ROYAL CANADIAN AIR FORCE

DESCRIPTION AND MAINTENANCE INSTRUCTIONS HAMILTON STANDARD HYDROMATIC PROPELLERS

REVISION NOTICE

LATEST REVISED PAGES SUPERSEDE THE SAME PAGES OF PREVIOUS DATE
Insert revised pages into basic publication.
Destroy superseded pages.

ISSUED ON AUTHORITY OF THE CHIEF OF THE AIR STAFF

20 FEB 57
Revised 21 May 63

LIST OF RCAF REVISIONS

DATE	PAGE NO	DATE	PAGE NO
29 Jun 62	60A		
29 Jun 62	63		
7 Dec 62	100		
7 Dec 62	100A		
21 May 63	i		
21 May 63	8		
21 May 63	11		
21 May 63	16		
21 May 63	29		
21 May 63	41		
21 May 63	46		
21 May 63	59		
21 May 63	72		
21 May 63	76		
21 May 63	96		
21 May 63	97		
21 May 63	99		
21 May 63	100		
21 May 63	100A		
21 May 63	100B		
21 May 63	101		

TABLE OF CONTENTS

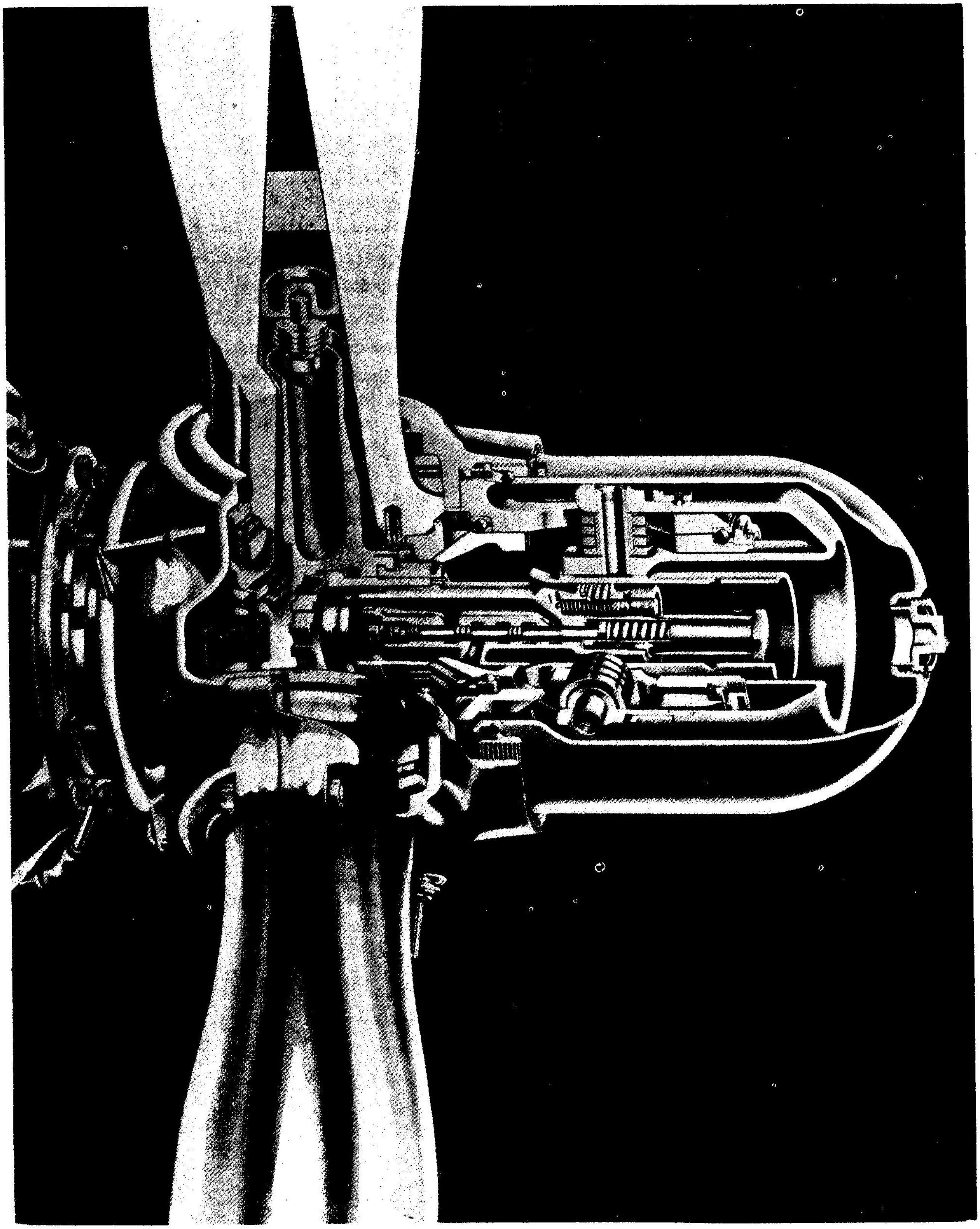


Figure 1—Cutaway View of Hydromatic Propeller

SECTION I
INTRODUCTION

1. GENERAL.

a. This Handbook is issued as the basic technical instructions for Hamilton Standard *Quick-Feathering* Hydromatic Propellers. It includes a detailed description of parts and assemblies, instructions for installation and removal, a discussion of operation, and directions for line maintenance, overhaul, reassembly, and test.

b. Since all models of the Hydromatic propeller are fundamentally alike in operating principles and design of major assemblies, this Handbook is based on the most widely used model, the 23E50, with supplementary instructions for the other models wherever necessary. The small variations in parts, procedures, etc., are pointed out in the applicable sections. The other models are:

22D30	33D50	23EX	24E60
22D40	24D50	33E60	23F60
23D40	24D60	24E50	24F60

c. These propellers are manufactured by Hamilton Standard Propellers, Division of United Aircraft Corporation, East Hartford, Connecticut, and by Licensees of that Corporation.

d. Reference should be made to Parts Catalog EO 15-30AB-4 for detailed information on part numbers. When installed on an aircraft, Hydromatic propellers require the use of Hydromatic governors. For information on these governors, refer to Handbook of Instructions, EO 15-30DB-2 and Parts Catalog, EO 15-30DB-4.

2. PROPELLER THEORY.

a. The first aircraft propellers were the *fixed pitch* type which, at best, represented a compromise between the blade angle requirements of take-off, cruising, and diving. The *two-position* propeller, which permitted selection by the pilot of a low angle for take-off and climb and a higher angle for cruising, was next developed. This type was a definite improvement over the fixed pitch model, but it still utilized only two compromise blade angles, high or low. To adequately provide for all conditions of aircraft operation, the governor-controlled *constant speed* type propeller, in which the blade angle is automatically adjusted at any setting between the high and low limits, was developed.

b. A propeller incorporating a variable blade pitch mechanism serves the same purpose in an aircraft as the transmission in an automobile. The changing relationship between power and speed needed to meet normal operating conditions is satisfactorily accomplished in an automobile by changing the gear ratio between the engine and the wheels. It would be impossible for the pilot to satisfactorily control engine output to meet the constantly changing requirements brought about by variations in aircraft attitude, altitude of flight, etc. The constant speed propeller in which the blades automatically change pitch is the aircraft equivalent of an automobile gear shift.

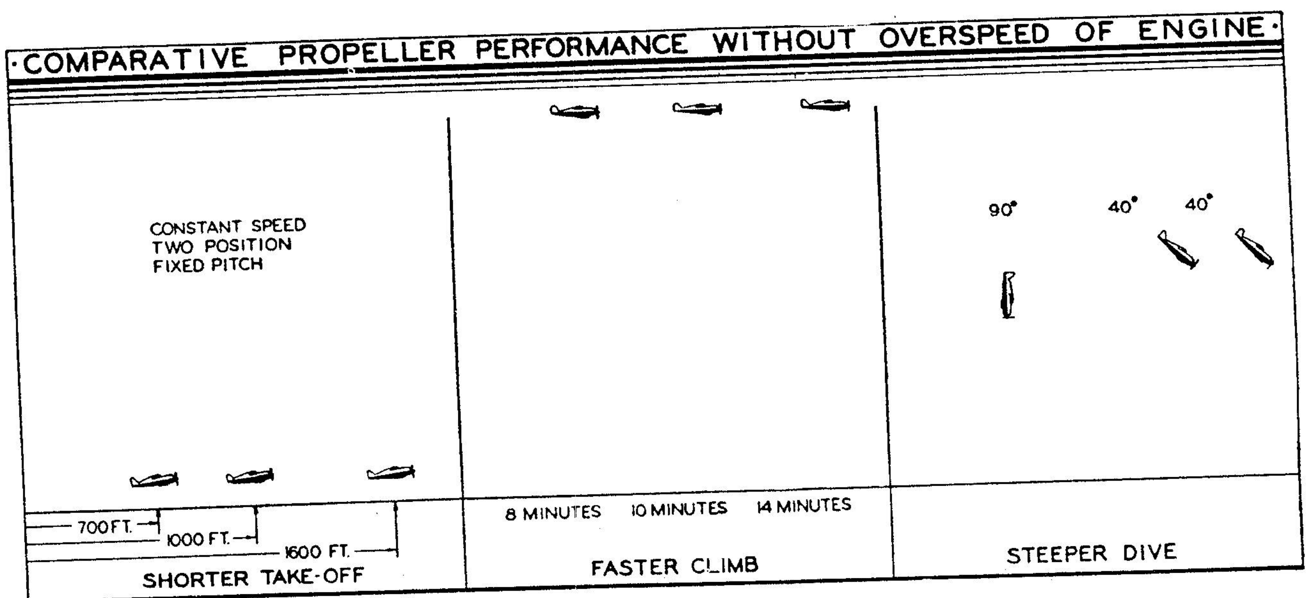


Figure 2—Comparative Performance of Constant Speed, Two-Position, and Fixed Pitch Propellers

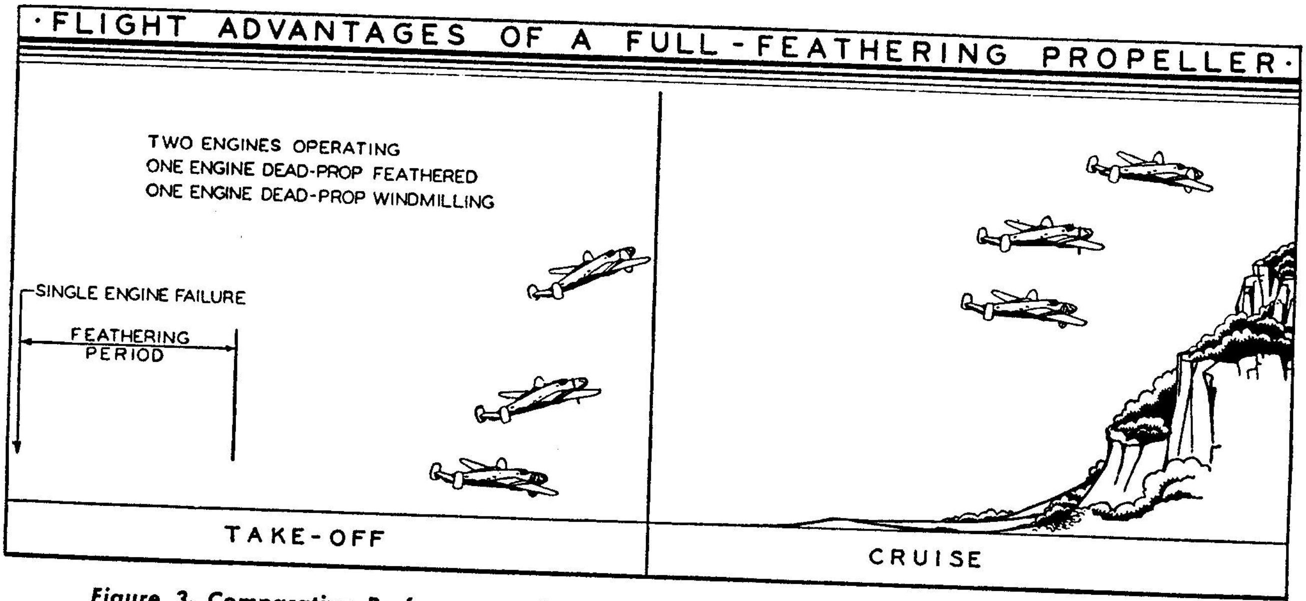


Figure 3—Comparative Performance of Feathering and Non-Feathering Propellers

c. If all other factors remain unchanged, the power required to operate a propeller at any given speed can be altered by changing the pitch of the propeller blades. It would take greater power to turn a propeller in which the blades were set at a high angle than it would if the blades were set at a lower angle. The constant speed propeller is adjusted by means of the engine driven *constant speed control* unit (propeller governor) to absorb more power by going to a higher blade angle when the engine tends to overspeed, and to absorb less power by going to a lower blade angle when the engine tends to underspeed.

d. As an example, if the pilot had set his throttle and propeller controls for 2300 rpm, and then changed the attitude of the aircraft from level flight to a dive, the engine would for an instant pick up speed as a result of the increase in aircraft speed brought about by the dive. The resulting change in engine speed actuates the pitch regulating mechanism in the engine driven propeller governor, and this unit in turn supplies the required amount of oil in the Hydromatic type propeller to move the blades to a higher angle. An increase in blade angle requires an increase in engine power output, and consequently the engine (and propeller) return to the on-speed condition.

e. Besides the constant speed mechanism, Hamilton Standard Hydromatic propellers include the *feathering* feature. Feathered, as applied to a propeller, means the blades are turned to such an angle that their average chord lies in the direction of aircraft flight. In this position, they act as powerful brakes to stop rotation of the propeller and engine, and at the same time, are in the position to offer the least possible drag on the aircraft. The ability to stop an engine from rotating in case of an engine failure on multi-engine aircraft is, from the safety standpoint, a great asset of the full-feathering propeller. A feathered propeller eliminates vibration due to windmilling of a damaged engine, and permits continued flight with improved handling quality and ease of control over that of an aircraft with non-feathering propellers.

f. Feathering a propeller is accomplished by introducing high pressure auxiliary oil from an independent source of supply on the inboard side of the propeller piston. Once the blades have been moved to the full-feathered position, they will remain at that angle and windmilling (cranking of an engine by virtue of the air passing through the propeller) is eliminated.

SECTION II
DESCRIPTION

1. GENERAL DESCRIPTION.

a. GENERAL.

(1) The Hydromatic propeller is composed of four major assemblies: the hub assembly; the dome assembly; the distributor valve assembly (for feathering, single-acting installations) or the engine shaft extension assembly (for non-feathering or double-acting installations); and the de-icing device assembly. The hub assembly is composed of the barrel assembly and the proper number of identical blade assemblies. In addition to these major assemblies, there is the extra parts group, made up of parts used in every propeller but not belonging to any one assembly.

Note

The terms "single-acting" and "double-acting" refer to propeller operational characteristics. Since the propeller is dependent upon the constant speed control (or governor) for its control, the type of governor determines the type of propeller so far as operation is concerned. This is more fully explained in paragraph 1b of this section and in section IV.

(2) The hub assembly is the basic propeller mechanism in that it contains the blades and the means of holding them in position. The blades are supported by the spider and retained by the barrel. Each blade is free to turn about its axis under control of the dome assembly.

(3) The dome assembly is the pitch changing mechanism for the blades. It mounts onto the outboard end of the barrel and its rotating cam meshes with the gear segments on the blades to turn them as it is acted upon by oil from the governor and the engine.

(4) The distributor valve and engine shaft extension assemblies provide oil passages from the engine-propeller shaft to both sides of the piston in the dome. In the distributor valve only, these internal passages can be reversed to permit unfeathering.

(5) The de-icing device assembly mounts on the inboard end of the barrel and directs the de-icing fluid to the leading edge of the blades.

(6) The extra parts group contains the retaining parts and the adapter used for either crankcase breathing or shaft breathing engines.

b. BASIC OPERATING PRINCIPLES.

(1) GENERAL.—The pitch-changing mechanism of the Hydromatic propeller is a mechanical-hydraulic system in which hydraulic forces acting upon a piston are transformed into mechanical twisting forces acting upon the blades. Piston movement causes rotation of a cam which incorporates a bevel gear. This bevel gear, meshing with bevel gear segments attached to the butt ends of the blades, turns the blades. The oil forces which act upon the piston are controlled by the governor. A single-acting governor directs its pump output against the inboard side of the piston only, while the double-acting governor can direct its output against either side of the piston as the operating condition requires. A single-acting propeller uses a single-acting governor, and a double-acting propeller use a double-acting governor. Physically, the two propellers may be identical, although for a feathering installation they are different in that the double-acting propeller uses an engine shaft extension instead of a distributor valve.

(2) SINGLE-ACTING PROPELLER CONTROL FORCES.—The single-acting type propeller makes use of three forces during constant speed operation: blade centrifugal twisting moment, oil at governor pressure applied against the inboard side of the piston, and oil at engine pressure applied against the outboard side.

(a) CENTRIFUGAL TWISTING MOMENT.—The centrifugal force acting on a rotating blade includes a component force in a direction such that the resulting twisting moment about the blade center line tends at all times to move the blade toward low pitch. This force, as shown in figure 5, may be represented by arrows whose common point of origin is the propeller (or engine-propeller shaft) axis. To analyze blade centrifugal twisting moment, an imaginary slice is taken in the propeller blade and the resulting airfoil section isolated as shown. Two points on this imaginary section

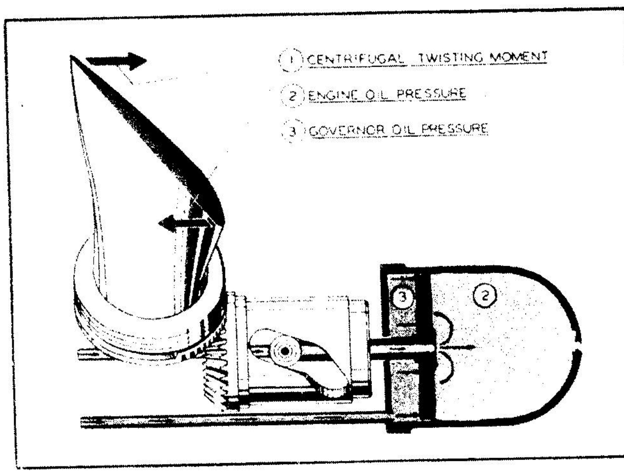


Figure 4—Fundamental Forces Diagram

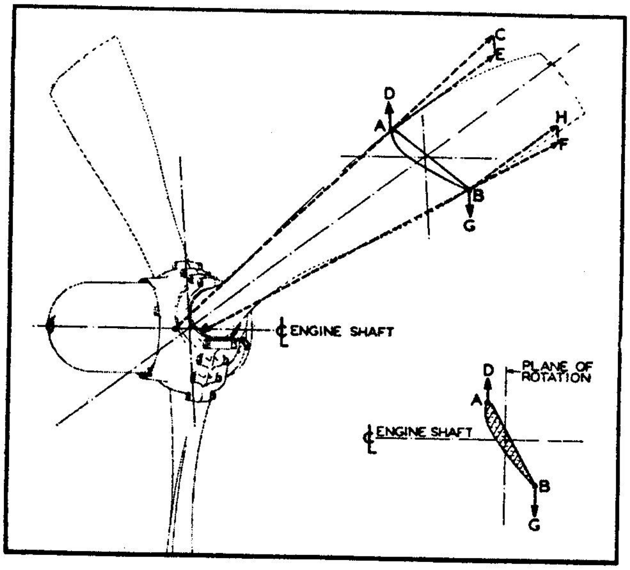


Figure 5—Blade Centrifugal Twisting Moment Diagram

are established, one at the leading edge marked "A", and one at the trailing edge marked "B". For purposes of analysis, these points, and the forces which act on them, may be considered as representative of any and all points of a rotating propeller blade.

1. Imagine point A as the center of a ball which is held within a given circle of rotation by a cord fixed at the same point as the center line of the propeller shaft. Rotating the ball sets up a centrifugal force which tends at all times to move the ball away from its axis of rotation. This centrifugal force may be represented by the arrow C (or F) whose direction is along the line connecting the point with the axis of rotation; and, continuing the analogy of the rotating ball, the direction of the arrow would be a prolongation of the cord holding the ball to the center of rotation. The length of this arrow is scaled to represent the force acting at any given time; consequently, as the speed of rotation increases, centrifugal force becomes greater and the arrow representing this force becomes longer.

2. Once the direction and magnitude of the arrow AC has been determined, it may be resolved into two forces at right angles whose final effect is the same as the original arrow. These component arrows are marked AD and AE.

3. The same process applied to point B on the trailing edge of the blade results in an arrow (representing centrifugal force) marked BF, and its component arrows BG and BH.

4. If the imaginary airfoil section is taken out of the blade and analyzed separately as shown in the lower right-hand corner of figure 5, force arrows AD and BG are still represented on the leading and trailing edges of the blade. However, it now becomes apparent that these forces tend to move the blade into low pitch, and together they represent what is commonly called ***the centrifugal twisting moment*** of a rotating propeller blade.

(b) ENGINE OIL.—As shown in figure 4, oil at engine pressure, supplied to the outboard side of the propeller piston to supplement the centrifugal twisting moment toward low pitch during constant speed operation, is the second force used to control the propeller blade angle.

(c) GOVERNOR OIL.—Governor oil, taken from the engine oil supply and boosted in pressure by the engine driven propeller governor, is the control force which balances centrifugal twisting moment and oil at engine pressure. By metering this high pressure oil to or draining it from the inboard side of the propeller piston through the constant speed control unit, a force toward high pitch is provided which balances and controls the two forces toward low pitch and thereby regulates the propeller blade angles by means of the cam and piston arrangement shown.

(3) DOUBLE-ACTING PROPELLER CONTROL FORCES.

(a) CENTRIFUGAL TWISTING MOMENT.—This natural force is present in all types of propellers, and acts the same way in all.

(b) GOVERNOR OIL. — Double-acting governor pump output oil is directed by the governor to either side of the propeller piston.

(c) PROPELLER RETURN OIL.—The oil on the side of the piston opposite the governor oil returns to the intake side of the governor pump and is used over again. Engine oil at engine supply pressure does not enter the propeller but is supplied only to the governor.

c. MODEL DESIGNATION SYSTEM.

(1) HUB ASSEMBLY.

(a) Hamilton Standard Hydromatic propellers are identified by a model designation system which explains in part the type and use of the propeller. The numbers and letter group in front of the dash describes the basic propeller model, and the number group following the dash indicates the minor modifications incorporated in that basic model. As an example, on a propeller designated as Model 23E50-501, the numbers and letter preceding the dash indicate the following:

1. The first number, namely, "2", is used to identify the number of *major* changes incorporated in the propeller; succeeding major changes will be identified by 3, 4, etc. as 33E50-, 43E50-, etc.

2. The second number, "3" in this example, indicates the number of blades in the propeller. Hydromatic propellers are manufactured with 2, 3, or 4 blades.

3. The letter "E" describes the blade shank size. Hydromatic propeller blade sizes are D, E, and F, which

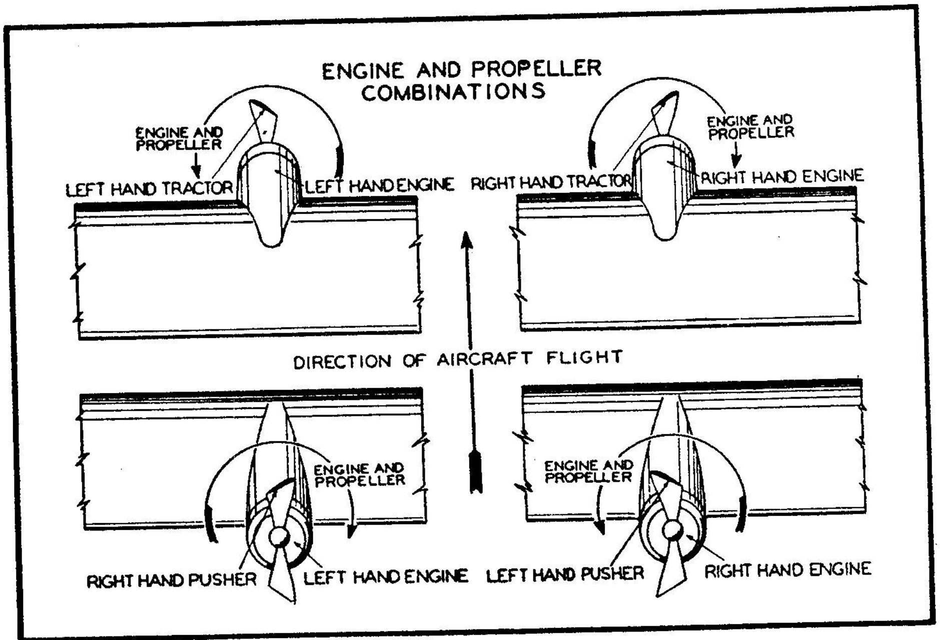


Figure 6—Engine-Propeller Combinations

are approximately equivalent in shank diameter to SAE blade shank sizes 1-1/2, 2, and 3.

4. The last two numbers preceding the dash, in this example "50", indicate the spline size of the propeller shaft. Hydromatic type propellers are built in 30, 40, 50, and 60 SAE propeller shaft spline sizes.

(b) The numbers following the dash indicate the following:

1. Minor modifications incorporated in a propeller are identified by the number group following the dash. In this example, the propeller is modified to a "-501" model. 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 the left-hand version of the propeller bearing the next lower (odd) "dash" number.

Note

As shown in figure 6, direction of propeller rotation is determined by viewing the propeller from the slip stream, whereas direction of engine rotation is determined by viewing the engine shaft from the rear of the engine.

2. By selecting the parts list (or by referring to the parts catalog) under the model designation etched on the propeller barrel, plus the parts list for the particular blade involved, it is possible to determine exactly the parts and assemblies by name and number composing the complete propeller assembly.

(2) BLADE ASSEMBLY.—In addition to the hub designation, the blades are identified by design numbers stamped on the circumference of the butt end of each blade. The blade designation system is similar to that used for the hub in that it describes (in part) the use and type of the unit. As an example, on a blade designated as a C6353A-18B, the numbers and letters indicate the following:

(a) The first letter, in this case "C", indicates that a molded rubber fairing has been added over the blade shank. Various styles of fairings are indicated by changes in this letter designation.

(b) The first number group, in this case 6353, specifies the basic blade design.

(c) The letter "A" which follows the basic blade design number group shows that the blade is a blade assembly; an assembly generally includes the bearing assembly, the bushing, bushing drive pins, the shim plate drive pins, the bushing screws, and the balancing plug assembly.

(d) The first dash number group following the basic blade design number indicates the number of inches the the propeller diameter is reduced by straight cut-off from that provided by the basic blade design. In this case the basic blade design, if used, would be identified as C6353A-0; however, the "-18" in the first example shows that the propeller diameter has been reduced 18 inches which would mean each blade has been cut down nine inches as outlined in figure 7. If the letter "B" is incorporated in the cut-off identification number, it indicates that a bushing with oversize bearing diameters is used in the blade.

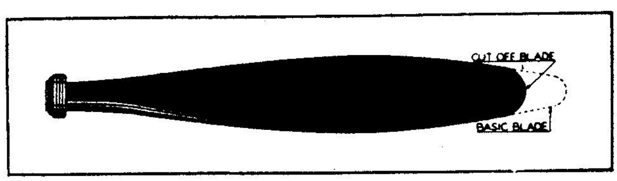


Figure 7—Typical Blade Cut-Off Diagram

d. REVISED MODEL DESIGNATION SYSTEM.

(1) GENERAL.

(a) The Hydromatic propellers model designation system has been revised to improve its Field utility. This is accomplished by limiting changes in the propeller model dash number to those affecting *functional* interchangeability, and by adding a parts list number to the propeller model number to indicate *physical* differences in detail parts and assemblies which do not affect utility of the unit. In addition, the de-icing device assembly is no longer included as one of the major assemblies of the propeller, but is instead classed as a separate accessory specified for a given installation in the same manner as feathering pumps, relays, etc., and spinner attaching parts are removed from the barrel assembly and added to the spinner assembly. By treating the de-icing device and spinner attaching parts in this way it is not necessary to change propeller dash numbers merely because one uses a de-icing device and/or a spinner and the other does not. This new system, which substantially reduces the quantity of different dash numbers of a certain model in the Field, permits greater interchangeability since propellers of the same dash number designation are then usable on specified aircraft. Of course, it will still be necessary when selecting a replacement propeller to take into account certain installation factors which do not affect propeller model designation, such as the type and size of the blades, the blade angle setting, governor rpm setting, and the like.

(b) The terms "functional" and "physical" interchangeability are used throughout this paragraph. For purposes of definition in this discussion, functional interchangeability means that one propeller will operate or function in place of another, and physical interchangeability means that the part or assembly will fit or can be installed in place of another.

(2) FORMER DESIGNATION SYSTEM.

(a) Under the former designation system, a propeller is identified by a basic model number and a dash number, for example 23E50-473. The numbers and letter group preceding the dash identify the basic model, and the number group following the dash specifies the particular variation and the parts list number of the basic model. Any functional change or any physical change requiring a new part number is reflected in the propeller designation by a change in the dash number. While this is logical, and in some respects desirable, it results in a larger number of different model designations than may be necessary from the standpoint of maintenance operations.

