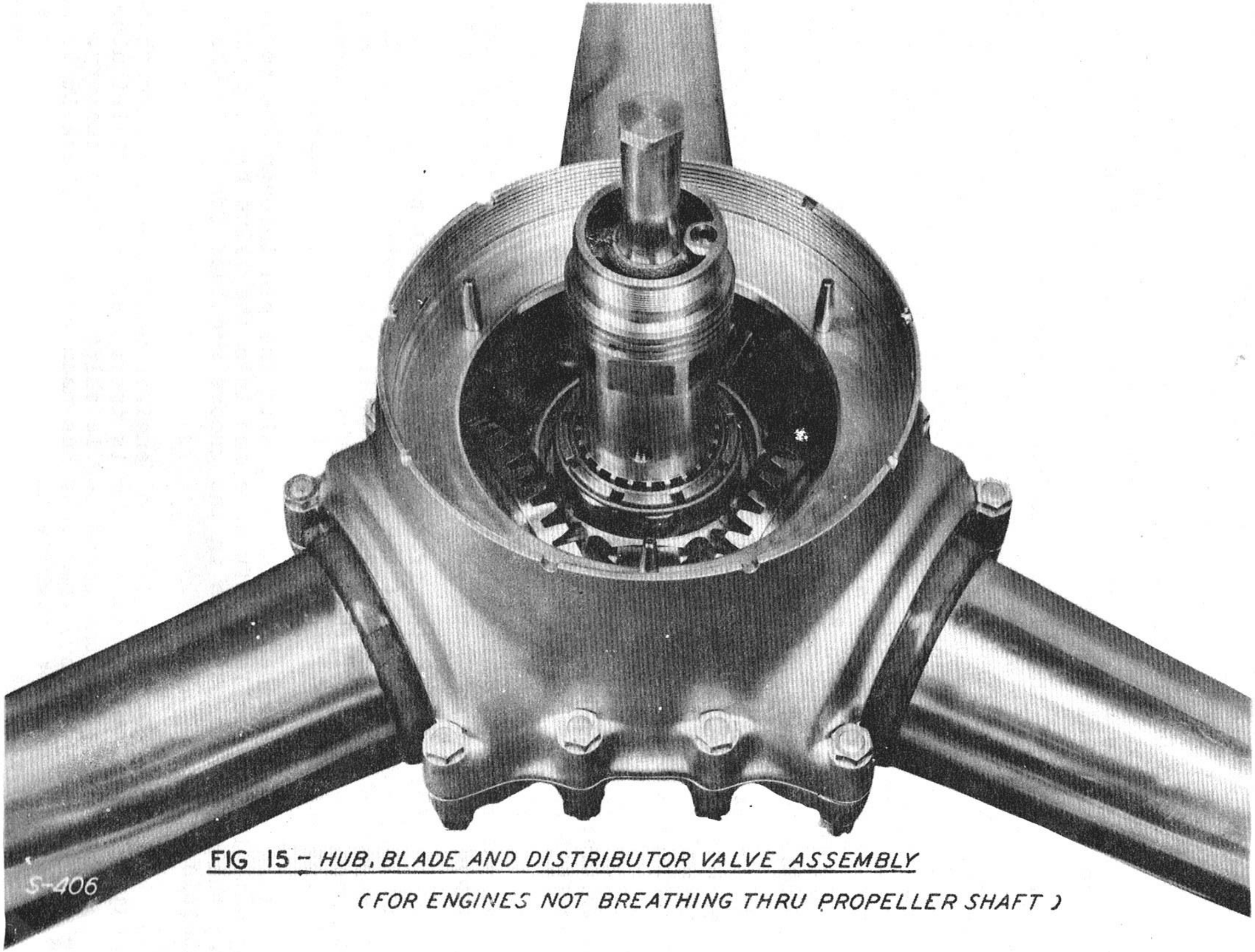


FIG 15 - HUB, BLADE AND DISTRIBUTOR VALVE ASSEMBLY

(FOR ENGINES NOT BREATHING THRU PROPELLER SHAFT)

(1) The oil transfer plate, for use with engines which breathe through the propeller shaft, has a 1-1/4" hole through its center to allow engine breathing.

(2) On the plate for use with engines which do not breathe through the shaft, the hole in the center does not go through the plate but connects with the dome oil pressure line in the side of the valve housing.

d. Oil the threads of the valve assembly, screw it into the shaft and tighten it with composite wrench, using adapter, part No. 41B1862. The use of adapter, part No. 41B1862, will permit equal application of torque on all sides of the valve housing and will prevent the crushing effect encountered when using only the composite wrench. Apply a force of approximately 100 pounds at the end of the bar and, while this force is being maintained, strike the bar near the wrench one light blow with a hammer weighing not more than 2-1/2 pounds. If the locking slots in the valve housing are not aligned with the holes in the propeller shaft, repeat this tightening operation until the slots and holes are in alignment.

CAUTION: Under no conditions will the valve housing be backed off even slightly in order to obtain slot and hole alignment. If alignment cannot be obtained, a new gasket will be used or the original gasket lapped slightly to reduce thickness.

e. Tighten the propeller retaining nut on the shaft using the tubular wrench together with composite wrench and a bar about three feet long.

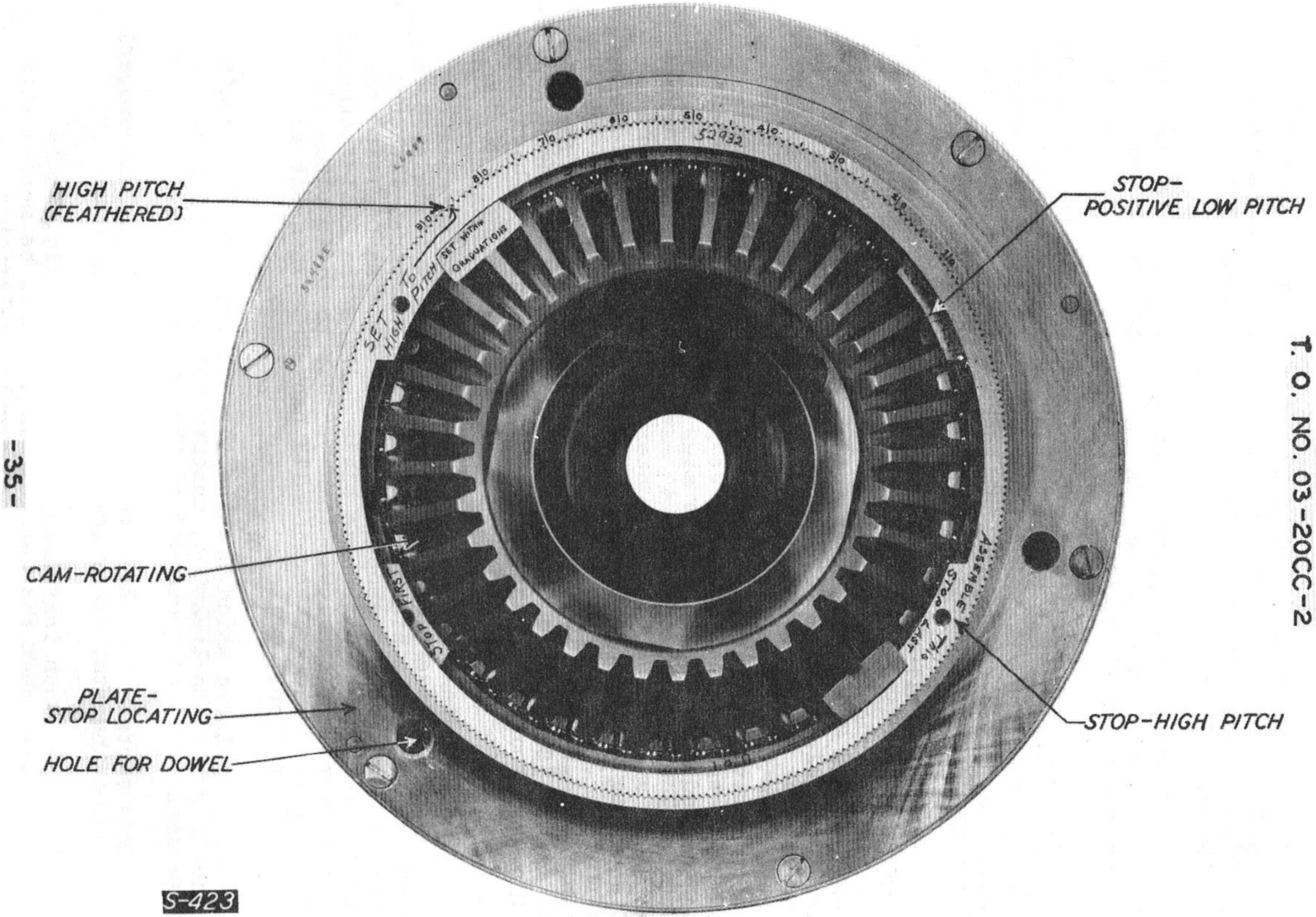
(1) Apply a force of approximately 180 pounds at the end of the bar and, while this force is being maintained, rap the bar close to the wrench with a hammer weighing about 2-1/2 pounds.

(2) Determine if one of the locking slots in the nut is in alignment with one of the holes in the propeller shaft. If not, repeat the tightening procedure until one slot and hole are in alignment. Spacing of the slots in the nut is such that alignment of a slot and hole will occur each five degrees of rotation.

f. Install the locking ring with the pin through the retaining nut slot, propeller shaft hole and into the valve housing slot. Snap the wire into position in the groove provided for it in the retaining nut.

(1) On propellers for engines which breathe through the propeller shaft, the breather tube is installed on the distributor valve assembly before the propeller is shipped from the factory. If, for any reason, this breather tube has been removed, check it to be sure that it is screwed tightly to the distributor valve housing and safetied with a brass wire through a slot in the skirt of the breather and the hole drilled into the dome pressure duct in the valve housing.

CAUTION: When installing the breather tube, extreme care will be exercised to insure that the threads are started properly and that the wrench torque for tightening will not exceed *100 + 20 - 000 lb. ft. to avoid damage to the valve housing and * gasket.



S-423

FIG. 16-DOME ASSEMBLY WITH POSITIVE HIGH AND LOW PITCH STOPS

g. Before installing the dome assembly on the propeller, check to insure that the low and high angle limit adjustments are correct. If readjustments are necessary the following procedure will be followed.

(1) Lift out the uppermost stop ring. This is the high angle stop ring and is marked "Set to High Pitch" on one lug and "Assembly This Stop Last" on the other lug.

(2) Lift out the lower stop ring. This is the low angle stop ring and is marked "Set to Low Pitch" on one lug, and "Assemble This Stop First" on the other lug. The stop rings may be removed by inserting No. 10-24 screws in the tapped holes provided in the rings for this purpose.

(3) Reinstall the low angle stop ring to the desired low angle limit by inserting it so that the arrow on the stop ring coincides with the desired degree mark (indicating the degrees of blade angle at the 42" station) stamped on the stop locating plate. The lowest possible setting is 10 degrees and, by inserting the stop ring so that the arrow on it is aligned with graduation "10" on the stop locating plate, the propeller will be adjusted to 10 degrees low limit. Any low limit higher than 10 degrees can be obtained by inserting the low angle stop ring with the arrow aligned with the desired degree mark on the stop locating plate. To insert the low angle stop ring, it may be necessary to rotate the cam gear a small amount in a counter-clockwise direction to permit inserting the stop ring without interfering with the stop lugs on the gear. It will be noticed that this rotation causes the piston in the dome assembly to move forward. The stop lug on the cam gear marked "Set Within Graduations" must be within the graduated arc of the stop locating plate after the stop rings have been installed.

(4) Reinstall the high angle stop ring to the desired high angle limit by inserting it, on top of the low angle stop ring, so that the arrow on the high angle stop ring coincides with the desired degree mark on the stop locating plate. The highest possible setting is 90° but with some blade designs the full-feathered setting is a degree or two lower than 90° due to their pitch distribution which causes them to windmill backwards when set to 90° at the 42" station.

h. On propellers which breathe through the propeller shaft, remove the breather cup lockwire, unscrew the breather cup and remove the seal from the front end of the dome assembly.

i. Make certain that the dome and barrel oil seal is properly installed around the stationary cam base against the dome.

CAUTION: When installing the dome assembly, it is ABSOLUTELY ESSENTIAL that the cam gear in the dome be meshed with the blade gear segments in the proper angular relationship and the following steps should be carried out to insure correct meshing.

j. By turning the rotating cam gear, move the piston in the dome assembly into the extreme forward position. This position will be reached when the cam gear stop lugs are against the high angle stop lugs.

k. Turn each blade to the high angle position against the stop pins.

l. Slide the dome assembly over the end of the valve assembly, making sure that the oil seal rings on the valve assembly enter properly into the sleeve inside the piston. Turn the dome in a counter clock-wise direction until the dowels in the barrel dome shelf engage the aligning holes in the stop locating plate. (The dome unit may be installed in any of three possible positions, one of which is suitably marked.) The cam gear and blade gears are now in proper alignment; slide the dome assembly, without turning it, into the barrel until the dome retaining nut can be started.

(1) On engines which breathe through the propeller shaft, make sure that the breather tube on the front end of the valve assembly is properly started in the hole in the front end of the dome.

(2) Turning the dome assembly in a clockwise direction in order to align the dowels and holes should be avoided, as this will tend to move the stop lugs on the rotating cam away from the high angle position, thus allowing the gears to mesh incorrectly.

(3) Tighten the dome retaining nut, using composite wrench, in the manner indicated for tightening the propeller retaining nut by applying a force of approximately 180 pounds at approximately four foot radius. With the dome assembly properly seated in the barrel, the front face of the dome retaining nut will be approximately flush with the front edge of the barrel.

(4) It is essential that the dome unit be firmly seated on the retaining shoulder in the barrel. Tightening of the dome retaining nut, in addition to fastening the dome unit to the hub, serves to apply the preloading force to the gears and to compress the dome and barrel seal. Its tightening, therefore, requires a relatively high wrench torque as indicated above. Failure to tighten the dome unit securely in the hub will result in elongation or failure of the assembly screws which fasten the dome cylinder and the stop locating plate to the stationary cam.

NOTE: In some cases, depending on the blade design, it is necessary to limit the full-feathering blade angle to slightly less than 90° (at the 42" station) in order to eliminate any tendency of the propeller to windmill backwards when feathered. Propellers, in these cases, are provided with stop pins which limit the blade angle to less than 90°.

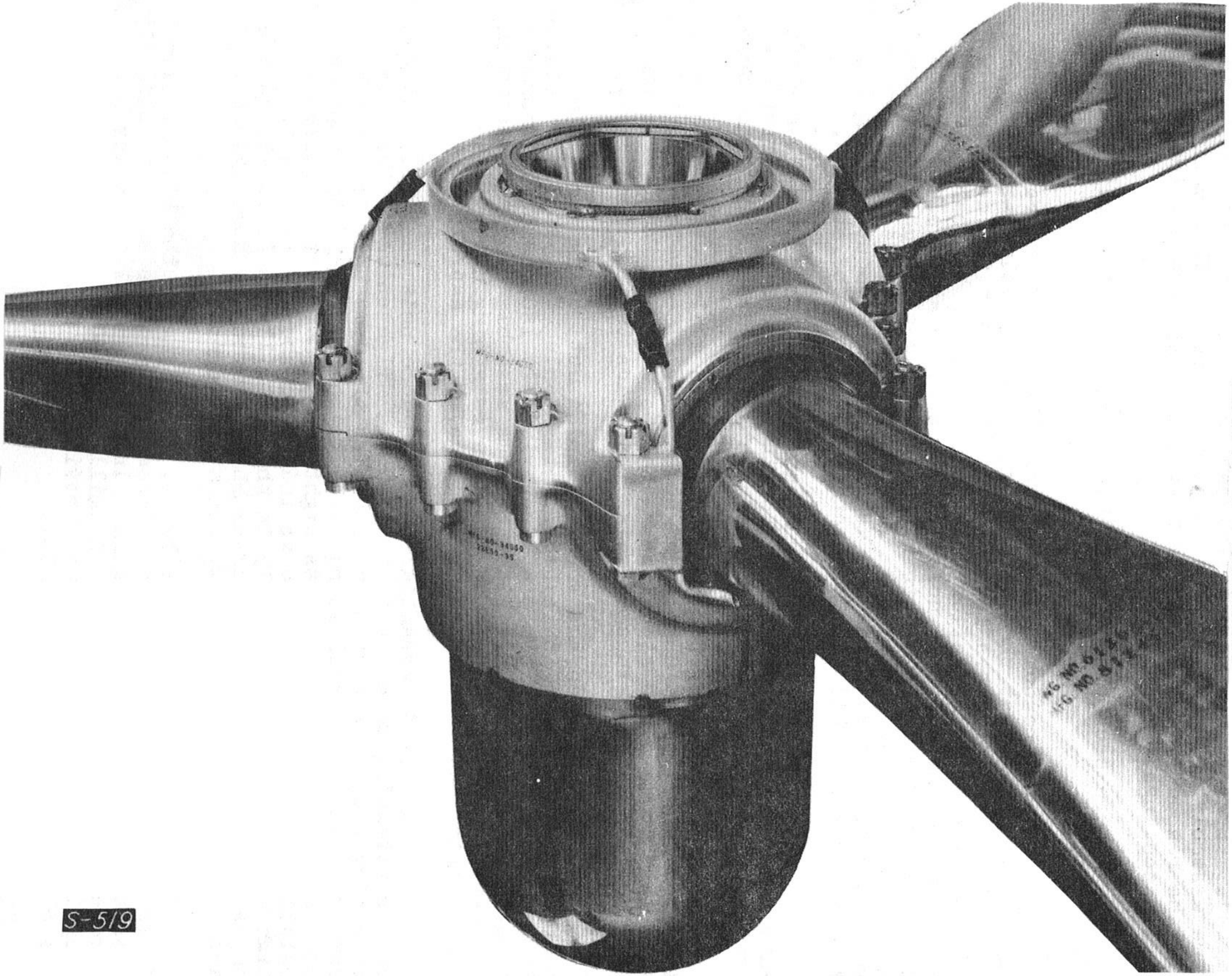


FIG. 17 - VIEW SHOWING DE-ICER SLINGER RING

m. Install the dome retaining nut lockscrew and safety the screw with a 1/16" x 1/2" steel cotter pin.

(1) On engines which do not breathe through the propeller shaft: Make sure that the dome breather hole nut in the front of the dome is tight and that the lock wire is in place.

(2) On engines which breathe through the propeller shaft: Insert the gasket between the breather tube and the front end of the dome.
Install the breather cup and safety it with the locking ring provided.

CAUTION: Using suitable levers to turn the blades, shift the propeller into ~~full low angle~~ F.P. and check all three blade angles by the index lines on the blades and the graduations on the barrel or with a protractor. These angles should be equal and should agree with the ~~low angle~~ F.P. stop setting. This check indicates that the correct relationship between the blade gears and the cam gear has been obtained.

n. Check all external screws, nuts, etc., for proper safetying.

4. Anti-Icing Equipment.

a. Before mounting the propeller on the engine shaft, the shield and feeder tube assembly should be mounted on the front section of the engine.

(1) Propellers for Wright engines are supplied with a single thrust bearing cover plate to replace the one already mounted on the engine.

(2) Propellers for P&W engines are supplied with ten individual spacers to replace the 3/8" spacers already mounted on the engine.

(3) On P&W engines remove the hold-down nuts of the engine's front section thrust bearing cover plate and remove the spacer washers. Install shield over studs with the opening for the feeder tube toward the top.

(a) Install the fixed bracket for the feeder tube through the cutout in the shield and over the two upper studs near the top of the shield.

(b) Place the spacers supplied with the propeller over the studs and bolt the assembly down tight.

(c) On Wright engines the same installation procedure applies as above, with the exception of the individual spacers. For Wright engines a ring spacer is provided which takes the place of the thrust bearing cover plate.

(d) Install the feeder tube through the cutout in the shield and secure to the fixed bracket.

(e) After the propeller is mounted adjust the feeder tube sliding bracket until the feeder tube clears the slinger ring by 1/32".

(f) Install cover plate over shield and safety wire it in place.

(g) Connect the anti-icing fluid supply pipe to the 1/8 I.P.T. connector.

5. Removal Instructions.

a. The procedure for removing the propeller from the propeller shaft is, in general, the reverse of the installation procedure.

(1) For installations on engines which breathe through the propeller shaft, remove the lock ring and breather cup from the front of the dome.

(2) Remove the lock screw from the dome retaining nut and unscrew the nut. This nut is attached to the dome and acts as a puller when the nut is unscrewed.

(3) Remove the dome assembly.

(4) Remove the lock ring from the propeller retaining nut.

CAUTION: It is imperative that this ring be removed before unscrewing the distributor valve in order to prevent shearing of the valve housing locking splines.

(5) Loosen retaining nut.

(6) Unscrew and remove the valve assembly.

(7) Unscrew and remove the propeller retaining nut and remove the propeller from the shaft.

NOTE: The hub snap ring and related parts inside the spider are so arranged that, as the retaining nut is backed off, it pulls the propeller with it until the nut reaches the end of the propeller shaft thread.

SECTION V

PRINCIPLE OF OPERATION

1. General

In the following description of propeller operation it is assumed that the Individual Electric Motor Driven Pump feathering system is used in which a motor-pump unit, installed in each engine nacelle, supplies oil from the engine tank to the propeller. This system is shown schematically in Fig. 18 (A), (B), and (C), shows diagramatically the principal propeller components and their functions during constant-speed, feathering and unfeathering.

2. Constant-Speed Operation (Fig. 18 (A)

a. The angle changing mechanism, by means of which oil forces are translated into blade twisting moments, consists essentially of a double acting piston in a cylinder, a pair of co-axial, cylindrical cams (the stationary, or external, cam is not shown in the figure) and bevel gears between the rotating cam and the blades.

b. The Constant-Speed Control is a governor of the centrifugal flyball type. It incorporates a gear pump to boost the engine oil to the required pressure, and a pilot valve, which is sensitive to changes in engine r.p.m., to meter the oil to or from the propeller in order to adjust the blade angle as required for the maintenance of constant engine speed.

c. The principal control force toward ~~low angle~~ F.P. is produced by the centrifugal twisting moment of the blades. This moment, about the longitudinal blade axis, is the result of a force couple consisting of the resultant of components of centrifugal force acting on the mass of the blade on either side of its longitudinal axis. This centrifugal moment is modified by the aerodynamic twisting moment of the blade which, during normal level flight, is relatively small and acts toward ~~high angle~~ C.P. tending to reduce, to some extent, the net twisting moment toward ~~low angle~~ F.P.

d. Supplementing the blade centrifugal moment, to insure adequate control force toward ~~low angle~~ F.P. when propeller speed is low, is an oil pressure moment obtained by allowing engine oil, under normal engine pressure, to act on the outboard end of the propeller piston.

e. Control force toward high angle is provided by allowing oil pressure from the governor to enter the inboard end of the cylinder. This pressure opposes the two previously mentioned low angle moments and is capable to overcoming them readily when the governor demands an increase in blade angle. Thus, by admitting oil to, or draining it from, the inboard end of the cylinder in the required quantity and under the proper pressure, the governor is able to maintain the blade angle required for constant engine speed.

FIG. 18 – CONSTANT SPEED FEATHERING & UNFEATHERING POSITIONS

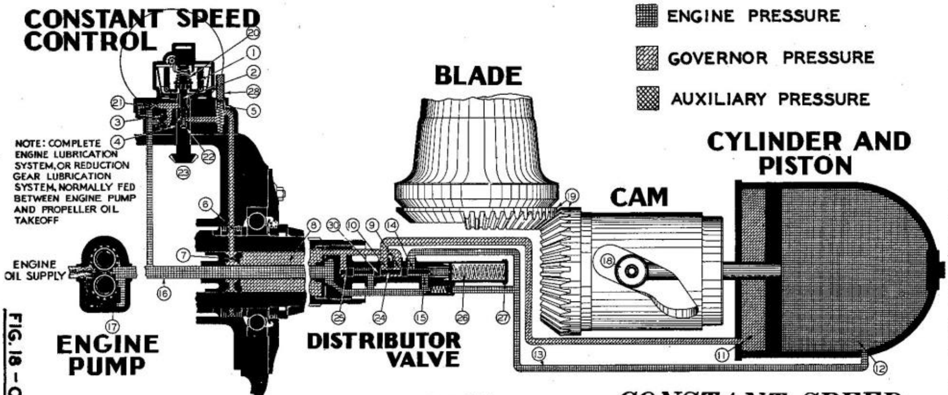


FIG. 18A

CONSTANT SPEED

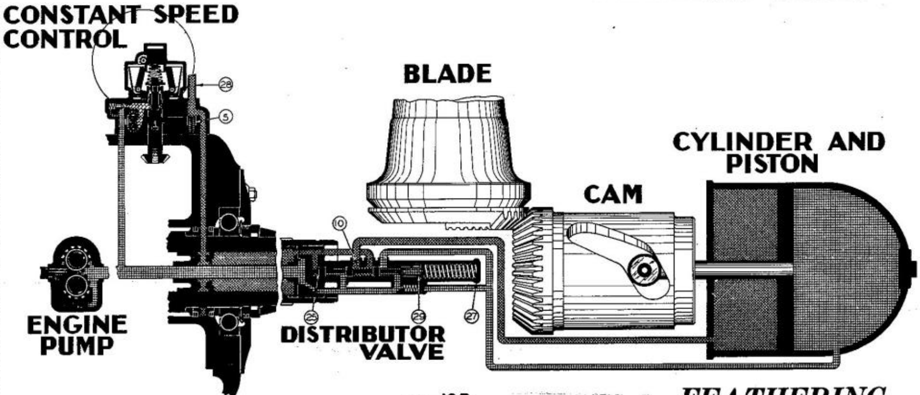


FIG. 18B

FEATHERING

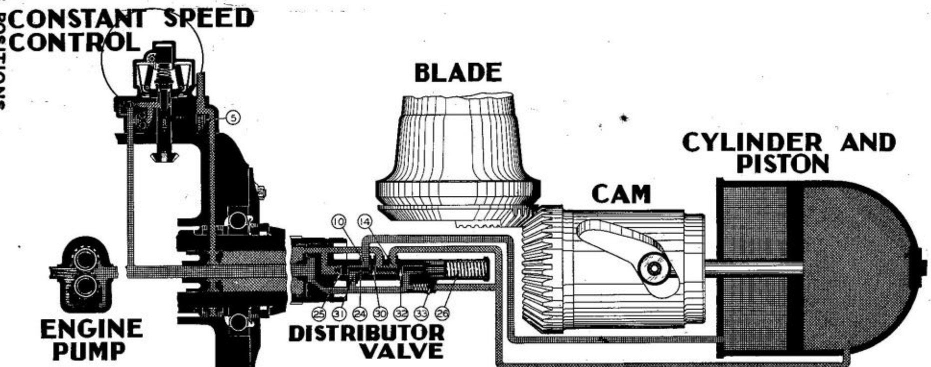


FIG. 18C

UNFEATHERING

(1) Governor Flyweight
(2) Governor Pilot Valve
(3) Governor Pump
(4) Hollow Drive Shaft
(5) Governor Cut-off Valve
(6) Engine Shaft Oil Transfer Rings
(7) Propeller Shaft Air Separator Plug
(8) Propeller Shaft Oil Passage
(9) Distributor Valve Port
(10) Distributor Valve Port
(11) Propeller Cylinder — Inboard End
(12) Propeller Cylinder — Outboard End
(13) Oil Supply Tube — Outboard Cylinder End (Schematic Only)
(14) Distributor Valve Port
(15) Distributor Valve Port
(16) Engine Oil Pressure Supply Tube
(17) Engine Pump Relief Valve
(18) Cam Slot Rollers
(19) Bevel Gears
(20) Governor Control Spring
(21) Governor Relief Valve
(22) Governor Drain Port
(23) Governor Drive Gear
(24) Propeller Distributor Valve
(25) Propeller Distributor Valve
(26) Distributor Valve Spring
(27) Distributor Valve Spring Housing
(28) External High Pressure Oil Line
(29) Distributor Valve (Outboard End)
(30) Distributor Valve Land
(31) Distributor Valve Port
(32) Distributor Valve Land
(33) Dome Pressure Relief Valve

f. The operation is as follows: Should the engine speed increase to an r.p.m. above that for which the governor is set, the governor flyweights (1) move outward, raising pilot valve (2) and admitting oil from the governor pump (3) into the hollow drive shaft (4). From the drive shaft, the oil flows thru the governor cut-off valve (5), thru the engine transfer rings (6), the air separator plug (7), the shaft (8) and thru the propeller distributor valve ports (9) and (10) into the inboard end of the cylinder (11). When the pressure on the inboard side of the piston exceeds the combined forces toward low angle plus the mechanical friction of the mechanism, the piston moves outward, and oil in the outboard end of the cylinder is displaced into the engine lubricating system; its path being from the cylinder at (12), thru tube (13), past the distributor valve ports (14) and (15) and into the engine shaft tube (16). From this point the pressure is dissipated by the leakage of oil past the engine bearing clearances, or thru the engine bearing clearances, or thru the engine pump relief valve (17). The outward motion of the piston is translated, by means of cam rollers (18) into rotary motion of the cam which, thru bevel gears (19), increases the blade angle. The increase in blade angle is accompanied by a decrease in engine r.p.m. and because of decreased centrifugal force, the governor flyweights move inward under the action of spring (20), lowering the pilot valve until, when the engine is again running at the speed for which the governor is set, the supply of governor oil to the propeller is completely shut off, and the engine continues to run On Speed. The output of the governor pump is now discharged thru the relief valve (21) back into the intake side of the governor.

g. When the engine speed drops below the r.p.m. for which the governor is set, the flyweights move inward, lowering the pilot valve and allowing oil from the inboard end of the cylinder to flow back thru the distributor valve and shaft passages into the governor, where it is discharged, thru governor drain port (22), into the engine nose housing at (23). Under the action of centrifugal twisting moment and engine oil pressure, the blades now assume a lower angle the engine speed increases, and the pilot valve rises due to the outward motion of the flyweights. When the engine has reached the r.p.m. for which the governor is set, the pilot valve again assumes a neutral position, neither admitting oil to, nor draining it from, the propeller cylinder. The forces are now in equilibrium and again the propeller runs on Speed.

h. The sensitivity of the entire propeller-governor system is such that a deviation of two or three r.p.m. from the speed for which the governor is set is sufficient to bring into action the forces necessary to return the system to the On Speed condition.

i. The net pressure available for moving the blades to a higher angle is, of course, the difference between the pressure on the inboard and outboard sides of the piston. This net pressure might vary considerably with variations in engine pressure, were the governor relief valve not balanced to prevent such variations. It will be noted that engine oil is directed to the rear side of the governor relief valve (21), to aid the relief valve spring, at substantially the same pressure under which it enters the outboard end of the cylinder. Thus, the maximum net pressure available to move the piston toward high pitch is approximately equal to that for which the governor relief valve spring is set, and is independent of back pressure in the outboard end of the cylinder.

j. When 6153 or 6139 blades, or other blades having similar centrifugal twisting moment characteristics are used, the relief valve spring is set to deliver a maximum pressure of 180 p.s.i. With 6159 blades, or other blades having relatively higher twisting moments, a 300 p.s.i. spring is used.

k. It will be noted that the distributor valve (24) does not function during constant-speed operation; its ports merely providing passages for the flow of oil to and from the propeller cylinder. Because these same passages are used for feathering and unfeathering pressures, the governor pressure necessarily acts upon the inboard end of the distributor valve (25). The initial compression of the distributor valve (26), which opposes this pressure, is such that a pressure of 200 p.s.i. is required to start to move the valve outward from position shown in Fig. 18 (A) and 400 p.s.i. is required before port (10) is closed by the adjacent land (30) on the distributor valve. Engine oil, at approximately the same pressure as that directed behind the governor relief valve plunger at (21) is led, thru holes in the outer end of the distributor valve, into the spring housing (27) where it assists the spring. The maximum net pressure tending to move the distributor valve outward is, therefore, equal to the value for which the governor relief valve spring is set. Since the maximum setting for this spring is, in any case, 300 p.s.i. and the pressure required to close port (10) is 400 p.s.i., the governor cannot operate the distributor valve; although, in extreme cases, where governor pressures greater than 200 p.s.i. are required momentarily, the distributor valve may move slightly.

l. In engines which incorporate propeller shaft constructions similar to that shown in Fig. 18 it is essential that an air separator plug, equivalent to that shown at (7), be provided. The purpose of this plug is to allow any air, which may collect at the center of the shaft after propeller installation, to be bled from the system thru the governor drain. At the same time, it prevents oil being forced from the shaft, under the action of air and centrifugal force, when the propeller is running in the full low angle position and at a speed lower than that for which the governor is set. These conditions prevail during the "run-up" to test the engine manifold pressure prior to take-off. Without the separator plug, some oil would be lost from the shaft and during the first part of the take-off run, temporary overspeeding might occur until the governor could replace the oil which had been lost and move the blades to a higher angle in the normal manner.

m. Only the steep portion of the cam slots, between their inboard end and the break in the slot profile, is used during constant-speed operation. This portion of the slot provides a blade angle range of 35 degrees; normally from 10 degrees to 45 degrees at the 42 in. radius. The slope of this portion of the cam slot is such that the mechanical advantage of the piston, in translating oil pressure into cam and blade twisting moments, is very high. Neglecting friction of the mechanism, one p.s.i. oil pressure on the piston produces a cam torque of approximately 200 lb. in. and taking into account the 5:4 gear reduction between the cam and the blades this is equivalent to a blade twisting moment of about 83 lb. in. per blade. On the outer, or feathering, end of the slots the mechanical advantage is approximately one-fifth of that of the constant-speed portion of the slope, and here a pressure of one p.s.i. in the cylinder produces a blade twisting moment of approximately 17 lb. in. per blade.

3. Feathering Fig. 18 (B)

a. When using the individual pump system, shown diagrammatically in Fig. 19 the only operation required on the part of the operator to feather the propeller is to depress the propeller control switch (C). This closes the electrical circuit from ground (G), thru battery (B), switch (C) and solenoid switch (S) to ground (F), thus closing the switch at (S) to complete the circuit, G-B-D-S-M-L and start the pump. At the same time, holding coil (H) is energized thru circuit G-B-D-H-E-R. This maintains switch (C) closed without further attention from the operator and the pump continues to run, supplying oil to governor cut-off valve (5), thru external line (28), Fig. 18 (B) At a pressure of approximately 150 p.s.i., valve (5) disconnects the governor from the system by closing the governor port. Simultaneously, the valve connects the pump with the inboard end of the propeller cylinder by means of the identical passages which formerly were used to conduct governor oil to the propeller for constant-speed operation. The piston moves toward the outboard end of the cylinder, and the blades are feathered, at a speed proportional to the rate at which oil is supplied to the cylinder. The pressure in the system during the feathering stroke is determined by the mechanical friction and the blade twisting moment. In any case the pressure is less than 400 p.s.i. since, as noted under "CONSTANT-SPEED OPERATION," 400 p.s.i. is sufficient to close port (10) leading to the inboard cylinder end. During the outward motion of the piston, oil in the outboard end of the cylinder is displaced into the engine lubricating system thru the same passages as during constant speed.

b. Having reached the full-feathered position, further movement of the mechanism is prevented by the positive high angle stops on the rotating cam. The pressure in the inboard cylinder end, and in the passages connecting it with the pump, now increases rapidly and upon reaching a value of approximately 400 p.s.i., opens the pressure cut-out switch (E), Fig. 19 This de-energizes holding coil (H), allowing the control switch (C) to return to the off position.

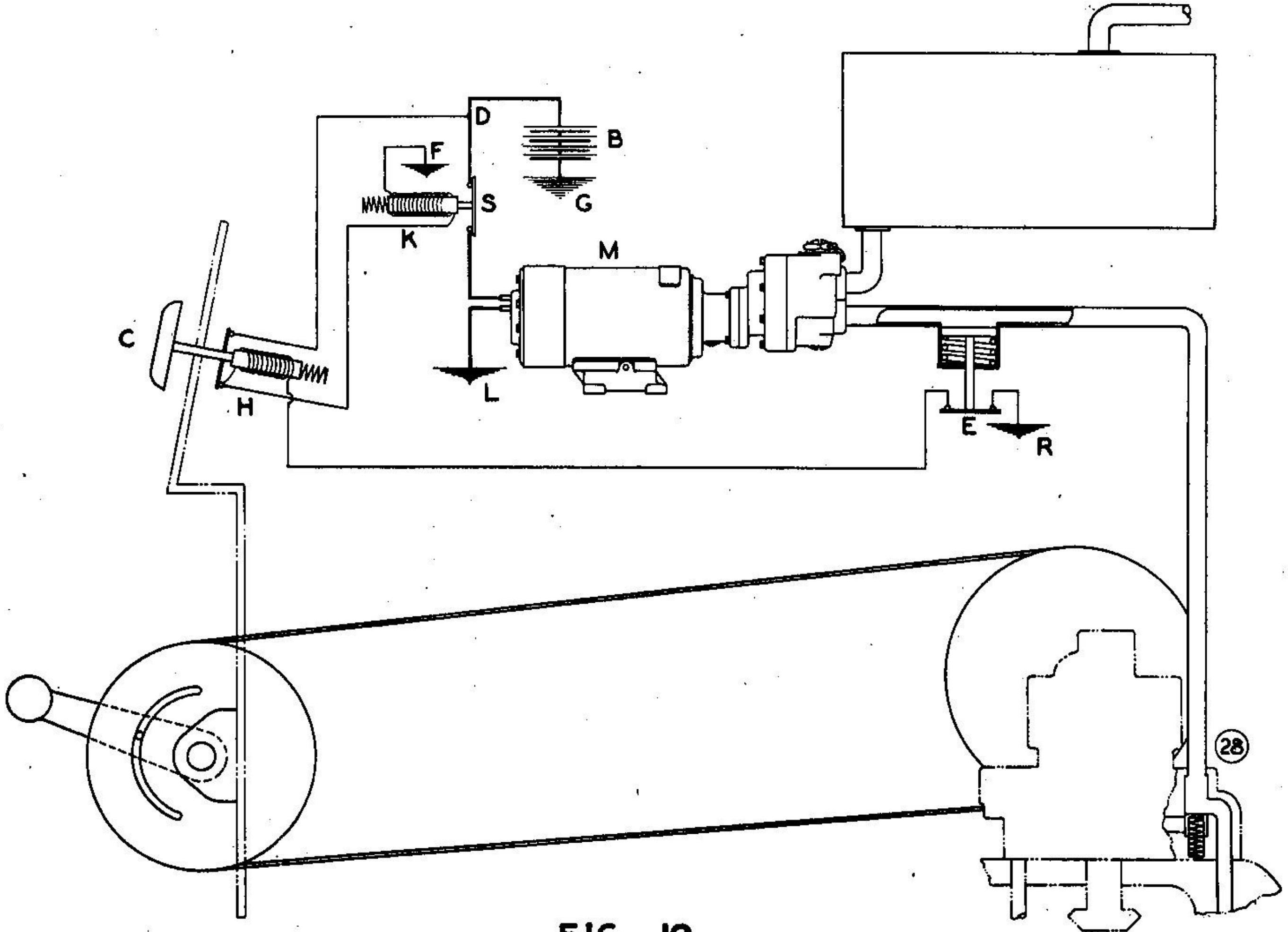


FIG. 19
AUXILIARY CONTROL SYSTEM

This, in turn, de-energizes the coil (K) which breaks the motor circuit and stops the pump. The pressure in both ends of the propeller drops to zero and the propeller remains in the feathered position by virtue of balanced forces on the blades.

c. It will be noted that the distributor valve (24) does not function during the feathering operation. As during constant speed, the spring housing (27) remains connected with the outboard cylinder end. This allows any back-pressure in this end of the cylinder to act also on the outboard end of the distributor valve at (29), assisting the spring (26), and increasing by an equal amount the pressure required at the inboard end of the valve at (25) to close port (10). This insures that a maximum pressure difference of approximately 400 p.s.i. will be available for moving the piston in the feathering direction regardless of the back-pressure it may encounter in forcing the oil from the outboard end of the cylinder into the engine lubricating system.

4. Unfeathering

a. In this case the pump motor circuit is completed in exactly the same manner as during the feathering operation, and the pressure is again delivered to the propeller supply passages and the inboard cylinder end. As this pressure increases thru 400 p.s.i., pressure cut-out switch (E) opens and de-energizes holding coil (H). This, however, does not break the pump circuit, as the operator continues to hold control switch (C) closed. Also, as the pressure in the distributor valve passages increases, distributor valve (24) moves outward against spring (26) under the action of the pressure on its inboard end at (25). When this pressure increases thru 400 p.s.i. land (30) on the distributor valve passes port (10), shutting off the connection between the pump and the inboard cylinder end, and at the same time connecting this end of the cylinder with the engine lubricating system thru ports (10) and (31). As the pressure increases further, the distributor valve continues to move outward until, at 500 p.s.i., land (30) just uncovers port (14) and admits the high pressure oil from the pump to the outboard end of the cylinder. At 600 p.s.i. the valve assumes the position shown in Fig. 18 (C) ports (10) and (14) being full open.

b. With the inboard end of the cylinder connected with the engine lubricating system, and high pressure on the outboard end of the piston, the piston moves inward, unfeathering the blades and forcing the oil on its inboard end into the engine lubricating system. As the blades are unfeathered, they begin to windmill, and unfeathering is assisted by the centrifugal blade moment. When the engine has reached a specified r.p.m. (depending on the blade design, engine-propeller gear ratio and air speed), the control switch (C) is released. This discontinues the high pressure oil from the pump and allows the propeller distributor valve (24), and the governor cut-off valve (5), to return to their normal positions as shown in Fig. 18 (A) The governor is again connected with the inboard end of the cylinder and constant-speed operation is automatically resumed at the r.p.m. for which the governor is set.

c. The dome pressure relief valve (33), Fig. 18 (C) is designed to prevent excessive pressures in the outboard cylinder end, should the propeller be unfeathered until the mechanism reaches the positive low angle stops. In this case the pressure would tend to reach the maximum value capable of being supplied by the pump. The dome relief valve is set to limit this pressure to 300 p.s.i., which is adequate to unfeather the propeller under any conditions. It will be seen from Fig. 18 (C) that, as in the case of the distributor valve and the governor relief valve, the dome pressure relief valve is balanced so that a maximum pressure difference of 300 p.s.i. is available in the outboard cylinder end for unfeathering regardless of the back-pressure which may be encountered by the piston in displacing the oil on its inboard side into the engine lubricating system. This is accomplished by allowing the back- pressure, Fig. 18 (C) to assist the relief valve spring. This relief valve normally would not be called upon to function in flight because, in unfeathering the propeller, excessive windmilling speeds normally would exist before the blades reached the low angle stops and the operator would have shut off the auxiliary pump.

d. The engine oil pressure is used only to assist the blade twisting moment in moving the blades toward low angle, and the entire control of the propeller during constant-speed, feathering and unfeathering is accomplished by means of a single oil passage between the governor base and the propeller. Variations in pressure and volume of the oil flowing in this passage are depended upon to control the propeller.

5. Engine Operation

a. Ground Test of Governing Action - (1) Upon completion of propeller installation the blades should be moved into low angle by means of blade torque arms.

UNFEATHERING THE PROPELLER WITH OIL PRESSURE BEFORE THE ABOVE MENTIONED CHECK FOR PROPER ASSEMBLY HAS BEEN MADE MAY RESULT IN SERIOUS DAMAGE TO THE MECHANISM SHOULD THE DOME ASSEMBLY HAVE BEEN INSTALLED WITH INCORRECT ANGULAR RELATIONSHIP BETWEEN THE ROTATING CAM GEAR AND THE BLADE GEAR SEGMENTS.

(2) With the governor control set to the high r.p.m. position start the engine in the normal manner, warming it up in accordance with existing instructions. Upon starting the engine, the outboard end of the propeller cylinder will fill immediately with engine oil at normal engine pressure. This pressure, combined with the blade centrifugal twisting moment, will hold the blades against the low angle stops.

(3) After completing the engine warm-up, open the throttle to some intermediate engine speed, for example, 1800 r.p.m. Move the governor control to the minimum r.p.m. position. The engine will be turning faster now than the speed for which the governor is set and the governor will supply oil to the inboard slide of the propeller piston. When the inboard end of the cylinder has been filled (which should require from 35 to 45 seconds) the propeller will move toward high angle and the r.p.m. will drop to the minimum governor speed. If the governor control is moved now several times between the minimum governor setting and the 1800 r.p.m. position, all air will be eliminated from the system. The effect of air trapped in the propeller and shaft system is to cause hunting or surging of the governor. The action of centrifugal force on the oil in the propeller throws it to the periphery of the cylinder. This forces any air which may remain in the inboard end of the cylinder to the center of the system where it is expelled thru the governor during the under-speed cycles and replaced with governor oil during the over-speed cycles. Similarly, any air in the outboard end of the cylinder is expelled thru the engine shaft and replaced with engine oil. It is for this reason that moving the governor control thru the quadrant several times will eliminate air from the system and permit accurate governing and rapid response.

(4) The governor control may be moved now to the high r.p.m. position and the throttle opened to make the customary check of engine manifold pressure against engine r.p.m. with the propeller running on the low angle stops.

* b. Checking The Feathering & Unfeathering Control: -

Checking of the feathering and unfeathering controls will be accomplished with the engine stopped and the engine sump drain plug removed so that the oil pumped from the propeller will not collect in the engine crankcase. This check will be made after the engine has been operated and the required oil temperatures have been reached. The oil should be drained in a suitable container and disposed of in accordance with existing instructions covering used oil. Upon completion of the feathering and unfeathering cycle, the engine sump drain plug will be reinstalled and the oil system serviced. *

c. **Feathering and Unfeathering in Flight:** - Starting the auxiliary pump, or otherwise applying high pressure oil to the system, for feathering or unfeathering the propeller automatically disconnects the governor from the system by means of a pressure actuated governor cut-off valve in the base of the governor. Upon reopening the switch, or discontinuing the high pressure oil supply, the governor automatically takes control and adjusts the engine speed to that for which the governor is set. This is true provided the r.p.m. at the time when the high pressure is discontinued, is sufficient to provide adequate control forces toward low angle.

d. **Anti-Icing** - For anti-icing, the cockpit control should be operated to admit the anti-icing fluid to the propeller as directed by the operating instructions for the installation used.

SECTION VI

ACCESSORIES

* 1. This service manual is intended to supply necessary information for inspection, and maintenance of Hydromatic Propellers. *

2. For installation of pumps and accessories, comprising the feathering oil supply system, see installation drawings covering the particular airplane involved.

SECTION VII

INSPECTION, MAINTENANCE & LUBRICATION

1. Service Inspection.

These instructions will be used in lieu of the inspections specified in Technical Order No. 00-20A, except "Pre-Flight."

* a. Column No. 28 - Propellers & Accessories. *

(1) Daily - (a) Inspect for bent or damaged blades.

(b) The exterior of all parts of the propeller will be carefully examined for cracks or other failures.

(c) Check for oil leakage from propeller.

(d) At the completion of each day's flying, clean and oil in accordance with instructions under paragraph 2, Service Maintenance.

(e) If vibration is noted or reported, check the blade angle setting. If necessary, check the track of each blade.

(f) Perform pre-flight inspection as specified in the Handbook for the airplane in which installed.

* (2) 50-Hour - (a) The exterior of all parts of the propeller will be examined for cracks or other failures and for bends, nicks, and other damage. The entire leading edge, trailing edge and tip portion of the blades will be carefully watched for development of cracks. Use a magnifying glass and when the condition of blades warrants, perform local etching. *

(b) Check for deterioration of markings on both the blades and hub.

(c) Check the entire installation for security of mounting, and for proper operation.

* (3) 200-Hour - (4th fifty hour) - Check retaining nut for looseness. Each check will be made with the proper wrench and each nut tightened as required and properly safetied. If repeated tightening of propeller hub retaining nuts is necessary to maintain the proper tightness, the propeller will be removed and the cause ascertained. *

NOTE: Check to see whether or not the propeller is due for overhaul or disassembly.

(4) Special. - (a) As soon as possible after a propeller strikes or is struck by any object, the propeller will be carefully examined for possible damage. A propeller involved in an accident will not be used before it is first disassembled and the parts carefully inspected for damage and misalignment. Specified steel parts will be magnafluxed. The aluminum alloy blades, if otherwise serviceable, will be given a general etching.

(b) If, for any reason, the propeller is removed from the shaft prior to the required overhaul inspection, the propeller hub cone seats, cones, and other attaching parts will be inspected for galling, wear, bottoming, proper fit, etc. Before reinstallation all defects will be corrected. (See T. O. No. 03-20A-1).

(c) The overhaul of these propellers will be performed at the period outlined in T. O. No. 03-20-5. At overhaul each propeller assembly and governor installed will be removed and completely disassembled and all parts thoroughly inspected. All ferrous parts will be inspected by the magnaflux system.

(d) Service Activities not equipped to perform the work will not overhaul these propellers but will arrange with their respective control depot for the accomplishment of this work.

(e) Propellers returned to Control Depots will be properly tagged in order that depot personnel will be able to determine the work to be performed and at all times propellers will be accompanied by Air Corps form No. 61, as contemplated in Air Corps Circular No. 15-61.

* (f) In case an airplane equipped with hydromatic propellers is not to be used for several days, the propeller will be feathered and unfeathered as outlined under Section V, paragraph 5 b. This procedure is recommended in order to remove deposits of carbon or sludge from the propeller control system thereby eliminating the possibility of corrosion of the parts during the period of idleness of this equipment. *

2. Service Maintenance.

a. Coating with Oil. - Immediately after completing inspection and other work following each cleaning or etching, all unoiled surface of blades and hubs will be thoroughly coated with clean engine oil. On completion of each day's flying, all outside surfaces of each propeller involved will be coated with clean engine oil. Exposed surfaces of blades and hubs installed but not in actual service will also be coated with clean engine oil as often as required to prevent corrosion. Coating of propeller blades and hubs with engine oil serves a dual purpose. The oil protects the exposed surfaces of the propeller from rust and corrosion, and also seeps into any crack that might appear in the blade or hub, making the otherwise obscure crack stand out.

b. Cleaning and Polishing of Aluminum-Alloy Blades.