(b) At present, the factors which would affect functional interchangeability in Hydromatic type propellers can be classified as follows: one, the distributor valve assembly, and in this case the pressure setting may be either 500, 600, or 800 p.s.i., the unit may be shaft or crankcase breathing, or an engine shaft extension may be used; two, the type of cams used, and these may be either standard, faired knee, fast-acting, reversing, straight slope, or inverted pressure; three, the piston, which may or may not incorporate bleed holes; four, propeller rotation, which may be right or left-hand; and five, installation clearance. This fourth factor, propeller rotation, under both the former and the new designation system is indicated by odd and even dash numbers for right- and left-hand rotation respectively. Any one of these five factors, or combinations of them, would affect functioning of the propeller and limit its use to certain aircraft.

(c) As stated above, the dash number in conjunction with the basic model number is also used to call out the propeller parts list. The identification number of each major assembly and the part numbers of certain attaching parts which together constitute the propeller are shown on this propeller parts list. Whenever a part is changed so that it is no longer functionally or physically interchangeable with the other part, then a new part number is assigned. This new part number requires a change in the pertinent assembly number, which in turn requires a change in the propeller dash number.

(3) NEW DESIGNATION SYSTEM.—Under the new model designation system, the propeller is identified by a model number and a propeller parts list number, both etched on the propeller barrel; for example,

23E50—473
PL 10,063

Changes in the propeller dash number are limited to those affecting functional interchangeability of the propeller. At the present time, these changes, or variations, are limited to those previously mentioned under the description of the former designation system. As is the case under the former designation system, the propeller parts list shows each major assembly and the attaching parts by number which constitute the propeller. These lists can be used to identify parts and for stocking purposes. The propeller parts list number will be changed to indicate various physical differences which make certain parts and assemblies non-interchangeable, but so long as these differences do not affect the operational characteristics (functions) of the propeller, the propeller dash number will remain the same.

(4) RE-MARKING PROPELLERS.—Below is a listing of the Hydromatic propeller dash numbers

which are affected under the new system. To cover the vast majority of propellers in the Field, this change is made retroactive on each basic model to the design change where the distributor valve setting was increased from 500 to 600 p.s.i., and two bleed holes in the piston were established as standard. If it is desired to re-mark a propeller with a dash number not shown, the correct new designation will be furnished on request.

Note

The model variation summary in paragraph 4 of this section has not been altered since the tabulation below indicates the only changes required.

PRESENT DESIGNATION	NEW DESIGNATION
22D30-33	22D30-33, PL 10062
22D30-35	22D30-33, PL 10063
22D30-49	22D30-33, PL 10064
22D30-51	22D30-33, PL 10065
22D40-31	22D40-31, PL 10066
22D40-37	22D40-31, PL 10067
22D40-45	22D40-31, PL 10068
22D40-47	22D40-31, PL 10069
23D40-31	23D40-31, PL 10070
23D40-35	23D40-31, PL 10071
23D40-37	23D40-37, PL 10074
23D40-41	23D40-31, PL 10072
23D40-45	23D40-31, PL 10073
23D40-47	23D40-37, PL 10075
33D50-101	33D50-101, PL 10076
33D50-105	33D50-105, PL 10082
33D50-107	33D50-101, PL 10077
33D50-109	33D50-109, PL 10085
33D50-111	33D50-111, PL 10087
33D50-115	33D50-109, PL 10085
33D50-119	33D50-109, PL 10085
33D50-121	33D50-121, PL 10090
33D50-135	33D50-101, PL 10078
33D50-137	33D50-105, PL 10083
33D50-139	33D50-101, PL 10079
33D50-141	33D50-109, PL 10086
33D50-143	33D50-111, PL 10088
33D50-145	33D50-109, PL 10086
33D50-147	33D50-109, PL 10086
33D50-149	33D50-109, PL 10086
33D50-151	33D50-151, PL 10092
33D50-153	33D50-153, PL 10094
33D50-155	33D50-101, PL 10080
33D50-157	33D50-105, PL 10084
33D50-159	33D50-101, PL 10081
33D50-161	33D50-109, PL 10087
33D50-163	33D50-111, PL 10089
33D50-165	33D50-109, PL 10087
33D50-167	33D50-109, PL 10087
33D50-169	33D50-121, PL 10091
33D50-171	33D50-151, PL 10093
33D50-173	33D50-153, PL 10095
33D50-191	33D50-191, PL 10096
33D50-193	33D50-193, PL 10097
33D50-195	33D50-101, PL 10078
33D50-197	33D50-191, PL 10096
33D50-201	33D50-101, PL 10078
33D50-203	33D50-105, PL 10083

PRESENT DESIGNATION	NEW DESIGNATION
33D50-205	33D50-151, PL 10092
33D50-207	33D50-153, PL 10094
33D50-209	33D50-101, PL 10080
33D50-211	33D50-105, PL 10084
33D50-213	33D50-111, PL 10089
33D50-215	33D50-109, PL 10087
33D50-217	33D50-121, PL 10091
33D50-219	33D50-151, PL 10093
33D50-221	33D50-153, PL 10095
33D50-223	33D50-191, PL 10096
33D50-225	33D50-101, PL 10078
33D50-227	33D50-191, PL 10096
23E50-471	23E50-471, PL 10098
23E50-473	23E50-473, PL 10099
23E50-489	23E50-489, PL 10101
23E50-491	23E50-491, PL 10102
23EX-493	23EX-493, PL 10103
23E50-495	23E50-495, PL 10104
23E50-499	23E50-495, PL 10105
23E50-501	23E50-473, PL 10100
23E50-505	23E50-505, PL 10106
23E50-543	23E50-543, PL 10108
23EX-545	23EX-545, PL 10109
23E50-547	23E50-489, PL 10101
23E50-551	23E50-471, PL 10098
23E50-553	23E50-473, PL 10099
23E50-563	23E50-489, PL 10101
23E50-565	23E50-491, PL 10102
23E50-567	23E50-567, PL 10110
23E50-569	23E50-495, PL 10104
23E50-573	23E50-505, PL 10106
23E50-577	23E50-505, PL 10107
23E50-579	23E50-473, PL 10099
23EX-581	23EX-581, PL 10111
23EX-583	23EX-583, PL 10112
23E50-587	23E50-587, PL 10113
23E50-589	23E50-505, PL 10106
23E50-591	23E50-591, PL 10114
23E50-593	23E50-591, PL 10114
23E50-595	23E50-543, PL 10108
23E50-751	23E50-567, PL 10110
23E50-753	23E50-471, PL 10098
23E50-755	23E50-473, PL 10099
23E50-759	23E50-489, PL 10101
23E50-761	23E50-491, PL 10102
23E50-763	23E50-495, PL 10104
23E50-765	23E50-495, PL 10105
23E50-767	23E50-473, PL 10100
23E50-769	23E50-471, PL 10098
23E50-771	23E50-473, PL 10099

PRESENT DESIGNATION	NEW DESIGNATION
23E50-773	23E50-489, PL 10101
23E50-775	23E50-491, PL 10102
23E50-777	23E50-567, PL 10110
23E50-779	23E50-495, PL 10104
23E50-781	23E50-505, PL 10106
23E50-783	23E50-505, PL 10107
23E50-785	23E50-505, PL 10106
23E50-787	23E50-543, PL 10108
23E50-793	23E50-591, PL 10114
23E50-795	23E50-795, PL 10169
33E60-31	33E60-31, PL 10115
33E60-33	33E60-33, PL 10119
33E60-35	33E60-35, PL 10122
33E60-37	33E60-31, PL 10116
33E60-39	33E60-33, PL 10119
33E60-41	33E60-31, PL 10116
33E60-45	33E60-35, PL 10123
33E60-47	33E60-31, PL 10117
33E60-49	33E60-31, PL 10117
33E60-51	33E60-33, PL 10120
33E60-53	33E60-31, PL 10118
33E60-55	33E60-33, PL 10121
33E60-57	33E60-33, PL 10120
33E60-71	33E60-31, PL 10115
33E60-73	33E60-33, PL 10119
33E60-75	33E60-35, PL 10122
33E60-79	33E60-79, PL 10124
33E60-81	33E60-79, PL 10125
33E60-83	33E60-79, PL 10126
33E60-85	33E60-85, PL 10127
33E60-89	33E60-79, PL 10125
33E60-91	33E60-91, PL 10129
33E60-93	33E60-79, PL 10125
33E60-95	33E60-33, PL 10119
33E60-97	33E60-31, PL 10115
33E60-101	33E60-31, PL 10115
33E60-103	33E60-33, PL 10119
33E60-105	33E60-35, PL 10122
33E60-107	33E60-31, PL 10116
33E60-109	33E60-31, PL 10115
33E60-111	33E60-33, PL 10119
33E60-113	33E60-35, PL 10122
33E60-117	33E60-79, PL 10124
33E60-119	33E60-79, PL 10125
33E60-121	33E60-91, PL 10129
33E60-123	33E60-85, PL 10128
33E60-125	33E60-79, PL 10125
33E60-127	33E60-31, PL 10115
23F60-35	23F60-35, PL 10130

PRESENT DESIGNATION	NEW DESIGNATION
23F60-37	23F60-35, PL 10130
23F60-41	23F60-41, PL 10131
23F60-51	23F60-35, PL 10130
23F60-53	23F60-35, PL 10130
24D50-65	24D50-65, PL 10132
24D50-71	24D50-71, PL 10135
24D50-73	24D50-65, PL 10133
24D50-75	24D50-65, PL 10133
24D50-77	24D50-71, PL 10135
24D50-79	24D50-79, PL 10137
24D50-81	24D50-71, PL 10136
24D50-85	24D50-65, PL 10133
24D50-87	24D50-65, PL 10132
24D50-95	24D50-71, PL 10135
24D50-97	24D50-71, PL 10136
24D50-105	24D50-65, PL 10132
24D60-11	24D60-11, PL 10138
24D60-13	24D60-13, PL 10140
24D60-17	24D60-11, PL 10139
24D60-19	24D60-19, PL 10141
24D60-25	24D60-11, PL 10138
24D60-27	24D60-13, PL 10140
24D60-29	24D60-11, PL 10138
24E50-21	24E50-21, PL 10142
24E50-27	24E50-21, PL 10142
24E50-31	24E50-31, PL 10143
24E50-61	24E50-61, PL 10144
24E50-63	24E50-61, PL 10144
24E50-65	24E50-65, PL 10145
24E50-67	24E50-67, PL 10146
24E50-73	24E50-73, PL 10147
24E50-81	24E50-81, PL 10148
24E50-83	24E50-81, PL 10148
24E50-101	24E50-21, PL 10142
24E50-111	24E50-31, PL 10143
24E50-153	24E50-61, PL 10144
24E50-155	24E50-65, PL 10145
24E50-157	24E50-67, PL 10146
24E60-23	24E60-23, PL 10149
24E60-29	24E60-29, PL 10151
24E60-33	24E60-33, PL 10152
24E60-37	24E60-29, PL 10151
24E60-39	24E60-23, PL 10150
24E60-41	24E60-33, PL 10152
24E60-43	24E60-43, PL 10153
24E60-45	24E60-45, PL 10154
24E60-47	24E60-47, PL 10155
24E60-75	24E60-75, PL 10156
24E60-97	24E60-75, PL 10156
24E60-99	24E60-47, PL 10196
24E60-103	24E60-23, PL 10149
24E60-105	24E60-33, PL 10152
24E60-109	24E60-29, PL 10151
24E60-113	24E60-23, PL 10150
24E60-121	24E60-75, PL 10157
24F60-11	24F60-11, PL 10158
24F60-13	24F60-13, PL 10159
24F60-17	24F60-17, PL 10160
24F60-19	24F60-19, PL 10161
24F60-21	24F60-21, PL 10162
24F60-23	24F60-23, PL 10163
24F60-25	24F60-25, PL 10164
24F60-27	24F60-25, PL 10164
24F60-29	24F60-25, PL 10165
24F60-31	24F60-25, PL 10165
24F60-33	24F60-33, PL 10166
24F60-35	24F60-35, PL 10167
24F60-43	24F60-35, PL 10167
24F60-73	24F60-35, PL 10167
24F60-101	24F60-35, PL 10167
24F60-103	24F60-35, PL 10167
24-F60-105	24F60-35, PL 10167
24F60-301	24F60-301, PL 10168
24F60-303	24F60-301, PL 10168
24F60-305	24F60-301, PL 10168
24F60-339	24F60-301, PL 10168

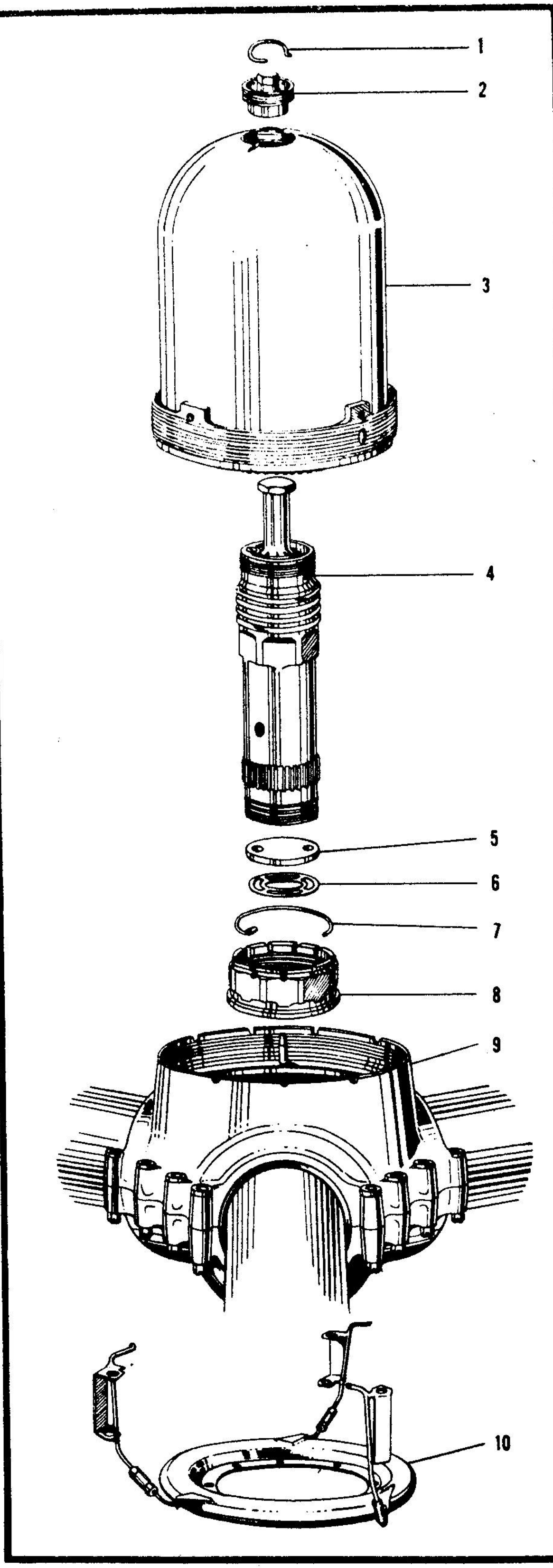


Figure 8—Complete Model 23E50 Propeller

2. DETAILED DESCRIPTION—MODEL 23E50.

a. GENERAL.

(1) A great deal of similarity exists among all models of the Hydromatic propeller. For this reason, this manual is based on the most widely used model, namely, the 23E50. The detailed description of the other models is based on their variations from the 23E50 model.

Note

Throughout this section reference to major assemblies and parts is often made according to the model number of the propeller. For example, a dome assembly might be described as a "24F60" dome. This does not mean that 24F60 is the assembly number of the dome. It merely indicates that the dome in question is used in the 24F60 propeller model.

(2) A typical model 23E50 Hydromatic propeller, shown in figure 8, is composed of four major assemblies: the hub assembly; the dome assembly; the distributor valve or shaft extension assembly; and the de-icing device assembly. The hub assembly is further subdivided into the barrel assembly and the blade assemblies. Besides these major assemblies there are certain parts which do not belong in any of the major assemblies, yet are used in all models. These compose the extra parts group.

b. BARREL ASSEMBLY. (See figure 9.)

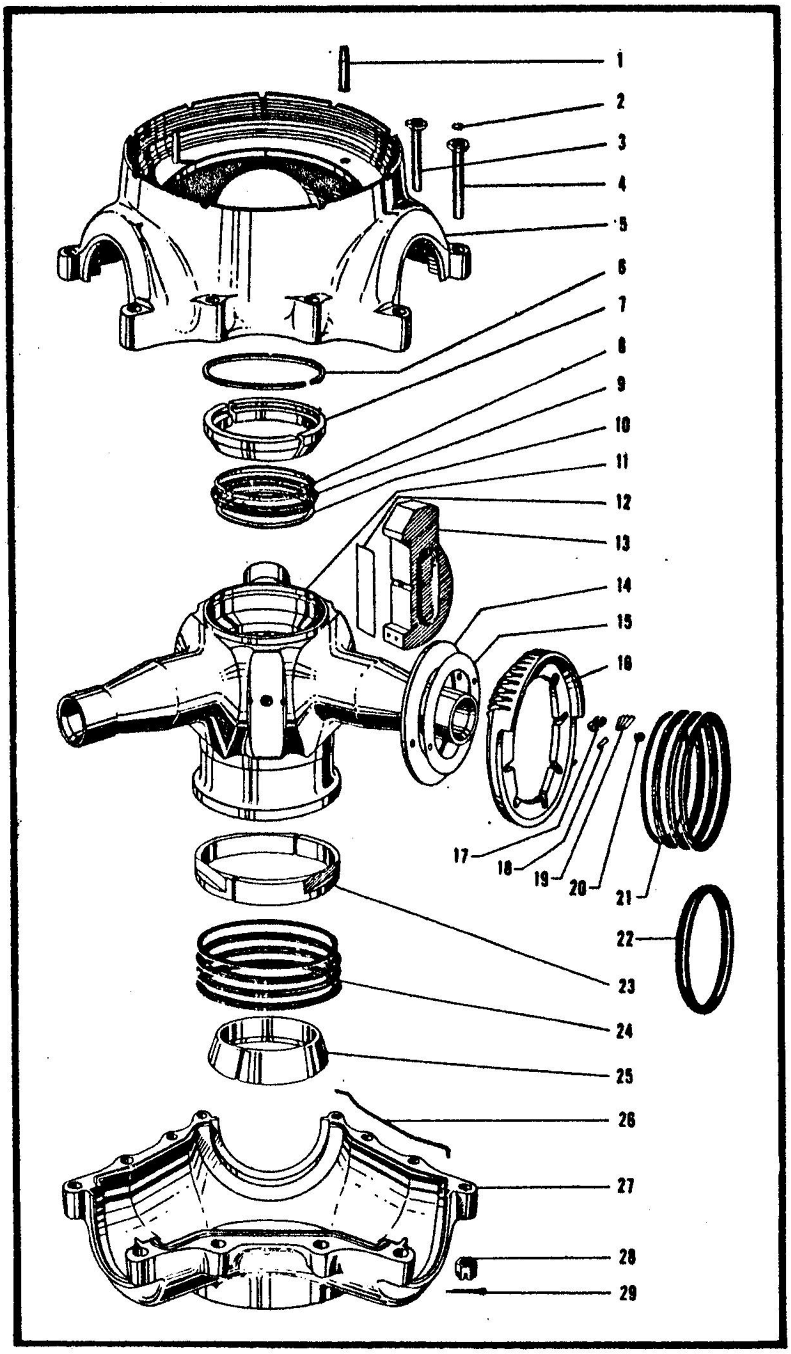
(1) SPIDER.

(a) The spider may be considered the foundation for the entire propeller. It is made from forged chromium-nickel-molybdenum steel which is carefully heat-treated to bring the physical properties of the piece to the best combination of strength and machineability.

(b) Its central bore is splined to fit the engine-propeller shaft, with one raised spline segment omitted to match the wide spline on the propeller shaft. A finely ground cone seat is located at each end of the central bore spline; the rear cone seat is at 15 degrees and the front cone seat at 30 degrees with the propeller axis. The splines and cones transmit engine torque to the propeller. Forged integral with the central portion of the spider are

Nomenclature for Figure 8

1 DOME BREATHER HOLE NUT LOCK WIRE
2 DOME BREATHER HOLE NUT
3 DOME ASSEMBLY
4 DISTRIBUTOR VALVE ASSEMBLY
5 VALVE HOUSING OIL TRANSFER PLATE
6 TRANSFER PLATE-PROPELLER SHAFT GASKET
7 PROPELLER RETAINING NUT LOCK WIRE
8 PROPELLER RETAINING NUT
9 HUB ASSEMBLY
10 DE-ICING DEVICE ASSEMBLY



1 FIXED CAM LOCATING DOWEL
2 WELCH PLUG
3 BARREL BOLT (SHORT)
4 BARREL BOLT (LONG)
5 OUTBOARD BARREL HALF
6 HUB SNAP RING
7 FRONT CONE
8 SPIDER-SHAFT SEAL RING
9 SPIDER-SHAFT SEAL
10 SPIDER-SHAFT SEAL WASHER
11 SPIDER
12 BARREL SUPPORT SHIM
13 BARREL SUPPORT
14 SPIDER SHIM PLATE
15 SPIDER SHIM
16 BLADE GEAR SEGMENT
17 SPRING PACK
18 SPRING PACK SHIM
19 SPRING PACK SPRINGS
20 SPRING PACK RETAINER
21 CHEVRON TYPE BLADE PACKING
22 TOROID TYPE BLADE PACKING
23 SPIDER RING
24 SPIDER-BARREL PACKING
25 REAR CONE
26 BARREL HALF SEAL
27 INBOARD BARREL HALF
28 BARREL BOLT NUT
29 COTTER PIN

Figure 9—Barrel Assembly for Model 23E50

arms which extend into the blades and locate them in the propeller assembly. The spider arms support the blades and take the greater part of the blade thrust and torque loads. These arms incorporate two finely ground bearing surfaces. The larger diameter bearing is located adjacent to the central portion of the spider, and the smaller bearing is on the outer portion of each arm. The inside of each spider arm is hollow to lighten the propeller assembly, and two holes connect this hollow arm portion with the middle of the barrel support face. Under operating conditions, these holes provide a passage for oil which enters the hollow bore of the blade shank and passes around the bearing surfaces between the spider arms and the blade bushings.

(c) A ledge at the base of the spider supports the chevron type synthetic rubber spider-barrel packings used to form the oil seal between the base of the spider and the barrel. These packings, made up of a header ring, two

seal rings, and a follower ring, are installed over the spider with their open lips towards the spider arms. The follower ring which is installed last is identified by a red stripe. After the packings are in place, the split type phenolic spider ring is put on top of them so that each flat surface on the ring aligns with a spider shim plate surface.

(d) A groove just outboard of the front cone ledge accommodates the hub snap ring. When the propeller is installed on the engine, this snap ring is inserted around the propeller retaining nut near the outboard face of the front cone, and dropped into place in the groove. As the propeller retaining nut is backed off the shaft during propeller removal, the nut advances along the engine-propeller shaft threads until the front cone contacts the snap ring and thereby moves the entire hub off the rear cone.

(e) Flat surfaces on the spider in line with the central axis and between the arms seat the barrel supports which provide a support for the barrel on the spider.

(f) The oil seal between the spider and the engine-propeller shaft includes the metal spider-shaft seal washer, a synthetic rubber spider-shaft seal, and a metal spider-shaft seal ring. The washer acts as a seat for the seal, and the seal ring fits into the open end of the chevron type seal to keep it expanded. These parts are inserted just inboard of the front cone bearing surface, and fit between the spider and the shaft. The lips of the seal face outboard.

(2) BARREL.

(a) The barrel itself may be considered as a casing which encloses the propeller hub assembly. It is made from drop forged chromium-vanadium steel carefully heat-treated to insure maximum strength. The barrel is manufactured in half sections which are ground and balanced as a pair and kept together throughout the service life of the propeller.

CAUTION

Barrel halves are not interchangeable between assemblies. These halves are kept together during manufacture, and each cannot be used with any other barrel half.

(b) The barrel carries the high centrifugal blade loads by means of shoulders provided at each blade bore, and lips are incorporated outside the shoulders to hold the blade packings. Earlier models had angle graduations on the blade bore lip to facilitate checking blade angle.

(c) Grooves cut into the barrel halves at the parting surfaces provide for the barrel half oil seals. These seals are shaped to conform with the general outline of the barrel section between the blade arms. A small tip included at each end of the barrel half oil seal groove matches with an extended tip section at each end of the barrel half seal. The barrel half seals used in model 23E50 propellers are identified by a yellow mark.

(d) The outboard barrel half incorporates a shelf just inboard of the dome retaining nut threads which locates and supports the dome assembly, and includes a fixed cam locating dowel hole in the center of the arc between each blade bore. Dowels are pressed into these holes so that the base section of the dowel seats on the top of the corresponding barrel support, and the tip section (at propeller assembly) protrudes through the base of the fixed cam. On current production barrels, three lines are stamped on the ID of the barrel shelf, midway between the dowel holes, over the center of each blade bore, for indexing the blades.

(e) The barrel halves are held together by nuts and bolts which fit through bolt bosses incorporated in each barrel half in the arc between the propeller blades. The centers of these bolts are drilled out to provide for the lead wool used in final balance of the propeller. Each bolt is closed with a welch plug. Special spinner mounting nuts and bolts are provided when a spinner is used.

(f) Several half-circle notches which accommodate the dome retaining nut lock screw are cut in the outer rim of the outboard barrel half.

(3) BARREL SUPPORTS.—Phenolic supports are used between the barrel and the spider to provide for alignment and support of the barrel on the spider. A solid brass shim fits between each support and the spider making possible adjustment of spider-barrel concentricity and squareness. Two lips keep the block from moving inboard or outboard on the spider. Certain earlier models should be reworked to incorporate reinforcing pins in the support. They may be modified according to instructions given in section VI. The inside face of the block matches with and locates on the barrel support seat of the spider, while the outside surface is curved to correspond with the curved inside portion of the inboard barrel half. This arrangement and the use of shims between the barrel supports and the spider results in a light drive fit of the barrel halves over the barrel supports.

(4) BLADE—BARREL PARTS.—The parts and assemblies listed below are fitted directly on the blades, yet they are considered as parts of the barrel assembly.

(a) BLADE GEAR SEGMENT.—The blade gear segments are made from steel forgings. Each segment incorporates fifteen bevel gear teeth which engage with the teeth on the rotating cam. Eight spring pack slots are equally spaced around the inner periphery of the segment, and correspond to those in the blade bushing. Attachment of the gear segment to the blade is accomplished by the spring pack assemblies which fit into these eight slots.

(*b*) BLADE PACKING.—The blade assembly is made oil tight in the barrel by the use of synthetic rubber, chevron type blade packings which fit between the outer thrust washer and the blade packing lip of the barrel blade bore. The chevron type packing consists of a header ring, two lip rings, and a follower ring. A toroid type blade packing has superseded the chevron type on current production models. Figure 10 shows how this type of packing fits into the hub assembly. Note that the two types are interchangeable.

(*c*) SPRING PACK ASSEMBLIES.—To provide gear preload between the blade gear segment and the teeth of the rotating cam, spring packs are included between the blade gear segment and the blade bushing. A spring pack assembly consists of two horseshoe spring retainers, a number of spring leaves, and, when necessary for a snug fit of the springs in the retainers, one or two spring shims. There are two types of springs: one is identified by a straw color, while the other is bluish. The endurance properties of the straw colored springs are superior to those of the blue steel springs, and, as a result, the newer type springs should be used with blades which have large twisting moments. The older type springs are entirely satisfactory for all other installations.

(*d*) SHIM PLATES AND SHIMS.—A solid brass shim and a cast iron shim plate are included between the blade bushing face and the spider arm shoulder, and are held in place by two shim plate drive pins which fit into the bushing drive pins. The solid brass shims are used to adjust the blade torque during assembly.

c. BLADE ASSEMBLY. (See figure 11.)

(1) BLADE.—Hydromatic propeller blades are made from aluminum forgings, heat-treated for high strength. Two alloys of aluminum are used: the standard alloy, and the hard alloy. These differ somewhat in their properties, the hard alloy having the higher specific gravity. Two blades of the same physical design but different alloys have two separate design numbers. The butt end incorporates a shoulder (perpendicular to the shank center line of the blade) which rests on steel rings. To lighten the blade and to provide for the blade bushing, a portion of the shank section of the blade is forged hollow and bored to finished size. Many blade designs have the "E" type shank and are, therefore, interchangeable for use in the model 23E50. However, in any one propeller, all blades must be of the same design.

(2) THRUST WASHERS.—Before the butt end of the blade is formed in the forging operation, two hardened steel rings (part of the thrust bearing assembly) are slipped over the blade to fit between the airfoil section and the butt face. These thrust washers, which are not replaceable on a finished blade, carry the centrifugal load; the one nearest the blade butt incorporates a radius to match the fillet machined on the blade butt, and the other is a flat washer which fits against the rollers on one side and the blade retaining shoulders in the barrel on the other. The centrifugal blade loads are transmitted from the shoulders on the blade butt, through a phenolic chafing ring, to the inner (beveled) thrust washer. The outer (flat) thrust washer transmits this load to the shoulders on the barrel blade bore. The bearing assembly is completed by adding the roller thrust bearings between the two thrust washers. These bearings are designed for low frictional torque under high centrifugal blade loads.