(1) Warm water and soap, gasoline or kerosene, and suitable brushes or cloth, as may be available and practicable, will be used for the cleaning of aluminum-alloy blades.

(2) Except as authorized herein for operations of etching and repair, scrapers, power buffers, steel wool, steel brushes, and any other tool or substance that will scratch or otherwise mar the surface will not be used on such blades.

(3) In special cases where a polish is desired, Commanding Officers may authorize the use of a good grade of metal polish, provided that on completion of the polishing all traces of the polish are immediately removed and the blades are completely coated with a thin film of clean engine oil. This provision is necessary to prevent corrosion by acid contained in the metal polish.

c. Cleaning of Steel Hubs. - Steel Hubs will likewise be cleaned with soap and water, or with gasoline or kerosene, and suitable cloth or brushes. Tools and abrasives that will scratch or otherwise damage the plating will not be used, and under no circumstances will acid or caustic material be used on such parts.

d. Prohibited Use of Caustic Material. - Except in the case of etching, caustic material will not be used on any propeller.

NOTE: The removal of enamel, varnish, etc., from propellers and parts will be accomplished by the use of suitable solvents, such as approved paint and varnish removers.

e. Removal of Cleaning Substances. - All cleaning substances will be immediately removed on completion of the cleaning of any propeller part. Soap in any form will be removed by thoroughly rinsing with fresh water, after which all surfaces will be dried and coated with clean engine oil.

f. Removal of Salt. - As soon as possible after being subjected to salt water, all traces of salt on all parts of propellers will be flushed off with fresh water. All parts will then be thoroughly dried and coated with clean engine oil.

g. Markings.

(1) Blades. - (a) Between the 18 and 24 inch station on the camber side, each blade will bear markings as described in the following: The size of the numbers and letters will be 1/2 inch.

1 Air Corps Serial number.
2 Part of drawing number.
3 Blade angle settings on all blades installed in hub, whether in stock or on aircraft.

(b) The foregoing data will be painted or stenciled with black enamel, or stamped with a rubber stamp and printer's ink. In no instance will such markings be indented or cut into the metal. The markings will be protected by a coat of spar varnish or clear lacquer.

(c) No decorative markings or coating of any nature will be placed on propellers except when required for night flying and other flights in which propeller glare is objectionable. (Manufacturers' trade marks are not considered decorative). In such cases the flat side of blades extending from the 24 inch station to the tip may be coated with maroon lacquer, Spec. No. 3-158. No primer coating will be necessary. The lacquer can be brushed on when thinned with butyl, or amyl acetate. For spraying, application dope thinner, Spec. No. 3-154 should be used, when thinning is necessary. If lacquer is not available A. N. maroon enamel, Spec. No. 3-98 may be used. Before applying lacquer or enamel, the surfaces to be coated will be thoroughly cleaned of all grease or oil, with a final cleaning with dope thinner immediately prior to applying the lacquer or enamel coating. After the coatings have dried, the propeller will be checked for balance. Any unbalanced condition caused by the application of the finishes will be eliminated by adding lacquer or enamel to the coated surface of the light blade.

(2) Hubs. - Propeller hubs being furnished by the Contractor will have the part or drawing number applied by etching.

h. Repair--Maintenance.

(1) Local Etching. - (a) The purpose of local etching is to determine whether visible lines and other marks within small areas of the blade surfaces are actually cracks instead of slight scratches, etc.

(b) Determine with a minimum removal of metal, when shallow cracks and doubled-back edges of metal have been fully removed. Expose cracks that are not apparent without etching.

(c) Provide a simple means for accomplishing this work, without removing or disassembling the propeller.

(d) Caustic solution for local etching will be prepared locally by adding to the required quantity of water, as much commercial caustic soda as the water will dissolve. The quantity of solution will depend on the amount of etching to be done. Glass or earthenware containers of convenient size will be used for such solutions.

(e) Any activity may accomplish local etching whenever necessary. The operations to be performed are as follows:

1 With #00 sandpaper, clean and smooth off the area containing the apparent defect. With a small swab or

stick apply to the suspected area a small quantity of caustic solution.

2 After the area is well darkened thoroughly wipe it off with a clean cloth dampened with clean water. Too much water may remove the solution from a defect and thereby spoil the check.

3 If a crack or other defect extending into the metal exists, it will appear as a dark line or other mark, and with the use of a magnifying glass, small bubbles may be seen forming in the dark line or mark.

4 Several applications of the caustic solution may be necessary to determine when all the shallow cracks and doubled-back edges of metal have been removed. However, immediately on completion of the final checks, all traces of the caustic soda will be removed with nitric acid solution, which, in turn, will be thoroughly rinsed off with clean water. The blade will then be dried and coated with clean engine oil. See Paragraph 42 of T. O. No. 03-20A-1 for preparation of acid solution.

NOTE: General etching will be accomplished only at Repair Depots.

(2) General. - (a) To avoid dressing off an excess amount of metal, checking by local etching will be accomplished at intervals during the progress of removing cracks and double-back edges of metal.

(b) Suitable sandpaper or fine cut files may be used for removing the necessary amount of metal, after which, in each case, the surfaces involved will be smoothly finished with No. 00 sandpaper. Each blade from which any appreciable amount of metal has been removed will be properly balanced before it is used.

(c) Cracks, cuts, scars, scratches, nicks, etc., will be removed or otherwise treated as explained herein, provided their removal or treatment does not materially weaken the blade, materially reduce its weight, or materially impair its performance.

(d) The metal around longitudinal surface cracks, narrow cuts, and shallow scratches will be removed to form shallow saucer-shaped depressions as shown in Fig. 20 (View C). Blades requiring the removal of metal forming a finished depression more than 1/8 inch in depth at its deepest point, 3/8 inch in width overall, and one inch in length overall, will be condemned.

(e) The metal at the edges of wide scars, cuts, scratches, nicks, etc., will be rounded off and the surfaces within the edges will be smoothed out as shown in Fig. 20 (View B). Blades that require the removal of metal to a depth of more than 1/8 inch and a length of more than 3/4 inch overall will be condemned.

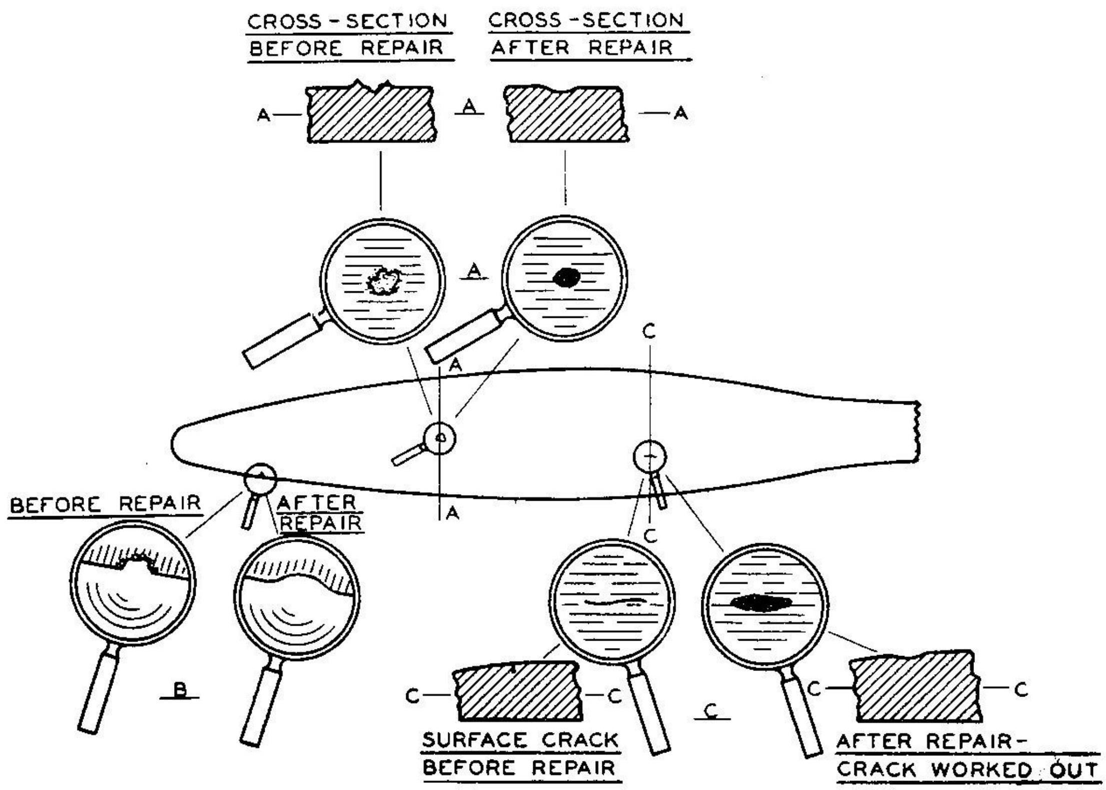


FIG. 20 - METHOD OF REPAIRING SURFACE CRACKS, NICKS, ETC.

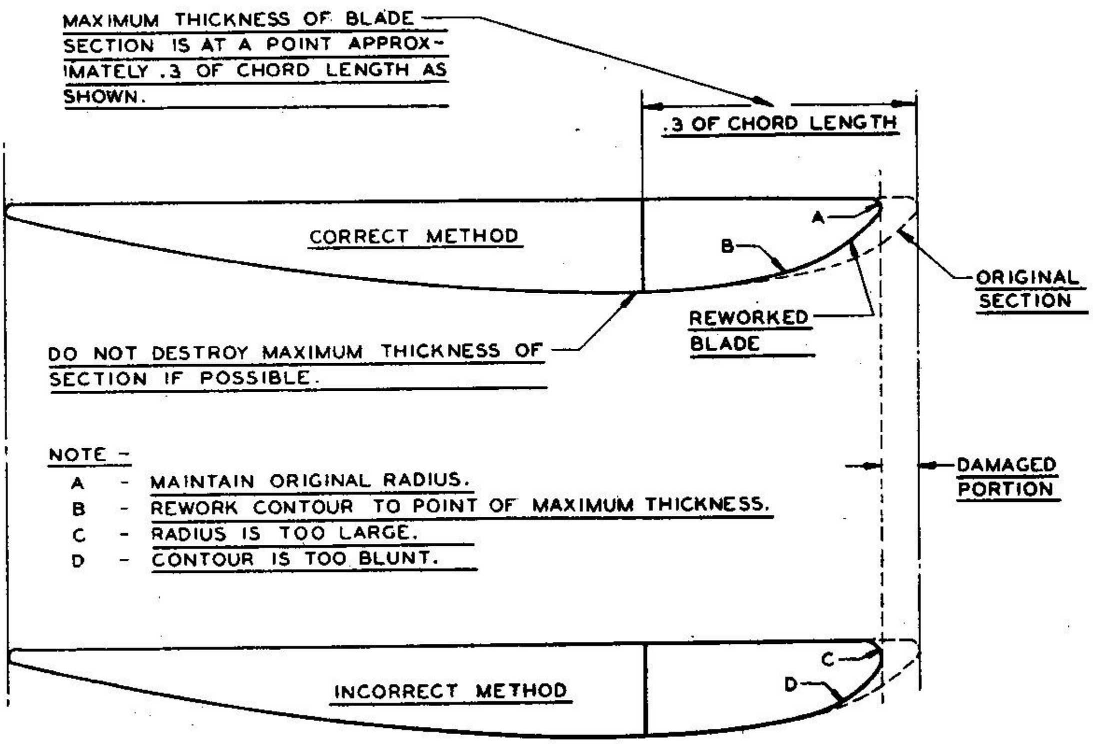


FIG. 21 - CORRECT & INCORRECT METHOD OF REWORKING LEADING EDGE

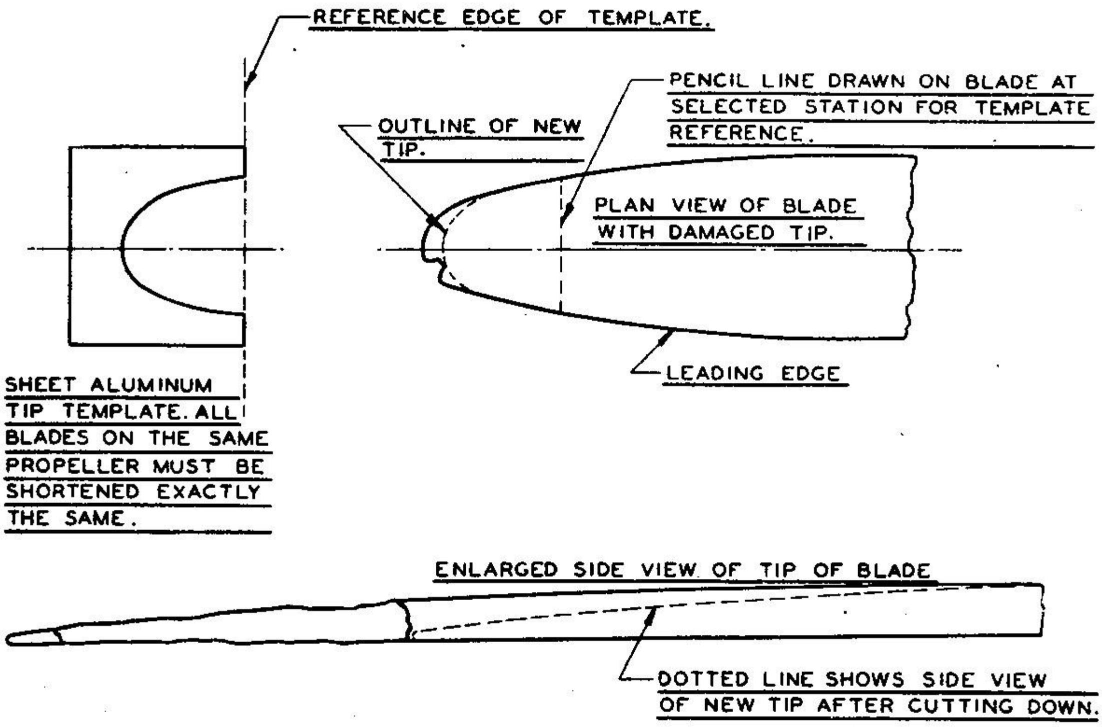


FIG. 22 - METHOD OF REPAIRING DAMAGED TIP

(f) Raised edges at wide scars, cuts, nicks, etc., will be carefully penned down to reduced the area of the defect and the amount of metal to be removed as shown in Fig. 20 (View A).

(g) With the exception of cracks, it is not necessary to completely remove or "saucer out" all of a comparatively deep defect. Properly rounding off the edges and smoothing out the surface within the edges is sufficient, as it is essential that no unnecessary amount of metal be removed.

(h) More than one defect falling within the above limitations is not sufficient cause alone for rejection of a blade. A reasonable number of such defects per blade is not necessarily dangerous, if within the limits specified, unless their location with respect to each other is such as to form a continuous line of defects that would materially weaken the blade.

(i) Blades that have the leading edges pitted from normal wear in service may be reworked by removing sufficient material to eliminate the defects. In this case, the metal will be removed by starting at approximately the thickest section, as shown in Fig. 21, and working forward over the nose camber so that the contour of the reworked portion will remain substantially the same, avoiding abrupt changes in section or blunt edges.

(j) When the removal or treatment of defects on the tip necessitates shortening a blade, each blade used with it will be likewise shortened. Such sets of blades will be kept together (See Fig. 22 for method used). Whenever the performance of a propeller has been materially impaired by shortened blades, it will not be used pending receipt of instructions from the Chief of the Materiel Division.

(k) No attempt will be made to straighten a bend that extends more than 8" in from the tip of the blade without specific authority from the Chief of the Materiel Division in each case. Straightening of other repairable bends in aluminum-alloy blades will be accomplished, at depots only, by pressing with blocks shaped to reform the blade into its original alignment. Hard wood is preferable for these blocks. Under no circumstances will harder material be placed in contact with the blade for the purpose of straightening, and no heat will be applied. After straightening, the affected portion of the blade will be etched and thoroughly inspected for cracks and other flaws.

i. Condemnation. - (1) Defects that are definitely identified as slag inclusions or cold shuts will not be considered cause for condemning a blade, unless such defects are excessively numerous.

(2) Unless otherwise specified herein, a blade having any of the following defects will be condemned.

(a) A longitudinal crack, cut, scratch, scar, etc., that cannot be dressed off or rounded out without materially weakening or unbalancing the blade or materially impairing its performance.

(b) Unserviceability due to removal of too much stock by etching, dressing off defects, etc.

(c) An excessive number of slag inclusions or cold shuts or an excessive number of both.

(d) A transverse crack of any size.

j. Disposition

(1) Propellers and Parts.

(a) General. - Unless otherwise specified, all propellers, blades, hubs and attaching parts (except those on service test) that are worn out through fair wear and tear, or damaged beyond economical repair will be disposed of in accordance with existing instructions.

(b) Blades to be Reported to Materiel Division. - Each blade having the following defects will be reported to the Chief of the Materiel Division, and, unless otherwise specified, will be held pending receipt of disposition instructions. In each case the Air Corps serial number, if any, and the part or drawing number will be given. In the case of any bend, more than 8" in from the tip, the report will be accompanied by a sketch or photograph showing the approximate length of the bend and its smallest radius.

1 Any crack or other failure that, within the provisions of this Order, is not removable or repairable and is not directly due to a crash or other form of collision.

2 Unserviceability due to removal of too much metal by etching, dressing off defects, etc. Such blades need not be held for disposition instructions, but will be mutilated to an extent that will prevent possible repair.

3 Materially impaired performance due to shortening of blade. An excessive number of slag inclusions. An excessive number of cold shuts. A bend at any point more than 8" from the blade tip. A bend whose radius at any point is less than 12".

4 When blades or hubs damaged beyond repair are disposed of, a copy of the Air Corps Form 61, listing all data covering such blades or hubs, will be forwarded to the Materiel Division as contemplated by A. C. Circular 15-61.

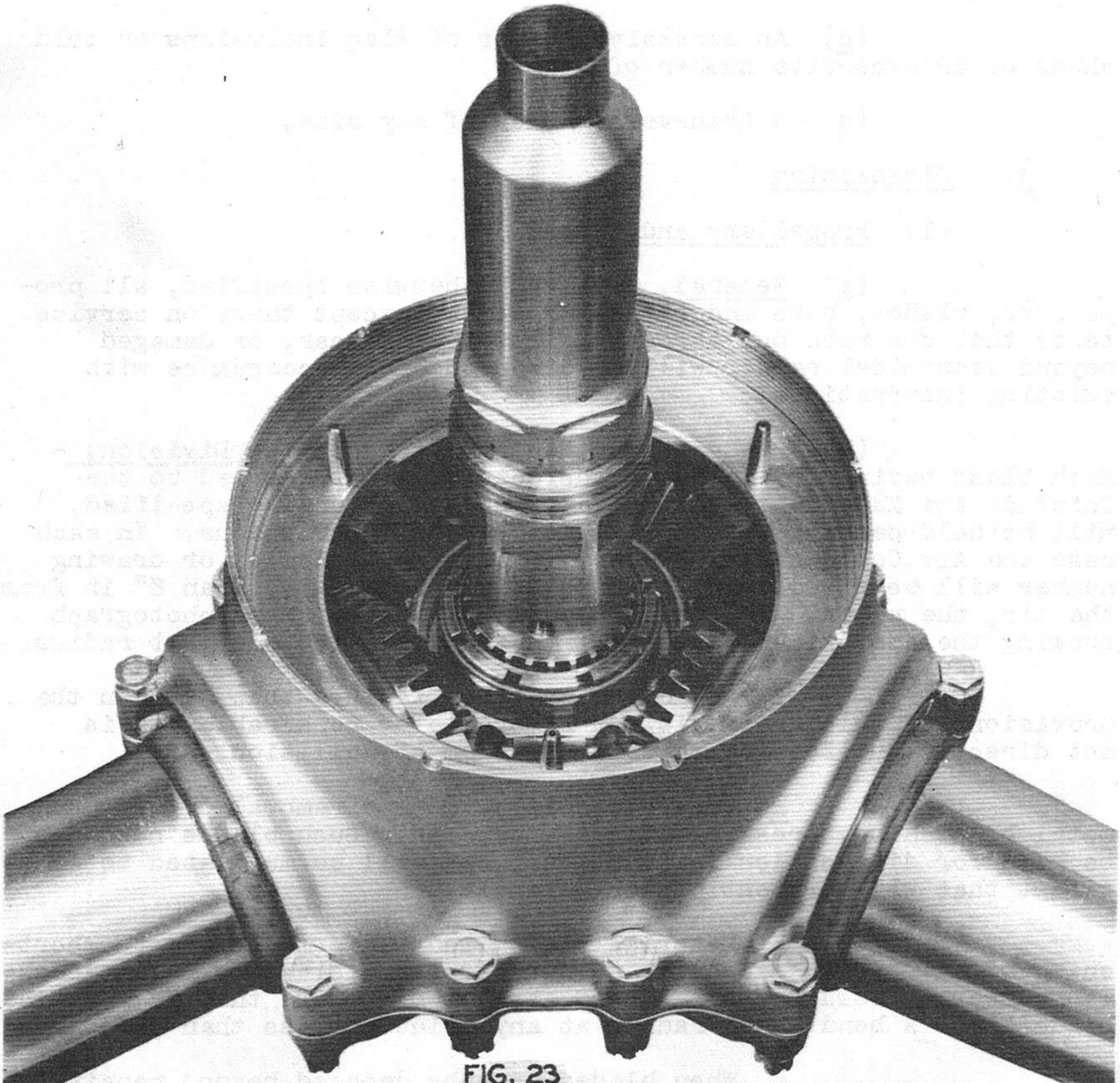


FIG. 23
HUB ASSEMBLY AND DISTRIBUTOR VALVE ASSEMBLY WITH BREATHER TUBE
(FOR ENGINES BREATHING THRU PROPELLER SHAFT)

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3. <u>Lubrication</u>

The operating mechanism is fully enclosed and lubricated by engine oil pressure, consequently, special or periodic lubrication, other than the oiling specified in paragraph 2, Service Maintenance, is not necessary.

SECTION VIII

DISASSEMBLY, INSPECTION, REASSEMBLY AND FINAL TEST

NOTE: For special tools necessary to overhaul this equipment see Tools listed at the end of this section.

The work prescribed herein may be performed by service activities having facilities and properly trained personell.

1. Disassembly.

a. Hub. (1) Before placing the hub assembly on the bench spindle, remove the barrel and spider packing lock ring, retaining ring, gland ring and spacer. Remove the packing.

(2) Place the unit on the assembly spindle.

(3) Remove all barrel bolts.

(4) Split the barrel halves about .010" at the parting line by driving aluminum wedges in the tapered reliefs at each blade bore.

(5) Remove the blade packing nut locks, unscrew the nuts, and remove the packing.

(6) Remove the front and rear barrel halves by wedging them apart as above and, if necessary, driving them off with a non-metallic mallet.

CAUTION: Be careful not to mar or scratch the parting surfaces of the barrel. Sharp edges adjacent to blade oil seals should be carefully preserved.

(7) Remove the blades, barrel supports, and the phenolic spider ring.

(8) Remove the snap ring, retaining nut, front cone, oil seal and oil seal washer from the spider.

(9) Remove the shim plates, shims, gear segments, and spring packs from the blades.

b. Dome. - (1) Remove the dome barrel oil seal.

(2) Lift out uppermost stop ring.

(3) Lift out the lower ring stop.

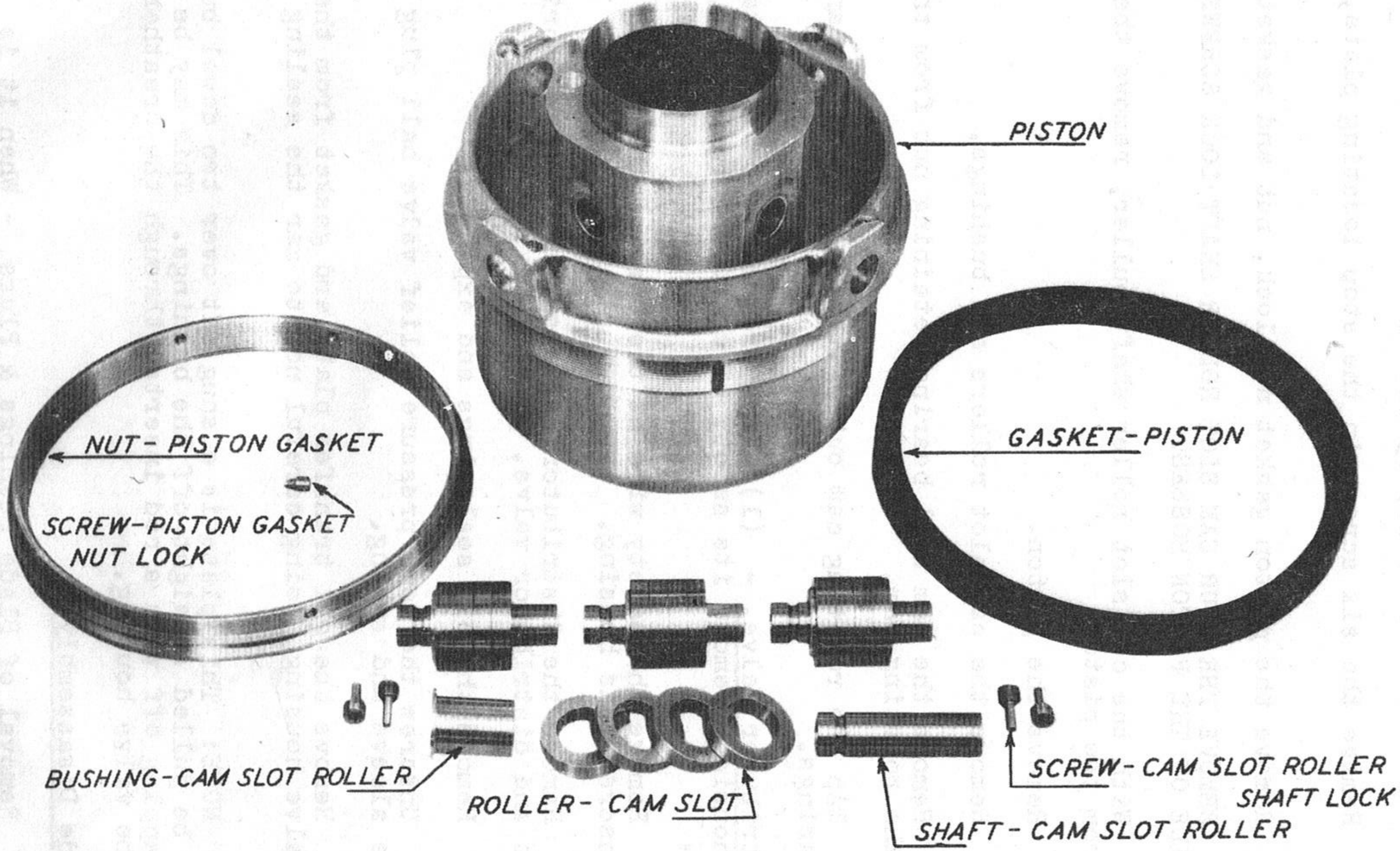

FIG 24 - PISTON ASSEMBLY PARTS

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(4) Remove the six screws in the stop locating plate, and stops.

(5) Remove the piston gasket nut lock, nut and gasket.

(6) REMOVE THE FOUR CAM SLOT ROLLER SHAFT LOCK SCREWS IN THE REAR SIDE OF THE PISTON BOSSES.

(7) With the cam slot roller shaft puller, remove the four shafts from the piston.

(8) Remove the piston.

(9) Remove the cam slot rollers and bushings.

(10) Remove the cam ball bearing retaining nut from the front end of the rotating cam.

(11) Tap the rotating cam out of the stationary cam and remove the bearings.

c. Distributor Valve. - (1) If a breather tube is installed on the valve housing, remove its safety wire and unscrew the breather tube.

(2) Remove the safety wire at the base of the spring housing and unscrew this housing.

(3) Remove the distributor valve spring, washer, spring housing gasket and distributor valve.

(4) Remove the oil seal rings and expanders.

(5) Unscrew the dome pressure relief valve ball plug and remove the sleeve and spring.

(6) Remove the oil transfer plate and gasket from the base of the valve housing, being careful not to mar the sealing surfaces.

NOTE: This plate is a snug fit over two dowel bushings and must be pulled straight off the bushings. This may be assisted by tapping off with a rod inserted through the breather passages in the valve housing.

d. Blade Disassembly.

(1) Removal of Blade Bushings & Plugs. - When it is necessary to replace either a blade bushing or a plug, the following is required:

(a) Hot water or oil bath for the heating of blade shank. (If water is used the temperature should be about (212° F.), 100° C., and if oil is used a temperature of (275° F.) 135° C., should be maintained.

Puller, blade bushing, No. 35D2742
Inserter, blade bushing, No. 35D2886
Holder, tap (1/2" pipe thd. tap) No. 35B3165
Tap, 1-1/2" standard pipe thread
Puller, oil seal plug, No. 35B3161
Drift, balancing plug inserting, No. 35B3488
Puller, balancing plug, No. 35B3161

(2) Removal of Blade Bushing. - First remove locking screws. Next install puller tool No. 35D2742, being sure that the flange on the split bushing No. 35A2747, is properly seated in the relief at the end of the large bearing.

(a) Tighten puller screw nut a sufficient amount to hold tool securely in place while shank end of blade is submerged in the hot water bath. After the blade has been thoroughly heated, remove from the bath, and while still hot, tighten puller screw nut until bushing has been loosened or freed from taper.

(3) Removal of Oil Seal Plug. - Submerge blade end in cold water to cool for handling. Enter standard 1-1/2" pipe thd. clamped in tap holder Part No. 35B3165 in the inside of plug; cut enough threads to permit oil seal plug puller, No. 35B3161, to be screwed in place securely enough to grip plug when same is being removed from blade.

(a) Install puller in blade and plug and tighten puller nut enough to secure it in place while blade is submerged in the bath of hot water. Remove blade and tighten puller screw nut until blade plug taper breaks loose from blade.

(b) It would be advisable to secure the blade bushing puller as well as the oil seal plug puller to the blade by means of wiring to the blade as in some cases the blade bushing or plug loosens from the blade while in the hot water, and, if this should happen the assembly would drop to the bottom of the tank.

(4) Installation of Blade Plugs and Blade Bushings. - Heat shank end of blade in a bath of hot water, and at the same time, cool the bushing and balancing plug in a bath of cold water. When the blade is sufficiently hot, thoroughly dry the tapered hole, enter the plug and tightly tap it to its seat with hammer and drift, Part No. 35B3488.

(a) Next enter blade bushing, placing dowels in proper blade and bushing dowel holes. Tap bushing and dowels in place until properly seated. Install inserter tool, No. 35D2886, and tighten down on pusher screw until bushing is firmly seated, tap in dowels until they are also seated. Submerge assembly in bath of cold water and when blade is thoroughly cooled, remove. Tap pusher screw several times to insure having the bushing firmly seated against the shoulder. Remove tool and install bushing screws, staking the bushing material over in the slots of the screws when they have been firmly screwed into place.

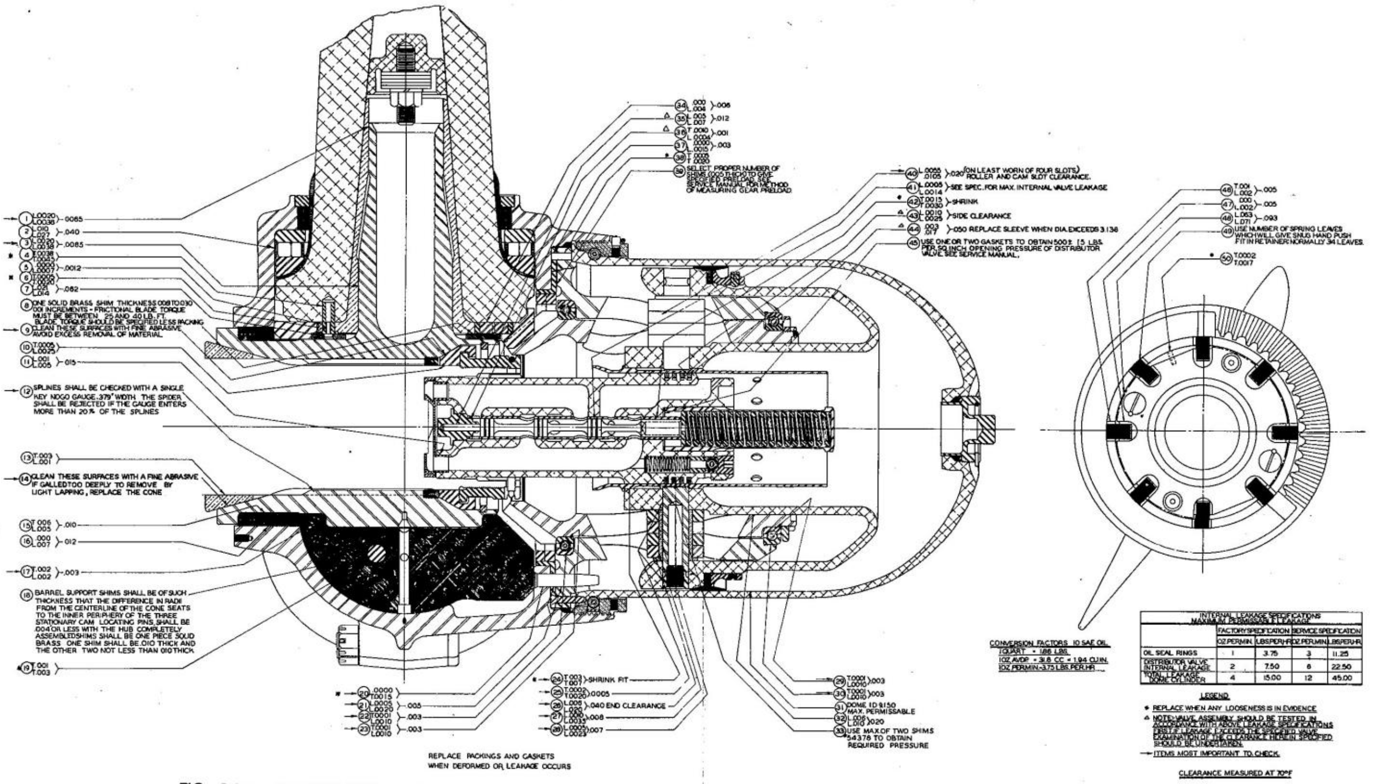
2. <u>Inspection.</u>

a. Thoroughly clean and carefully inspect all parts of the propeller for excessive wear and defects. Inspect the following steel parts by the magnaflux method, examining carefully to determine if any fatigue cracks have developed.

Barrel--Front Half
Barrel--Rear Half
Bolt--Barrel
Nut--Barrel Bolt
Spider
Washer (race)--Thrust Bearing, Flat
Washer (race)--Thrust Bearing, Beveled
Gear Segment--Blade
Cam--Stationary
Cam--Rotating
Roller--Cam
Shaft--Cam Roller
Stop Rings--Positive High and Low Angle
Shaft--Drive Gear (Constant-Speed Control)
Gear--Idler Pump (Constant-Speed Control)

b. It will probably be found that the shim plates, as well as the spider arms, have galled or chafed spots. These should be lightly dressed by stoning or polishing. The brass deposits on the bearing surfaces of the arms of the spider should be removed. The rear cone seat should be inspected for galling and lapped if necessary as outlined in T. O. No. 03-20A-1. Each blade will be thoroughly inspected, and all defects found will be corrected as outlined under Section VII. In addition, the blade bushings will be checked for wear, galling, or looseness. If it is found that the diameters of the blade bushing bearings are greater than "E" size shank, small bearing 2.1298 inches, large bearing 2.6303, it will be necessary to remove the bushing and replace it with a new one.

c. For allowable clearances, refer to Clearance Chart Figure 24A.



CONVERSION FACTORS 10 SAE OIL
1 QUART = 1.86 LBS.
1 OZ. AVDP. = 31.8 CC = 1.94 CU. IN.
1 OZ. PER MIN. = 3.75 LBS. PER HR.

INTERNAL LEAKAGE SPECIFICATIONS MAXIMUM PERMISSABLE LEAKAGE				
	FACTORY SPECIFICATION		SERVICE SPECIFICATION	
	OZ. PER MIN.	LBS. PER HR.	OZ. PER MIN.	LBS. PER HR.
OIL SEAL RINGS	1	3.75	3	11.25
DISTRIBUTOR VALVE INTERNAL LEAKAGE	2	7.50	6	22.50
TOTAL LEAKAGE DOME CYLINDER	4	15.00	12	45.00

LEGEND

- * REPLACE WHEN ANY LOOSENESS IS IN EVIDENCE
- △ NOTE: VALVE ASSEMBLY SHOULD BE TESTED IN ACCORDANCE WITH ABOVE LEAKAGE SPECIFICATIONS FIRST. IF LEAKAGE EXCEEDS THE SPECIFIED VALVE EXAMINATION OF THE CLEARANCE HEREIN SPECIFIED SHOULD BE UNDERTAKEN.
- → ITEMS MOST IMPORTANT TO CHECK.

CLEARANCE MEASURED AT 70°F

FIG. 24A - CLEARANCE CHART

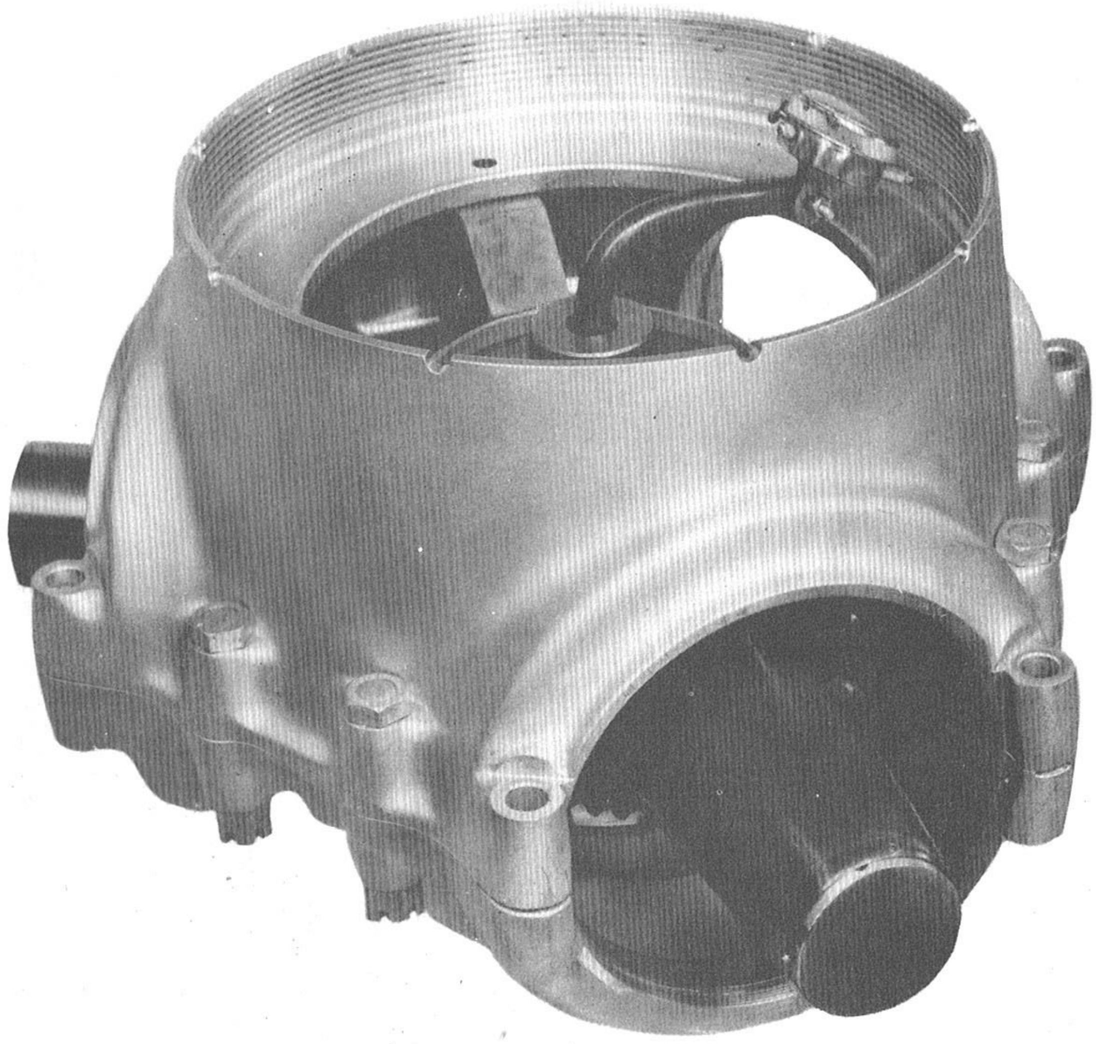


FIG. 25 - *INDICATOR FOR CHECKING BARREL AND SPIDER ALIGNMENT*

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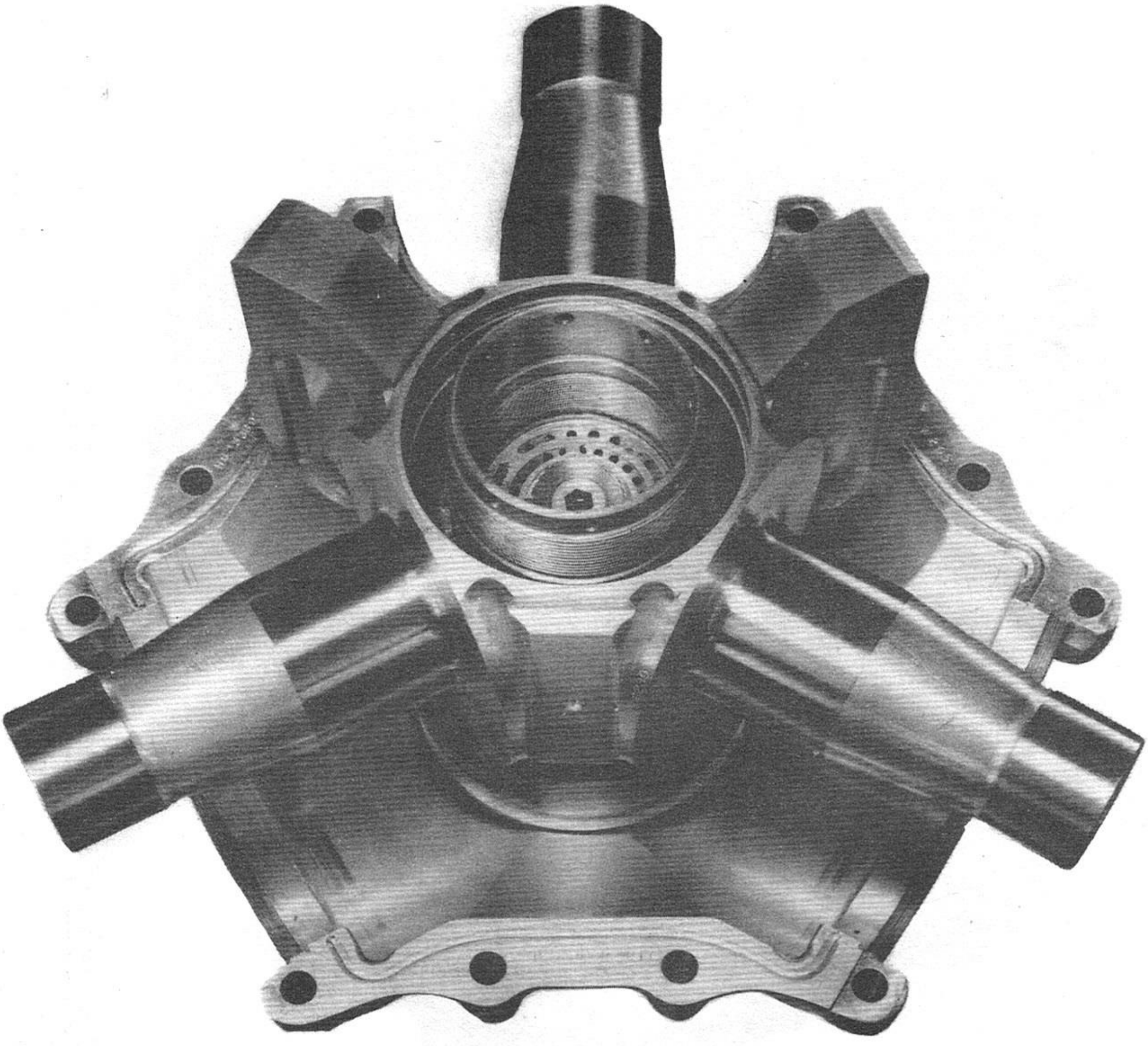

FIG. 26 - SPIDER, BARREL (REAR HALF) AND BARREL SUPPORTS

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Clearance Between	Clearance Limit New Part	Replacement Required When Exceeds Clearance
Blade Bushing and Spider Arm	L.002 to L.0035	L.006
Cam Slot Roller and Cam Slot	L.0055 to L.0105	L.020
Cam Slot Roller and Bushing	L.001 to L.0035	L.008
Cam Slot Shaft and Bushing	L.0005 to L.0025	L.005
Cam Slot Shaft and Piston	L.0005 to T.0015	L.001

NOTE: L. denotes Loose Fit
T. denotes Tight Fit
Clearances are taken at 21° C., (70° F.)

3. Reassembly--Propeller.

NOTE: When assembling the Hydromatic Propeller, the following steps should be carried out in the order listed. Before assembly, all parts of the propeller will be cleaned and carefully inspected and all defective parts replaced. The various component parts of the propeller assembly are numbered to indicate their relative location on the spiders. It is imperative that these parts be installed in the position indicated by these numbers in order to obtain proper fit and balance of the assembly.

a. Barrel and Spider Alignment.

NOTE: When replacing barrel blocks, the following check will be made.

(1) Install a splined sleeve in the spider.

(2) Insert the flange of the propeller retaining nut in the corresponding grooves in the split front cone and install this assembly in the spider. Run the nut down snugly on the sleeve using tubular wrench with composite wrench.

(3) Install the split phenolic spider ring in the recess near the bottom of the spider in such a manner that the three flats on the ring register with the shim plate bearing surfaces on the spider.

(4) Coat three .005" barrel support shims with grease and place them on the spider between the arms.

(5) Install the three barrel supports over these shims with the flat ends toward the front of the spider.

(6) Place the spider assembly in the rear half of the barrel and install the front half of the barrel over it.

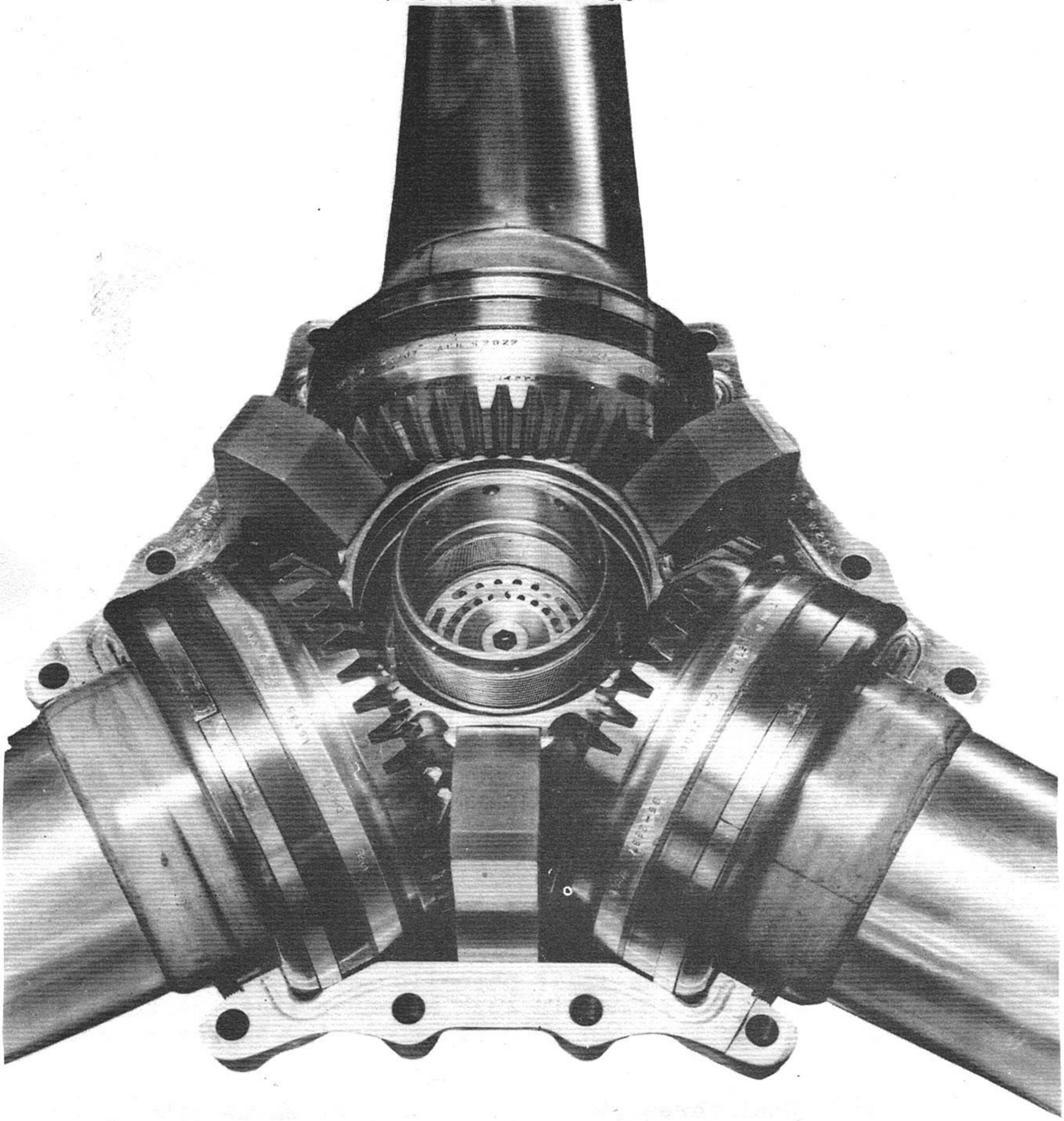

FIG. 27
SPIDER, BARREL (REAR HALF), BLADES AND BARREL SUPPORTS

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NOTE: The barrel and spider should be assembled so that the numbers 1, 2, and 3 on the parting surface of each barrel half at the blade sockets correspond with the same numbers on the spider arms.