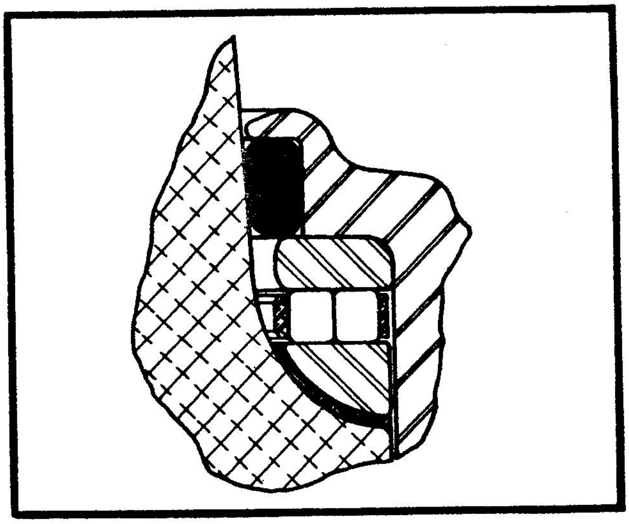
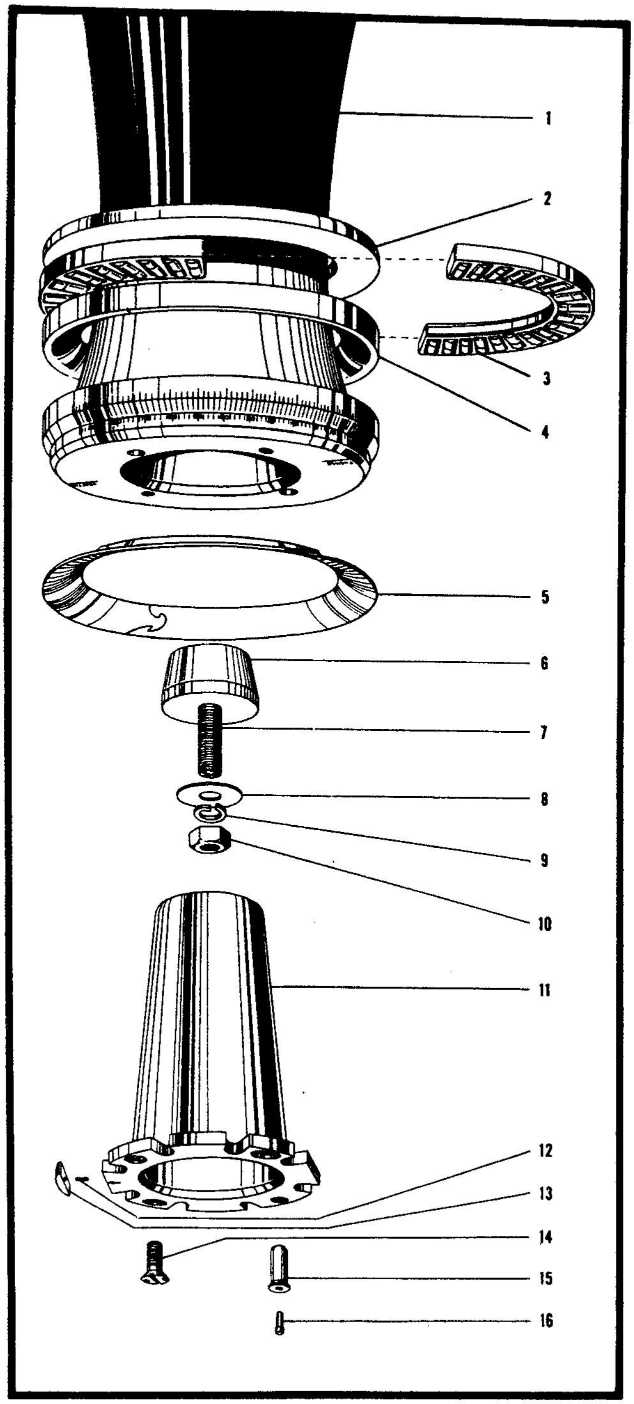


Figure 10—Toroid Blade Packing in Position

(3) BLADE BUSHINGS.—Blade bushings are made of an aluminum-bronze alloy. At assembly of the blade, the bushings are shrunk into the tapered blade bore and located by two drive pins (which also include the shim plate drive pins) and two screws. These bushing drive pins are available in several oversizes, and may be replaced according to directions given in section VI, paragraph 5. To provide a better grip of the bushing in the blade, the outside tapered portion of the bushing is sandblasted. Each blade bushing incorporates eight approximately half-circle slots which hold one end of the spring packs. Two of these spring pack slots are offset to provide an initial preload (in an assembled propeller) between the mating rotating cam gear and blade gear segment 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.

(4) BLADE BALANCING PLUG.—Each blade is fitted with an aluminum plug which is pressed into the blade bore at a point just beyond the outer end of the blade bushing. This plug serves two purposes; it prevents oil from passing into the extreme end of the taper bore, and it incorporates a stud on which washers may be installed for initial blade balance. This plug is so designed that it may be withdrawn from the blade bore without first removing the blade bushing.



1 BLADE
2 THRUST BEARING FLAT WASHER
3 THRUST BEARING RETAINER
4 THRUST BEARING BEVELED WASHER
5 BLADE CHAFING RING
6 BLADE PLUG
7 BLADE PLUG STUD
8 BALANCING WASHER
9 LOCK WASHER
10 NUT
11 BLADE BUSHING
12 THRUST PLATE PIN
13 BLADE BUSHING THRUST PLATE
14 BLADE BUSHING SCREW
15 BLADE BUSHING DRIVE PIN
16 SHIM PLATE DRIVE PIN

Figure 11—"E" Shank Blade Assembly

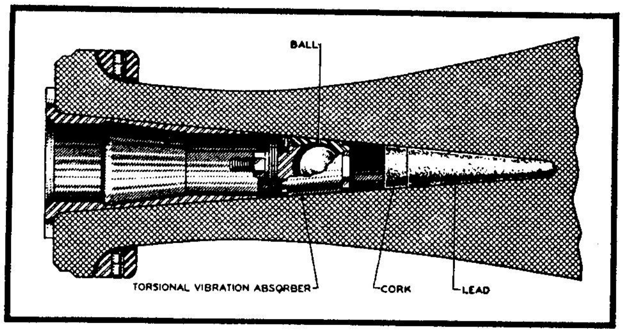


Figure 12—Single-Unit Type Torsional Vibration Absorber

(5) TORSIONAL VIBRATION ABSORBERS.—The purpose of the absorber, as the name implies, is to absorb certain torsional vibrations present in some particular engine-propeller combinations by allowing a slight movement of a steel ball in a spherical seat. It should be remembered that each absorber is designed for a certain vibratory characteristic which is caused only by certain installations. Other installations of the same propeller model on a different engine generally do not have the same torsional stresses.

(a) SINGLE-UNIT TYPE.—This torsional vibration absorber is essentially a blade balancing plug which has been redesigned to contain a steel ball in a nearly spherical cavity. The assembly consists of a housing shaped to fit the blade bore, the ball, a cap with a seal, and a lock ring. The proper number of balancing washers are held onto the stud in the cap by a nut and lock washer. The 6507A blade becomes a 6541A blade when the absorber is installed.

(b) TRIPLE-UNIT TYPE.—This absorber is of a different design but is the same in principle as the preceding one. It consists of a steel ball and a ball seat. A toroid seal is added to the regular balancing plug to seal off the absorber cavity in the bore. The ball seat is positioned in the blade bore directly above the cork which seals off the balancing lead. The ball is limited in its movement outward by the ball seat and inward by the balancing plug which is situated in its usual position in

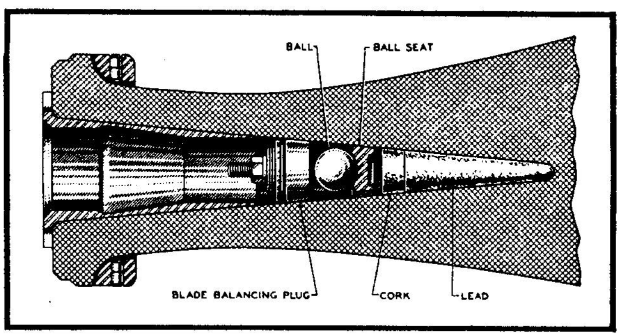


Figure 13—Triple-Unit Type Torsional Vibration Absorber

the bore. The blade taper bore requires no rework but the balancing plug must be modified to accommodate the toroid seal mentioned above. The 6353A blade becomes a 6565A blade when the absorber is used, and the 6461A blade becomes 6575A.

(6) THRUST PLATE.—A steel thrust plate is pinned to the blade bushing and fits between the bushing and gear segment. It prevents excessive motion between the segment and the bushing during normal operation.

(7) CHAFING RING.—A phenolic chafing ring is used between the blade fillet and the bevel thrust washer. It serves to distribute the stresses evenly and to prevent chafing between the aluminum blade and the steel washer. Present production models incorporate a split-type interlocking chafing ring, which is available in thicknesses from .043 to .083 inch with .063 inch as standard. Earlier models used a ring molded directly onto the

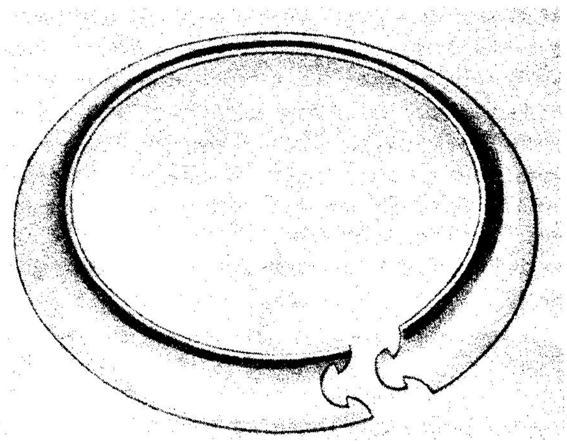


Figure 14—Interlocking Type Chafing Ring

(8) MISCELLANEOUS PARTS.

(a) All blades have the Hamilton Standard Propellers seal as a decalcomania. It is located about midway out on the blade.

(b) Many blades are painted black with yellow tips. However, painting is optional and may vary in color and manner of application.

d. DOME ASSEMBLY. (See figure 15.)—The dome assembly comprises the propeller pitch changing mechanism by means of which oil pressures are translated into blade turning forces. The dome assembly consists of three major components: the cams, the piston, and the dome shell. When the dome assembly is installed in the propeller hub, the outer (or fixed) cam rigidly held in the barrel on the fixed cam locating dowels provides support for the remaining parts in the dome unit. The inner (or rotating) cam is supported within the fixed cam by means of ball bearings which also serve to take the gear reactions and piston oil forces. Piston motion is transmitted (through the fixed cam) 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.

(1) CAMS.—Two cylindrical, coaxial cams are incorporated in the dome assembly; one is a fixed cam which remains stationary with respect to the hub in a completely assembled propeller, and the other is a rotating cam which revolves inside the fixed cam. Each cam incorporates an inclined cam track on which cam rollers operate to transform the translatory motion of the piston into rotating motion of the rotating cam. The cam tracks on the fixed cam are inclined in the opposite direction from those on the rotating cam, an arrangement that provides twice the rotating motion for a given straight line motion of the piston. The assembled cams include the fixed cam, the rotating cam, the inboard bearing, the outboard bearing, the cam bearing nut, and the cam bearing nut locking cotter. Each cam is independently balanced about its axis by grinding at the lightening holes.

(a) ROTATING CAM.—The rotating cam is made from a high nickel, low carbon steel, and is case hardened on the cam tracks and teeth. Four cam tracks are machined in the cylindrical body portion of the cam. These cam tracks are divided into two sections; the cam track section with the greater slope represents the constant speed operation range of the propeller, and the cam track of the lesser slope is used during feathering and unfeathering operations. Holes are drilled between the cam tracks to lighten the part. 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. Two steel induction hardened stop lugs, pressed in at the base of the cam gear teeth and spaced 180 degrees apart, contact the stop rings in the base of the fixed cam and thereby limit the angular motion of the cam.

(b) FIXED CAM.—The fixed cam is quite similar in construction to the rotating cam. It is made from nickel steel, heat-treated but not case hardened. It incorporates four cam tracks identical in design to those of the rotating cam except that they are inclined in the opposite direction. The inboard end of the fixed cam incorporates a flange which is serrated on the inner diameter to accommodate and match the stop rings. The inboard cam ball bearing is located just outboard of these serrations, and the outboard cam ball bearing is located on the inner diameter of the outboard fixed cam edge.

(c) TYPES OF CAMS.—Four different types of cam tracks are used in the Hydromatic propeller. They are the standard, the fast-acting, the straight slope, and the faired knee types. Cams are named according to the

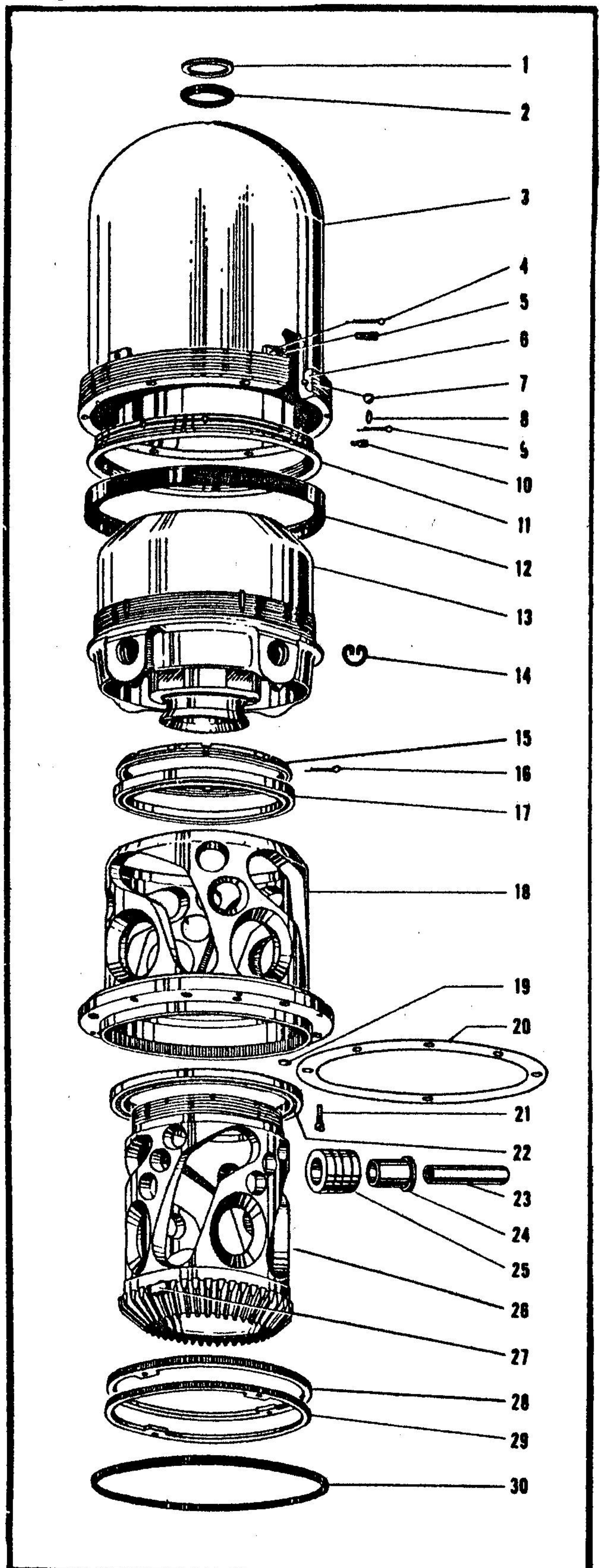


Figure 15—Dome Assembly for Model 23E50

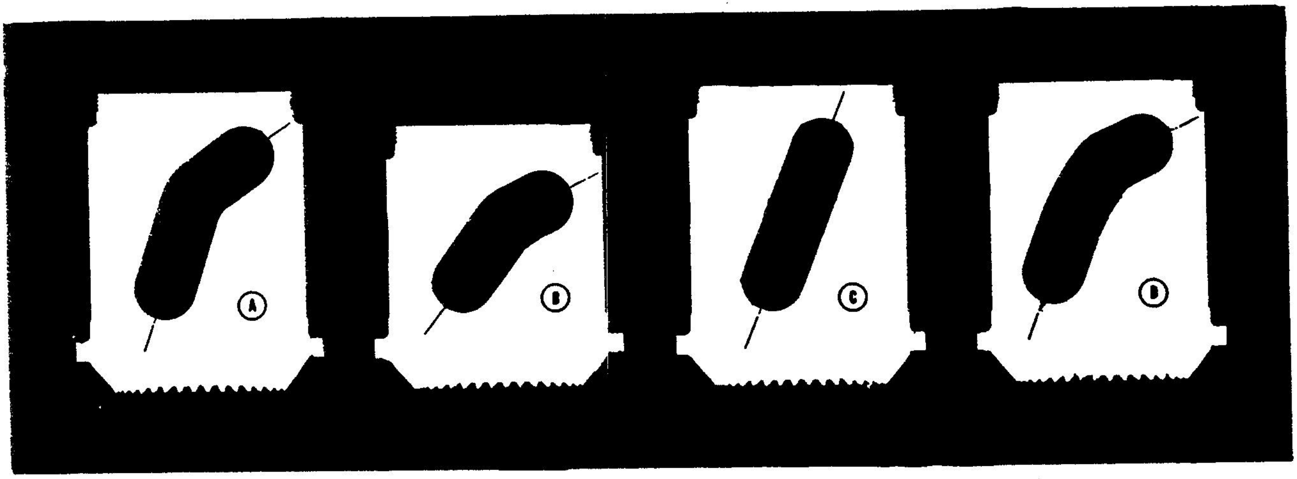
type of cam track incorporated; a faired knee cam has the faired knee cam track. It should be noted that in an assembly both fixed and rotating cams must have the same type of cam track. Current models have the name of the cam track design etched on the base of the cam.

1. STANDARD CAMS.—The "standard" cams incorporate the two slope cam tracks, i.e., the longer track for constant speed operation, and the shorter track for feathering. The ratio between the rotating cam gear teeth and the teeth on the blade gear segments is five-to-four, with a total *cam* range of about 100 degrees, and a constant speed *cam* range of about 39 degrees. This ratio establishes a 31-degree *blade* angle constant speed range. Indexing the blade (gear segment) one tooth with respect to the rotating cam changes the blade angle eight degrees.

2. FAST-ACTING CAMS. — A "fast-acting" type of cam has been developed for use in propellers in which a more rapid blade angle change is required. These cams incorporate a flatter cam track slope, and for the same piston travel these fast-acting cams will change the blade angles more quickly than the standard cams. The ratio between the rotating cam gear teeth and the teeth on the blade gear segments is five-to-four, with a total *cam* range of about 94 degrees, and a constant speed *cam* range of about 57 degrees. This ratio establishes a 45-degree *blade* angle constant speed range. Indexing the blade (gear segment) one tooth with respect to the rotating cam changes the blade angle eight degrees.

Nomenclature for Figure 15

1 DOME BREATHER HOLE WASHER
2 DOME BREATHER HOLE SEAL
3 DOME SHELL
4 COTTER PIN
5 DOME RETAINING NUT LOCK SCREW
6 DOME RETAINING NUT
7 BALL
8 WELCH PLUG
9 COTTER PIN
10 PISTON GASKET NUT LOCK SCREW
11 PISTON GASKET NUT
12 PISTON GASKET
13 PISTON ASSEMBLY
14 CAM ROLLER SHAFT LOCK WIRE
15 CAM BEARING NUT
16 COTTER PIN
17 OUTBOARD CAM BEARING
18 FIXED CAM
19 WELCH PLUG
20 GEAR PRELOADING SHIM
21 DOME SHELL RETAINING SCREW
22 INBOARD CAM BEARING
23 CAM ROLLER SHAFT
24 CAM ROLLER BUSHING
25 CAM ROLLERS
26 ROTATING CAM
27 STOP LUG
28 LOW PITCH STOP
29 HIGH PITCH STOP
30 DOME-BARREL SEAL



A. *Standard Cam Track Outline*
B. *Fast Acting Cam Track Outline*
C. *Straight Slope Cam Track Outline*
D. *Faired Knee Cam Track Outline*

Figure 16—Types of Cam Tracks

3. STRAIGHT SLOPE CAMS.—The "straight slope" cam is the third type now in use. In this type, the constant speed portion, of the same slope as the constant speed range in the standard cam, is extended, and the feathering range is omitted since straight slope cams are used only on non-feathering installations. The ratio between the rotating cam gear teeth and the teeth on the blade gear segments is five-to-four, with a total *cam* range of about 55 degrees. This ratio establishes a 44-degree *blade* angle constant speed range. Indexing the blade (gear segment) one tooth with respect to the rotating cam changes the blade angle eight degrees.

4. FAIRED KNEE CAMS.—Current production propellers now use "faired knee" cams exclusively. The track is very similar to the standard track except that the knee, between the constant speed and feathering sections, is faired in more than the standard type. The range and ratio are the same as for standard cams, but the faired knee fixed cam includes two separate sets of dowel holes to provide for indexing in increments of four degrees.

(2) PISTON.

(a) The piston is made from an aluminum forging which is machined to close tolerances and independently balanced. The part itself is a double-walled casing which fits over the two cams. It operates inside the dome shell and provides the mechanism for converting the oil pressures into forces which act through the cam assemblies to twist the propeller blades. The piston is balanced separately by drilling metal out of the inboard face of the inner wall.

(b) The inner diameter of the inside piston wall incorporates a steel sleeve which contacts the distributor valve oil seal rings and forms the inner oil seal between the high and low pressure sides of the piston. The piston is supported on the cams by the four roller assemblies, and guided axially by contact of the inner piston skirt on the inside diameter of the rotating cam.

(c) A ledge is incorporated on the outer piston wall just outboard of the cam roller shaft bosses. This ledge seats the double-acting piston gasket which is held in place by means of a ring nut. This gasket forms the seal between the piston and the dome shell. The nut in turn is locked by a piston gasket nut lock screw, and the screw is locked by a cotter.

(d) Small bleed holes, equally spaced if multiple, are incorporated in the outer piston wall. These holes circulate a small quantity of warm high pressure (governor) oil from the inboard piston side to the low pressure outboard piston side. On current models, the piston assembly number is followed by a two-digit dash number, the second digit of which indicates the number of bleed holes in the piston. For example, 61196-10, 61196-11, 61196-12, 61196-13, and 61196-14 are piston assemblies in which the piston detail has no bleed hole, one, two, three, and four bleed holes respectively. Piston detail numbers are followed by a single-digit dash number which indicates the number of bleed holes in a similar manner. All production propellers have two bleed holes unless otherwise specified.

(3) CAM ROLLER ASSEMBLY.—Through these rollers the motion of the piston is transmitted to the rotating cam. Each roller assembly consists of four bronze rollers operating on bronze bushings and supported by steel shafts. The cam roller shafts are held in place by a press fit in the piston, and locked by snap rings which fit in grooves cut into the cam roller shaft bosses just inside the outer face. The support bearings for these shafts are

incorporated in both the inner and outer walls of the piston, and the rollers fit between the piston walls.

(4) BLADE ANGLE STOP RINGS.—Stop rings are incorporated in the dome assembly to limit travel of the rotating cam, and thereby to regulate the blade high and low pitch settings. These rings, which fit in the stop ring flange at the base of the fixed cam, incorporate two lugs that contact the stop lugs on the rotating cam. One ring sets the low blade angle, and the other the high blade angle. The stop rings are made from steel forgings and the stop ring lugs are induction hardened. The outer diameter of each ring is serrated to match with a series of fine teeth cut on the inside diameter of the fixed cam stop ring flange. High and low pitch stop rings are identical except for markings which indicate the blade angle range setting. Due to a five-to-four gear reduction between the rotating cam gear and the blade gear segments, and since the stop rings are cut on the same ratio (the stop rings and mating fixed cam flange have 288 teeth each to cover the required 360 degrees), indexing one tooth on a stop ring changes the blade angle setting one degree. Propeller blade angle settings are therefore limited to the predetermined angular setting of the stop rings. A 10-24 tapped hole is incorporated in each stop lug on the blade angle stop ring to facilitate removal of the ring.

(5) DOME SHELL.—The dome shell is held in place on the fixed cam for handling and installation purposes by six fillister head screws which set in counterbored holes in the fixed cam base and extend into tapped holes in the base of the dome shell. This shell forms the cylinder in which the piston operates, and also serves as a modified spinner on an assembled propeller. The outboard end of the dome shell incorporates a tapped hole; this tapped hole is fitted with a dome breather hole plug on crankcase breathing installations, and a dome breather hole cap on shaft breathing installations. In the latter case, a passage is provided through the center of the dome shell, through the distributor valve housing, and then into the propeller shaft for engine breather gases. A dome breather hole seal and washer are included on both shaft and crankcase breathing installations.

(6) DOME RETAINING NUT.—A half-circle groove is ground on the outside diameter of the dome shell at the inboard end. This groove matches with a corresponding groove cut into the dome retaining nut. A number of balls, inserted through a hole in the dome retaining nut, fit into these matching grooves. This arrangement holds the dome retaining nut to the dome shell, and at the same time provides a ball bearing between the dome retaining nut and the dome shell. The balls are locked in place by a welch plug which closes the opening in the dome retaining nut. The retaining nut thus transmits the oil loads from the dome shell to the barrel. At dome installation on the propeller, the dome retaining nut is threaded into the outboard barrel half and locked in place by the dome retaining nut screw which fits into a half-circle groove in the barrel and screws into the dome retaining nut. This screw is in turn locked by a cotter pin.

(7) DOME-BARREL SEAL.—The oil seal between the barrel assembly and the dome assembly is formed by a compression type dome-barrel seal which seats between the inner diameter of the outboard barrel half (just inboard of the dome retaining nut) This trapezoidal shaped seal is available in two sizes, as required, for replacement or original assembly.

(8) GEAR PRELOADING SHIMS.—In order to establish the proper gear meshing load pressure between the rotating cam gear and the blade gear segments, shims are included between the base of the fixed cam and the outboard barrel half dome shelf. These shims are made of solid brass, and they incorporate holes which permit installation of the shims over the fixed cam locating dowels. The latest design of shim has six holes so spaced that the same shim may be used in certain models of both three- and four-blade propellers.

e. DISTRIBUTOR VALVE ASSEMBLY. (See figure 17.)—The distributor valve assembly fits inside the propeller shaft and extends into the dome assembly. During constant speed and feathering operations, the valve provides oil passages for governor or auxiliary oil to the inboard side of the propeller piston, and engine oil to the outboard side. However, during the unfeathering operation, the valve shifts under auxiliary pressure and reverses these passages so that oil from the auxiliary pump flows to the outboard side of the propeller piston and oil on the inboard side flows back to the engine.

(1) VALVE HOUSING ASSEMBLY.—The distributor valve housing is an aluminum alloy casting which is cored to provide the required oil passages. A steel sleeve, shrunk into the central bore of the housing, incorporates ports that align with the oil passages in the housing. The inboard end of the housing is threaded to match with the threads on the inside diameter of the propeller shaft, and the outboard end of the housing is threaded to accommodate the breather tube. Two steel bushings are driven into the base of the housing to hold the valve housing oil transfer plate. The valve housing incorporates oil seal rings near the outboard end which establish the oil seal between the inboard and outboard sides of the propeller piston inner bore. These rings are backed up by expanders which hold the rings evenly against the piston sleeve. The rings are marked "PRESS" to indicate the pressure side. It is important that this marking face inboard on the two inboard rings and outboard on the two outboard rings. The complete distributor valve assembly is locked into the propeller shaft by the

Nomenclature for Figure 17

1 DISTRIBUTOR VALVE SPRING HOUSING
2 VALVE SPRING GASKET
3 VALVE SPRING
4 VALVE SPRING WASHER
5 DISTRIBUTOR VALVE
6 BALL & PIPE PLUG ASSEMBLY
7 DOME RELIEF VALVE SLEEVE
8 DOME RELIEF VALVE SPRING
9 DOME RELIEF VALVE SHIM
10 OIL SEAL RING
11 OIL SEAL RING EXPANDER
12 HOUSING ASSEMBLY
13 VALVE HOUSING DOWEL BUSHING (SMALL)
14 VALVE HOUSING DOWEL BUSHING (LARGE)
15 DASH POT GASKET
16 DASH POT
17 VALVE HOUSING-TRANSFER PLATE GASKET

tip of the propeller retaining nut lock wire which fits between two of the integral splines on the housing. These splines are located just outboard of the propeller shaft-distributor valve threads.

(2) DOME RELIEF VALVE ASSEMBLY.—To prevent damage to the low pitch stop ring lugs which might arise from excessive oil loads on the outboard side of the propeller piston encountered either when maintaining the auxiliary pressure after the rotating cam has reached the low pitch stop, or during the warm-up period when the engine may be allowed to run at a high rpm under cold oil conditions, a check type dome relief valve is incorporated in the outboard end of the distributor valve housing. This valve serves to bypass excessively high oil pressures from the outboard side of the propeller piston to the inboard side. The valve assembly includes the dome relief valve ball & pipe plug assembly, the dome relief valve sleeve, the dome relief valve spring, and the dome relief valve shims. Opening pressure of the valve is adjusted by varying the number of shims.

(3) DISTRIBUTOR VALVE. — The distributor valve itself fits inside the distributor valve sleeve. It incorporates three lands which serve to reverse the oil passages mentioned above during unfeathering operation of the propeller.