(7) Secure the barrel halves together with six barrel bolts, two center bolts on each side of the barrel drawn up tightly.

(8) With an indicator, check the concentricity of an arbor through the splined sleeve with the inside surface of the front barrel half just forward of the dome shelf. The concentricity *must not exceed .004" full indicator reading. Adjustment is obtained by varying the barrel support shim thicknesses. For the final assembly, one solid shim, of thickness not less than .010", * is to be used under each support block. These shims may be obtained in .001" increments from .005" to .015".

(9) Number the blocks and shims 1, 2, and 3 in counterclockwise rotation starting with No. 1 between spider arms No. 1 and No. 2 and stamp the same numbers on the top chamber of the spider.

(10) Remove the arbor and install the assembly on the assembly post.

(11) Remove the front half of the barrel and drop the rear half.

b. <u>Blade and Gear Segment Assembly.</u> - (1) Check the blade bushings to be sure that they are properly installed in the blades.

CAUTION: Although the blade bushing appears symmetrical about its central axis, actually two of the spring pack slots are offset in order to preload the gear teeth. For this reason, there is only one angular position in which the bushing may be installed for a given type propeller. The same blade bushing may be used for any of the following combinations but it is absolutely essential that its position be as follows:

(a) For a right-hand screw, tractor propeller, on a right-hand engine, the bushing must be installed so that the locating arrow on the face of the bushing flange is aligned with the words "Tractor Blade" stamped on the blade butt.

(2) Install the shim plate drive pins in the holes in the blade bushing drive pins; two in each blade. These should be a light drive fit.

(3) Drive the thrust plate pin into the thrust plate,

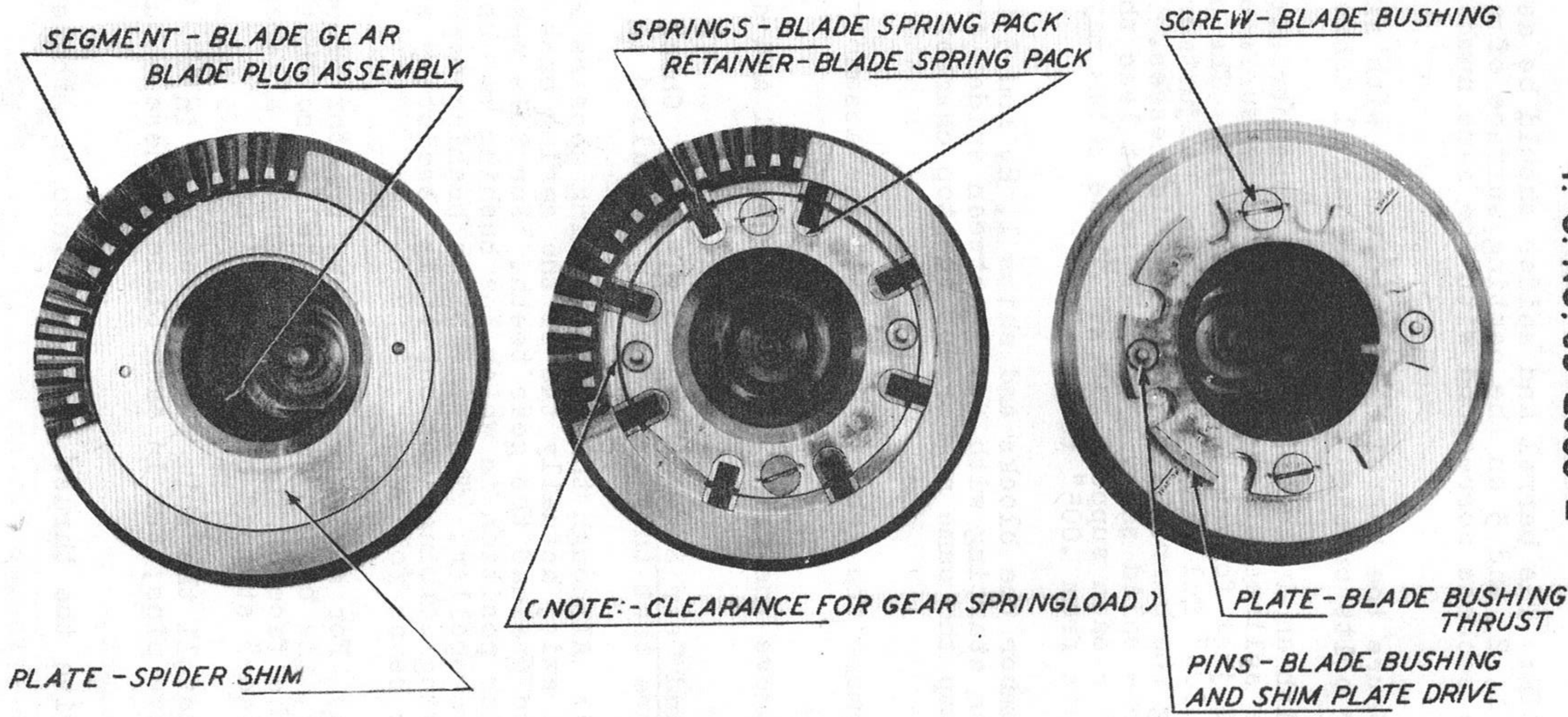

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FIG. 28 - BLADE BUSHING AND GEAR SEGMENT ASSEMBLY

place the thrust plate on the flat of the blade bushing flange and tap it into place so that the pin is flush with or slightly below the curved surface of the thrust plate.

NOTE: The thrust plate is not symmetrical and hence, if it is not properly installed, one end will overhang one of the bushing spring pack slots.

NOTE: Although there are two flats on each blade bushing, only one thrust plate per blade is required and should be placed toward the flat side of the blade on tractor propellers and toward the cambered side of the blade on pusher propellers.

(4) Thoroughly clean all spring leaves to remove any grit, and lubricate them with engine oil. Assemble 34 (See Note) spring leaves in each pair of spring retainers.

NOTE: Due to manufacturing tolerances, the number of leaves required to give the proper fit in the spring retainers will vary slightly. In any case, there should be used only a sufficient number of leaves to give a snug sliding fit of the retainer over the spring leaves. In no case will an attempt be made to force too many leaves into the retainer.

(5) Install the spring packs in the blade gear segments.

(6) Install the gear segments on the blades so that their numbers correspond with those of the blades, and so that the arrow on each segment is in alignment with the arrow on each blade bushing. Tap the spring packs into place, using a brass drift.

(7) Select a .015" shim for each blade, and install on the blade bushings over the shim plate drive pins. The purpose of these shims is to regulate the clearance between the blade thrust bearing assembly and the barrel to compensate for manufacturing tolerances. Therefore, the proper shim thickness to give the specified blade torque must be determined at assembly by trial. It has been found that a shim of .015" thickness is quite likely to give the proper torque and this thickness is recommended for the first trial assembly. After the proper torque has been obtained, number the shims to correspond to the blade numbers and remove any high spots caused by the numbering. Only one shim should be used in each blade assembly.

(8) Coat the shim plates with grease and install one on each blade over the above shims. It is essential that the shim be installed as indicated, that is, between the shim plate and the flange of the blade bushing. Make sure that the number on the shim plate corresponds with the blade number.

c. Assembly of Hub and Blades. - (1) With the top half of the barrel removed and the bottom half lowered, install the blade

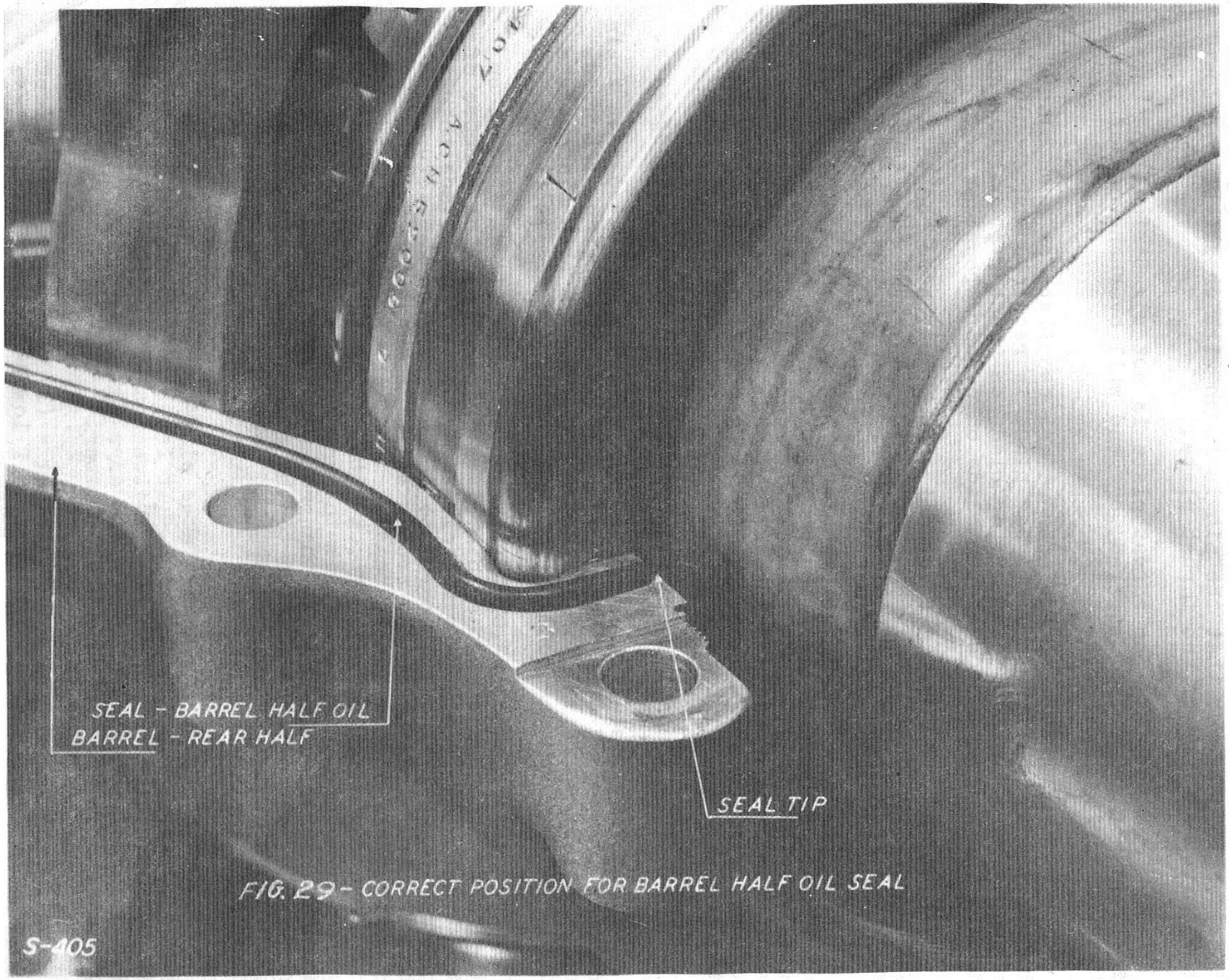

FIG. 29 - CORRECT POSITION FOR BARREL HALF OIL SEAL

assemblies on the proper spider arms, which are numbered, 1, 2, and 3 to correspond to the blade numbers. See that the "0" etched on the inside thrust race on each blade is aligned with the "0" stamped on the blade butt flange.

CAUTION: Before pressing the blades against the spider shim plate bearing bosses, be sure that the shims and shim plates are in their proper places over the shim plate drive pins.

(2) Install the thrust bearings between the thrust bearing races on the blades, two half bearings on each blade. These bearings are interchangeable among the blades.

(3) While holding the thrust bearings in place, raise the rear half of the barrel, making sure that the barrel and spider markings are in the proper relation. The barrel should be a light drive fit over the bearing races. After properly starting the barrel over the races, drive it into place with a non-metallic mallet.

(4) Lay the barrel seals in the grooves provided in the rear barrel half, making sure that the small tips on the ends of the seals are entered in the 1/32" diameter grooves at each blade socket. *When installing this part, the necessary precautions will be taken to insure the tip of the seal does not protrude into the plate socket. If this condition is found, cut off that portion of the seal protruding into the barrel. Care should be taken to maintain the * sharp edges of the parting surfaces of the barrel adjacent to the blade packings to insure perfect oil seal.

(5) Install the front barrel half in the proper angular position and drive it down until there is about 1/2" clearance between the barrel parting surfaces.

(6) Install the 12 barrel bolts which are numbered to correspond to the numbers on the spotfaces on the barrel The three long bolts, one of which is adjacent to the leading edge of each blade, hold the anti-icer discharge nozzles. When no anti-icer is installed, two washers are used on each of these three bolts. The remaining nine bolts are installed without washers.

(7) Check the barrel seals to be sure that they are in place and draw the barrel halves together tightly with the bolts. Tighten first the two center bolts on each side.

CAUTION: Avoid tightening the three barrel bolts which retain the blade seal nut locks excessively without the locks in place in order to prevent possible springing of the barrel.

ø (8) Check the frictional blade torque, which must be between 25 and 40 pound feet; that is, between 12-1/2 and 20 pounds force on a lever arm two feet from the center line of the blade, at the 42" station.

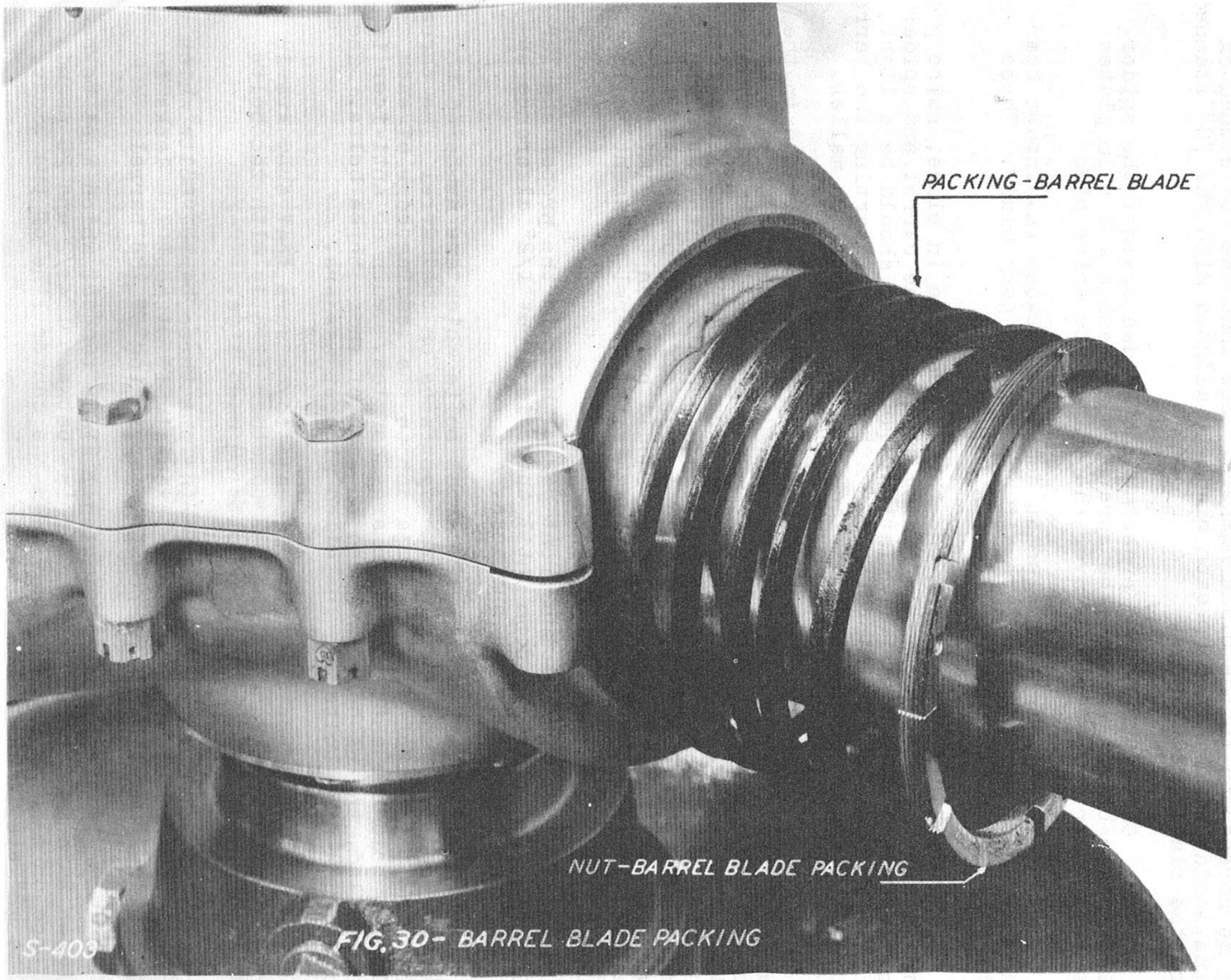

FIG. 30- BARREL BLADE PACKING

NOTE: If the torque of each blade does not fall between these limits, make appropriate changes in the shim thicknesses under the blade shim plates until the torque is within the limits.

(9) Loosen the barrel bolts and spread the barrel halves about .010" at the parting line.

(10) Thoroughly coat each ring of the blade packing with engine oil and insert in the space provided between the barrel and the blade chafing ring.

(a) The split ring of triangular cross-section (header ring) enters first with the flat side toward the thrust race. Seat the ring evenly, using a brass or fibre rod and be sure the split is overlapped in the proper manner.

(b) The next three (lip) rings are not split and must be slipped over the blade. This may be facilitated by oiling the blade edges. Insert these rings, one at a time, with the feather edge first and seat each one with the brass rod.

(c) The fifty packing (follower) ring is split and should be inserted with the feather edge first and with the flat side against the blade packing nut. Seat this packing ring with the brass rod and be sure its split is properly overlapped.

(d) Do not use a steel tool for seating the packings as it may scratch the sealing surfaces.

(11) Split the blade packing nuts and assemble them over the blade shanks.

CAUTION: These split nuts are manufactured as units and both halves of each nut bear the same number at the parting line. Be sure that both halves have the same number when assembled.

(12) Screw the blade packing nuts into the barrel using the composite wrench until the nuts seat against the shoulder in the blade socket. Back off each nut until the first locking hole is in alignment with the space between the barrel halves provided for the lock. The shoulder in the blade socket eliminates the possibility of the packing being compressed excessively.

CAUTION: Under no conditions should the threads of the blade packing nuts or the corresponding threads in the barrel be rechased. The relative pitch diameters of these threads are such that the nut is firmly clamped in the barrel when the two halves of the barrel are bolted together. The thread dimensions are held to

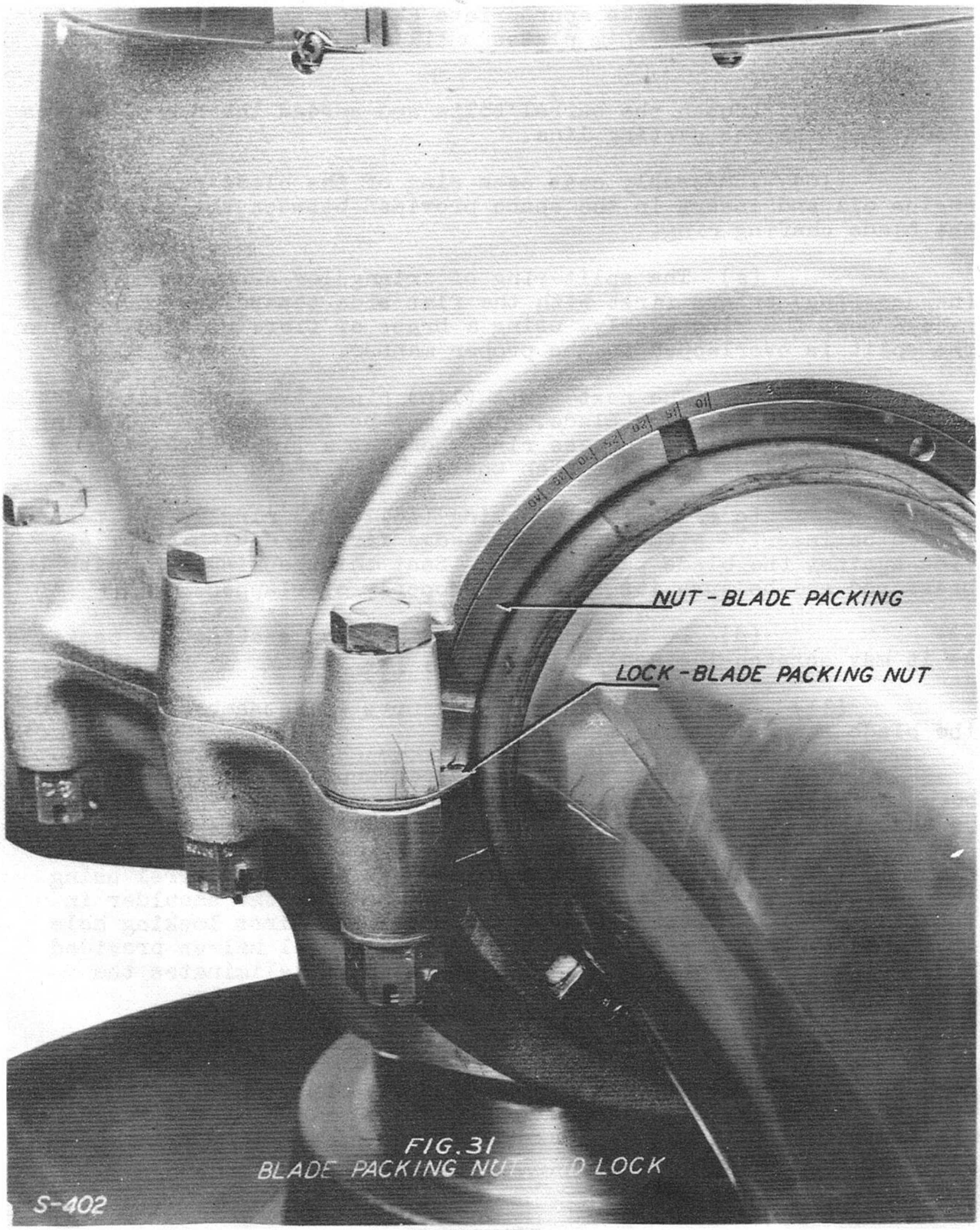

FIG. 31
BLADE PACKING NUT AND LOCK

close tolerances and special gauges are necessary to insure the proper clamp fit.

(13) Install the three blade packing nut locks.

(a) After proper adjustment of the blade packing nuts and before tightening the barrel bolts, place a discharge tube bracket over the barrel bolt boss at the leading edge of each blade arm and set the clearance between the end of the tube and blade shank 1/16".

(b) Tighten up the barrel bolts.

(14) With a protractor, set all blades at 25° at the 42" station.

(15) Remove the propeller from the assembly post.

(16) Install the packing between the spider and the rear half of the barrel in the manner indicated for the blade packings.

(17) Install the barrel and spider packing retainer assembly as follows:

(a) Spring the rear packing gland over the rear end of the spider with the flat edge toward the packing.

(b) Install the rear spider packing and anti-icer spacer and slinger ring on the barrel with the flat face of the spacer away from the barrel and fasten them in place with eight screws, safety-wired with .040" wire.

NOTE: The installation of the following parts make up the anti-icing equipment for the Hydromatic Propeller:

1 Blade discharge tube and bracket assembly.

2 Slinger ring assembly.

3 Shield and feeder tube assembly.

4 Connect the slinger ring nipples to the blade discharge tubes by means of hose connections. Safety wire hose connections in place.

(c) While holding the packing gland gap closed, slide the rear spider packing gland retaining ring over the gland, with its flat edge toward the rear, until the locking slots in the gland and the groove in the retaining nut are aligned.

(d) Install the rear spider packing gland spring lock in the assembly so that it engages the groove in the retaining

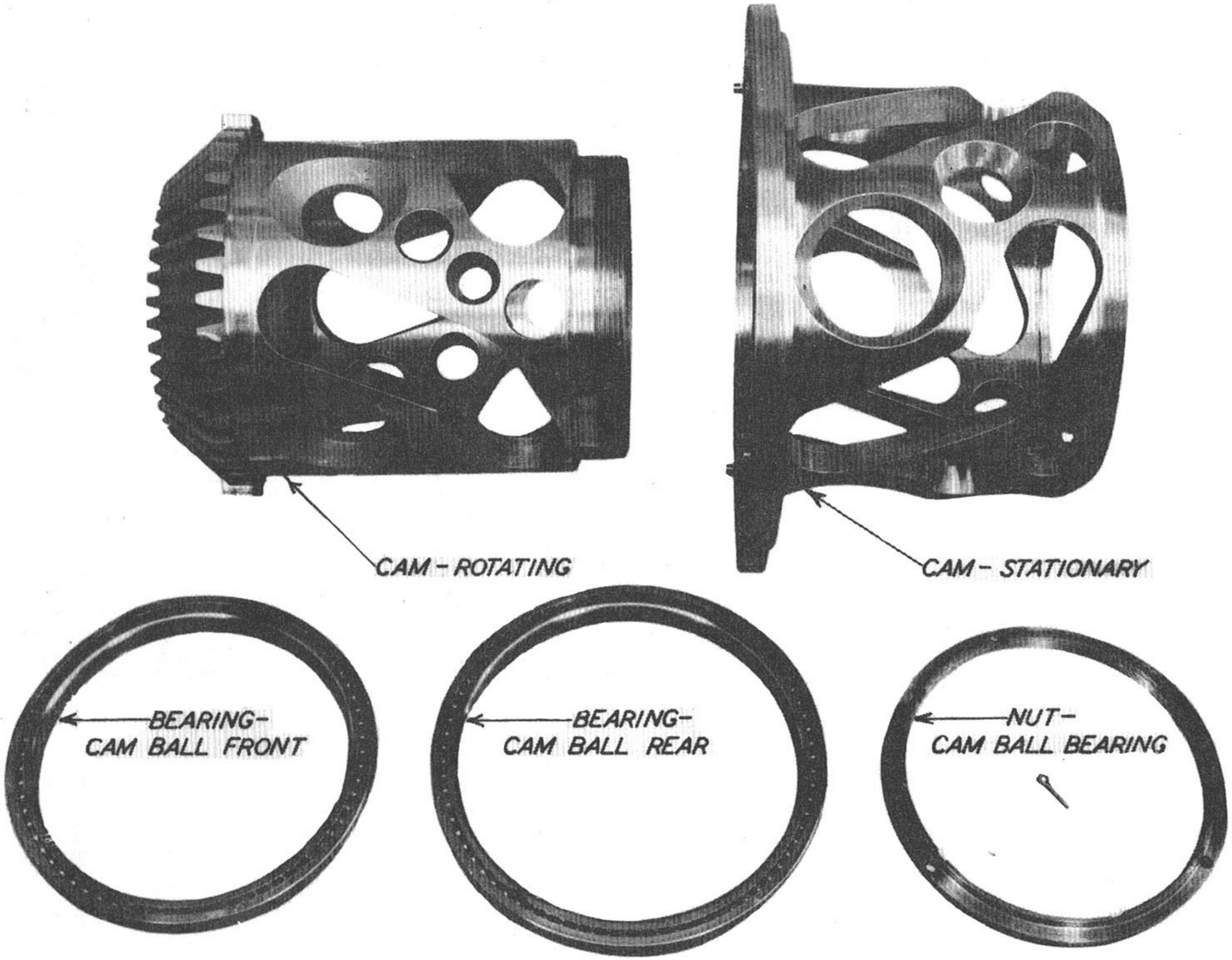

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FIG. 32 - CAMS AND CAM BEARINGS

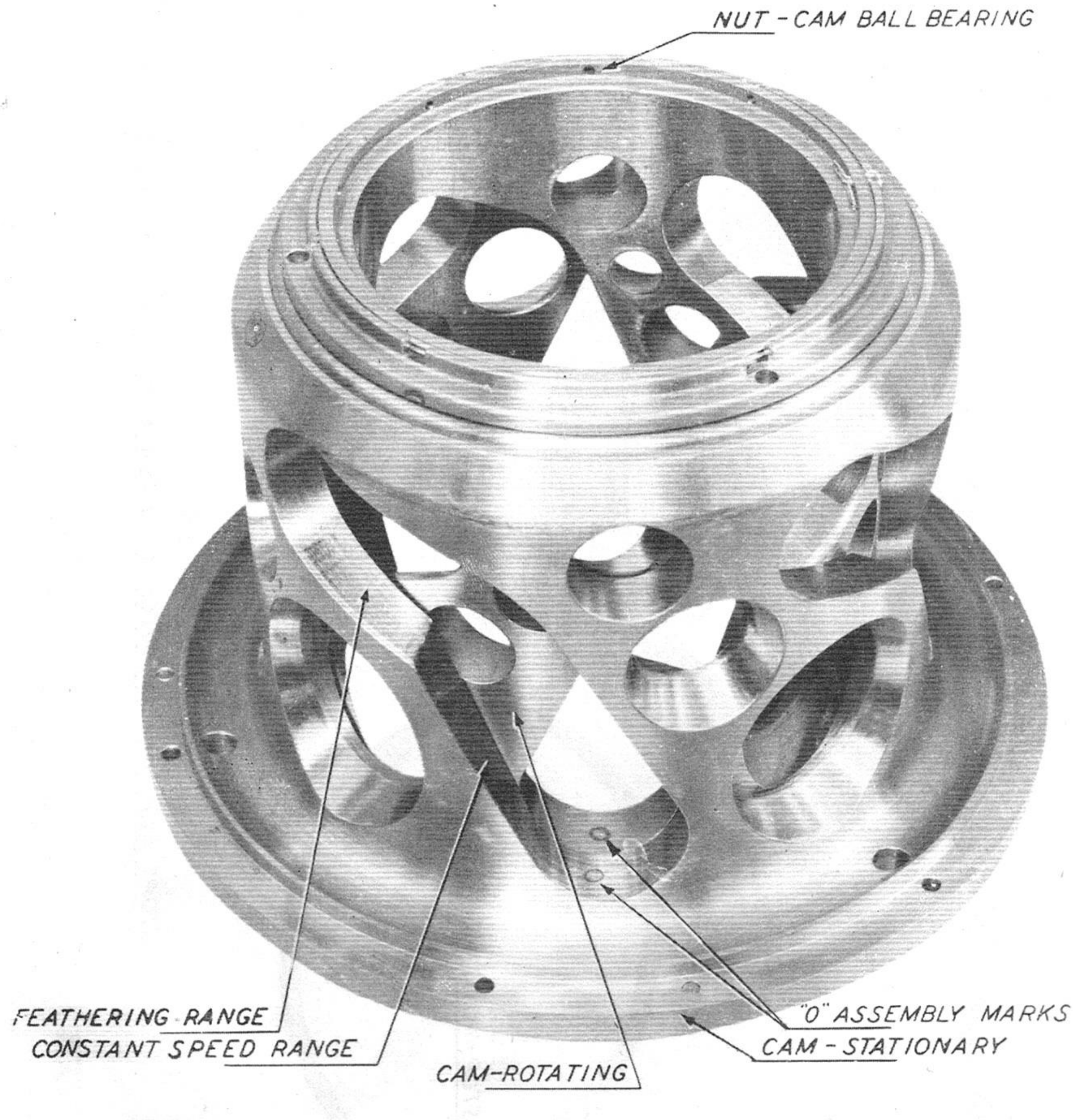

FIG 33 - CAMS ASSEMBLED

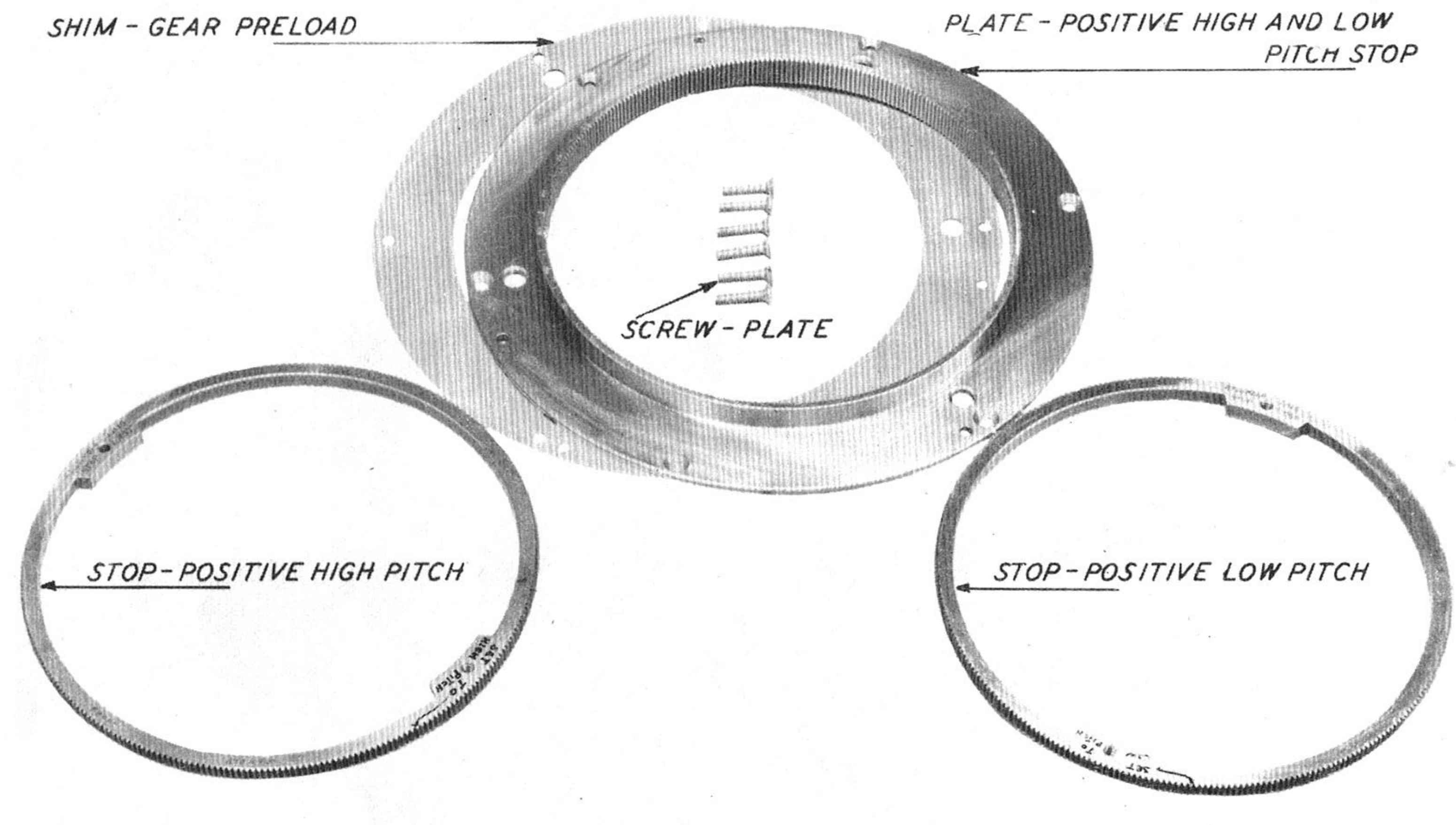

FIG. 34
"STOPS"-HIGH AND LOW PITCH WITH PLATE AND GEAR PRE-LOAD SHIM

S-426

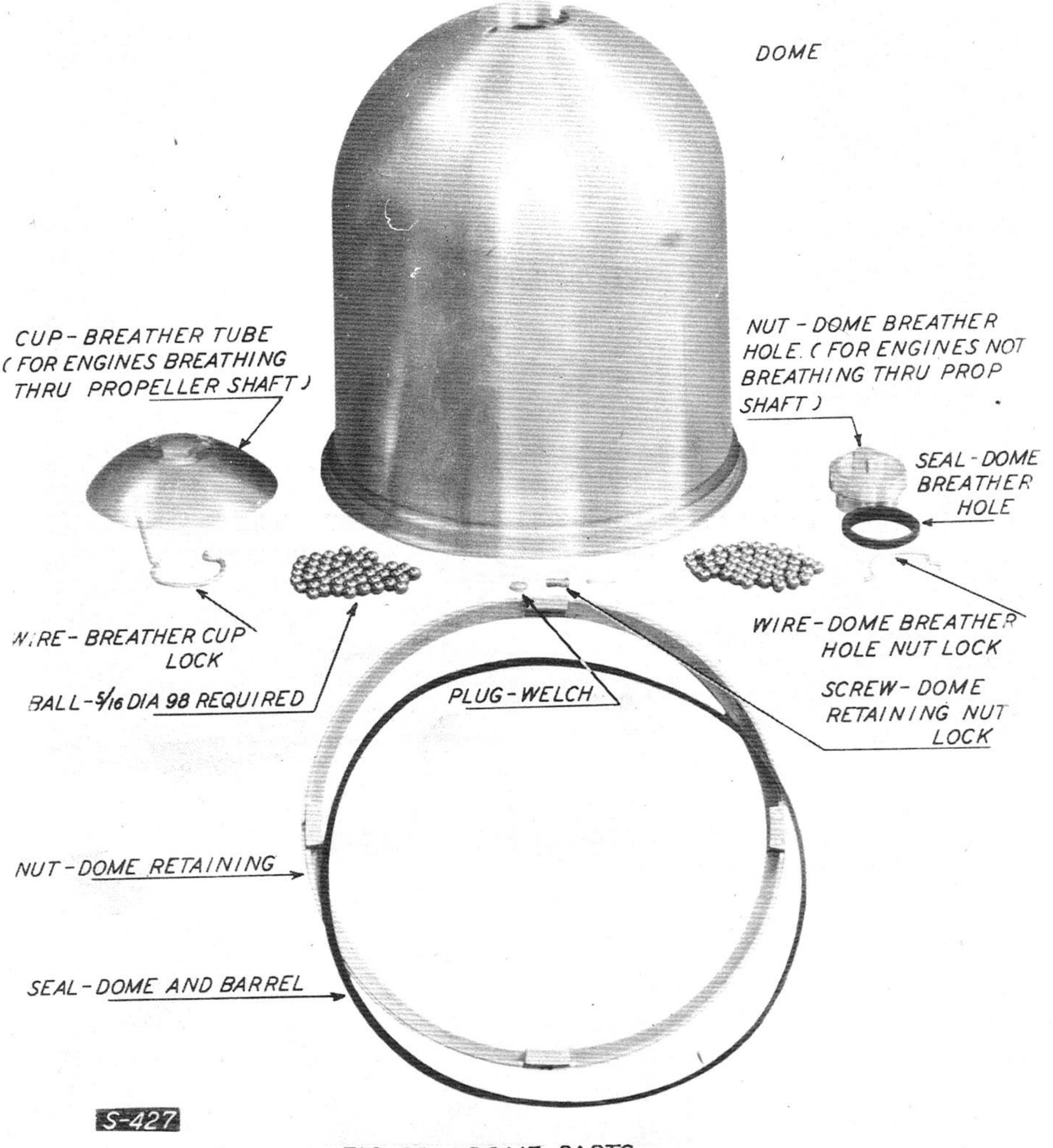

FIG. 35 - DOME PARTS

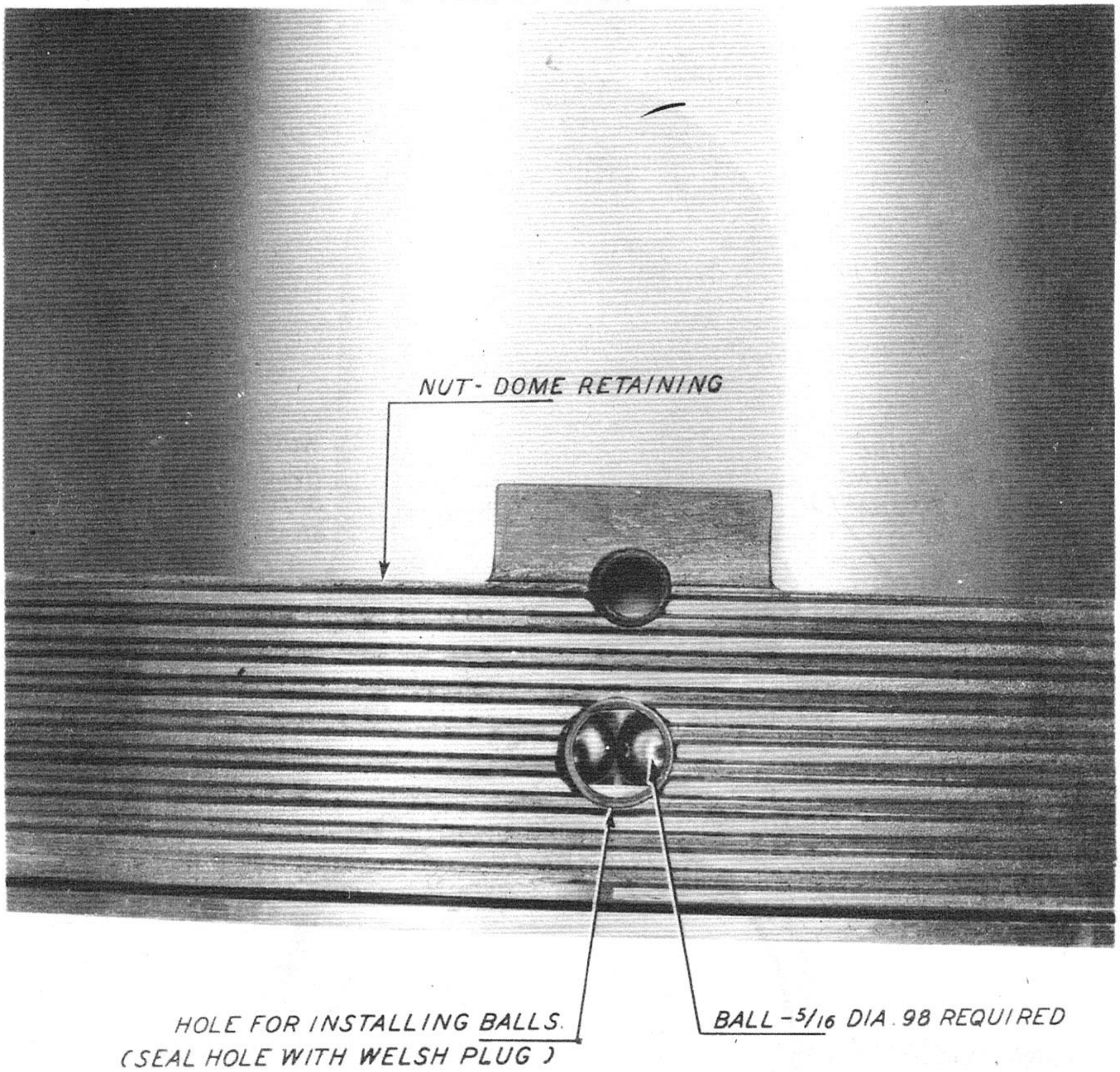

FIG. 36
DOME RETAINING NUT (SECTION)

ring thru the slots in the gland. When the retaining ring is properly installed, with its groove toward the rear of the propeller, its rear edge will be flush with the rear edge of the gland when the spring lock is in place.

(18) Balance the assembly (See "Propeller Balance").

(19) After final balance, install a welch plug in each barrel bolt head.

(20) Install the oil seal washer against the spline ends in the spider. Insert the spider-and-shaft oil seal ring in the seal and install this assembly, with the ring outermost, against the washer. Install the cone, propeller retaining nut and the hub snap ring.

(21) Test the propeller as indicated under "Assembly and Test."

(22) After completion of these tests, safety the barrel bolts with cotter pins.

d. Dome Assembly.

Before the dome is assembled, it is necessary to determine the gear preload and adjust it to within the required limits. (See "Gear Preload.")

(1) Install the cam ball bearings in the ends of the stationary cam so that the word "OUT" etched on each can be read when looking at the end of the cam.

(2) Insert the rotating cam in the stationary cam and drive it into place by dropping the assembly several times from about a one-foot height so that the gear lands squarely on a clean hard wood block.

(3) Install the cam ball bearing nut and tighten it with composite wrench sufficiently to cause the bearings to bind slightly and drop the assembly again as above. If necessary, tighten the nut again to get the same amount of binding and then back it off two cotter pin holes. In this manner, the bearings will be so adjusted that the cams will rotate without binding.

(4) Lock the nut with a 1/2" or 3/32" cotter pin inserted from the outside.

(5) Turn the cams so that the letters "O" etched in the bottom of one cam slot in each cam are in alignment.

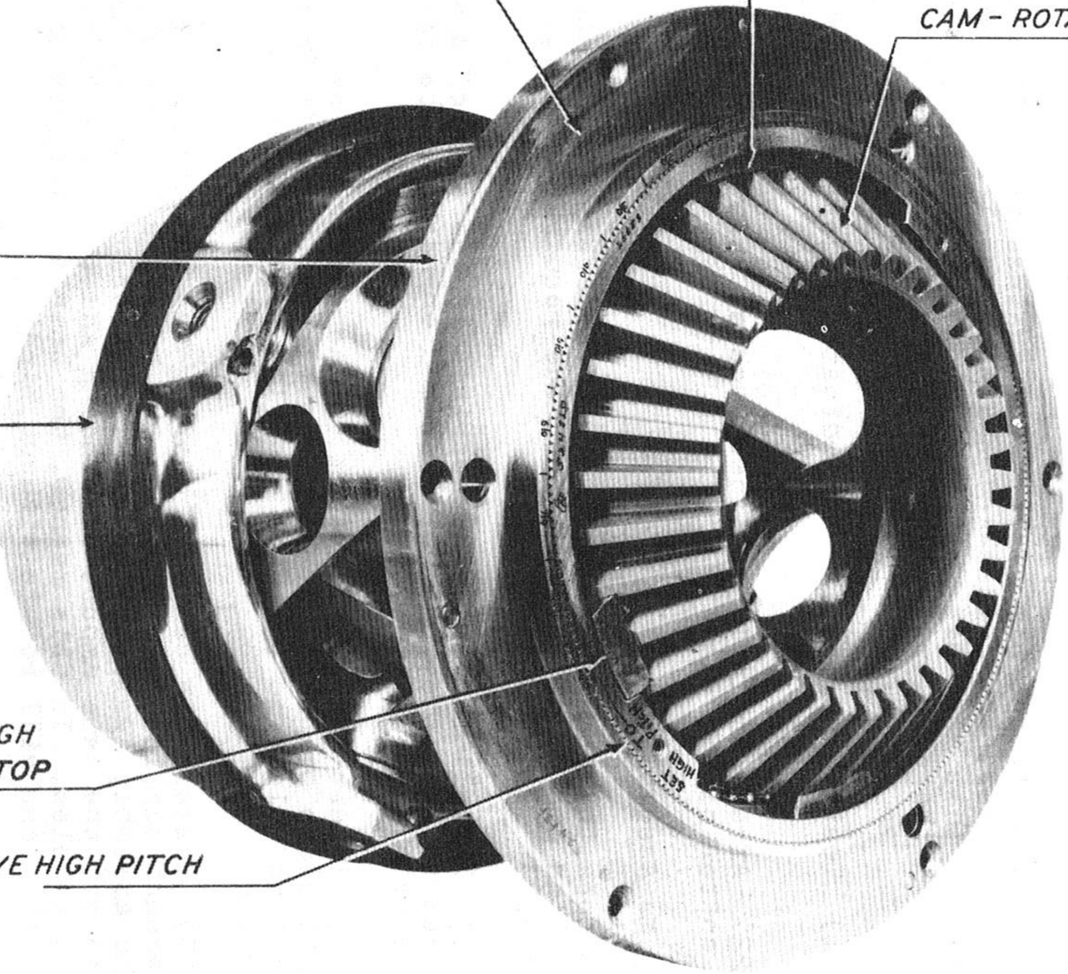

FIG. 37
PISTON AND CAM ASSEMBLY - HIGH PITCH POSITION (FEATHERED)

J-419

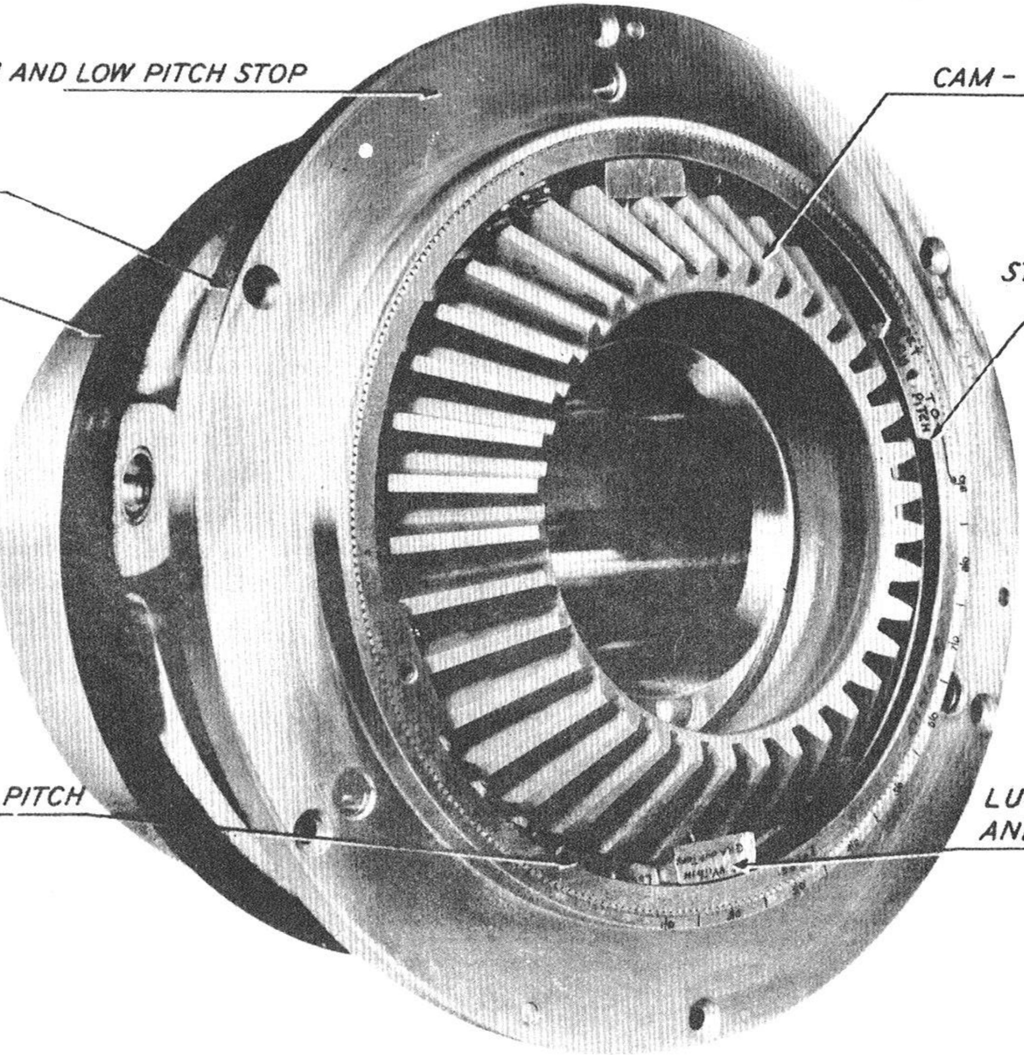

FIG. 38

S-420 PISTON AND CAM ASSEMBLY - LOW PITCH POSITION (HIGH RPM)

(6) Place four cam slot rollers on each cam slot roller bushing and install the four assemblies in the cam slots with the bushing flanges toward the outside.