(4) DASH POT.—A small dash pot is screwed into the base of the valve housing to fit around the inboard stem of the distributor valve. This dash pot damps out any oscillations which may be encountered during the valve shift required for unfeathering. Ample clearance is provided between the ID of the dash pot and the OD of the valve stem so that oil trapped between the base of the valve stem and the dash pot may slowly leak out and provide the required damping action. The dash pot assembly is held in place by a tab lock gasket which fits

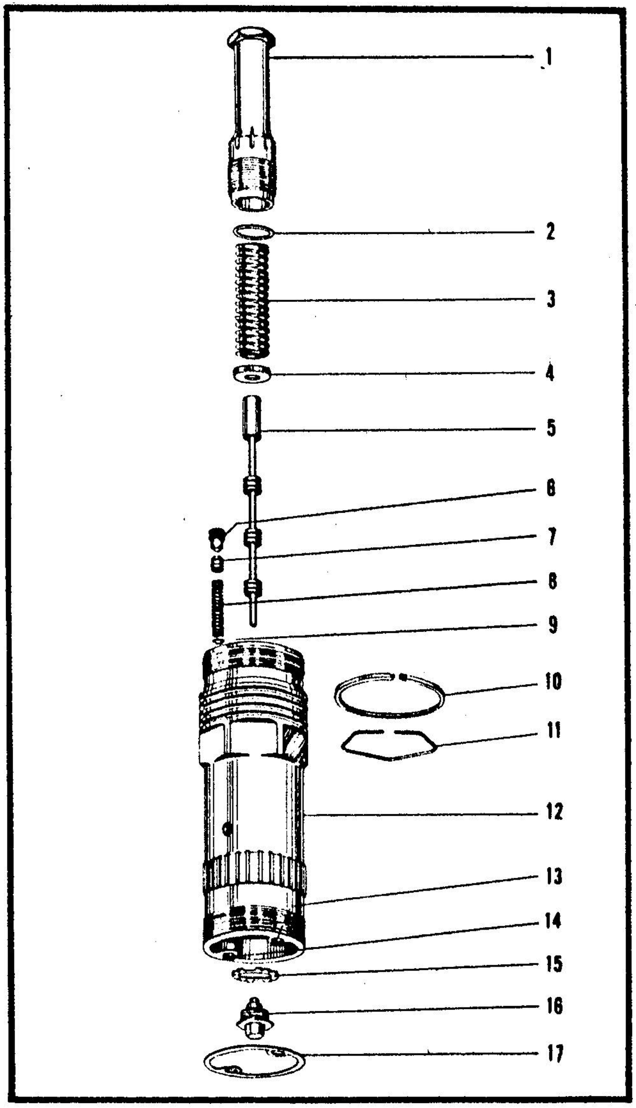
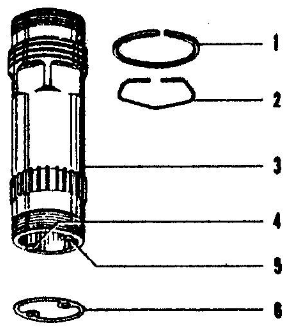


Figure 17—Distributor Valve Assembly for Model 23E50

between the dash pot and the housing and is bent over at assembly to form the lock.

(5) VALVE SPRING GROUP.—As mentioned above, auxiliary oil at a higher pressure than that required for constant speed or feathering when introduced into the propeller system brings about the required shift of the distributor valve for unfeathering. The valve itself is spring loaded in order to establish the pressure at which this shift occurs. The spring is held in place over the outboard end of the valve by the distributor valve spring housing which is screwed into the inner bore of the valve housing. This group consists of the valve spring housing, the valve spring, the valve spring washer, and the valve spring gaskets. The pressure at which the distributor valve shifts is adjusted by varying the number of the valve spring gaskets.



1 OIL SEAL RING
2 OIL SEAL RING EXPANDER
3 ENGINE SHAFT EXTENSION HOUSING
4 VALVE HOUSING DOWEL BUSHING (LARGE)
5 VALVE HOUSING DOWEL BUSHING (SMALL)
6 VALVE HOUSING—TRANSFER PLATE GASKET

Figure 18—Engine Shaft Extension Assembly for Single-Acting Model 23E50

f. ENGINE SHAFT EXTENSION ASSEMBLY.

(1) FOR SINGLE-ACTING PROPELLERS. (See figure 18.)

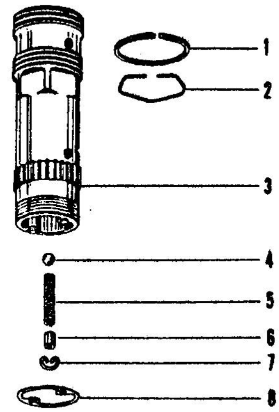
(a) On installations which do not include the feathering feature, an engine shaft extension assembly is used in place of a distributor valve assembly. The engine shaft extension is quite similar to the distributor valve housing; however, it does not include the valve itself, and it incorporates just two oil passages, one for governor oil which leads to the inboard side of the propeller piston, and one for engine oil which leads to the outboard side of the propeller piston.

(b) The extension is made from an aluminum alloy casting. The inboard end is threaded to match with the propeller shaft threads, and the outboard end is threaded to accommodate the breather tube. Locking splines are incorporated on the outer diameter of the housing just outboard of the propeller shaft threads, and wrench flats are included on the housing inboard from the oil seal rings.

(c) Two dowels are pressed into the oil passages at the base of the extension to hold the valve housing oil transfer plate and the included gasket. Oil seal rings are incorporated near the outboard end of the housing to lie between the housing and the piston sleeve in an assembled propeller, and provide the oil seal between the inboard and outboard sides of the piston.

(2) FOR DOUBLE-ACTING PROPELLERS. (See figure 19.)

(a) On all double-acting installations, both feathering and non-feathering, an engine shaft extension incorporating a check valve and two sets of oil seal rings is used. The check valve prevents excessive pressure from being built up on the outboard side of the piston during unfeathering operation. The inboard set of oil seal rings separates governor oil from propeller return oil during constant speed and feathering operation. During unfeathering operation, the outboard set of rings separates the auxiliary oil from the inboard side.



1 OIL SEAL RING
2 OIL SEAL RING EXPANDER
3 ENGINE SHAFT EXTENSION HOUSING
4 CHECK VALVE BALL
5 CHECK VALVE SPRING
6 CHECK VALVE PLUG
7 CHECK VALVE LOCK WIRE
8 EXTENSION HOUSING-TRANSFER PLATE GASKET

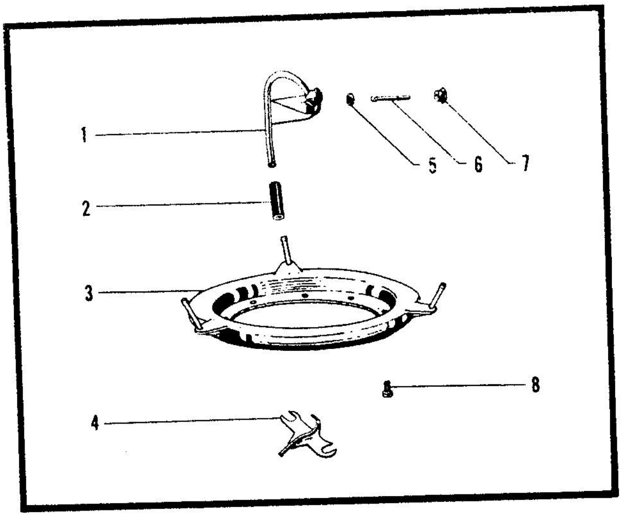
Figure 19—Engine Shaft Extension Assembly for Double-Acting Model 23E50

(b) This extension is made from an aluminum alloy casting, threaded on the inboard end to mate with the propeller shaft threads. Just outboard of these threads are locking splines on the OD of the housing, and wrench flats are incorporated on the OD inboard of the inboard set of oil seal rings. There are two oil passages, one to the inboard side of the piston and the other to the outboard side, both of which carry oil pressure, as required, during propeller operation.

(c) The check valve is located in the passage which connects the port between the two sets of rings to one of the inlet ports. It contains a ball, backed up by a spring and a plug, and safetied with a clip-type lock wire.

g. DE-ICING DEVICE ASSEMBLY. (See figure 20.)

(1) The Hydromatic propeller de-icing device assembly is fitted to the inboard barrel half and the attaching parts which lead to the blades are fitted over the barrel bolt bosses at the leading edge of each blade.



1 BRACKET & TUBE ASSEMBLY
2 HOSE COUPLING
3 SLINGER RING ASSEMBLY
4 FEEDER TUBE ASSEMBLY
5 NOZZLE BUSHING
6 NOZZLE
7 NOZZLE NUT
8 SLINGER RING ATTACHING SCREW

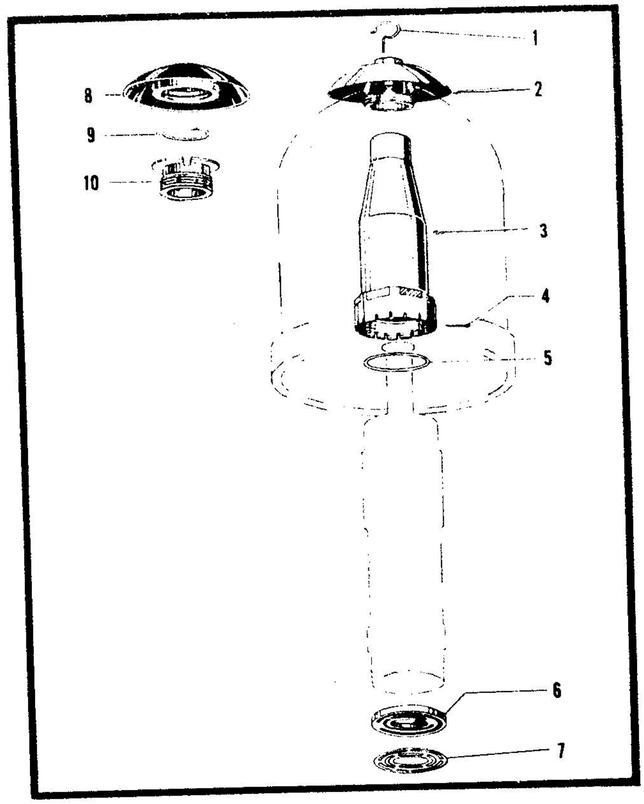
Figure 20—Adjustable Nozzle Type De-Icing Device Assembly for Model 23E50

(2) The device includes the steel slinger ring assembly which attaches to the inboard end of the inboard barrel half, receives the de-icing fluid from a feeder tube assembly mounted on the engine nose case, and leads it out through slinger ring nipples to the bracket & nozzle assemblies.

(3) On earlier models as shown in figure 8, the bracket and nozzle assemblies fit over the top and bottom faces of the barrel bolt bosses adjacent to the leading edge of each blade, and are held in place by the barrel bolts and castellated nuts. These tubes receive the de-icing fluid from the slinger ring, through the flexible hose couplings, and discharge it out over the leading edge surface of the blades. In newer models, the bracket & nozzle assemblies have a single lug which mounts on the top face of the barrel bolt bosses and adjustable nozzles which may be tightened in the desired position. The new feeder tube is so designed that it can be removed from the engine nose without first removing the propeller.

b. EXTRA PARTS GROUP.—The extra parts group consists of the retaining nut with its lock wire, the valve adapters with their gaskets, the breather tube with its gasket, the dome breather hole nut with its washer, seal, and lock wire, and the dome breather cap assembly.

(1) The propeller retaining nut, made of a bronze alloy, has a flange on its inboard end to accommodate the front cone. It is locked to the propeller shaft by a lock wire which fits in a groove on its OD and extends through the



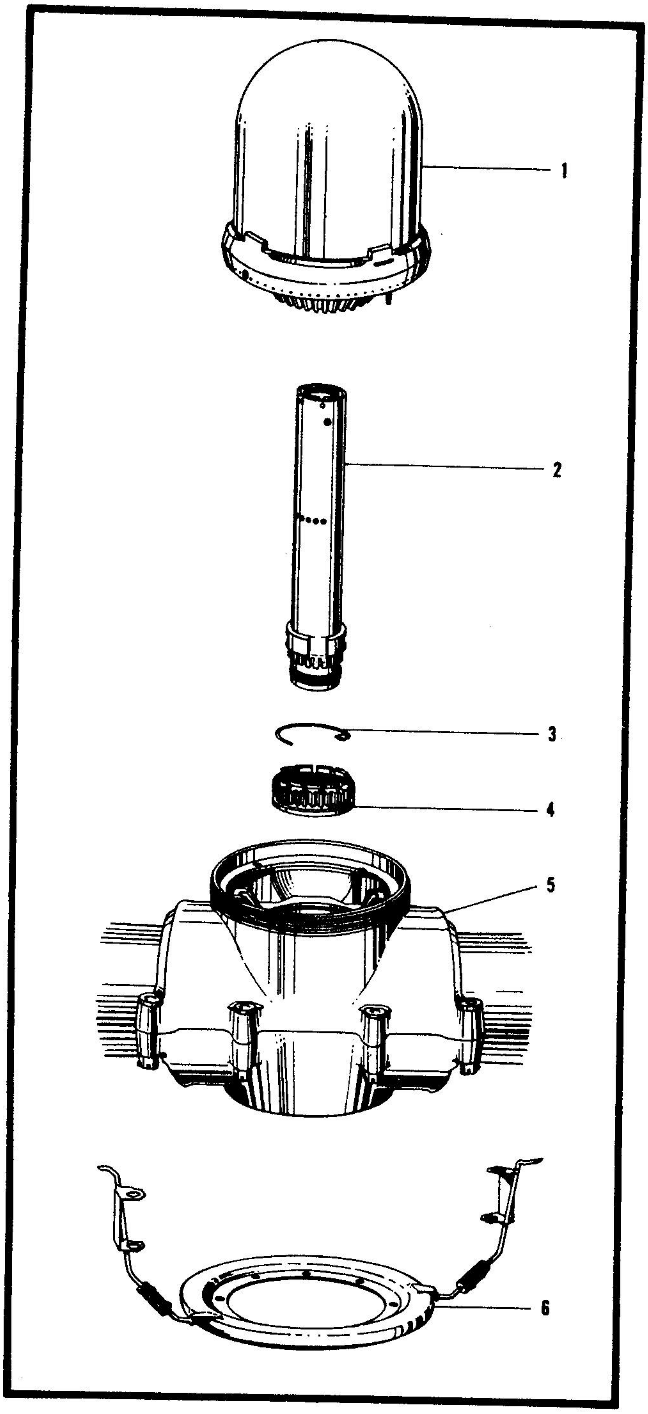
1 BREATHER CAP LOCK WIRE
2 BREATHER CAP
3 BREATHER TUBE ASSEMBLY
4 COTTER PIN
5 BREATHER TUBE GASKET
6 VALVE HOUSING OIL TRANSFER PLATE
7 TRANSFER PLATE-PROPELLER SHAFT GASKET
8 RUBBER BREATHER CAP
9 BREATHER CAP NUT LOCK WIRE
10 BREATHER CAP NUT

Figure 21—Shaft Breathing Parts for Model 23E50

nut, through the propeller shaft, and between two splines on the distributor valve (or shaft extension).

(2) Crankcase breathing engines use a valve oil transfer plate with two pick-up grooves leading to the two oil transfer dowels of the valve. These pick-up passages match the two oil outlets inside the engine-propeller shaft. A copper gasket seals between the oil transfer plate and the shaft. The dome breather hole nut with its washer, and lock wire, closes the opening at the outboard end of the dome.

(3) Shaft breathing engines employ a valve transfer plate having two circular oil pick-up grooves and an open hole in the center of the plate. This central hole permits the breather gases to pass through the center of the valve. A breather tube is fitted onto the end of the distributor valve (on feathering installations) or the shaft extension (on non-feathering or double-acting installations). An integral screen incorporated near the outboard end of the tube prevents large particles from



1 DOME ASSEMBLY
2 DISTRIBUTOR VALVE ASSEMBLY
3 PROPELLER RETAINING NUT LOCK WIRE
4 PROPELLER RETAINING NUT
5 HUB ASSEMBLY
6 DE-ICING DEVICE ASSEMBLY

Figure 22—Complete Propeller for Models 22D30 and 22D40

entering the engine breather passages. A copper gasket is used between the oil transfer plate and the engine shaft. At assembly a gasket is placed between the tube and the housing, and a cotter pin or safety wire is used to lock. A synthetic rubber breather cap fitting over a steel breather cap nut takes the place of the dome breather hole nut and fits into the outboard end of the dome shell. On older models, a one-piece steel cap and nut is used.

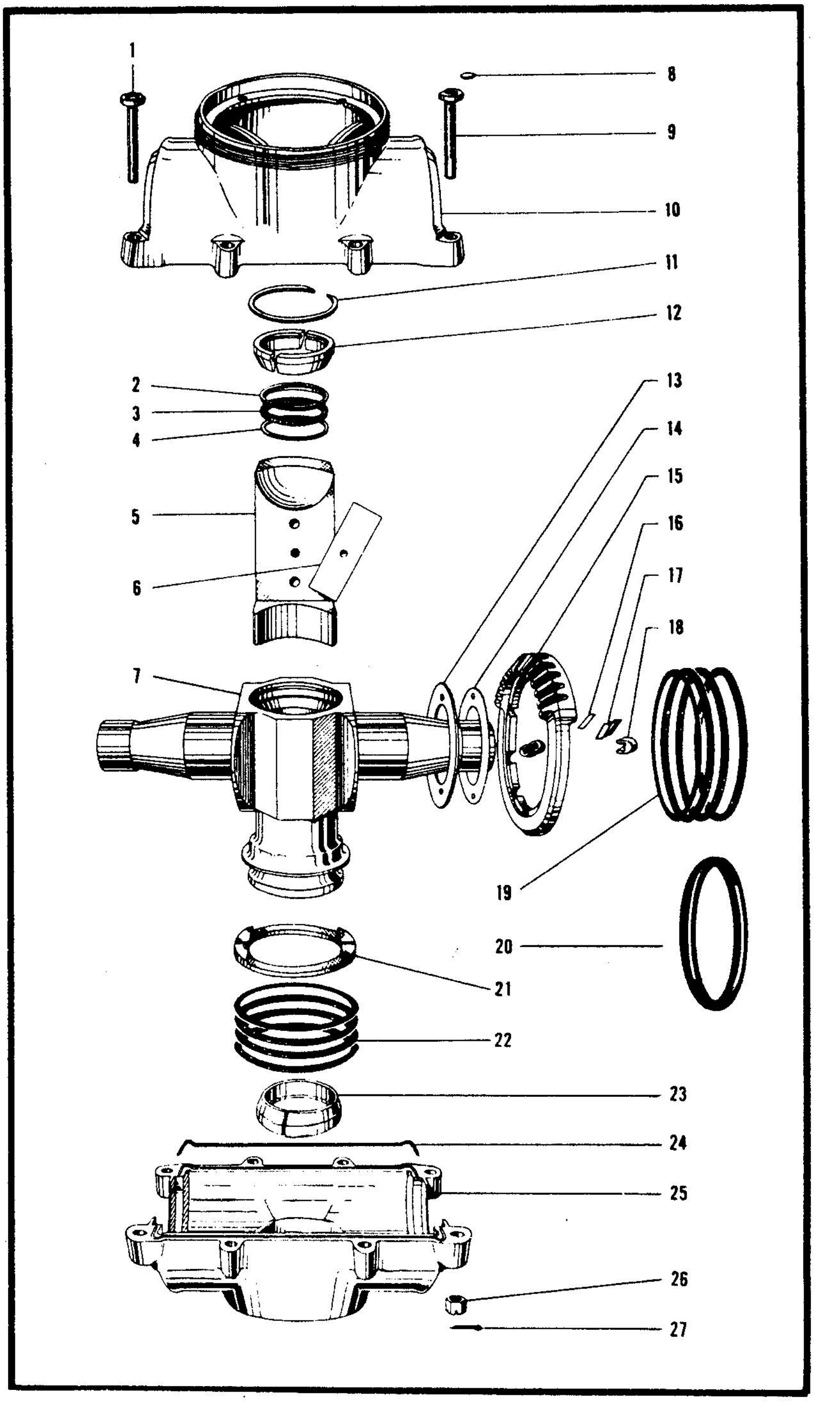
(4) When these breather parts are included in an assembly, engine crankcase gases flow from the propeller shaft, through the center portion of the valve housing oil transfer plate and gasket, into the cored breather passage in the distributor valve (or the engine shaft extension). From there they pass into the breather tube and then to atmosphere around the breather cap installed in the dome shell.

3. DETAILED DESCRIPTION—OTHER MODELS.

a. MODELS 22D30 AND 22D40. (See figure 22.)—These two propeller models are identical except for the size changes in the spider, retaining nut, distributor valve, etc. required by the two different SAE spline sizes, namely, 30 and 40. As indicated by the model numbers, the propellers incorporate two "D" shank blades and an SAE 30 or 40 spider spline. Two-bladed Hydromatic models are the smallest in the Hydromatic line, and are used mostly on engines ranging from 400 to 700 horsepower. Engine shaft extension assemblies (for non-feathering propellers) and shaft breathing parts have not as yet been incorporated in these two models. The average total *blade* angle range of these models is 83 degrees with a constant speed *blade* range of approximately 30 degrees. The complete propeller assembly consists of the dome assembly, the distributor valve assembly, the propeller retaining nut lock wire, the propeller retaining nut, the barrel assembly, the blade assemblies, and (if used) the de-icing device assembly. The propeller retaining nut incorporates involute type splines rather than hexagonal wrench flats. As in the case of the 23E50 model, the propeller retaining nut lock wire fits in a groove cut around the retaining nut and locks both the retaining nut and the valve assembly to the propeller shaft. The distributor valve does not incorporate an oil transfer plate, and at installation, a gasket lies directly between the base of the valve housing and against the adapter in the propeller shaft.

(1) BARREL ASSEMBLY. (See figure 23.)

(a) The same type barrel assembly parts are used in the 22D30 and 22D40 models as in the 23E50; however, slight variations in the shape of the parts are made to conform with the size requirements of the propeller. The outboard barrel half dome-barrel shelf incorporates two holes for the fixed cam locating dowels, and two half-circle notches for the pitch stop dowels. The dome



1 BARREL BOLT (LONG)
2 SPIDER-SHAFT SEAL RING
3 SPIDER-SHAFT SEAL
4 SPIDER-SHAFT SEAL WASHER
5 BARREL SUPPORT
6 BARREL SUPPORT SHIM
7 SPIDER
8 WELCH PLUG
9 BARREL BOLT (SHORT)
10 OUTBOARD BARREL HALF
11 HUB SNAP RING
12 FRONT CONE
13 SPIDER SHIM PLATE
14 SPIDER SHIM
15 BLADE GEAR SEGMENT
16 SPRING PACK SHIM
17 SPRING PACK SPRINGS
18 SPRING PACK RETAINER
19 CHEVRON TYPE BLADE PACKING
20 TOROID TYPE BLADE PACKING
21 SPIDER RING
22 SPIDER-BARREL PACKING
23 REAR CONE
24 BARREL HALF SEAL
25 INBOARD BARREL HALF
26 BARREL BOLT NUT
27 COTTER PIN

Figure 23—Barrel Assembly for Models 22D30 and 22D40

retaining nut threads are on the OD of the barrel. Barrel support shims, which fit between the support and the spider support seat are used to establish spider-barrel concentricity and squareness. Spider shims, which fit over the shim plate drive pins between the shim plate and blade bushing face, are used to establish blade torque.

(b) Older models used slotted gear segments similar to those on the 23E50 model except for size. Gear segments used in the latest model are serrated on the inner diameter to match with serrations cut on the outer diameter of the blade bushing. This arrangement (illustrated for the model 24D50 only) excludes the use of spring packs, but a line-on-line contact between the gears is required at assembly.

(c) The cast iron spider shim plate assembly incorporates the shim plate drive pin which fits into the

bushing drive pin, and the spider shim fits between the blade bushing face and the spider shim plate. Former models had the shim plate drive pin integral with the bushing drive pin.

(d) 'Barrel half seals, identified for these propellers by a green mark, are the compression type with small tips at each end that match and fit into small extensions in the barrel half seal grooves.

(e) Both chevron and toroid type blade packings are used, although not together in the same propeller.

(2) BLADE ASSEMBLY. (See figure 40.)

(a) Earlier models used a slotted type bushing, with four of the spring pack slots offset .015 inch with respect to the mating blade gear segment slots in such a way that the axis of the segment is moved off the axis of the bushing toward the cam gear. Also, the shim plate drive pin was made integral with the bushing drive pin.

(b) The latest models have blades which incorporate a serrated type bushing and do not include blade spring packs. Except for size, the parts used in "D" shank blades are very similar to those of the 23E50 model. However, the shim plate drive pin is part of the shim plate assembly in the barrel assembly.

(3) DOME ASSEMBLY. (See figure 24.)

(a) The dome assembly is somewhat different in construction from that used on the basic 23E50 model. The dome retaining nut is held in place by a lock wire which sets in a half-circle groove cut both in the retaining nut and on the retaining nut ring which is silver-soldered to the steel dome shell. One length of wire is fed through a slot in the retaining nut to fit half way around the dome shell, and then both ends of the wire are bent over at the slot to lock it in place. This same operation is then carried through on the opposite side of the dome retaining nut. Since the outboard end of the shell has no opening, there is no need for a dome breather hole nut, seal, or washer.

(b) The chevron type dome-barrel seal is installed under the dome retaining nut (to fit between the nut and the shell) with the feather edges of the seal facing toward the dome shell. The assemblies are made oil-tight by one lip of the seal pressing against the dome retaining nut ring, and the other lip against the rim of the outboard barrel half. A dome-barrel seal expander is included between the feather edges holding them against the shell.

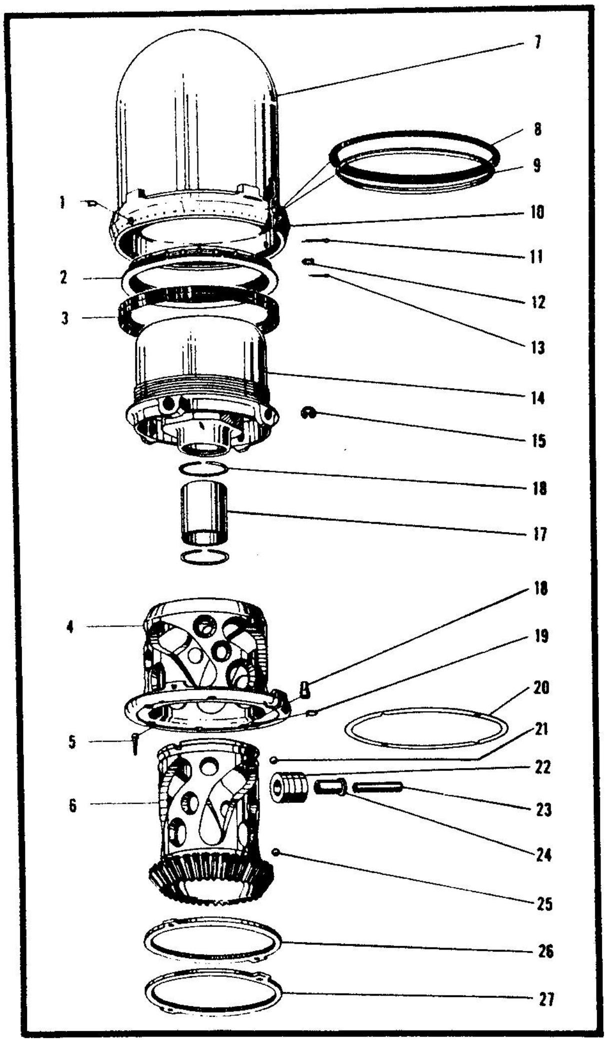


Figure 24—Dome Assembly for Models 22D30 and 22D40

Nomenclature for Figure 24

1 DOME SHELL SCREW
2 PISTON GASKET NUT
3 PISTON GASKET
4 FIXED CAM
5 FIXED CAM LOCATING DOWEL
6 ROTATING CAM
7 DOME SHELL
8 DOME-BARREL SEAL
9 DOME-BARREL SEAL EXPANDER
10 DOME RETAINING NUT
11 COTTER PIN
12 PISTON GASKET NUT LOCK SCREW
13 COTTER PIN
14 PISTON
15 CAM ROLLER SHAFT LOCK WIRE
16 PISTON SLEEVE SNAP RING
17 PISTON SLEEVE BUSHING
18 PITCH STOP DOWEL
19 WELCH PLUG
20 GEAR PRELOADING SHIM
21 BALL
22 CAM ROLLERS
23 CAM ROLLER SHAFT
24 CAM ROLLER BUSHING
25 BALL
26 LOW PITCH STOP RING
27 HIGH PITCH STOP RING

(*c*) Since the distributor valve used on these propellers does not incorporate oil seal rings, a bushing, held in place at both ends by snap rings, is incorporated in the inner wall of the piston to form the oil seal between the inboard and outboard sides of the piston.

(*d*) The fixed cam of the dome assembly incorporates two fixed cam locating dowels, and two pitch stop dowels. These dowels are a press fit in the fixed cam base. The fixed and rotating cams are held together by balls which run in half-circle grooves in the inboard and outboard ends of the cams. No integral bearing retainers or races are used. The ratio between the rotating cam gear teeth and the teeth on the blade gear segments is eight-to-six, with a total *cam* range of about 110 degrees, and a constant speed *cam* range of about 40 degrees. This ratio establishes a 30-degree *blade* angle constant speed range. Indexing the blade (gear segment) one tooth with respect to the rotating cam changes the blade angle seven and one-half degrees.

(*e*) The high and low pitch stop rings are serrated on the inside diameter to match with serrations cut on the rotating cam gear teeth. Each ring incorporates two lugs on the outside diameter which contact the pitch stop dowels in the base of the fixed cam and thereby regulate the angle setting of the propeller.

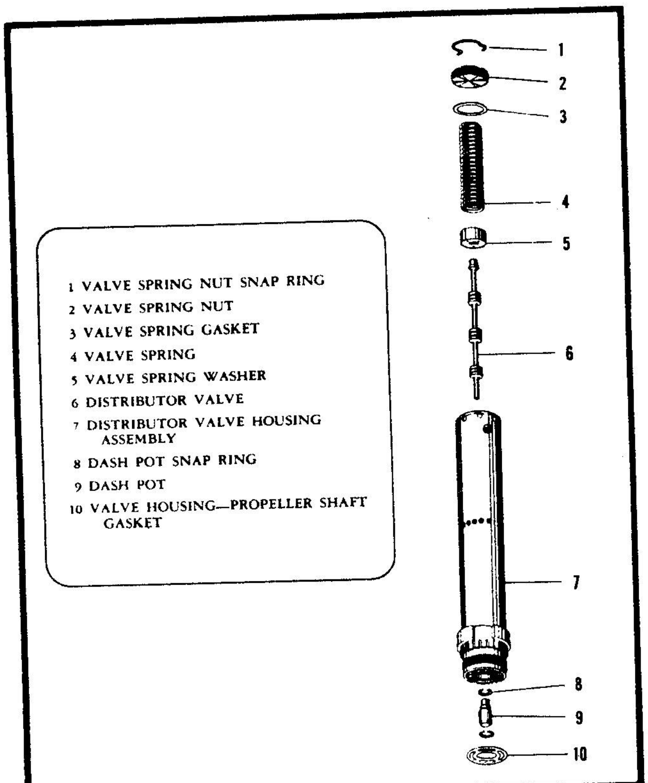


Figure 25—Distributor Valve Assembly for Models 22D30 and 22D40

(*f*) Since the fixed cam holds both the fixed cam locating dowels and pitch stop dowels, the gear preloading shims incorporate two holes and two half-circle slots. These shims are available in thicknesses of .005 inch or .015 inch.

(*g*) The dome shell is attached to lugs in the fixed cam (before the dome retaining nut is put in place) by four fillister head screws; however, it can be attached with the dome retaining nut in place by installing the screws through two holes provided in the nut.

(4) DISTRIBUTOR VALVE ASSEMBLY. (See figure 25.)

(*a*) The distributor valve assembly used in propeller models 22D30 and 22D40 does not incorporate a dome relief valve, but is instead the dome-dumping type. The operation of this type of valve is fully described in section IV. During the unfeathering operation, the dumping port in the distributor valve begins to function at a blade angle of approximately 30 degrees above the minimum low pitch setting.

(*b*) The spring housing is incorporated inside the valve housing on this type valve. A washer fitted over the end of the valve seats the valve spring. The oil seal between the spring housing and the outboard end of the dome is established by a gasket (or gaskets) which fits between the valve spring housing nut and a shelf in the housing. The opening pressure of the distributor valve during unfeathering operation of the propeller is regulated by the total thickness of these gaskets.

(*c*) The valve housing is brazed together in one compact piece. The outside diameter of the housing slides inside the bushing in the piston to establish the oil seal between the inboard and outboard side of the dome. No oil seal rings are used on this type valve. Two slots are cut in a collar near the base of the valve housing to

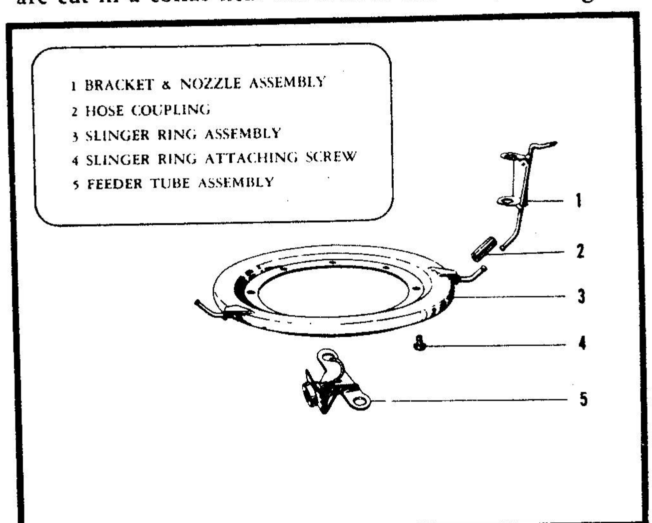


Figure 26—De-Icing Device Assembly for Models 22D30 and 22D40

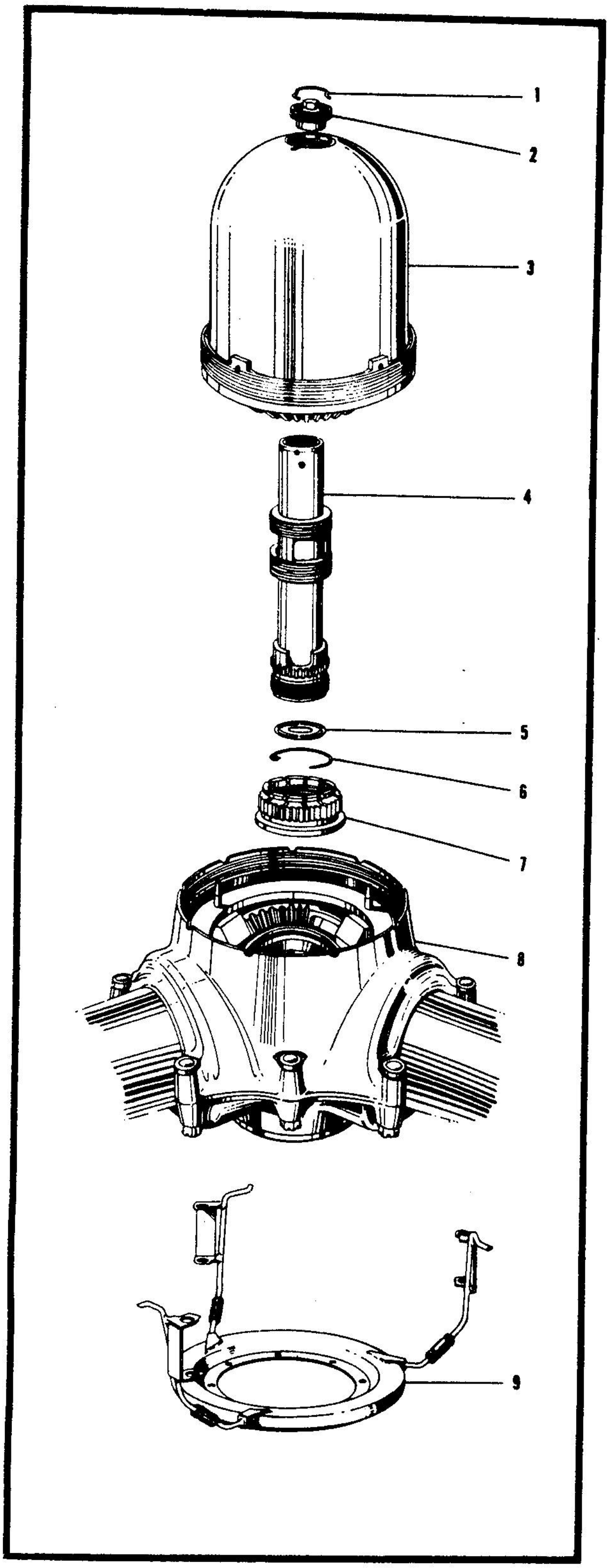


Figure 27—Complete Model 23D40 Propeller

accommodate the valve housing adapter wrench. This fitting makes it possible to use the propeller retaining nut wrench plus the adapter to tighten the valve assembly into the propeller shaft.

(d) A dash pot is fitted over the inboard end of the distributor valve, and held in place by a snap ring at each end. The dash pot serves to damp out oscillations of the valve, which might be encountered during the start of propeller unfeathering, by providing an oil cushion at the base of the valve stem.

(e) Since the valve assembly does not include an oil transfer plate, the only gasket required at installation fits between the base of the distributor valve housing and the engine shaft.

(5) DE-ICING DEVICE ASSEMBLY. (See figure 26.)—In the 22D30 and 22D40 models, the de-icing device assembly is similar to that used in the 23E50 except for size and the fact that the bracket & adjustable nozzle assembly is not available.

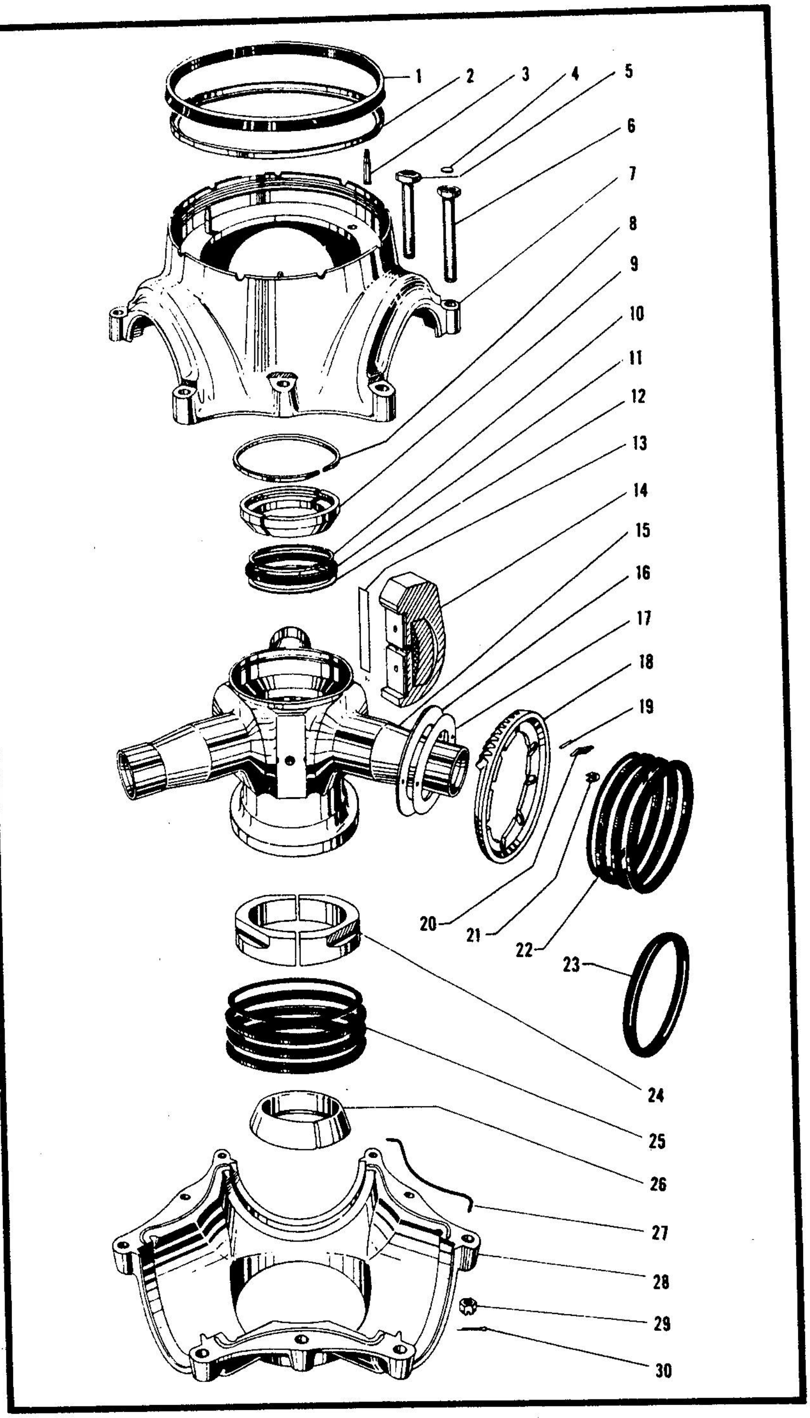
b. MODEL 23D40. (See figure 27.)—The 23D40 is in reality a small 23E50 model. Functionally, the two are identical except for the fact that the 23D40 incorporates a dome-dumping distributor valve instead of a dome relief valve type. The average *blade* angle range on this model is 80 degrees with approximately a 30-degree constant speed *blade* angle range. The propeller retaining nut used with 23D40 propellers incorporates an involute spline in place of wrench flats. The correct installation wrench to be used on this nut is listed in paragraph 1 of section III. The standard type propeller retaining nut lock wire, which rests in a groove cut in the retaining nut and locks both the retaining nut and the distributor valve to the propeller shaft, is used with these propellers. Because there has been no requirement, the 23D40 propeller has not been adapted for shaft breathing or non-feathering installations.

(1) BARREL ASSEMBLY. (See figure 28.)

(a) In the 23D40 model, the dome-barrel seal is considered part of the barrel assembly. This seal is the single chevron type, and it fits in a groove just outboard of the dome-barrel shelf. At installation, the feather edges

Nomenclature for Figure 27

1 DOME BREATHER HOLE NUT LOCK WIRE
2 DOME BREATHER HOLE NUT
3 DOME ASSEMBLY
4 DISTRIBUTOR VALVE ASSEMBLY
5 DISTRIBUTOR VALVE-PROPELLER SHAFT GASKET
6 PROPELLER RETAINING NUT LOCK WIRE
7 PROPELLER RETAINING NUT
8 HUB ASSEMBLY
9 DE-ICING DEVICE ASSEMBLY



1 DOME-BARREL SEAL
2 DOME-BARREL SEAL WASHER
3 FIXED CAM LOCATING DOWEL
4 WELCH PLUG
5 BARREL BOLT (SHORT)
6 BARREL BOLT (LONG)
7 OUTBOARD BARREL HALF
8 HUB SNAP RING
9 FRONT CONE
10 SPIDER-SHAFT SEAL RING
11 SPIDER-SHAFT SEAL
12 SPIDER-SHAFT SEAL WASHER
13 BARREL SUPPORT SHIM
14 BARREL SUPPORT
15 SPIDER
16 SPIDER SHIM PLATE
17 SPIDER SHIM
18 BLADE GEAR SEGMENT
19 SPRING PACK SHIM
20 SPRING PACK SPRINGS
21 SPRING PACK RETAINER
22 CHEVRON TYPE BLADE PACKING
23 TOROID TYPE BLADE PACKING
24 SPIDER RING
25 SPIDER-BARREL PACKING
26 REAR CONE
27 BARREL HALF SEAL
28 INBOARD BARREL HALF
29 BARREL BOLT NUT
30 COTTER PIN

Figure 28—Barrel Assembly for Model 23D40

of the seal face toward the shelf, and a metal expander ring is inserted between them to hold the outer edge against the barrel wall and the inner edge against the dome shell. On later models, the dome-barrel seal is given added support by installation of a dome seal guide ring which fits around the dome shell below the dome retaining nut, helping to fill the gap between the nut and the shell. Current production propellers eliminate the gap between the dome retaining nut and the dome shell by using a new design of dome retaining nut which fits more closely to the shell than the former nut.

(*b*) As previously stated, the 23D40 hub assembly parts are identical except for size with those used in the basic 23E50 model. Spider shims and blade chafing rings are available in a range of thicknesses.

(*c*) As in all of the latest "D" shank propellers, the gear segments in the 23D40 model are serrated to match serrations on the blade bushing. Earlier models (as illustrated) used slotted gear segments similar to those on the 23E50 model except smaller.

(d) The shim plate assembly includes the shim plate drive pin which fits into the bushing drive pin and the spider shim fits between the face of the blade bushing and the spider shim plate. Older models used a shim plate drive pin which was made integral with the bushing drive pin.

(e) Chevron type barrel half seals are used in place of the compression type. These seals incorporate a small tip extension at each end which fits in a similar extension in the barrel half oil seal grooves. Since the 23D40 is the only model which uses chevron type barrel half seals, the seal is not color coded.

(f) Both chevron and toroid type blade packings may be used, although not in the same assembly.

(2) BLADE ASSEMBLY. (See figure 40.)—Formerly, the 23D40 used a slotted type bushing, with four of the spring pack slots offset .015 inch with respect to the mating slots in the blade gear segment. Also, the shim plate drive pin was made integral with the bushing drive pin. Newer "D" shank blades include a serrated type bushing and do not have slots for spring packs. Also, the shim plate drive pin is part of the shim plate assembly in the barrel assembly.

(3) DOME ASSEMBLY. (See figure 29.)

(a) The dome assembly parts used on the 23D40 propeller are completely interchangeable with domes of the same number used on the 33D50 model. Again, the assembly is identical with that described for the basic 23E50 model except that the parts are smaller, and some changes in shape have been made to meet these requirements. Shims are fitted over the fixed cam locating dowels on the dome-barrel shelf to adjust the gear preload between the dome assembly and the hub assembly. These shims are available in .005- and .015-inch sizes.

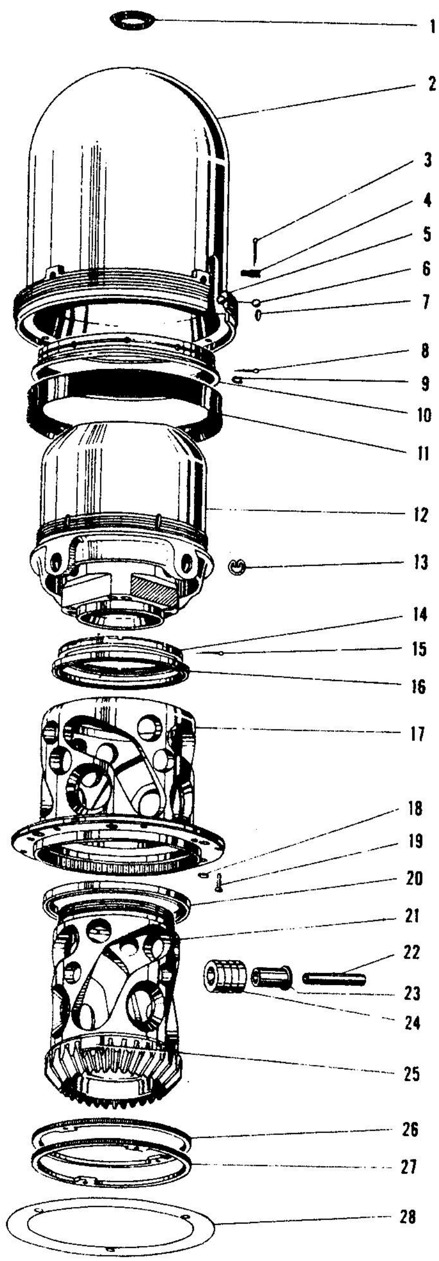


Figure 29—Dome Assembly for Models 23D40 and 33D50

Nomenclature for Figure 29

1 DOME BREATHER HOLE SEAL
2 DOME SHELL
3 COTTER PIN
4 DOME RETAINING NUT LOCK SCREW
5 DOME RETAINING NUT
6 BALL
7 WELCH PLUG
8 COTTER PIN
9 PISTON GASKET NUT LOCK SCREW
10 PISTON GASKET NUT
11 PISTON GASKET
12 PISTON ASSEMBLY
13 CAM ROLLER SHAFT LOCK WIRE
14 CAM BEARING NUT
15 COTTER PIN
16 OUTBOARD CAM BEARING
17 FIXED CAM
18 WELCH PLUG
19 DOME SHELL SCREW
20 INBOARD CAM BEARING
21 ROTATING CAM ASSEMBLY
22 CAM ROLLER SHAFT
23 CAM ROLLER BUSHING
24 CAM ROLLERS
25 STOP LUG
26 LOW PITCH STOP RING
27 HIGH PITCH STOP RING
28 GEAR PRELOADING SHIM

(*b*) The ratio between the rotating cam gear and the blade gear segments is eight-to-six with a resulting total *cam* range of approximately 106 degrees, and a constant speed *cam* range of about 40 degrees. This ratio establishes a 30-degree *blade* angle constant speed range. Indexing the blade (gear segment) one tooth with respect to the rotating cam changes the blade angle approximately seven and one-half degrees.

(4) DISTRIBUTOR VALVE ASSEMBLY. (See figure 30.)

(*a*) The distributor valve used with 23D40 propellers is the dome-dumping type, operation of which is fully described in section IV. The dome-dumping action takes place during unfeathering at approximately 25 degrees above the minimum low pitch blade angle setting. In all other respects, the valve functions exactly the same as the type used on the 23E50 propeller.

(*b*) This built-up type is composed of five sections brazed together to form the housing assembly. These sections are the valve housing retaining nut, the valve housing body, the valve spring housing, the valve housing tube, and the piston oil seal ring retainer. A dash pot is fitted over the inboard end of the valve stem, and a valve spring washer over the outboard end. The valve spring itself is contained completely inside the valve housing, and held in place by the valve spring housing nut. Opening pressure of the distributor valve is regulated by the thickness of shims used between the valve spring retaining nut and the valve spring housing ferrule. To obtain the required operating pressure, follow the test procedure outlined in section VII, paragraph 2. Any combination of .010- and .032-inch gaskets which does not exceed a total thickness of .096 inch is permitted.

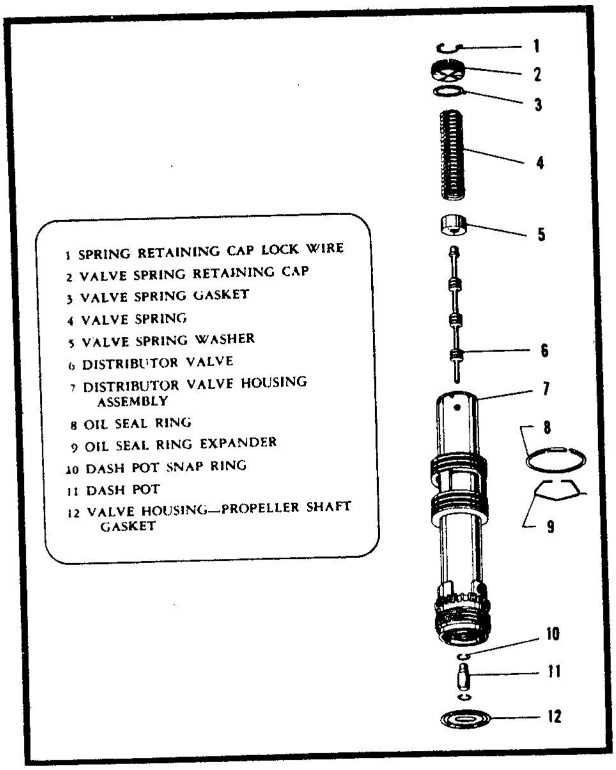


Figure 30—Distributor Valve Assembly for Model 23D40

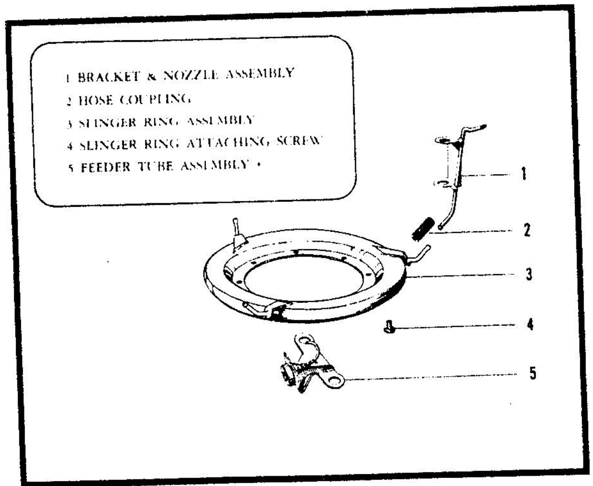


Figure 31—De-Icing Device Assembly for Model 23D40.

(5) DE-ICING DEVICE ASSEMBLY. (See figure 31.)—The de-icing devices used on the model 23D40 propeller are identical except for changes in size of the parts with the devices used on the basic 23E50 model.

c. MODEL 33D50. (See figure 32.)

(1) GENERAL.

(*a*) The model 33D50 propeller is basically a smaller version of the 23E50 model described previously. Slight modifications in design are incorporated in the 33D50 to accommodate certain installation requirements; however, except for the dome-dumping type distributor valve, the 33D50 is identical in principle of operation with all other models in the Hydromatic propeller line. The model 33D50 can be adapted to use standard or straight slope cams. When the standard cams are incorporated, the propeller has a *blade* angle range of 80 degrees with a constant speed *blade* range of about 30 degrees. With straight slope cams, the constant speed *blade* angle range is about 39 degrees.

(*b*) A typical 33D50 propeller group includes the barrel assembly, the distributor valve assembly, the dome assembly, and the de-icing device assembly. Depending upon the requirements; the distributor valve may be replaced by an engine shaft extension for non-feathering installations, and the dome and valve assemblies adapted for shaft breathing.

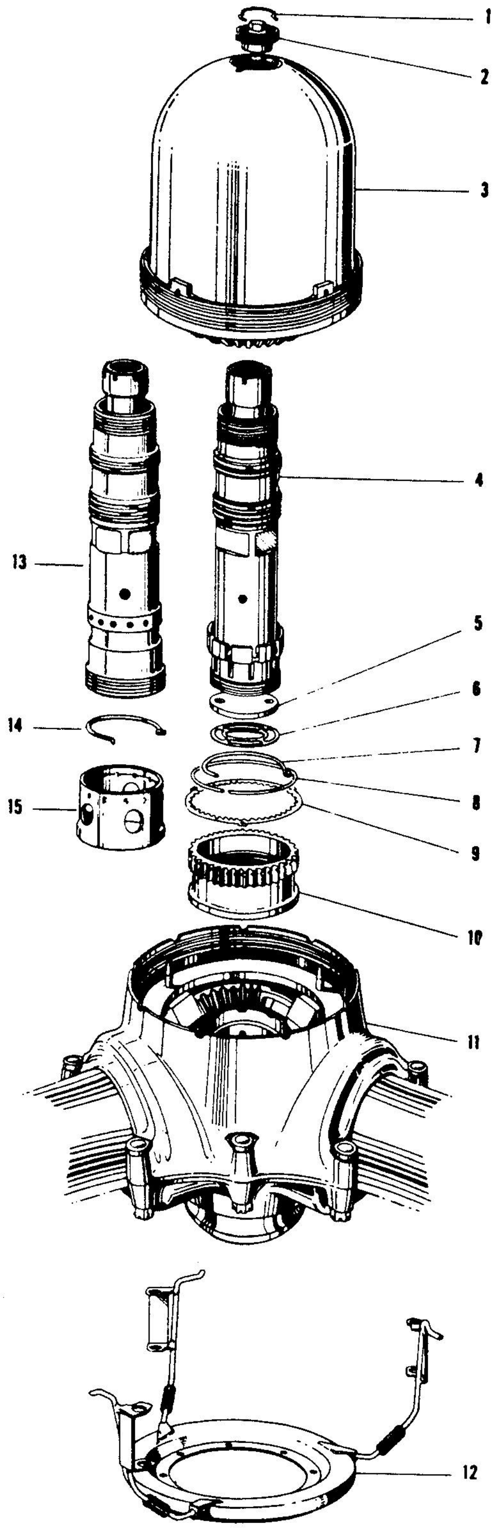


Figure 32—Complete Model 33D50 Propeller

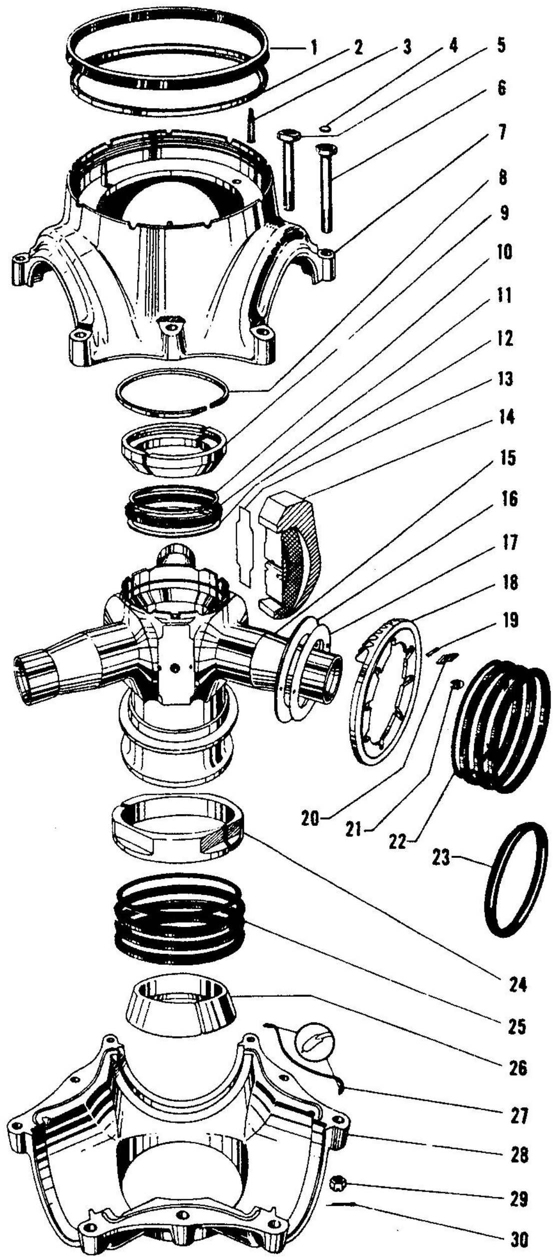
(*c*) Besides these major assemblies, the 33D50 propeller also includes a propeller retaining nut, lock wire, lock ring, and hub snap ring. Three notches are incorporated in the outboard rim of the spider to match with lugs on the propeller retaining nut lock ring. This ring is splined on the inner diameter to match with corresponding splines on the outer diameter of the propeller retaining nut. At installation, the propeller retaining nut is tightened until the nut lock ring can be set in the spider notches and still fit over the splines on the retaining nut. This arrangement locks the hub assembly to the propeller shaft. To secure the lock ring, the propeller retaining nut lock ring lock wire is set in place outboard of the retaining nut lock ring in a groove incorporated in the retaining nut.