(7) Slip the piston over the cam assembly so that the "O" stamped on the boss of one of the cam slot roller shaft holes is in alignment with the "O"s in the cam slot.

(8) Insert the four cam slot roller shafts in the piston with the tapped holes toward the outside, and drive them in until their outer ends are just flush with the outer surface of the piston. To facilitate installation of these shafts insert a 1/2"-13 U. S. Std. Thd. bolt in the tapped hole in the end of the shaft and drive the shaft in by striking the head of the bolt with a hammer.

(9) Insert the four cam slot roller shaft screws in the skirt of the piston and tighten them securely. These screws carry a pipe thread and are not provided with additional means of locking.

(10) Install the piston gasket and nut. To facilitate holding the piston while tightening this nut, it is advisable to insert a 1/2"-13 U. S. Std. Thd. bolt in each of two opposite cam slot roller shafts. Using composite wrench with a two-foot bar, pull up the nut as tight as practicable and align a lock screw hole in the nut with a milled slot in the piston.

(11) Insert the locking screw and safety it with a 1/16" x 1/2" cotter pin.

(12) Install the stop plate so that the three small dowel pins in the stationary cam engage in holes provided for them in the stop plate. There is only one position for this plate on the cam as the dowel pins are not arranged symmetrically.

(13) Slip the dome over the cam and piston assembly and screw into it, through the stop plate and cam base, the six flat-head screws. Be sure the heads of these screws are flush with the surface of the stop plate.

(14) Slip the dome retaining nut over the dome and align the hole through the threads of the nut with the milled groove in the lip of the dome ball race. Insert 98 balls and close the hole with a welch plug.

(15) Insert the positive low angle stop ring at the specified blade angle.

(16) Insert the positive high angle stop ring at the specified blade angle.

(17) Balance the assembly. (See "Propeller Balance.")

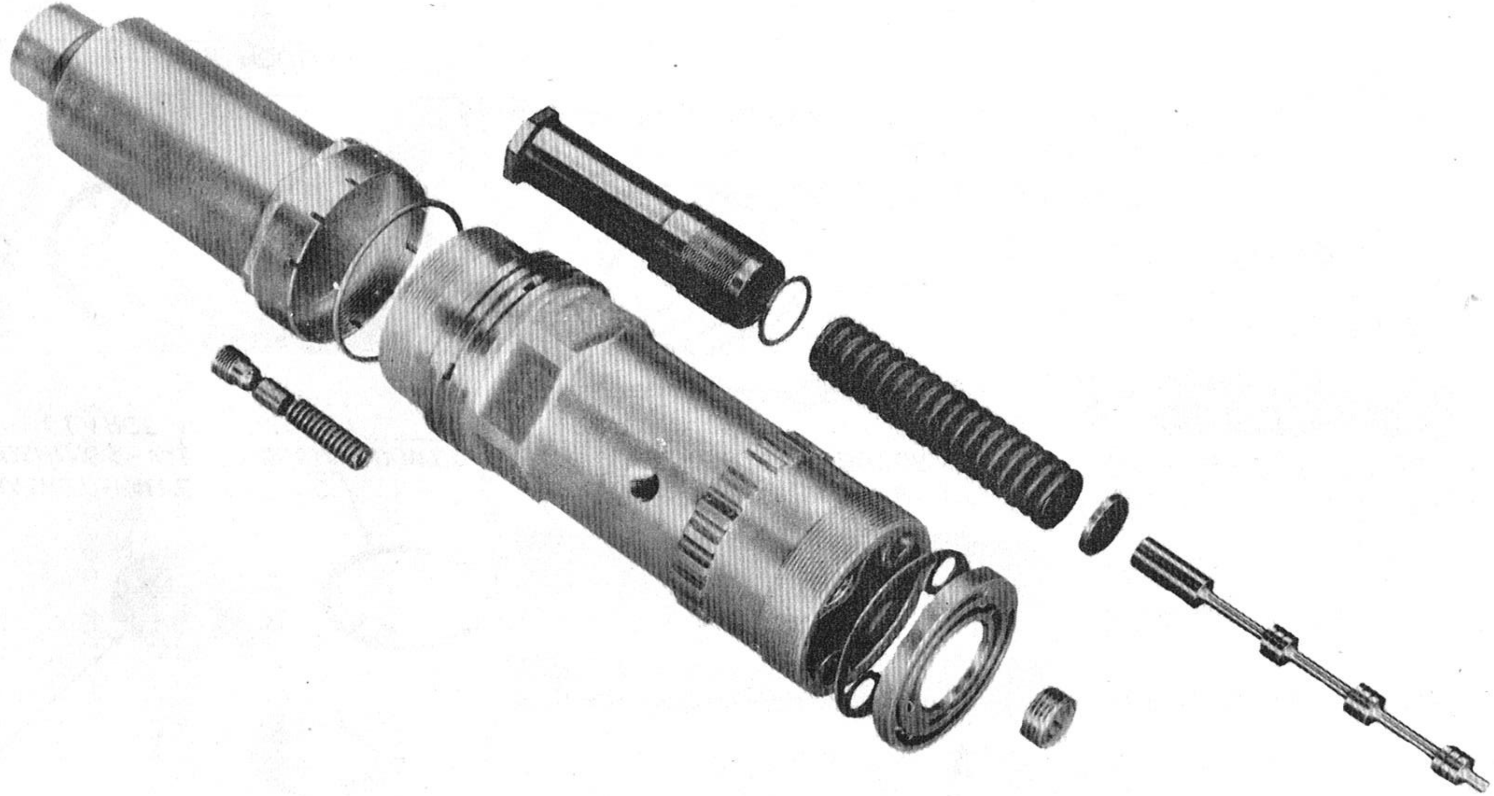

FIG. 39

VALVE ASSEMBLY (FOR ENGINES BREATHING THROUGH PROP. SHAFT)

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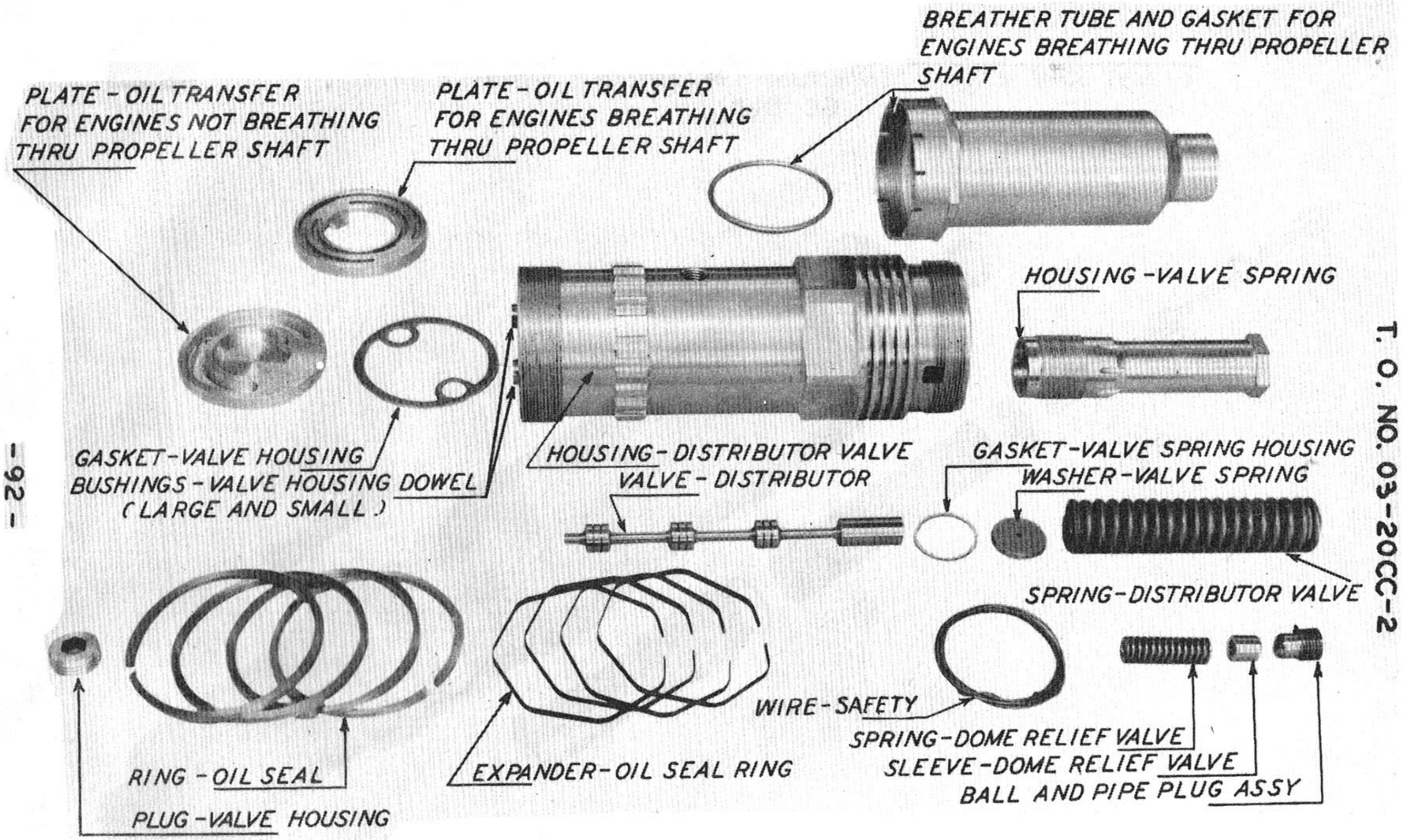

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FIG. 40
DISTRIBUTOR VALVE PARTS

(18) Stretch the dome and barrel seal over the base of the stationary cam so that its unbeveled edge lies adjacent to the dome flange.

(19) Install the breather hole seal in the front of the dome, the "V" edge going in first.

(20) Install the dome breather hole nut or the dome breather cup and install the lock wire.

e. Valve Assembly. - (1) Insert the distributor valve in the sleeve in the valve housing with the smaller end toward the Allen plug.

(2) Insert the spring and washer in the spring housing in the order mentioned, and lay the flat copper gasket in its place on the open end of the spring housing.

(3) Hold the valve housing with the Allen plug end up and screw the spring housing in from the bottom. This procedure avoids the possibility of the washer becoming wedged under the spring housing.

(4) Tighten the spring housing until the gasket is firmly seated and safety it with .040" brass wire inserted through the hole in the valve housing which is aligned with a milled slot in the spring housing.

(5) Insert the dome pressure relief valve spring and sleeve in the order mentioned, into the valve housing, making sure that the beveled end of the bronze sleeve, which is the ball seat is outermost. Screw the ball and plug assembly down tightly on them. Since the plug carries a pipe thread, no additional means of locking is provided.

(6) Install the four oil seal ring expanders and the four oil seal rings in the grooves provided on the valve housing.

(7) Install the 1/32" copper gasket over the two dowel bushings which extend from the rear end of the valve housing.

(8) Install the oil transfer plate on these bushings. These bushings are of two different diameters, as are the holes in the plate, therefore, the plate can be installed in only one position.

(a) For engines which breathe through the propeller shaft, the oil transfer plate has a 1-1/4" hole through its center for the passage of breather gases.

(b) For engines which do not breathe through the propeller shaft, the hole does not go through the center of the plate, but connects with the dome oil pressure line in the side of the valve housing.

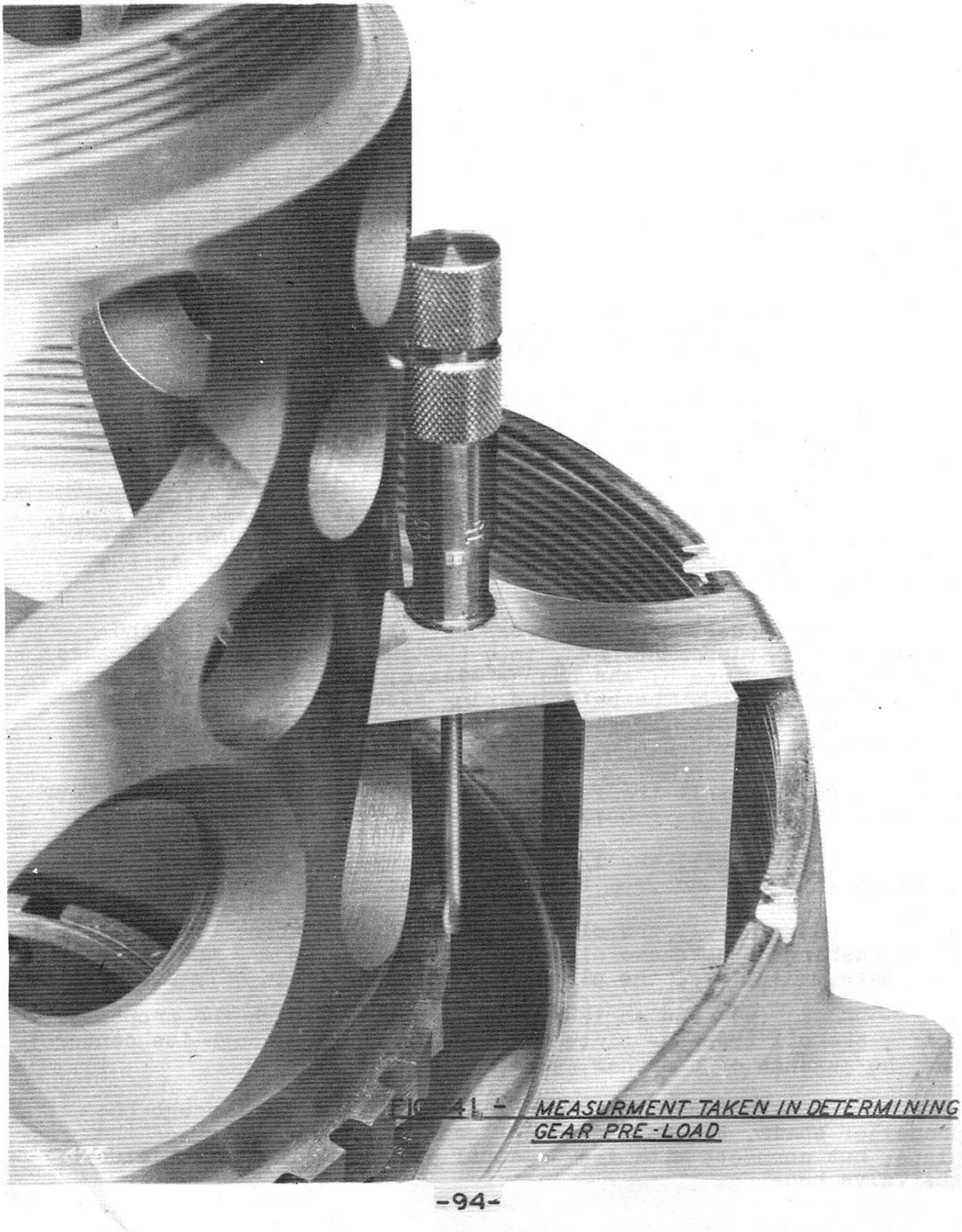

FIG. 41 - MEASURMENT TAKEN IN DETERMINING GEAR PRE-LOAD

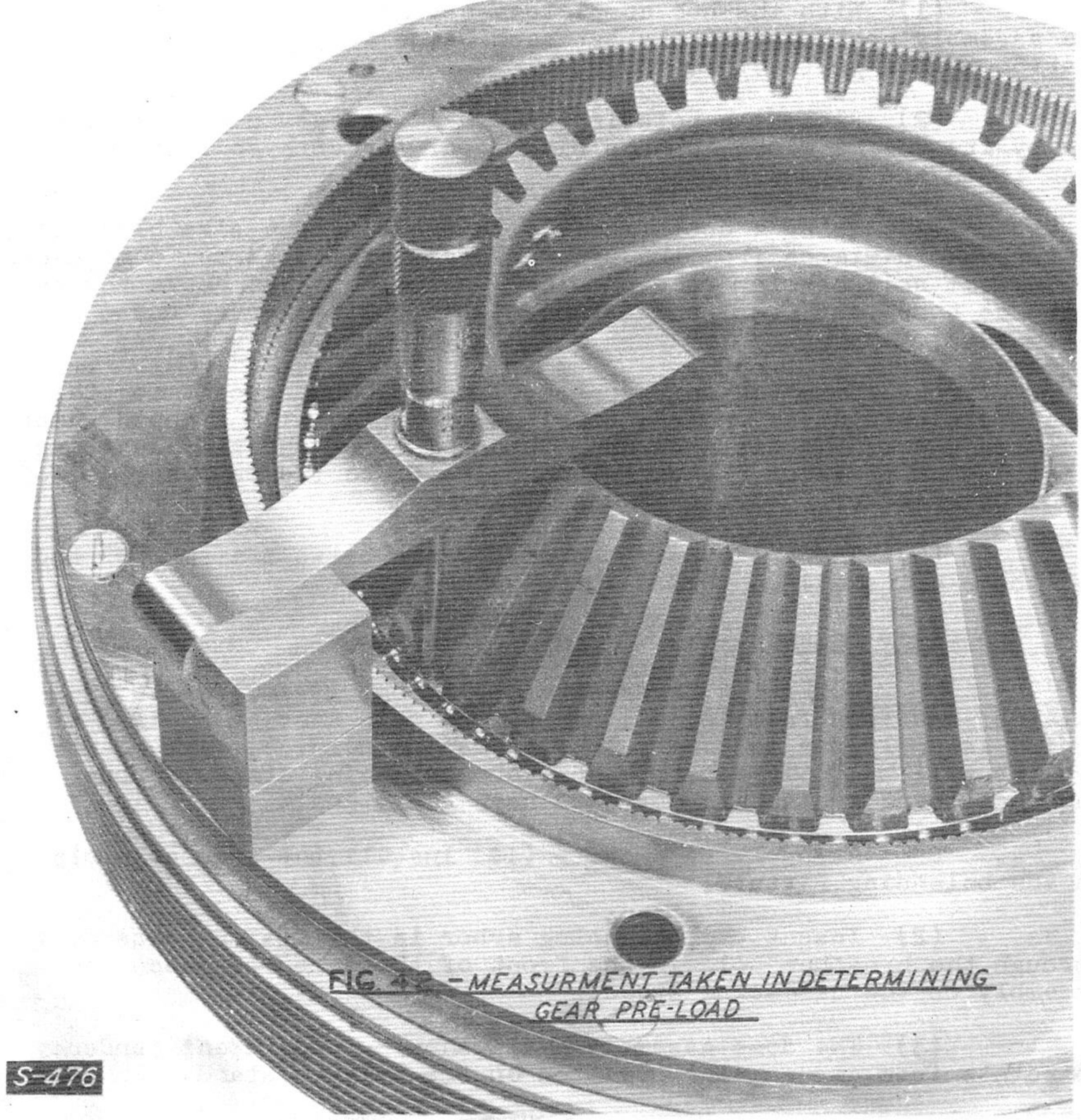

FIG. 42 - MEASURMENT TAKEN IN DETERMINING GEAR PRE-LOAD

(9) Engines which breathe through the propeller shaft require that the breather tube be installed on the valve housing. Insert the copper-asbestos gasket in the front end of the breather tube and screw the breather tube to the housing, drawing it up tightly and safety it with a brass wire through a slot in the skirt of the tube and the hole drilled into the dome pressure duct in the valve housing.

4. Gear Preload.

a. The gear preload is determined as follows:

(1) With the hub completely assembled and installed on the assembly post, accurately set each blade at 50° at the 42" station with a protractor.

(2) Place the rotating cam in its proper position, resting by its weight alone, on the blade gear segments so that the gear teeth are properly meshed.

(3) Using a depth gauge with the aid of a size block to measure the distance from the upper surface of the barrel dome shelf to the cam ball bearing race shoulder on the cam just above the gear teeth at three different points around the cam. Average these three readings.

(4) With the dome completely assembled, except for the positive high and low angle stop rings, measure, with a depth gauge and size block, the distance from the surface of the stop locating place, which rests on the barrel dome shelf, to the rear surface of the inner race of the rear cam ball bearing.

(5) The preload is the difference between items "3" and "4" above and shall be .018 ± .005.

5. Propeller Balance.

NOTE: It is necessary that the assemblies to be balanced are free from any oil except the thin coating applied during assembly for temporary lubrication; otherwise, any balance results will be incorrect. Be sure the balancing stand is true and that there are no air currents near the stand.

a. Dome Assembly Balance. - (1) Install the dome assembly on the balancing fixture.

(2) Insert the balancing arbor in the fixture extending through the breather hole in the front of the dome and place the assembly on the balancing stand.