(*d*) Also included with the complete propeller assembly is the distributor valve lock wire, the valve housing oil transfer plate and gasket, and the dome breather hole parts. The distributor valve (on feathering installations) or the engine shaft extension (on non-feathering installations) is locked in the propeller shaft by the valve lock wire which fits between the valve housing and the shaft. This wire incorporates a pin, one end of which extends into a valve locking slot and the other end fits through one of the locking holes in the shaft.

(*e*) On more recent models the distributor valve (or engine shaft extension) assembly has equally spaced holes replacing the locking slots on the base of the housing. Locking the assembly in the shaft is accomplished by the use of an intermediate steel sleeve and a locking sleeve lock wire assembly. Two projecting lugs on the OD of the base of the sleeve mate with two recesses on the ID of the propeller shaft and the lock wire assembly is fitted through two aligned holes in the outboard end of the sleeve and the housing.

Nomenclature for Figure 32

1 DOME BREATHER HOLE NUT LOCK WIRE
2 DOME BREATHER HOLE NUT
3 DOME ASSEMBLY
4 EARLY TYPE DISTRIBUTOR VALVE ASSEMBLY
5 OIL TRANSFER PLATE
6 TRANSFER PLATE-PROPELLER SHAFT GASKET
7 DISTRIBUTOR VALVE LOCK WIRE
8 RETAINING NUT LOCK RING LOCK WIRE
9 RETAINING NUT LOCK RING
10 PROPELLER RETAINING NUT
11 HUB ASSEMBLY
12 DE-ICING DEVICE ASSEMBLY
13 NEWER TYPE DISTRIBUTOR VALVE ASSEMBLY
14 DISTRIBUTOR VALVE RETAINING WIRE
15 DISTRIBUTOR VALVE LOCKING SLEEVE



1 DOME-BARREL SEAL
2 DOME-BARREL SEAL RING
3 FIXED CAM LOCATING DOWEL
4 WELCH PLUG
5 BARREL BOLT (SHORT)
6 BARREL BOLT (LONG)
7 OUTBOARD BARREL HALF
8 HUB SNAP RING
9 FRONT CONE
10 SPIDER-SHAFT SEAL RING
11 SPIDER-SHAFT SEAL
12 SPIDER-SHAFT SEAL WASHER
13 BARREL SUPPORT SHIM
14 BARREL SUPPORT
15 SPIDER
16 SPIDER SHIM PLATE
17 SPIDER SHIM
18 BLADE GEAR SEGMENT
19 SPRING PACK SHIM
20 SPRING PACK SPRINGS
21 SPRING PACK RETAINER
22 CHEVRON TYPE BLADE PACKING
23 TOROID TYPE BLADE PACKING
24 SPIDER RING
25 SPIDER-BARREL PACKING
26 REAR CONE
27 BARREL HALF SEAL
28 INBOARD BARREL HALF
29 BARREL BOLT NUT
30 COTTER PIN

Figure 33—Barrel Assembly for Model 33D50

(2) BARREL ASSEMBLY. (See figure 33.)

(a) All 33D50-51, and above, propellers include the modified spider on which the center line of the spider arms is moved forward one inch as compared with the spider used on 33D50-50, and below, models. This modification was made to provide sufficient clearance for certain installations between the propeller blades (in the full-feathered position) and the engine cowling.

(b) When the center line of the spider arms was moved forward, the position of the front cone with respect to the hub snap ring groove was increased by the same amount. In order that the front cone ledge would contact the hub snap ring when the propeller retaining nut was backed off the engine shaft, a ring spacer was included between the snap ring and the front cone. However, on all spiders No. 56634 change C or later, the snap ring groove has been moved inboard and consequently these propellers do not incorporate a spider ring spacer.

(c) As described previously, this spider incorporates three notches in the outboard rim which accommodate the propeller retaining nut lock ring.

(d) In earlier models, slotted gear segments were used which were similar to those on the 23E50 except for size. In later 33D50 models, as in other "D" shank propellers, the gear segments are serrated to match serrations on the blade bushing.

(e) The shim plate assembly includes the shim plate drive pin which fits into the blade bushing drive pin and the spider shim which fits between the face of the blade bushing and the spider shim plate. Older models used a shim plate drive pin which was made integral with the bushing drive pin.

(f) Barrel half seals used in the model 33D50 are the compression type. A small flattened (or spatulated) tip is incorporated at each end of the seal on newer propellers to match with smaller diameter extensions in the barrel half oil seal grooves. Earlier propellers incorporated barrel half seals with a constant cross section from one end to the other. The seals are identified (for this model propeller) because of the fact that each is entirely black. All other barrel half seals are color marked to identify them for the correct propeller model.

(g) The oil seal is maintained between the dome assembly and the hub assembly by a single chevron type seal. The seal rests in an annulus cut in the outboard barrel half just inboard of the dome retaining nut threads. At assembly, the seal is installed so that the feather edges face the dome-barrel shelf, with the inner lip sealing against the dome shell skirt, and the outer lip against the wall of the annulus. A metal "L" shaped ring is installed between the feather edges of the seal to hold the seal in position during dome installation.

(h) To provide greater support for the dome-barrel seal, a dome seal guide ring was incorporated on newer models to fit around the dome shell below the dome retaining nut, helping to fit the gap between the nut and the shell. On current production models, the gap between the nut and the shell is eliminated by use of a new design dome retaining nut which fits closer to the dome shell than the former design.

(i) Either chevron or toroid type blade packings may be used, but not together in one propeller.

(3) BLADE ASSEMBLY. (See figure 40.)—On earlier models, the 33D50 used a slotted type blade bushing, with four of the spring pack slots offset .015 inch with respect to the mating slots in the blade gear segment. Also the shim plate drive pin was made integral with the blade bushing drive pin. The newer "D" shank blades include a serrated type bushing which do not have slots for spring packings. Also the shim plate drive pin is part of the shim plate assembly in the barrel assembly Otherwise, except for size, the "D" shank blades are very similar to the "E" shank blades.

(4) DOME ASSEMBLY. (See figure 29.)—The 33D50 propeller uses the same dome assembly as the 23D40 model. Domes of the same assembly number are completely interchangeable between these two model propellers; however, the operator should make certain that the stop ring setting, propeller balance, and preload are adjusted to fit the requirements of the installation. As

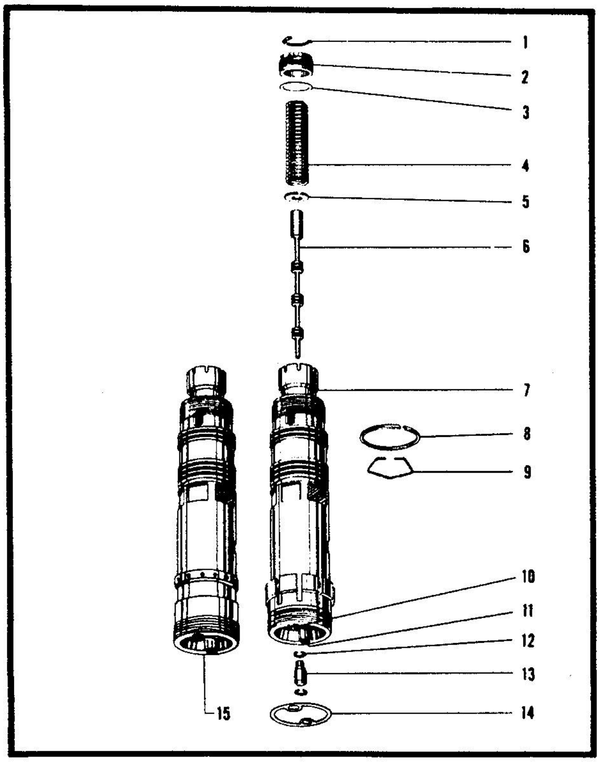


Figure 34—Distributor Valve Assembly for Model 33D50

Nomenclature for Figure 34

1 SPRING RETAINING CAP LOCK WIRE
2 VALVE SPRING RETAINING CAP
3 VALVE SPRING GASKET
4 VALVE SPRING
5 VALVE SPRING WASHER
6 DISTRIBUTOR VALVE
7 DISTRIBUTOR VALVE HOUSING ASSEMBLY (EARLIER TYPE)
8 OIL SEAL RING
9 OIL SEAL RING EXPANDER
10 VALVE HOUSING DOWEL BUSHING (LARGE)
11 VALVE HOUSING DOWEL BUSHING (SMALL)
12 DASH POT SNAP RING
13 DASH POT
14 VALVE HOUSING-TRANSFER PLATE GASKET
15 DISTRIBUTOR VALVE HOUSING ASSEMBLY (LATER TYPE)

Nomenclature for Figure 35

1 EARLY TYPE SHAFT EXTENSION HOUSING
2 OIL SEAL RING
3 OIL SEAL RING EXPANDER
4 EXTENSION HOUSING DOWEL BUSHING (LARGE)
5 EXTENSION HOUSING DOWEL BUSHING (SMALL)
6 EXTENSION HOUSING—TRANSFER PLATE GASKET
7 NEWER TYPE SHAFT EXTENSION HOUSING

previously mentioned, two styles of cams may be used in the model 33D50 propeller. If standard cams are incorporated, the ratio between the rotating cam gear and the blade gear segments is eight-to-six, the *cam* range is about 106 degrees, and the constant speed *cam* range 41.4 degrees. This ratio establishes the 30-degree *blade* angle constant speed range previously quoted. Indexing the blade (gear segment) one tooth with respect to the cam gear changes the blade angle seven and one-half degrees. These characteristics are about the same in straight slope cams except that the *cam* range (entirely devoted to the constant speed range) is 52 degrees, and the *blade* angle range is 39 degrees.

(5) DISTRIBUTOR VALVE ASSEMBLY. (See figure 34.)

(a) The cast type distributor valve is used with 33D50 propellers. This valve may be adapted for shaft breathing installations by including the breathing attachments shown in figure 37. The valve is functionally equivalent to the type used on 23E50 propellers with the exception that a dump port arrangement, incorporated between the two sets of valve oil seal rings, takes the place of a dome relief valve. A valve housing oil transfer plate is fitted over the base of the valve, and a copper gasket is installed between the housing and the plate.

(b) Opening pressure of the distributor valve is regulated by the thickness of shims used between the valve spring cap and the valve housing.

(c) The distributor valve oil seal rings are marked "PRESS" to indicate the pressure side of the rings. It is important that this marking face toward the engine on the three inboard rings, and away from the engine on the two outboard rings.

(d) Two types of locking arrangements have been used. In the earlier models the valve is locked to the engine shaft by means of a lock wire which projected through lugs on the inboard end of the housing. Later models have a sleeve which is locked to the housing by a lock wire and secured in the engine shaft by lugs on

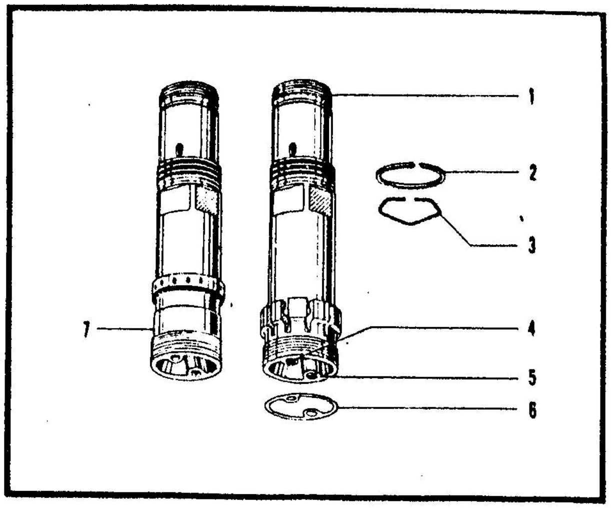
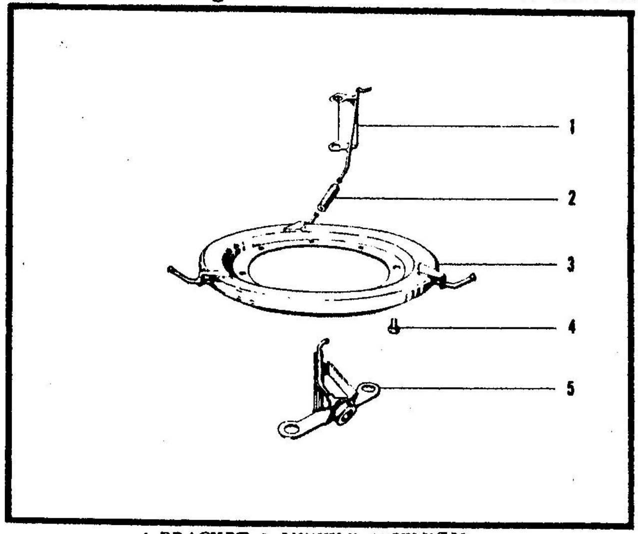


Figure 35—Engine Shaft Extension Assembly for Model 33D50

the outer surface of the sleeve. Both of these types are illustrated.

(6) ENGINE SHAFT EXTENSION ASSEMBLY. (See figure 35.)—On non-feathering installations an engine shaft extension assembly replaces the distributor valve assembly. This shaft extension, except for size of parts, is very similar to that used with the 23E50 model. However, the locking procedure is exactly the same as previously described earlier in this paragraph. The same oil transfer plate, gaskets, and breather parts may be used with a shaft extension as with a distributor valve.

(7) DE-ICING DEVICE ASSEMBLY. (See figure 36.)—The de-icing devices are similar to those used on



1 BRACKET & NOZZLE ASSEMBLY
2 HOSE COUPLING
3 SLINGER RING ASSEMBLY
4 SLINGER RING ATTACHING SCREW
5 FEEDER TUBE ASSEMBLY

Figure 36—De-Icing Device Assembly for Model 33D50

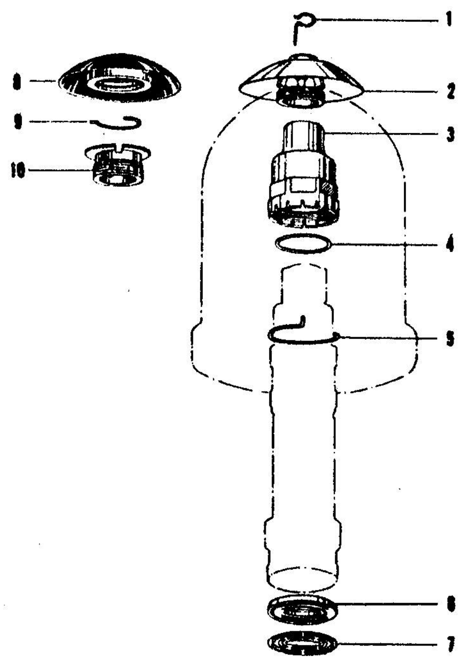


Figure 37—Breather Parts for Model 33D50

Nomenclature for Figure 37

1 BREATHER CAP LOCK WIRE
2 BREATHER CAP
3 BREATHER TUBE ASSEMBLY
4 BREATHER TUBE GASKET
5 BREATHER TUBE LOCK WIRE
6 VALVE HOUSING OIL TRANSFER PLATE
7 TRANSFER PLATE-PROPELLER SHAFT GASKET
8 RUBBER BREATHER CAP
9 BREATHER CAP NUT LOCK WIRE
10 BREATHER CAP NUT

the 23E50 model. Slight changes are made in the relative size of the parts, but a comparison between the de-icing device for the model 33D50 and the other shows the similarity. The adjustable discharge nozzle type (not illustrated) is very similar to the 23E50 type.

(8) BREATHER PARTS. (See figure 37.)—In order to convert an engine shaft extension, or a distributor valve, for shaft breathing, certain parts are required. These parts include a valve housing breather tube and gasket which are fitted over the outboard end of the valve, a synthetic rubber breather cap, a steel breather cap nut, seal, and lock wire which are installed in the dome breather hole, and a shaft breathing type oil transfer plate and gasket which are installed on the base of the valve. This arrangement provides a passage for breather gases from the engine crankcase, through the propeller shaft and distributor valve, out the dome breather hole to atmosphere.

d. MODELS 24D50 AND 24D60. (See figure 38.)

(1) GENERAL.

(a) These models are the smallest four-blade propellers in the Hydromatic group. They incorporate "D" shank blades, and the spider is splined to fit either an SAE 50 or 60 propeller shaft. The 50 shaft has a straight-sided spline, whereas the 60 shaft has an involute spline. Both models are identical except for minor changes in size of the distributor valve, spider, and related parts. The parts used in these propellers retain their identity as Hydromatic propeller parts, and the only operational difference between the 24D models and 23E50 is that the former include dump type distributor valves. Unless otherwise specified, the following paragraphs refer to both the 24D50 and 24D60 models.

(b) It is to be noted that only the 24D50 model uses the valve housing transfer plate and gasket, while the 24D60 model does not require these two parts. On the latter model, the valve housing is fitted directly into the propeller shaft with one valve housing gasket included between the base of the housing and the shaft itself.

(c) The distributor valve assembly is replaced on non-feathering installations by an engine shaft extension assembly. To date, no 24D installations have been made on shaft breathing engines, and, consequently, shaft breathing parts are not shown for the 24D propellers.

(d) The average *blade* angle range on non-feathering 24D propellers is 55 degrees. Since straight slope cams are used, the *blade* angle constant speed range is also 55 degrees. On feathering installations which incorporate standard cams, the total *blade* range is 100 degrees with a *blade* angle constant speed range of 38.8 degrees.

(2) BARREL ASSEMBLY. (See figure 39.)

(a) Except for the fact that the parts are modified to fit four blades, 24D barrel parts are the same as those used in the basic 23E50 model.

(b) Barrel supports are made of aluminum, and are located on the spider by two dowels; one dowel is incorporated in the upper segment of the support, and the other in the lower segment. Support shims are placed over these dowels to fit between the support and the spider and are used to establish spider-barrel concentricity and squareness. Each shim is drilled to accommodate the barrel support dowel. Since this hole is below the center line of the shim, the shim can be installed on the support in only one position. Two of the edges are bent over,

and these small extensions fit back over the sides of the support at assembly. The center portion of each support is cut out to provide clearance for the blade gear segments. Because of this, assembly stop pins cannot be used in the 24D propeller, and blade angles are adjusted by lining up a degree mark stamped on the blade butt flange with an index line stamped on the inner periphery of the dome-barrel shelf, or by using a protractor at the blade reference station.

(c) The model 24D50 propeller incorporates a phenolic blade butt spacer which fits between the cast iron spider shim plate and the spider arm face. This shim plate incorporates the shim plate drive pin which fits into the bushing drive pin, and the spider shim in turn fits between the blade bushing face and the spider shim plate. The 24D60 is the same except that it does not use a blade butt spacer.

(d) Gear segments used in these models are serrated on the inner diameter to match with serrations cut on the outer diameter of the blade bushing. With this arrangement, line-on-line contact between the gears is required.

(e) Synthetic rubber spider-barrel packings are used in 24D propellers. These packings are installed over the inboard end of the spider onto the second ledge. As in all other models, the lips of the packing face toward the spider arms. The follower ring of the spider-barrel packing is marked by a red stripe. A split phenolic spider ring which fits over the spider-barrel packing is installed so that the side incorporating a radius matches with the radius cut in the spider.

(f) On newer 24D propellers, compression type barrel half seals with small spatulated tips at each end which match small extensions incorporated in the barrel half oil seal grooves are used. Older models use the regular seals with round tips. Both types are identified by two green marks.

(g) Although both chevron and toroid type blade packings have been used on various dash number models of the 24D50 and 24D60 models, the toroid type has been used on all recent production propellers.

Nomenclature for Figure 38

1 DOME BREATHER HOLE NUT LOCK WIRE
2 DOME BREATHER HOLE NUT
3 DOME ASSEMBLY
4 DISTRIBUTOR VALVE ASSEMBLY
5 VALVE HOUSING OIL TRANSFER PLATE
6 OIL TRANSFER PLATE-PROPELLER SHAFT GASKET
7 PROPELLER RETAINING NUT LOCK WIRE
8 PROPELLER RETAINING NUT
9 HUB ASSEMBLY
10 DE-ICING DEVICE ASSEMBLY

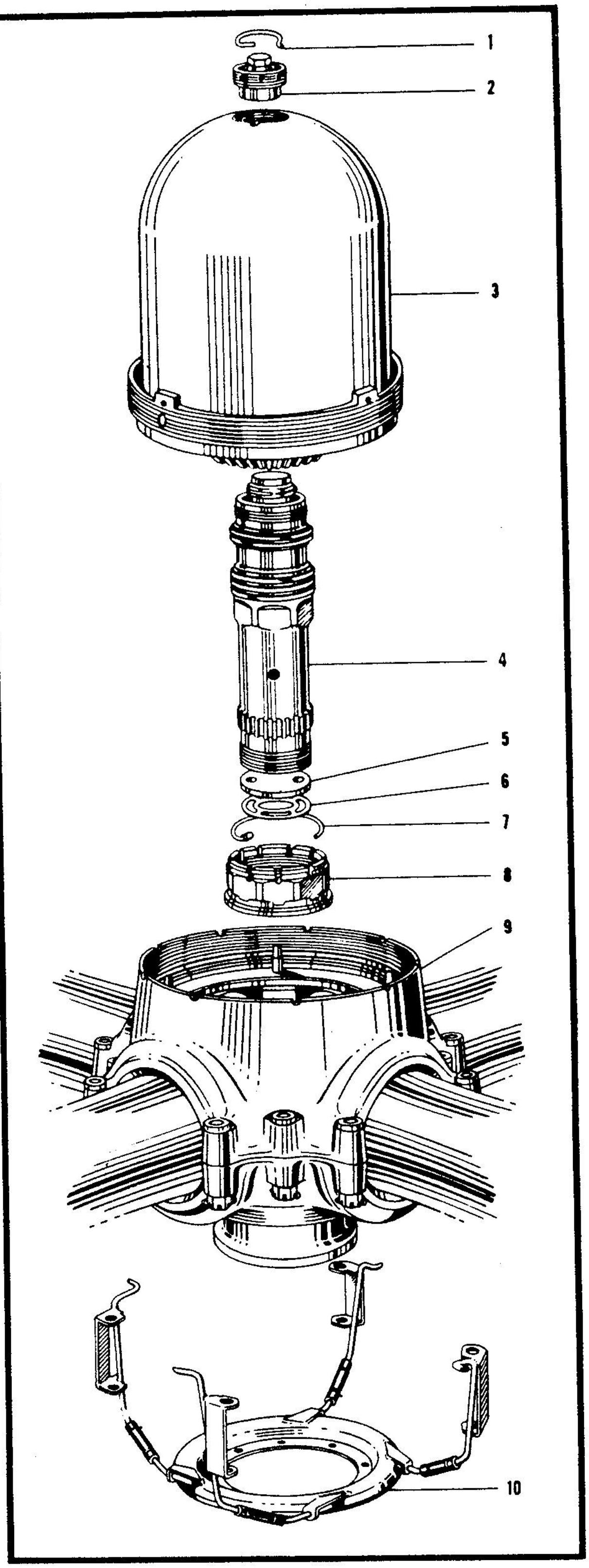
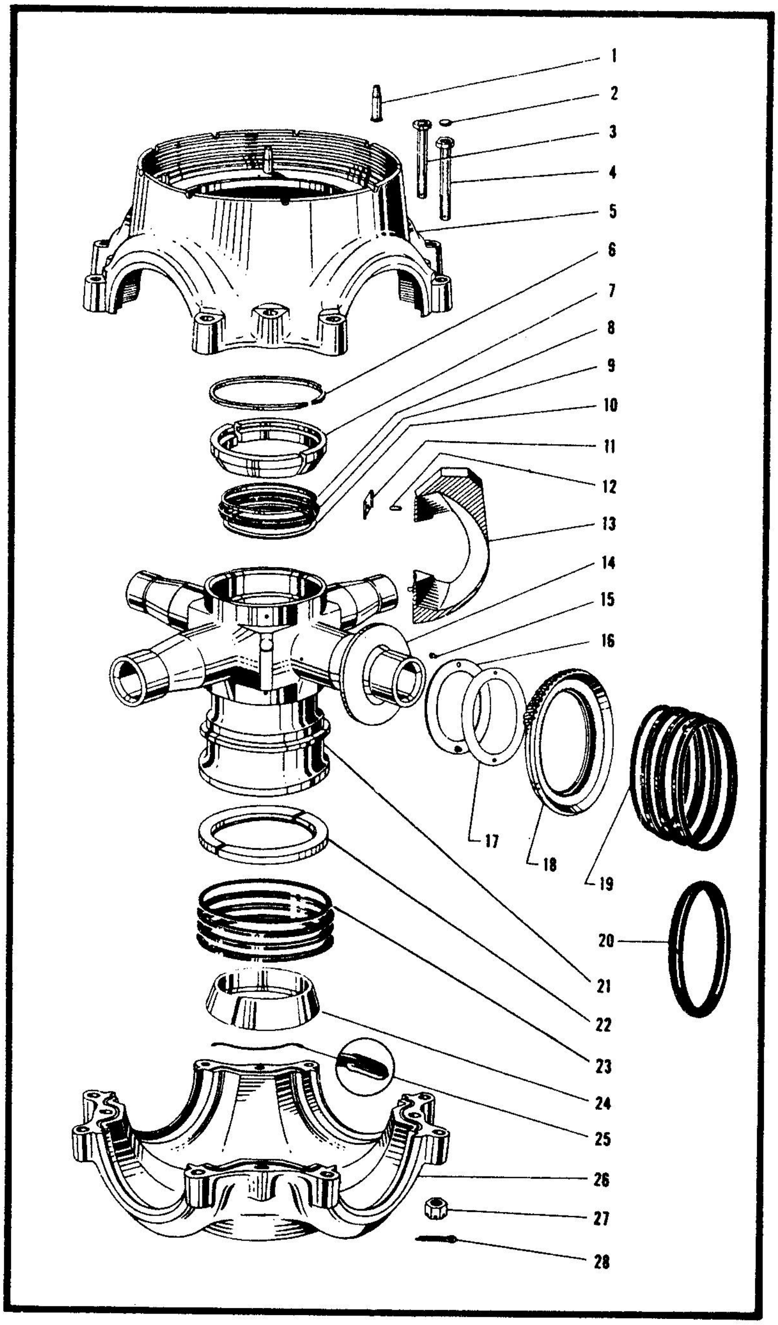


Figure 38—Complete Propeller for Models 24D50 and 24D60



1 FIXED CAM LOCATING DOWEL
2 WELCH PLUG
3 BARREL BOLT (SHORT)
4 BARREL BOLT (LONG)
5 OUTBOARD BARREL HALF
6 HUB SNAP RING
7 FRONT CONE
8 SPIDER-SHAFT SEAL RING
9 SPIDER-SHAFT SEAL
10 SPIDER-SHAFT SEAL WASHER
11 BARREL SUPPORT SHIM
12 BARREL SUPPORT DOWEL
13 BARREL SUPPORT
14 BLADE BUTT SPACER
15 SHIM PLATE DRIVE PIN
16 SPIDER SHIM PLATE
17 SPIDER SHIM
18 BLADE GEAR SEGMENT
19 CHEVRON TYPE BLADE PACKING
20 TOROID TYPE BLADE PACKING
21 SPIDER
22 SPIDER RING
23 SPIDER-BARREL PACKING
24 REAR CONE
25 BARREL HALF SEAL
26 INBOARD BARREL HALF
27 BARREL BOLT NUT
28 COTTER PIN

Figure 39—Barrel Assembly for Models 24D50 and 24D60

(3) BLADE ASSEMBLY. (See figure 40.)—The "D" shank blades used in 24D propellers incorporate a serrated type bushing and do not include blade spring packs. Since assembly stop pins cannot be used in 24D propellers, blade angles are set by lining up one of the degree marks stamped on the blade butt with an index line on the inner periphery of the dome-barrel shelf, or by using a protractor at the blade reference station.

(4) DOME ASSEMBLY. (See figure 41.)

(a) The dome assembly used on model 24D propellers is quite similar to the 23E50 type. The fixed cam incorporates four dowel holes to accommodate the fixed cam locating dowels included in the dome-barrel shelf between each pair of blades.

(b) The ratio between the rotating cam gear and the blade gear segments is one-to-one with a *cam* range

of 55 degrees with straight slope cams, and 100 degrees with standard cams. The resulting constant speed *cam* range is 55 degrees for the straight slope type, and 38.8 degrees for the standard cams. Since the gear ratio between the cams and the segments is one-to-one, the constant speed *cam* range is the same as the constant speed *blade* range. Indexing the blade (gear segment) one tooth with respect to the rotating cam gear changes the blade angle 8.18 degrees.

(c) A compression type seal provides the oil seal between the dome assembly and the barrel assembly. This seal, trapezoidal in shape, is formed of synthetic rubber and seats between the inboard end of the dome shell (just inboard of the dome retaining nut) and the inside diameter of the outboard barrel half (just inboard of the threads that mate with the dome retaining nut). One oversize of this seal is available, if required, for replacement or original assembly.

(d) This dome assembly also incorporates a steel dome breather hole washer which fits between the outboard end of the dome breather hole seal and the inboard end of the threads on the dome breather hole nut.

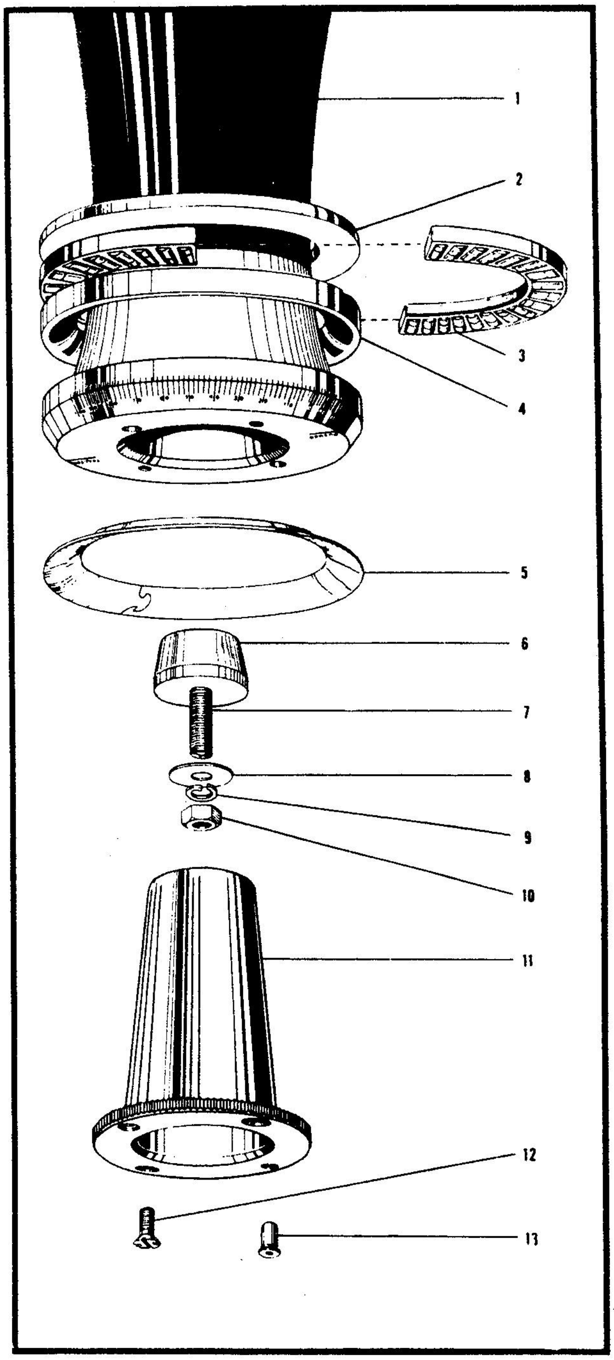
(5) DISTRIBUTOR VALVE ASSEMBLY. (See figure 42.)—A dome-dumping type distributor valve is used with 24D propellers. In construction, these valves are slightly different from the one used with 33D50 propellers in that the spring housing is extended beyond the outboard end of the valve, the valve spring gaskets are installed between the valve spring cap and this housing, and the spring cap, screwed onto the housing, is locked in place by a snap wire which fits around the outside of the cap. Operation of a dome-dumping distributor valve is described in section IV. The dome-dumping action takes place during unfeathering when the blade angle is about 25 degrees above the minimum blade angle setting. For all practical purposes, the valve is no different from that used in any other Hydromatic propeller.

(6) ENGINE SHAFT EXTENSION ASSEMBLY.

(a) FOR SINGLE-ACTING PROPELLERS. (See figure 43.)—On non-feathering installations, an engine shaft extension is used in place of a distributor valve. This assembly merely provides one passage for governor oil to the inboard piston side, and one for engine oil to the outboard piston side. The housing itself is quite similar to a distributor valve housing except that it is shorter, it incorporates but one set of oil seal rings, and the distributor valve mechanism is not included.

(b) FOR DOUBLE-ACTING PROPELLERS.

1. To date, the 24D50 propeller has not been adapted for double-acting operation, but the 24D60 model does have some double-acting applications. On the latter, a special type of engine shaft extension assembly is employed (for both feathering and non-feathering models) which incorporates a ball-type check valve. This



1 BLADE
2 THRUST BEARING FLAT WASHER
3 THRUST BEARING RETAINER
4 THRUST BEARING BEVELED WASHER
5 BLADE CHAFING RING
6 BLADE BALANCING PLUG
7 BLADE PLUG STUD
8 BALANCING WASHER
9 LOCKWASHER
10 NUT
11 BLADE BUSHING
12 BLADE BUSHING SCREW
13 BLADE BUSHING DRIVE PIN

Figure 40—"D" Shank Blade Assembly

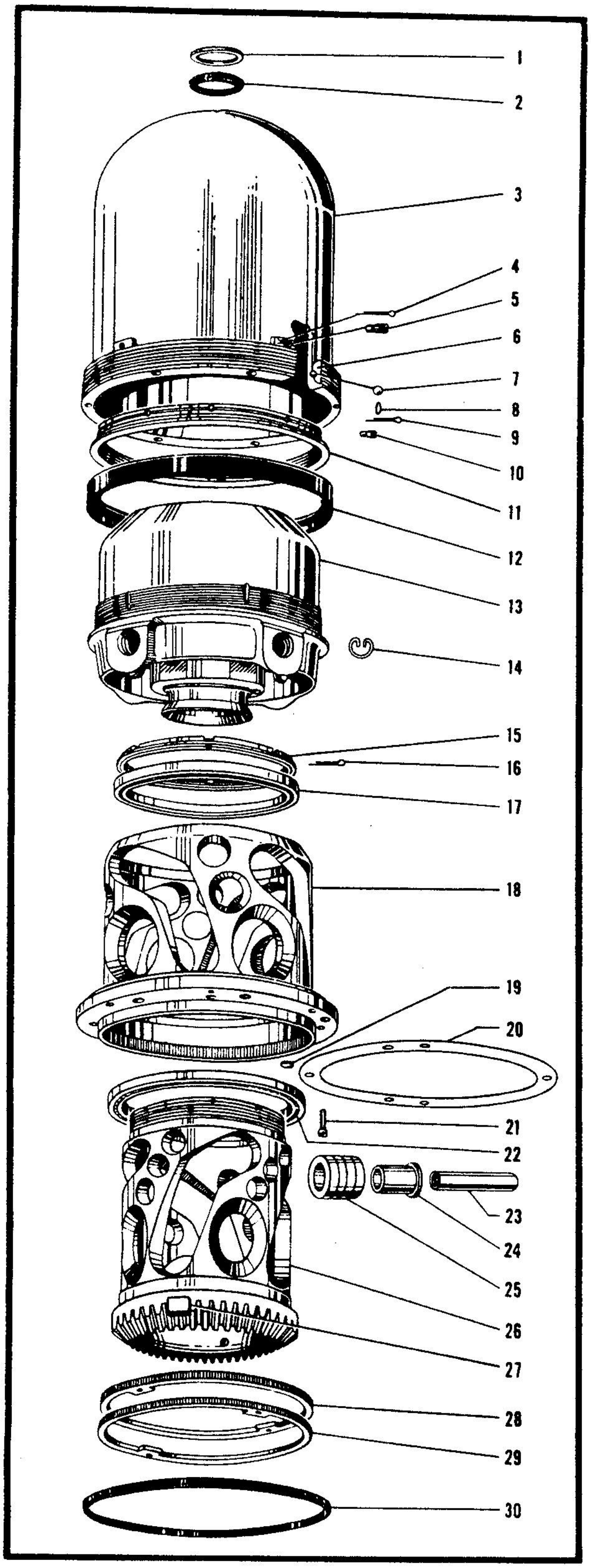


Figure 41—24D50 and 24D60 Dome

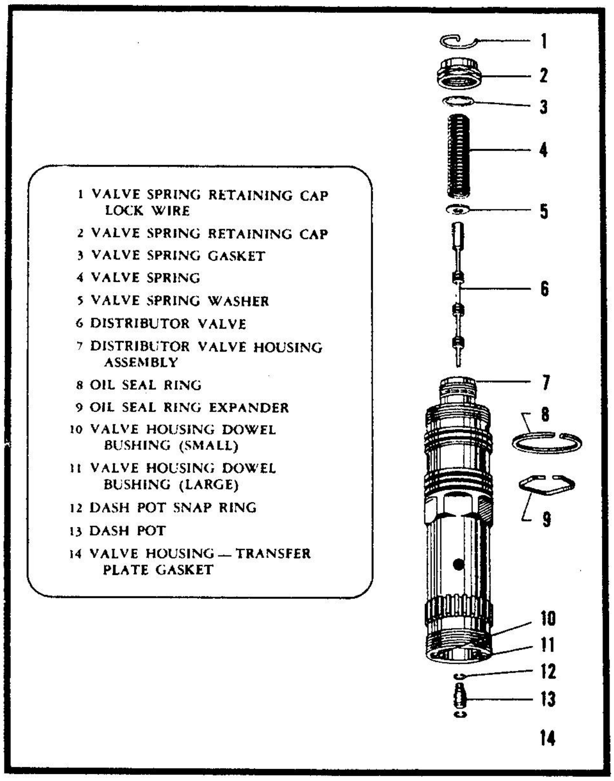


Figure 42—Distributor Valve Assembly for Model 24D50

Nomenclature for Figure 41

1 DOME BREATHER HOLE WASHER
2 DOME BREATHER HOLE SEAL
3 DOME SHELL
4 COTTER PIN
5 DOME RETAINING NUT LOCK SCREW
6 DOME RETAINING NUT
7 BALL
8 WELCH PLUG
9 COTTER PIN
10 PISTON GASKET NUT LOCK SCREW
11 PISTON GASKET NUT
12 PISTON GASKET
13 PISTON ASSEMBLY
14 CAM ROLLER SHAFT LOCK WIRE
15 CAM BEARING NUT
16 COTTER PIN
17 OUTBOARD CAM BEARING
18 FIXED CAM
19 WELCH PLUG
20 GEAR PRELOADING SHIM
21 DOME SHELL RETAINING SCREW
22 INBOARD CAM BEARING
23 CAM ROLLER SHAFT
24 CAM ROLLER BUSHING
25 CAM ROLLERS
26 ROTATING CAM ASSEMBLY
27 STOP LUG
28 LOW PITCH STOP RING
29 HIGH PITCH STOP RING
30 DOME-BARREL SEAL

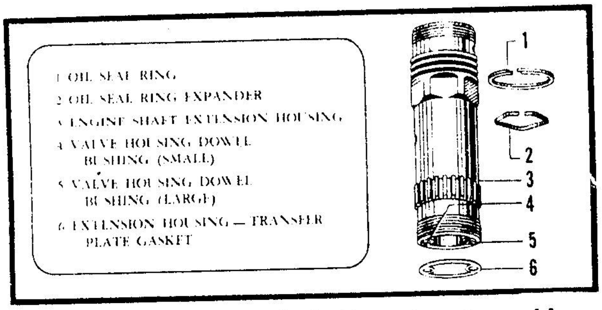


Figure 43—Engine Shaft Extension Assembly for Model 24D50

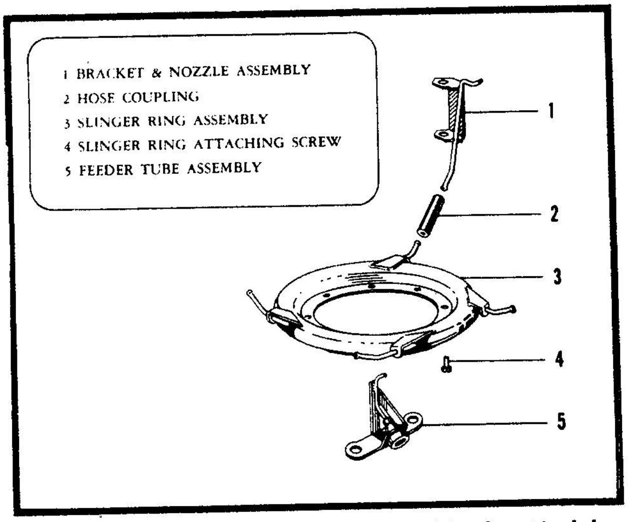


Figure 44—De-Icing Device Assembly for Models 24D50 and 24D60

assembly is quite similar to the one for the 33E60 propeller. During the unfeathering operation, this check valve prevents excessively high pressure from building up in the outboard side of the dome piston. There are two oil passages, one to each side of the dome piston. During constant speed operation, governor oil pressure is supplied through both of these passages, as required, since engine oil pressure supplies only the intake side of the governor pump.

2. The extension housing is fabricated of aluminum alloy, threaded on the inboard OD to mate with the propeller shaft threads. Just outboard of these threads

Nomenclature for Figure 45

1 DOME BREATHER HOLE NUT LOCK WIRE
2 DOME BREATHER HOLE NUT
3 DOME ASSEMBLY
4 DISTRIBUTOR VALVE ASSEMBLY
5 SLEEVE
6 PROPELLER RETAINING NUT LOCK WIRE
7 PROPELLER RETAINING NUT
8 HUB ASSEMBLY

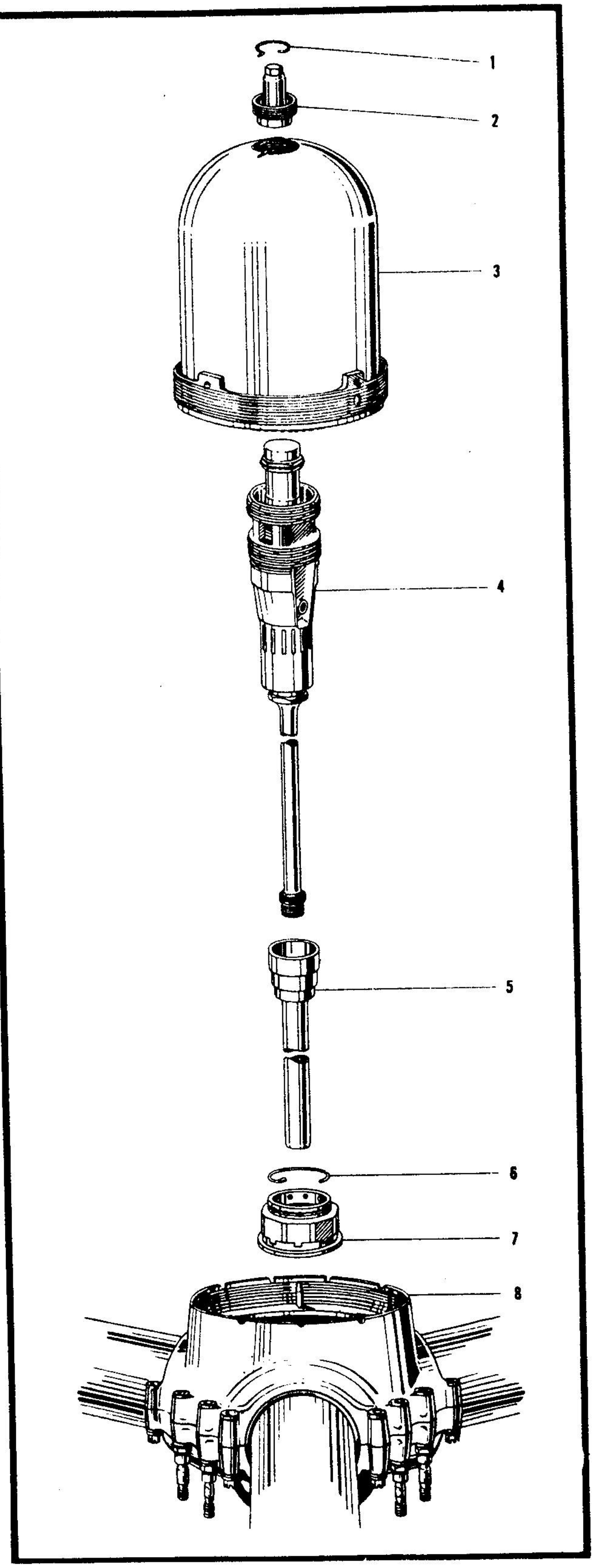


Figure 45—Complete Model 23EX Propeller

are locking splines, and wrench flats are machined just inboard of the inboard set of oil seal rings.

3. Two sets of oil seal rings, separated by the port leading to the check valve, provide the oil seal between the inboard and outboard sides of the dome piston. Expanders keep the rings centered on the housing.

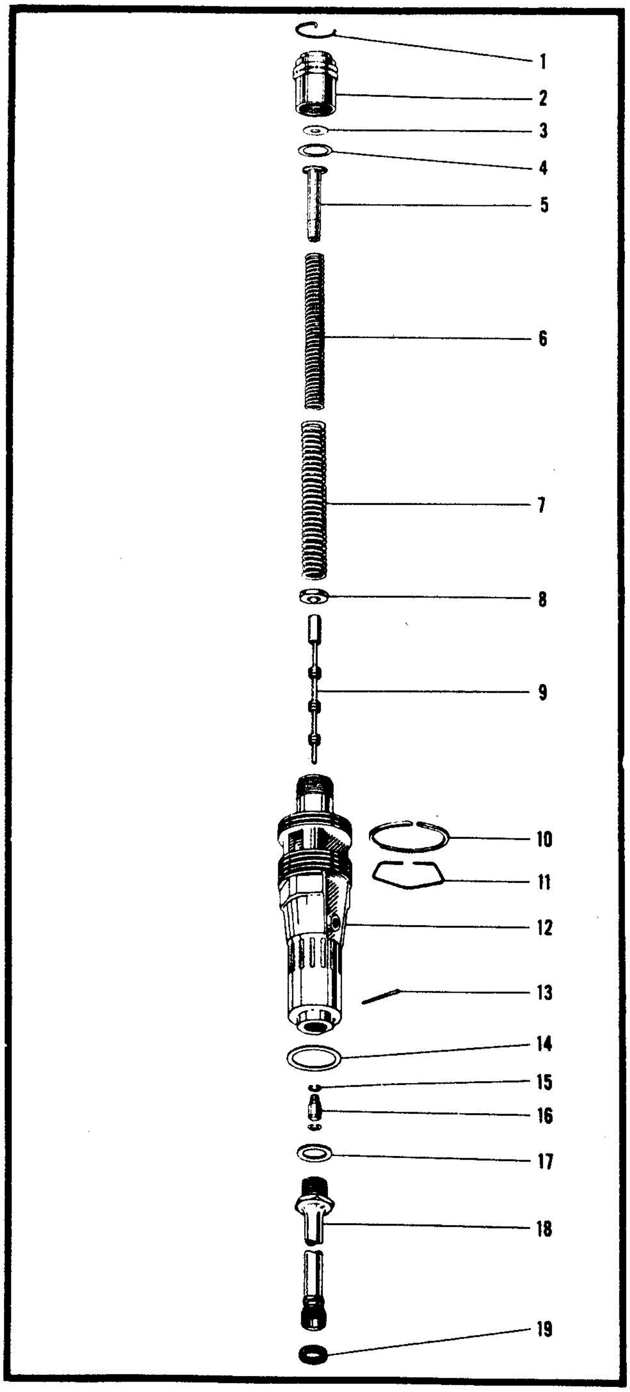


Figure 46—Distributor Valve Assembly for Model 23EX

4. The check valve is comprised of a steel ball, backed by a spring and plug, and safetied with a lock wire.

(7) DE-ICING DEVICE ASSEMBLY. (See figure 44.)—The de-icing device assemblies used on 24D propellers are identical in style to those used on the basic 23E50 model. The adjustable nozzle type is not illustrated, but is very similar to that shown for the 23E50.

Nomenclature for Figure 46

1 VALVE SPRING RETAINER CAP LOCK WIRE
2 VALVE SPRING RETAINER CAP
3 GUIDE TUBE ADJUSTING WASHER
4 VALVE SPRING GASKET
5 VALVE SPRING GUIDE TUBE
6 VALVE INNER SPRING
7 VALVE OUTER SPRING
8 VALVE SPRING WASHER
9 DISTRIBUTOR VALVE
10 OIL SEAL RING
11 OIL SEAL RING EXPANDER
12 DISTRIBUTOR VALVE HOUSING ASSEMBLY
13 TUBE-HOUSING TAPER PIN
14 SLEEVE-HOUSING WASHER
15 DASH POT SNAP RING
16 DASH POT
17 TUBE-HOUSING WASHER
18 TUBE
19 SLEEVE-TUBE OIL SEAL

e. PROPELLER MODEL 23EX. (See figure 45.)

(1) GENERAL.

(a) The model 23EX propeller is basically a model 23E50 adapted to fit the Rolls Royce Merlin engine. Because of the great similarity between the 23EX and 23E50 models, only the differences between the two are described. For all other considerations, the descriptions and data given on the basic 23E50 model apply as well to the model 23EX. If propeller balance and stop ring settings are taken into account, dome assemblies of the same number may be used interchangeably between the 23EX and 23E50 models. The barrel is almost identical with the 23E50 type except that the inner bore of the spider is splined to fit a No. 5 British shaft. The distributor valve incorporates a long tube and sleeve extension which connect with the oil passages deep inside the propeller shaft. Model 23EX propellers have not been used on either shaft breathing or non-feathering installations; consequently, breather parts and an engine shaft extension assembly are not shown.

(b) This model propeller has a *blade* angle range from 10 degrees low pitch to 90 degrees high pitch measured at the blade reference station, and a constant speed *blade* angle range of 31 degrees.

(c) The outboard rim of the propeller retaining nut incorporates a groove and a series of holes which hold

the propeller retaining nut lock wire. The wire incorporates a pin that fits through a hole in the retaining nut, through a corresponding hole in the propeller shaft, and into a locking spline on the distributor valve housing thereby locking the retaining nut and distributor valve assembly to the propeller shaft.

(*d*) To accommodate the spinner, a special dome breather hole nut is fitted in the dome shell and spinner attaching studs are added on the barrel bolts.

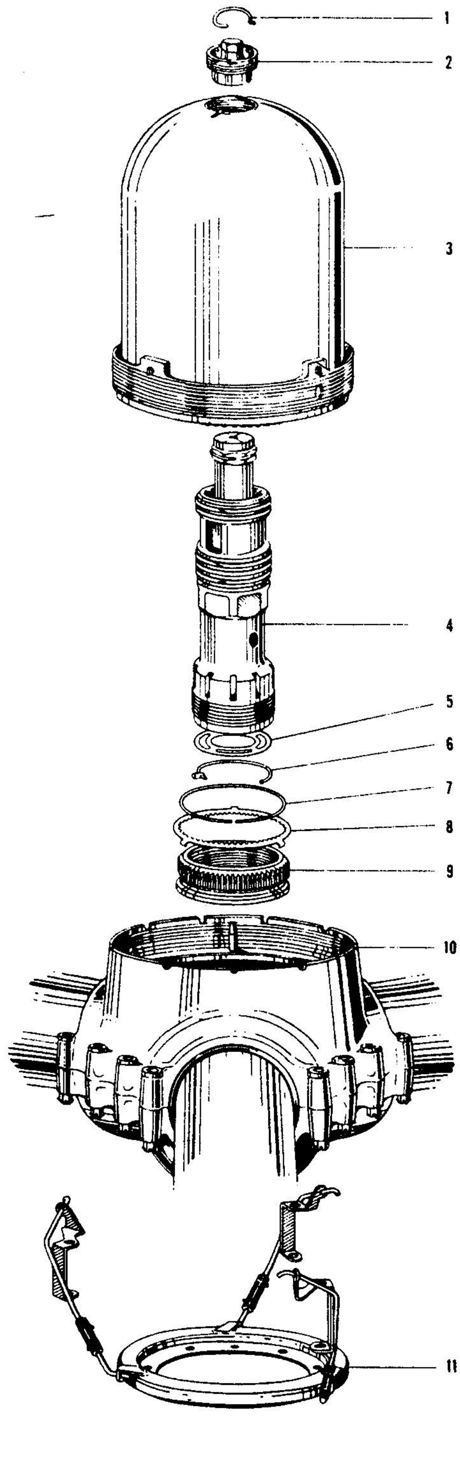
(2) BARREL ASSEMBLY. (See figure 9.)—The barrel assembly incorporated in the model 23EX propeller is the same as that used on the basic 23E50 except: the inner bore of the spider is splined to fit a No. 5 British shaft, the barrel bolts are used in conjunction with spinner mounting bolts, the spider-shaft seal is slightly different in size, and the inboard ledge of the front cone is a little heavier.

(3) BLADE ASSEMBLY.—"E" shank blades which meet the requirements of the installation are completely interchangeable between the models 23EX and 23E50.

(4) DOME ASSEMBLY. (See figure 15.)—Model 23EX propellers use the same dome assembly as the basic 23E50 model, and assemblies of the same number are interchangeable between the two. The ratio between the rotating cam and the blade gear segments is five-to-four, the cam range is 100 degrees and the constant speed *cam* range is 38.8 degrees. This ratio establishes the 31-degree *blade* angle constant speed range previously quoted. Indexing the blade (gear segment) one tooth with respect to the rotating cam changes the blade angle eight degrees.

(5) DISTRIBUTOR VALVE ASSEMBLY.
(See figure 46.)

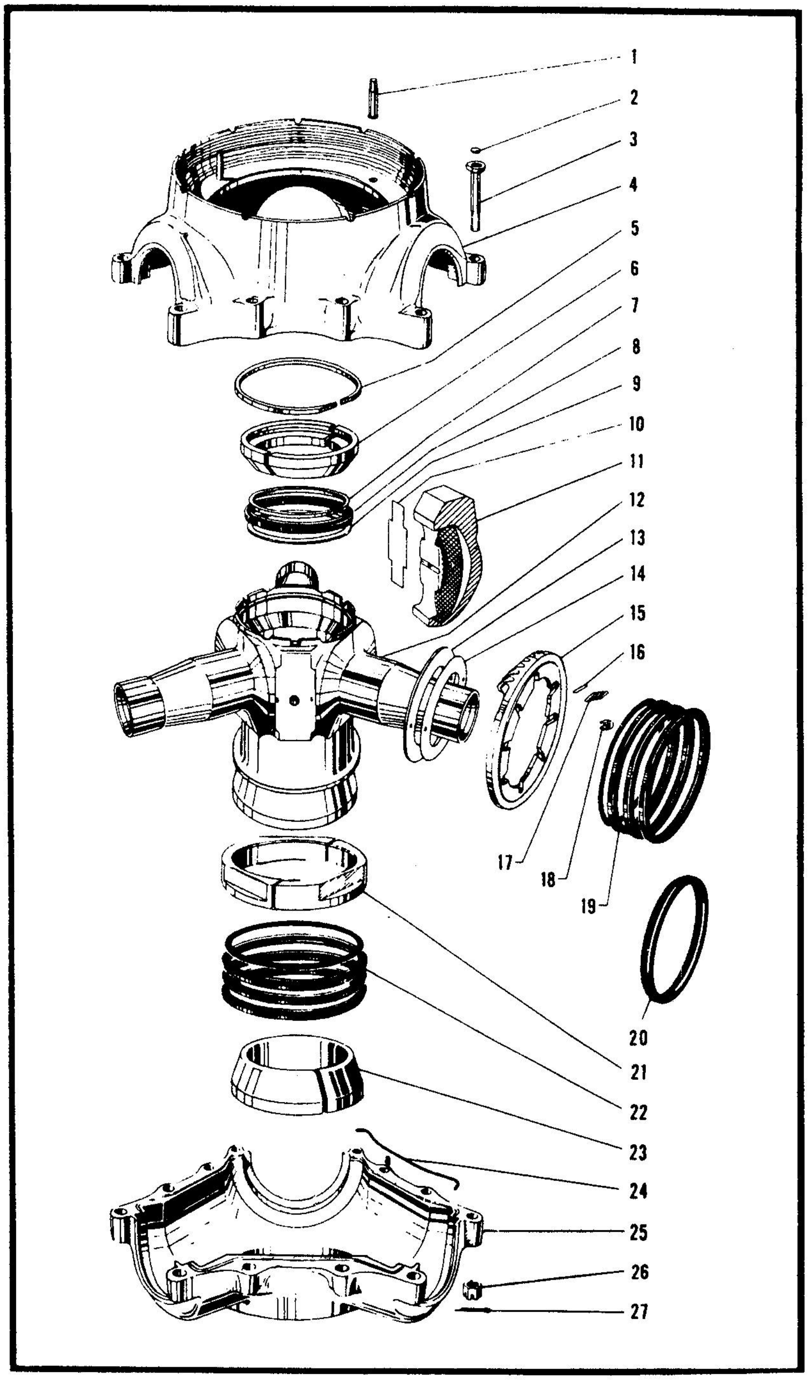
(*a*) Except for the fact that certain modifications and parts are added to meet installation requirements, the distributor valve for the model 23EX propeller is fundamentally the same as any other Hydromatic type. On this particular model, a tube is attached to the base of the valve housing which connects with the engine oil supply inside the propeller shaft. This tube in turn is enclosed within a sleeve also extending from the base of the valve to the inside of the propeller shaft, and the passage thus



Nomenclature for Figure 47

1 DOME BREATHER HOLE NUT LOCK WIRE
2 DOME BREATHER HOLE NUT
3 DOME ASSEMBLY
4 DISTRIBUTOR VALVE ASSEMBLY
5 VALVE HOUSING-PROPELLER SHAFT GASKET
6 VALVE LOCK WIRE
7 RETAINING NUT LOCK RING LOCK WIRE
8 PROPELLER RETAINING NUT LOCK RING
9 PROPELLER RETAINING NUT
10 HUB ASSEMBLY
11 DE-ICING DEVICE ASSEMBLY

Figure 47—Complete Model 33E60 Propeller



1 FIXED CAM LOCATING DOWEL
2 WELCH PLUG
3 BARREL BOLT
4 OUTBOARD BARREL HALF
5 HUB SNAP RING
6 FRONT CONE
7 SPIDER-SHAFT SEAL RING
8 SPIDER-SHAFT SEAL
9 SPIDER-SHAFT SEAL WASHER
10 BARREL SUPPORT SHIM
11 BARREL SUPPORT
12 SPIDER
13 SPIDER SHIM PLATE
14 SPIDER SHIM
15 BLADE GEAR SEGMENT
16 SPRING PACK SHIM
17 SPRING PACK SPRINGS
18 SPRING PACK RETAINER
19 CHEVRON TYPE BLADE PACKING
20 TOROID TYPE BLADE PACKING
21 SPIDER RING
22 SPIDER-BARREL PACKING
23 REAR CONE
24 BARREL HALF SEAL
25 INBOARD BARREL HALF
26 BARREL BOLT NUT
27 COTTER PIN

Figure 48—Barrel Assembly for Model 33E60

formed between the sleeve and the tube leads oil from the propeller governor to the distributor valve. Current production models incorporate a double distributor valve spring (one fitting inside the other) and a distributor valve guide tube. Formerly, only one spring was used.