(3) The dome assembly shall show no persistent tendency to rotate from any angular position on the balance stand. In case

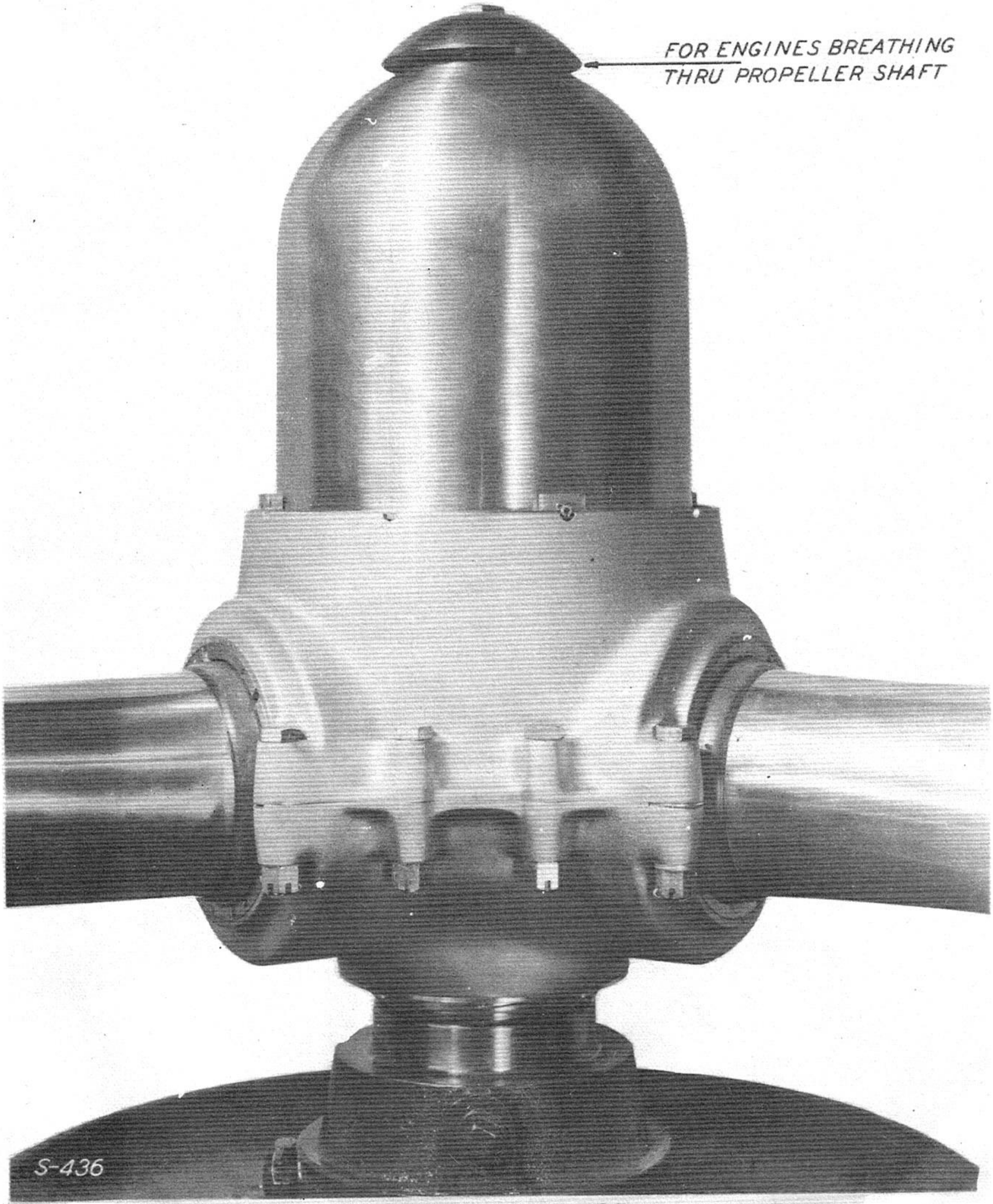

FIG. 43 - COMPLETE ASSEMBLY FOR BENCH TEST

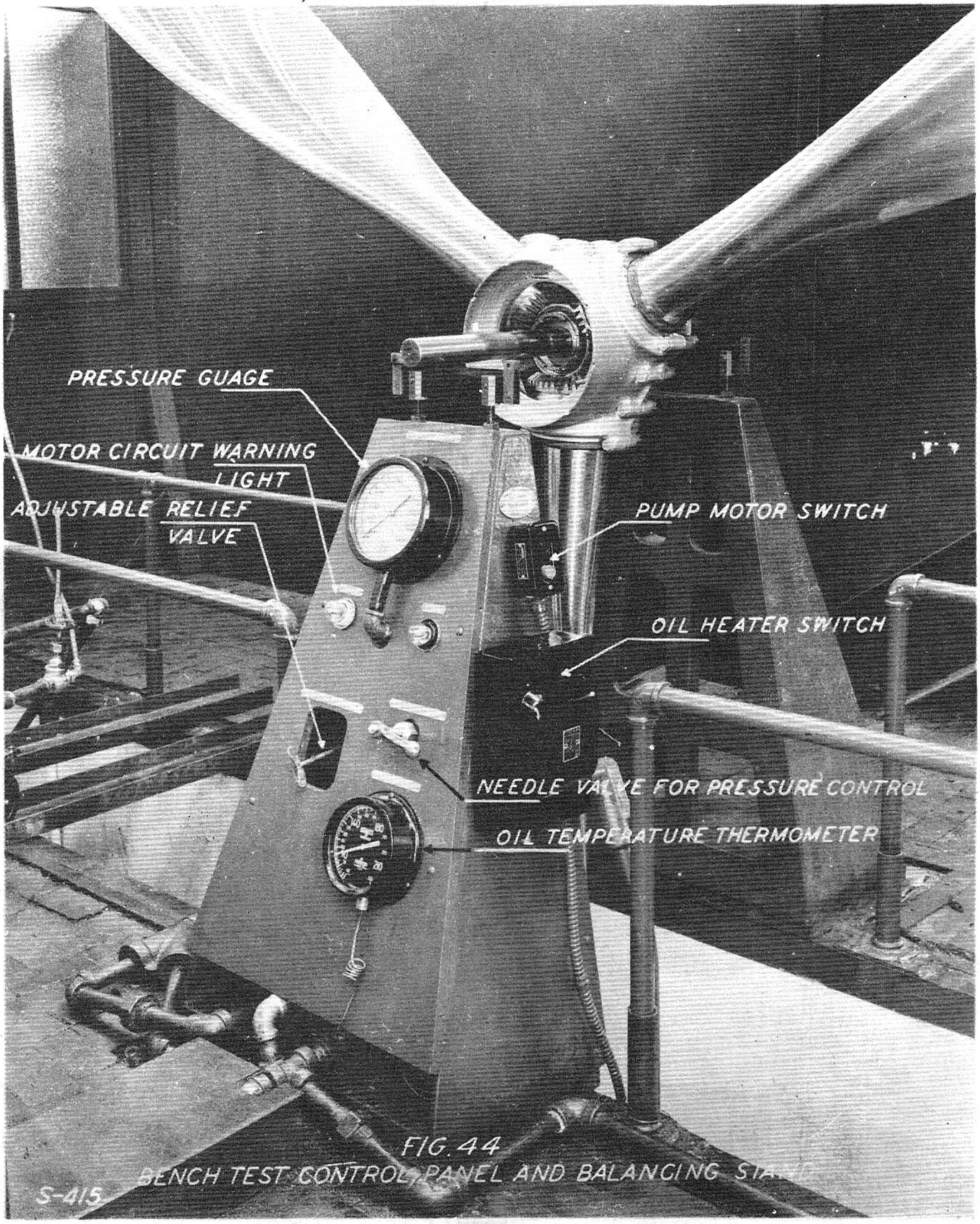

FIG. 44
BENCH TEST CONTROL PANEL AND BALANCING STAND

it does rotate apply putty to the light side until the dome is in perfect balance. The weight of the putty thus applied represents the weight of lead to be inserted in the balancing holes provided in the base of the stationary cam under the stop locating plate. NOTE: There are six (6) holes, approximately 3/8" diameter, and 3/8" deep located equidistant in the base of the stationary cam.

b. Hub Assembly Balance--(Including the Blades Only) -

(1) Insert the balancing arbor in the splined sleeve in the hub assembly and install the assembly on the balancing stand.

NOTE: The blades shall have been set at 25° at the 42" station.

(2) Check each blade in a horizontal position. The assembly should show no tendency to rotate.

(3) Recheck the balance and the accuracy of the balancing stand by repeating "2" with the blades horizontal on the opposite side of the stand.

(4) For horizontal and vertical balance, apply putty to the two (2), (if necessary, to the four), hub barrel bolts adjacent to the light blade until the propeller balancer in both the horizontal and vertical position. The weight of the putty thus applied represents the weight of lead to be inserted in the holes of these bolts or removed from filled bolts on the heavy side of the propellers. When the bolts are completely empty, approximately .0125 pounds of lead may be inserted in each bolt. If the weight of the putty exceeds .05 pounds to obtain horizontal balance, recheck the balance by applying putty to the light blade, at a point corresponding to the location of the blade plug. The propeller should be disassembled, the light blade removed, and either a lead or steel washer, corresponding in weight to the weight of the putty, be installed on the blade plug stud. Reassemble the propeller and recheck for balance. Slight of balance condition can now be corrected by adding or removing lead from the hub barrel bolts.

c. Hub Assembly--(Including Dome Assembly) - (1) With the splined sleeve in the hub assembly, install the dome unit on the hub assembly and set the blades to 25° at the 42" station.

(2) Insert an arbor through the splined sleeve so that one end protrudes through the breather hole in the dome. For this balance, it is necessary that the arbor be reduced on each end to 1-1/2" diameter so that one end will pass through the hole in the dome.

(3) Install the assembly on the balancing stand and check the balance as above. (Items "2" and "3" under "Hub Assembly Balance.")

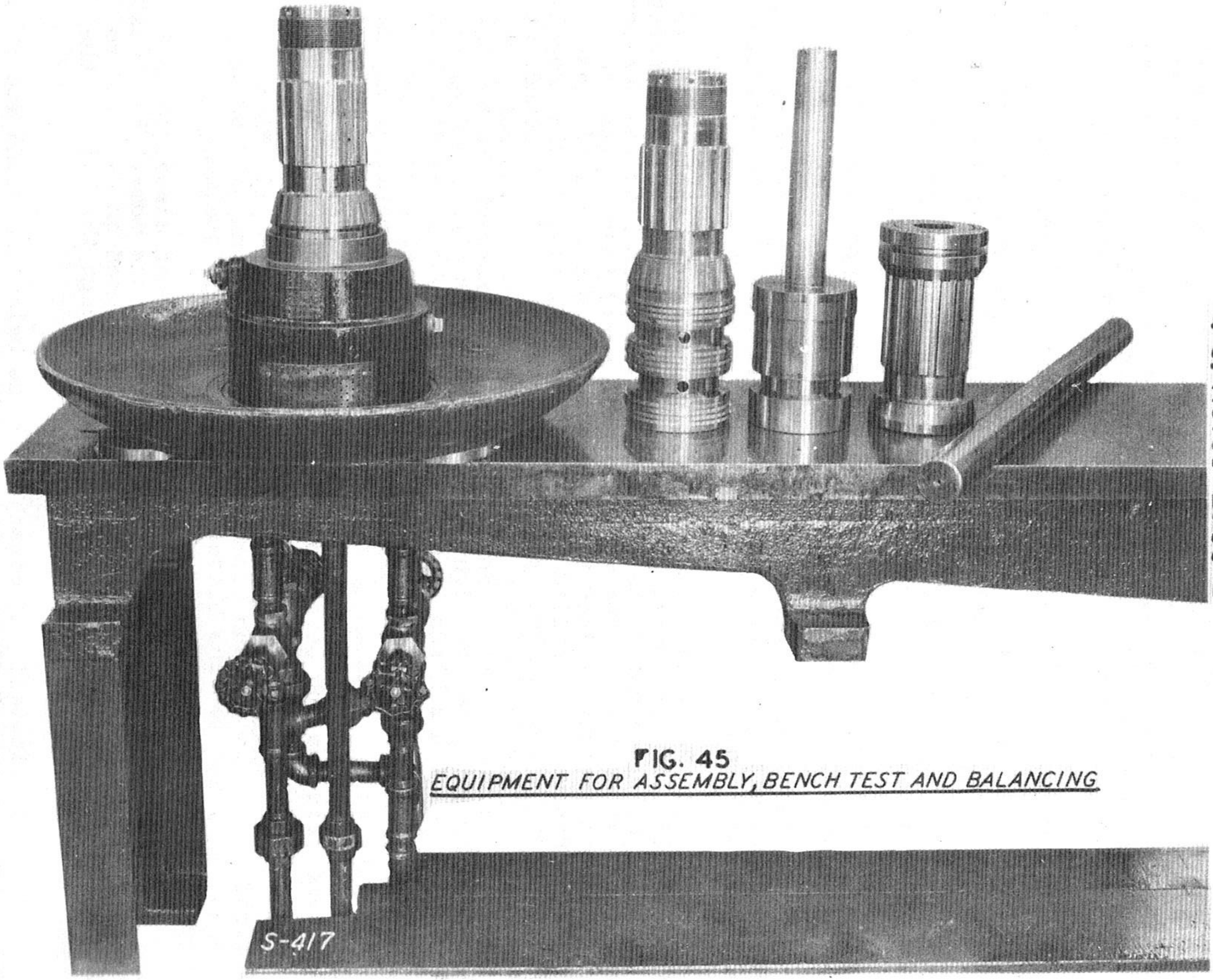

FIG. 45
EQUIPMENT FOR ASSEMBLY, BENCH TEST AND BALANCING

(4) Final balance is obtained by readjustment of the lead in the barrel bolts.

6. Test Procedures.

NOTE: The tests described below are to be made on Stand Assembly - Hydromatic Propeller Test, Part No. 39D5824. The oil used for the tests shall have a viscosity equivalent to S.A.E. No. 10 or 20 oil at room temperature.

NOTE: The pressure gages shall be calibrated at least once every twenty propeller tests.

a. Assembling Test Stand. - Assemble test stand as received from stock in accordance with drawing No. 39D5824. The principles of operation and adjustment to be made are as follows:

(1) Motor driven pump No. 306A supplies oil at a pressure of 1000 p.s.i. to the various regulators which by-pass sufficient oil to provide the required test pressures.

(2) Gage "N", drawing 39K4302, indicates the low pressure normally found in the outboard end of the dome and should be 80 ±5 p.s.i. This pressure is controlled by regulator "K" and should be readjusted whenever it exceeds the limits given above.

(3) Gage "M" indicates the high pressure to the inboard side of the dome selected by valve "L". With "L" in the feathering or 400 p.s.i. position, "M" should read 400 ±15 p.s.i. and may be adjusted by regulator "I". Similarly the 600 ±15 p.s.i. pressure for unfeathering may be adjusted with regulator "J".

(4) Gages "M" and "N" are not damped and the petcocks in the gage lines should be closed except when readings are being taken.

(5) During tests the high pressure valve and the low pressure valve should be open and the low pressure by-pass valve closed. After feathering and unfeathering it will probably be necessary to open the by-pass valve to reduce the low pressure to 80 p.s.i. as the unfeathering oil leaks into the low pressure line during the test.

b. Spider, Barrel and Blades. - Place the assembled spider, barrel and blades on the stand, using standard front cone, packing and retaining nut.

c. Installation of Distributor Valve. - Install distributor valve in shaft, using gasket No. 53151 for propellers for non-shaft breathing engines and 53152 for propellers for shaft breathing engines. The plug, Part No. 895-B-103, normally installed in the plug assembly, drawing No. 39J3876, should be removed when testing propellers for non-shaft breathing engines.

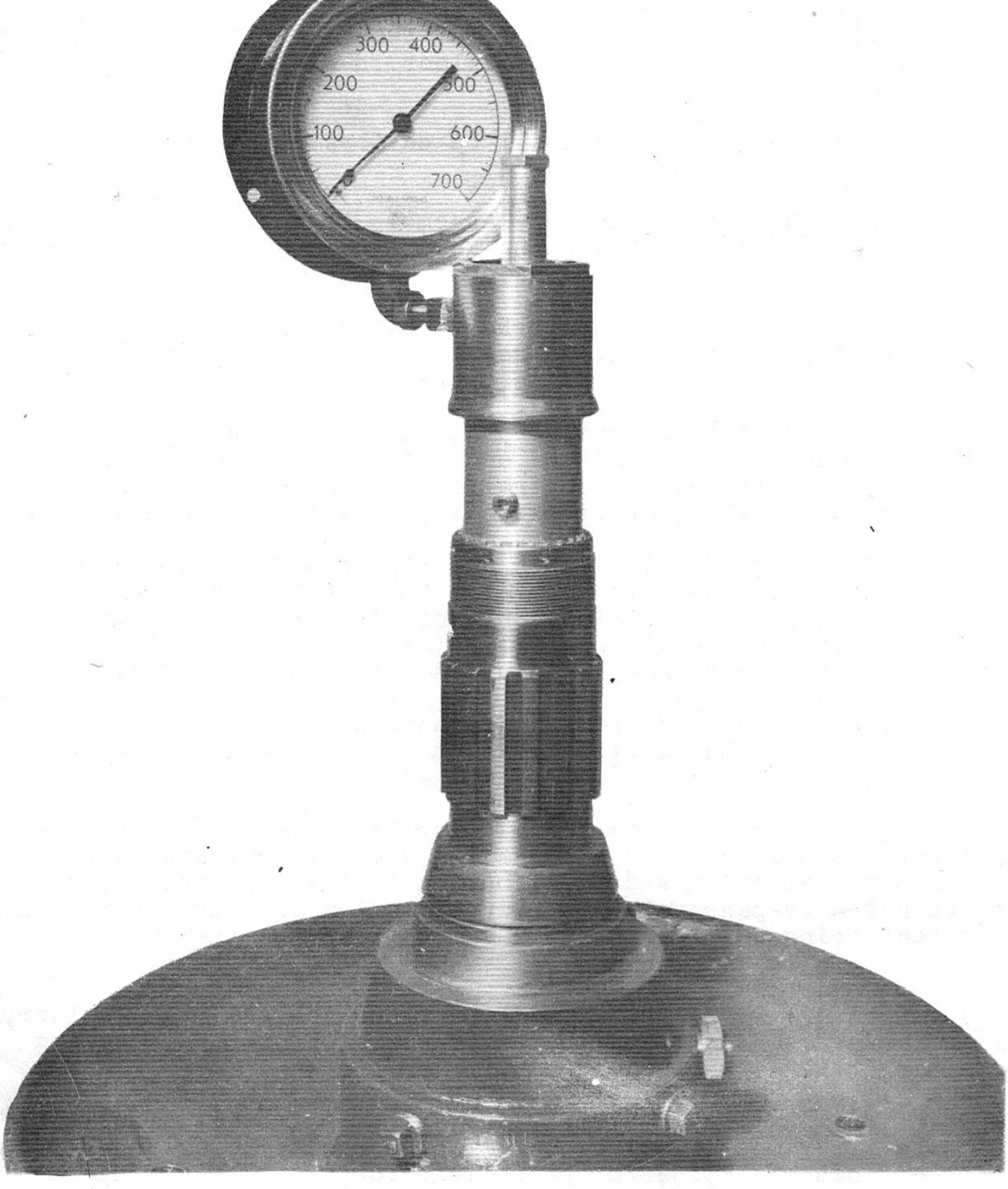

FIG. 46 - METHOD OF BENCH TESTING DISTRIBUTOR VALVE SHOWING TEST SLEEVE & GAGE IN POSITION

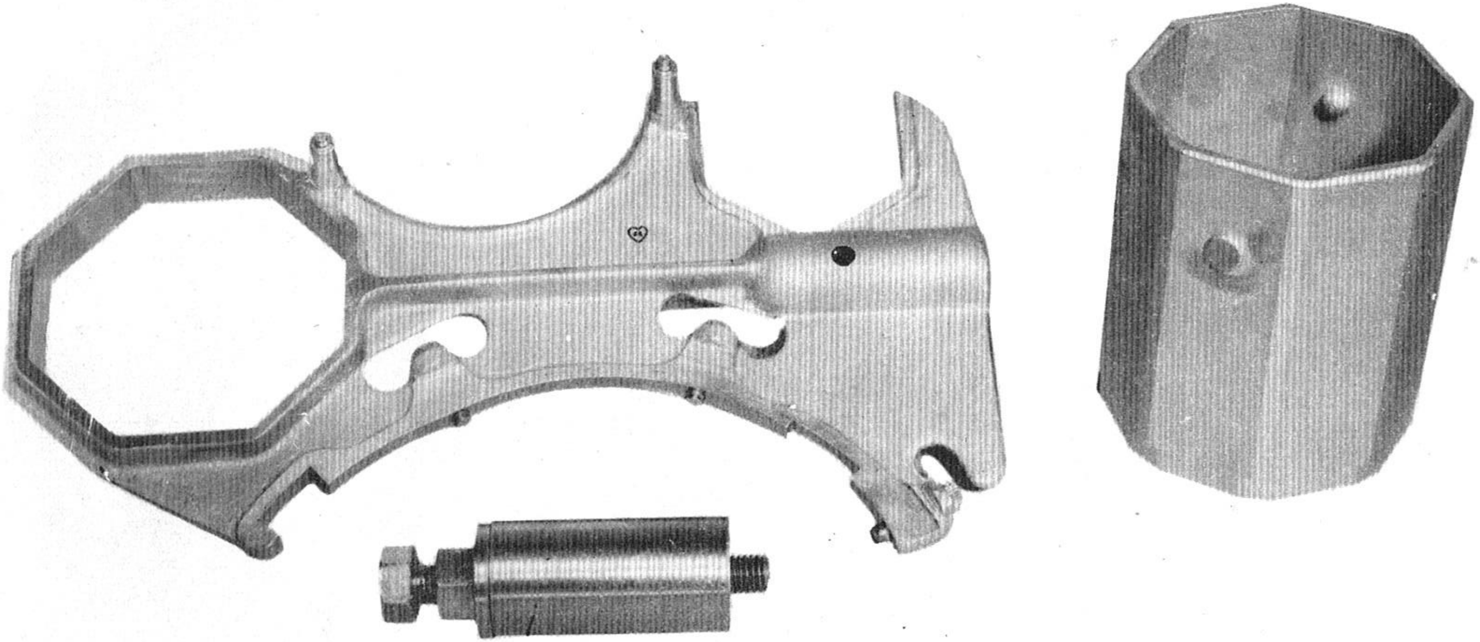

FIG 47 - *TOOLS*

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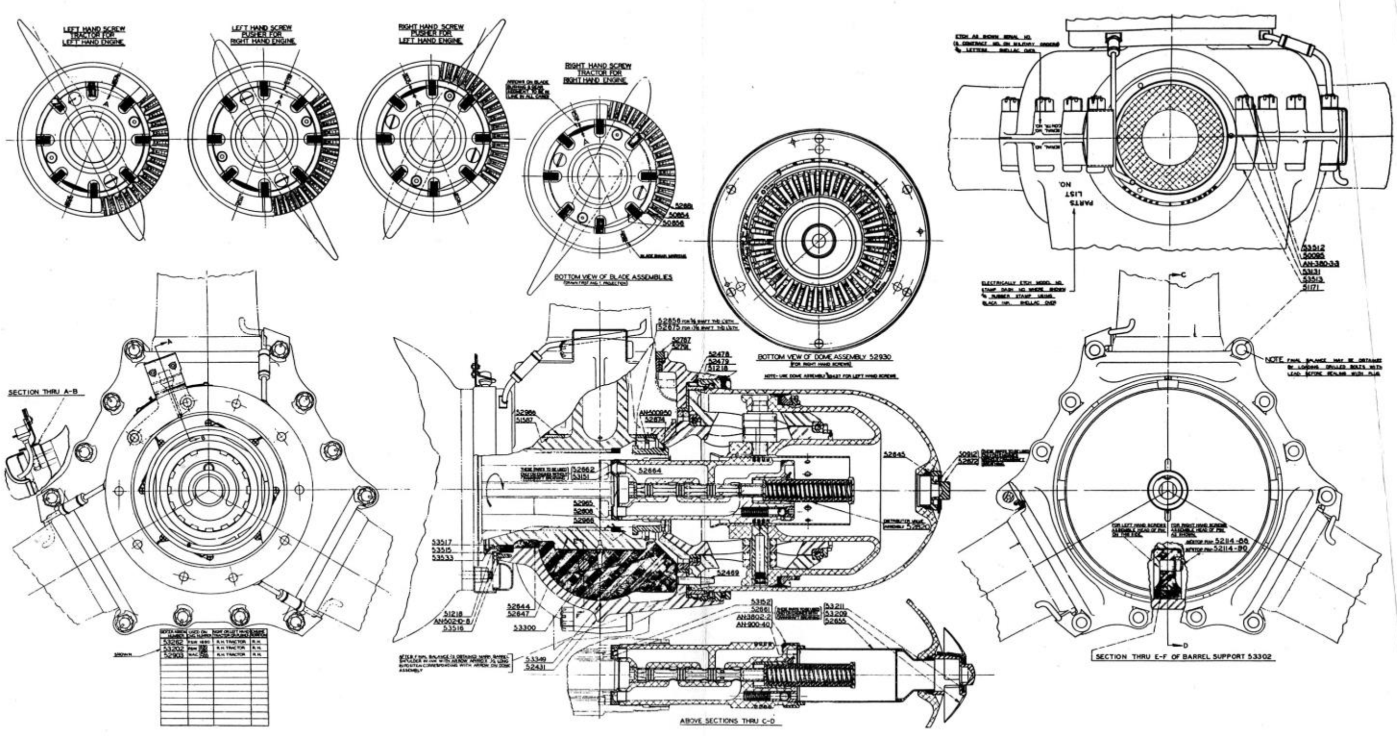

FIG. 48 - ASSEMBLY DWG. 53400

d. Test of Distributor Valve (before dome assembly is installed). - (1) Plug both barrel pressure outlet holes in the sides of the housing with 1/4" pipe plugs and install sleeve assembly and gage listed on drawing No. 39D5824 for shaft size used.

(2) Move lever "L" to feathering or 400 p.s.i. setting. The pressure on the gage on the valve should be 60 ±20 p.s.i. and should correspond to engine pressure.

(3) Move lever "L" to unfeathering or 600 p.s.i. setting. Close low pressure valve and observe steady pressure on gage on valve. This pressure should be between 400 and 600 p.s.i., which indicates that the distributor valve has shifted to the unfeathering position.

(4) Open the low pressure valve and the low pressure by-pass valve and close the petcock on the low pressure gage. Observe the steady pressure on the valve gage. This pressure should be 350 ±50 p.s.i. and indicates the setting of the dome relief valve.

(5) Under the conditions of paragraph (3) above, there shall be no leakage into the breather passages, and leakage past the oil seal rings shall not exceed 1/2 lb. per minute.

(6) Remove plugs and sleeve assembly from distributor valve.

e. Test of Assembled Propeller. - (1) Install dome assembly on hub and distributor valve, already tested.

(2) Move the blades throughout their entire range by hand, and check the extreme blade angles with those for which the positive dome stops are set. This will insure correct relationship of the cam and blade gears and avoid possible damage to the latter.

(3) Check for normal feathering and unfeathering action by operating lever "L".

(4) Check for external oil leaks. With the propeller against the low pitch stops and lever "L" in the unfeathering position, there should be no external leakage. The following parts should be checked:

(a) Barrel and blade packings
(b) Barrel and spider packings
(c) Spider and shaft seal
(d) Barrel half seals
(e) Dome breather seal.

f. Balancing of Propellers. - Assembled propellers may be balanced, using the shaft and balancing bushing specified on drawing No. 39J3576. The shaft alone may be used as a propeller hub assembly fixture.