(b) The base of the housing does not incorporate threads, and the housing itself is not screwed inside the propeller shaft but is held in place by left-hand threads on the inboard end of the tube. A synthetic rubber washer fits over the inboard end of the tube to form the oil seal between the tube and the shaft. The tube is locked to the housing by a pin.

(c) The distributor valve on a model 23EX propeller is the dome-dumping type, the operation of which is described and shown in section IV.

(6) DE-ICING DEVICE ASSEMBLY.—This propeller uses a British de-icing system.

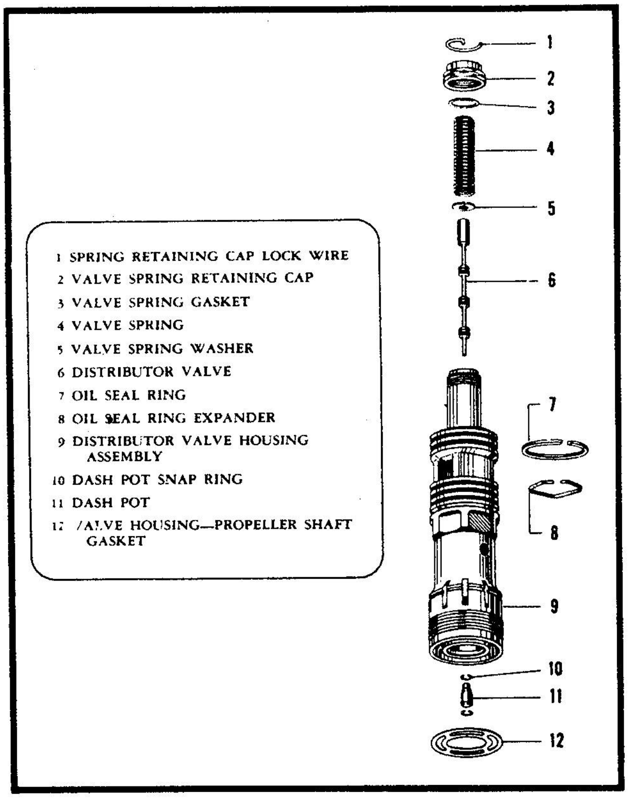


Figure 49—Distributor Valve Assembly for Model 33E60

f. MODEL 33E60. (See figure 47.)

(1) GENERAL.

(a) The model 33E60 is equivalent to a 23E50, enlarged so as to fit on an SAE 60 propeller shaft. As indicated in the propeller model designation, it includes three "E" shank blades. The average total *blade* range is 80 degrees with a constant speed *blade* angle range of 31 degrees.

(b) Faired knee cams (described earlier in this section) are now used exclusively in current 33E60 models. Formerly, as in the 23E50 model, the cams were standard, fast-acting, or straight slope.

(c) A typical 33E60 installation includes the barrel, blade, dome, distributor valve, and de-icing device assemblies. On non-feathering installations, the distributor valve is replaced by an engine shaft extension. As yet, no 33E60 shaft breathing installations have been made, and, consequently, these parts are not shown.

(d) Besides the major assemblies, there are certain smaller parts, such as the propeller retaining nut, lock ring, dome breather hole nut, etc. which are used during installation. The propeller retaining nut is locked to the hub assembly by a serrated ring which fits over the nut and locks into slots cut on the outboard rim of the spider. This arrangement is the same as that used on the

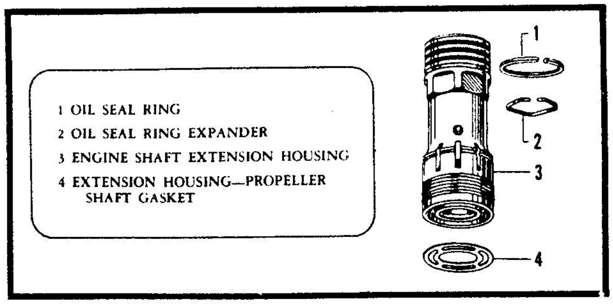


Figure 50—Engine Shaft Extension Assembly for Single-Acting Model 33E60

33D50 model, except that it is not possible on the 33E60 model to obtain alignment between the ring and the spider merely by repositioning the ring.

(e) The valve is fitted directly into the propeller shaft with a gasket between the base of the housing and the shaft. Distributor valves and engine shaft extensions used with 33E60 propellers do not incorporate an oil transfer plate or plate gasket.

(2) BARREL ASSEMBLY. (See figure 48.)—Three notches are cut in the outboard rim of the spider to accommodate the propeller retaining nut locking ring. One notch is incorporated between each pair of arms. Compression type barrel half seals identified by one yellow and one red mark are used to form the oil seal between the barrel halves. Both chevron type and toroid type blade packings are used, depending on the particular model, but not together in one propeller.

(3) BLADE ASSEMBLY. (See figure 11.)—"E" shank blades as used in the model 33E60 propeller are identical with those used in the basic 23E50 model.

(4) DOME ASSEMBLY. (See figure 15.)—A dome assembly used on a model 33E60 propeller is completely interchangeable with an assembly of the same number as used on the basic 23E50.

(5) DISTRIBUTOR VALVE ASSEMBLY. (See figure 49.)—The 33E60 distributor valve is practically the same as the type used on model 24D50 propellers. It incorporates the dome-dumping feature, and the outboard part of the valve is slightly smaller than the inboard end in order that the dome assembly from the model 23E50 propeller may be used on this 60 spline size propeller. The dome-dumping action takes place at 20 degrees above the minimum blade angle setting.

(6) ENGINE SHAFT EXTENSION ASSEMBLY.

(a) FOR SINGLE-ACTING PROPELLERS. (See figure 50.)—The engine shaft extension assembly provides an oil passage for governor oil to the inboard side of the piston and engine oil to the outboard side of the piston on non-feathering installations. Since the operating oil pressure is always applied on the inboard side, only one set of oil seal rings is used.

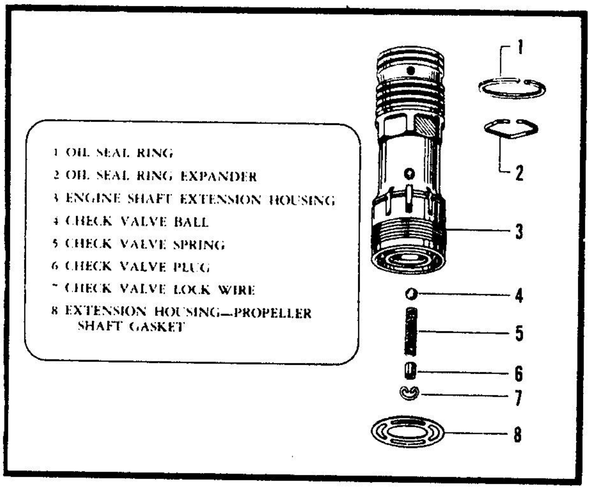


Figure 51—Engine Shaft Extension Assembly for Double-Acting Model 33E60

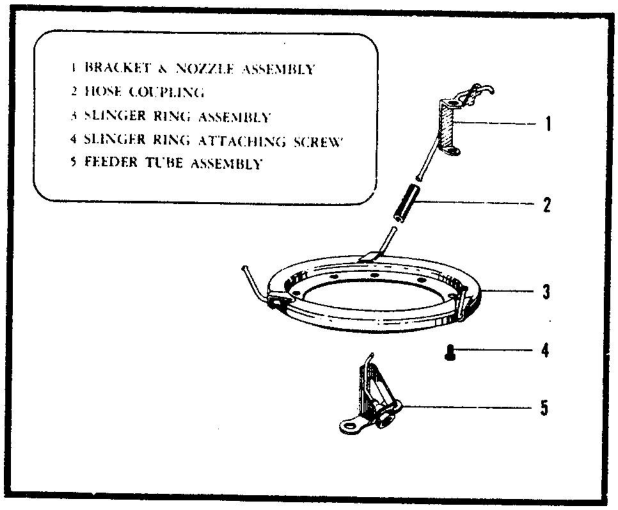


Figure 52—De-Icing Device Assembly for Model 33E60

(*b*) FOR DOUBLE-ACTING PROPELLERS. (See figure 51.)

1. The double-acting propellers, both feathering and non-feathering installations, use a type of engine shaft extension assembly which includes a check valve consisting of a ball, backed up by a spring and plug, and safetied with a clip-type lock wire. This valve prevents excessive oil pressure from building up on the outboard side of the piston during the unfeathering operation. Governor oil pressure, as required, is directed to either the inboard or outboard sides of the piston through the two oil passages in the shaft extension. There is no passage in the shaft extension for engine oil since this pressure does not enter the propeller in a double-acting application.

2. The engine shaft extension housing is fabricated of aluminum alloy, threaded on the OD of the inboard end to mate with the propeller shaft threads. Locking slots are situated just outboard of these threads, and wrench flats just inboard of the inboard set of oil seal rings.

3. There are two sets of oil seal rings, separated by the port connecting to the check valve, which form the oil seal between the inboard and outboard sides of the dome piston. Spring steel ring expanders center the oil seal rings on the housing.

(7) DE-ICING DEVICE ASSEMBLY. (See figure 52.)—The de-icing device assembly is the same as that used on the basic 23E50 model with the exception that a feeder tube with a longer stem is incorporated. This is necessary since the model 33E60 propeller sets well forward on the engine shaft. The adjustable nozzle type (not illustrated) is also very similar to the 23E50 adjustable type.

g. MODELS 24E50 AND 24E60. (See figure 53.)

(1) GENERAL.

(*a*) These models incorporate four "E" shank blades, and the internal bore of the spider is splined to fit either an SAE 50 or 60 propeller shaft. The 50-spline model uses a straight-sided spline, whereas the 60 has an involute spline. Both models are identical except for minor changes in the spider (and some of its correlated parts), and the size of the valve. Unless otherwise specified, the following paragraphs refer to both the 24E50 and 24E60 models.

(*b*) The average total blade angle range is 80 degrees with a constant speed blade range of 38.8 degrees.

(*c*) The valves used on model 24E50 and 24E60 propellers do not incorporate oil transfer plates. The valve housing is fitted directly into the propeller shaft with one gasket included between the base of the housing and the shaft itself.

(2) BARREL ASSEMBLY. (See figure 54.)

(*a*) On 24E50 propeller models previous to -51, the spider was located one inch farther back on the shaft than the spider shown. Moving the spider forward necessitated the use of a spacer between the front cone and the hub snap ring. In all other respects, the older style barrel assembly is identical with the newer type.

(*b*) Chevron type spider-barrel packings establish the oil seal between the inboard end of the spider and the inboard barrel half. On barrel assemblies used with 24E50 propellers previous to -51, this packing is installed on the single ledge near the spider base so that the feather edges of the packing face toward the spider arms. On models 24E50-51 and above, this packing is installed on the second spider ledge with the feather edges facing toward the spider arms. In both cases, a phenolic spider ring is put over the packing to help in locating the inboard barrel half on the spider. The follower ring, installed last, is marked by a red stripe.

(c) The spider used in model 24E60 propellers is slightly different in that its central bore incorporates an involute type spline, and the spider-barrel packing is always installed on the first ledge.

(d) Aluminum supports locate the barrel halves with respect to the spider. Each support incorporates two steel dowels, one in the upper segment of the support, and one in the lower. These dowels locate the support on the support seat of the spider. Small brass shims are fitted between each segment of the support and over each dowel to establish spider-barrel concentricity during propeller assembly. The dowel hole in the shim is not on center; therefore, at assembly, the shim can be correctly put in place on the support in only one position. Each support is recessed near its center section to provide clearance for the blade gear segments. For this reason, assembly stop pins cannot be used in these propellers, and blade angles are adjusted either by a protractor at the blade reference station or by lining up a degree mark on the blade butt with an index line on the inner periphery of the dome-barrel shelf.

(e) A phenolic ring is fitted between the spider shim plate and the shim plate surface of the spider on the model 24E50 only. The cast iron spider shim plate is held in place on the blade gear segment by shim plate drive pins, and the spider shim fits between the shim plate and the segment. In order to make "E" shank blades interchangeable among all propeller models which use them, new 24E50 and 24E60 propellers incorporate two 1/2-inch holes in the segment directly over the bushing drive pins, and the shim plate drive pin holes are relocated 90 degrees from them. This arrangement makes it possible to use any suitable "E" shank blade without the necessity of pulling the shim plate drive pins. In most other models, the gear segment fits around the outer periphery of the blade bushing, the bushing itself incorporates the shim plate drive pins, and the spider shim plate and shim are attached over the face of the bushing.

Nomenclature for Figure 53

1 DOME BREATHER HOLE NUT LOCK WIRE
2 DOME BREATHER HOLE NUT
3 DOME ASSEMBLY
4 DISTRIBUTOR VALVE ASSEMBLY
5 DISTRIBUTOR VALVE-PROPELLER SHAFT GASKET
6 PROPELLER RETAINING NUT LOCK WIRE
7 PROPELLER RETAINING NUT
8 HUB ASSEMBLY
9 DE-ICING DEVICE ASSEMBLY

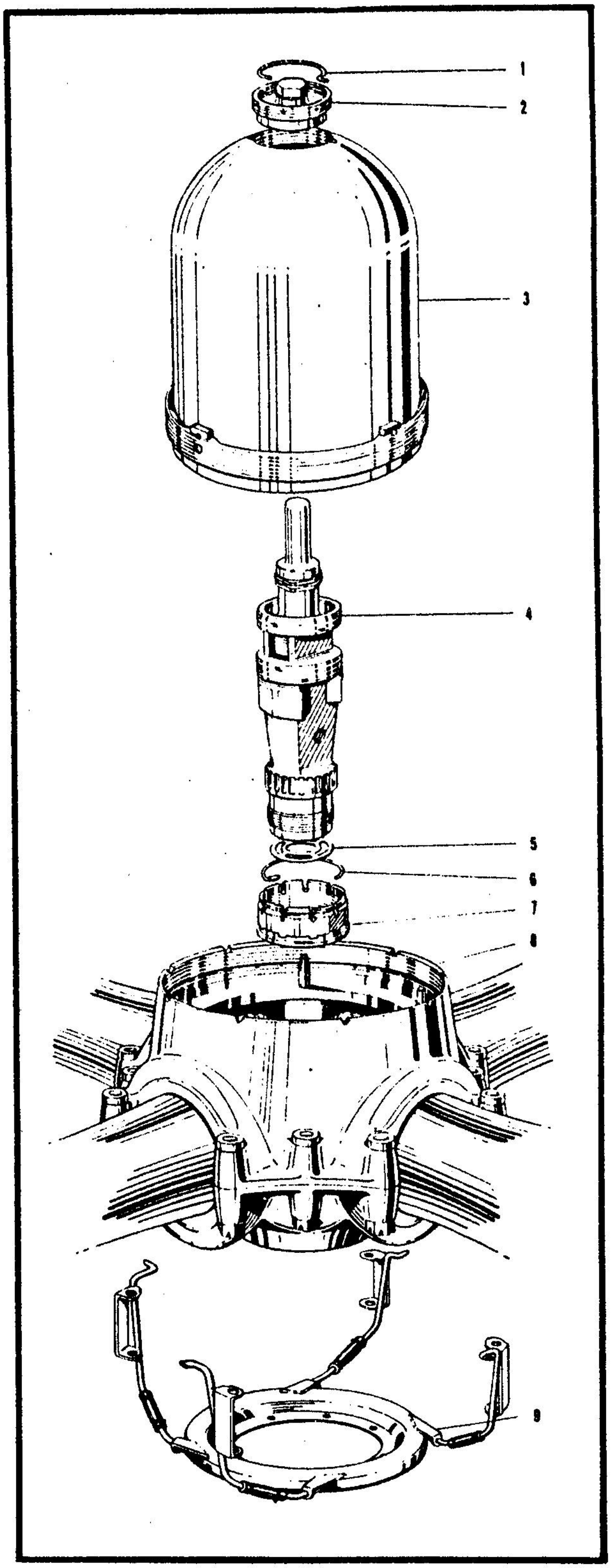
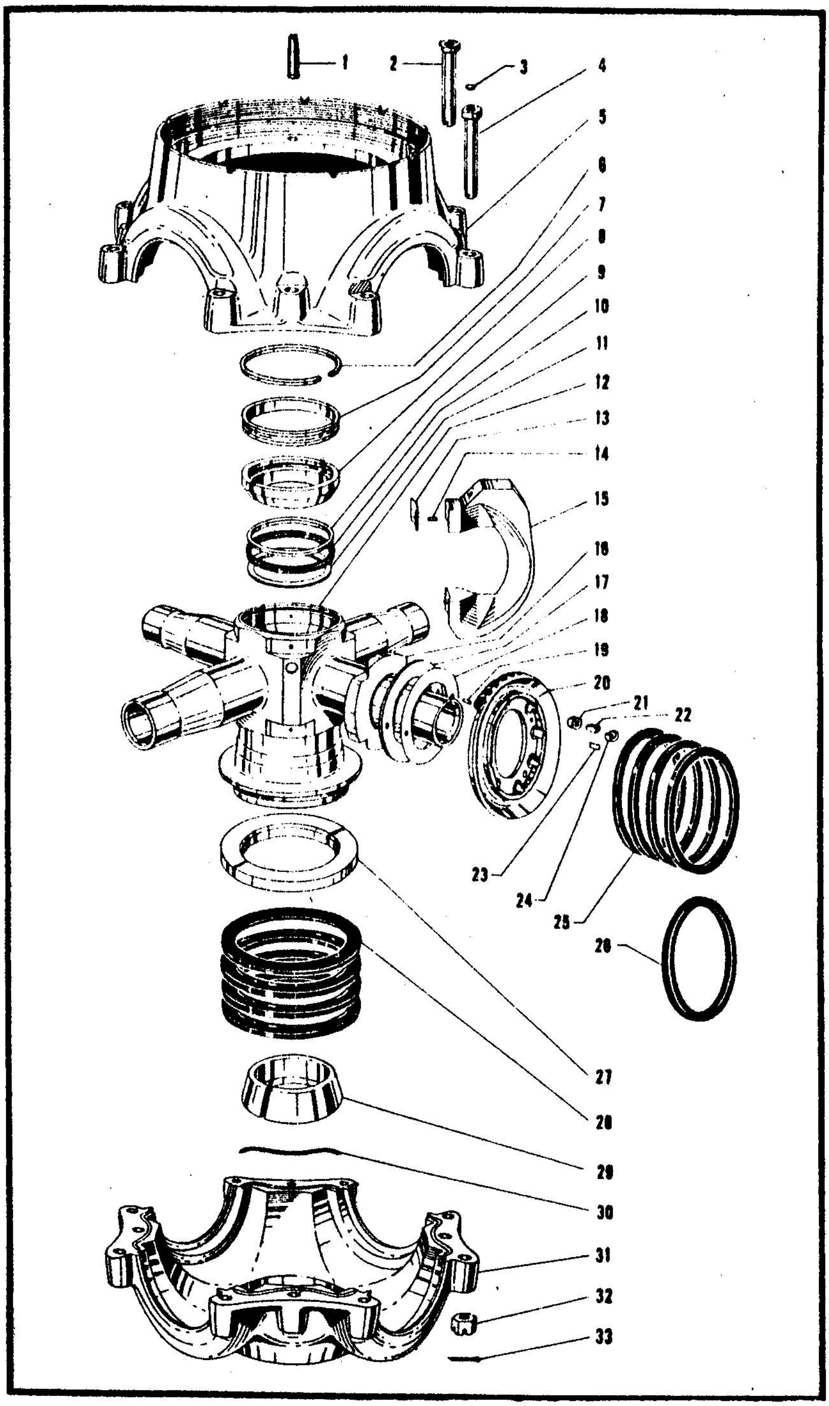


Figure 53—Complete Propeller for Models 24E50 and 24E60



1 FIXED CAM LOCATING DOWEL
2 BARREL BOLT (SHORT)
3 WELCH PLUG
4 BARREL BOLT (LONG)
5 OUTBOARD BARREL HALF
6 HUB SNAP RING
7 FRONT CONE SPACER
8 FRONT CONE
9 SPIDER-SHAFT SEAL RING
10 SPIDER-SHAFT SEAL
11 SPIDER-SHAFT SEAL WASHER
12 SPIDER
13 BARREL SUPPORT SHIM
14 BARREL SUPPORT DOWEL
15 BARREL SUPPORT
16 BLADE BUTT SPACER
17 SPIDER SHIM PLATE
18 SPIDER SHIM
19 SHIM PLATE DRIVE PIN
20 BLADE GEAR SEGMENT
21 CIRCULAR SPRING PACK RETAINER
22 SPRING PACK SPRINGS
23 SPRING PACK SHIM
24 SPRING PACK RETAINER
25 CHEVRON TYPE BLADE PACKING
26 TOROID TYPE BLADE PACKING
27 SPIDER RING
28 SPIDER-BARREL PACKING
29 REAR CONE
30 BARREL HALF SEAL
31 INBOARD BARREL HALF
32 BARREL BOLT NUT
33 COTTER PIN

Figure 54—Barrel Assembly for Models 24E50 and 24E60

(f) Both models incorporate vertical spring packs as shown in figure 54 in place of the horizontal type used on most other models. A horseshoe type spring pack retainer is fitted into each slot on the bushing, the spring leaves installed in this retainer in a position parallel to the blade axis, and then a circular retainer fitted over the protruding portion of the leaves.

(g) Synthetic rubber barrel half seals incorporating a smaller tip extension at each end are used to make the barrel halves oil-tight. The seal for the model 24E50 and 24E60 propellers is identified by two yellow marks on the black surface.

(h) Either chevron or toroid type blade packings may be incorporated.

(i) The model 24E60-159 incorporates a strengthened barrel for use on a particular aircraft. Except for the heavier barrel and longer bolts, there are no other changes in barrel assembly parts.

(3) BLADE ASSEMBLY. (See figure 11.)—"E" shank blades are used in the 24E50 and 24E60 model. The model 24E60-159 only uses model 6837A blades which are surface-treated for added strength.

(4) DOME ASSEMBLY. (See figure 55.)

(a) Except for the fact that dome assemblies used in 24E50 and 24E60 propellers are larger than the 23E50 type, both models are the same in operation and general form of parts. Domes of the same assembly number are completely interchangeable between the 24E50 and 24E60 propellers.

(b) The ratio between the rotating cam gear teeth and the teeth of the blade gear segments is one-to-one, with a total *cam* range of about 80 degrees, and a constant speed *cam* range of 38.8 degrees. With this one-to-one ratio between the cams and blades, the constant speed *cam* range of 38.8 degrees is the same as the constant speed *blade* range. Indexing the blade (gear segment) one tooth with respect to the rotating cam gear changes the blade angle 10 degrees.

(c) On current production models, faired knee cams are used. However, on earlier models,

Nomenclature for Figure 55

1 DOME BREATHER HOLE SEAL
2 DOME SHELL
3 COTTER PIN
4 DOME RETAINING NUT LOCK SCREW
5 DOME RETAINING NUT
6 BALL
7 WELCH PLUG
8 PISTON GASKET NUT LOCK SCREW
9 COTTER PIN
10 PISTON GASKET NUT
11 PISTON GASKET
12 PISTON ASSEMBLY
13 CAM ROLLER SHAFT LOCK WIRE
14 CAM BEARING NUT
15 COTTER PIN
16 OUTBOARD CAM BEARING
17 FIXED CAM
18 WELCH PLUG
19 INBOARD CAM BEARING
20 GEAR PRELOADING SHIM
21 DOME SHELL RETAINING SCREW
22 CAM ROLLER SHAFT
23 CAM ROLLER BUSHING
24 CAM ROLLERS
25 ROTATING CAM ASSEMBLY
26 STOP LUG
27 LOW PITCH STOP RING
28 HIGH PITCH STOP RING
29 DOME-BARREL SEAL

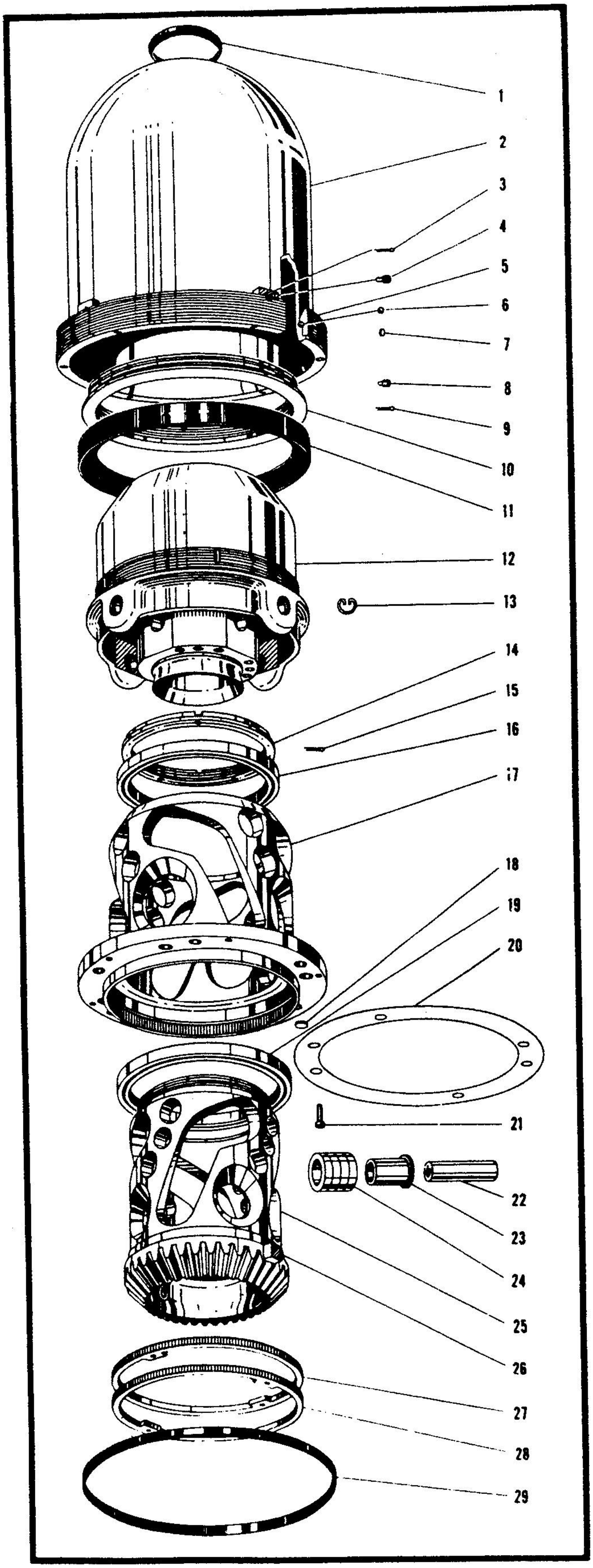


Figure 55—24E50 and 24E60 Dome Assembly

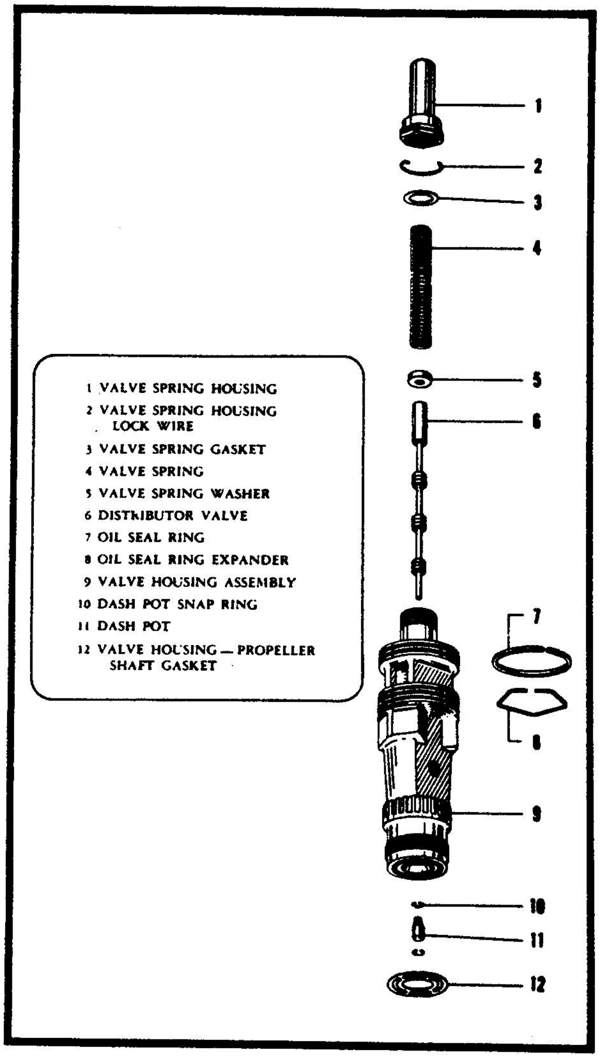


Figure 56—Distributor Valve Assembly for Model 24E50

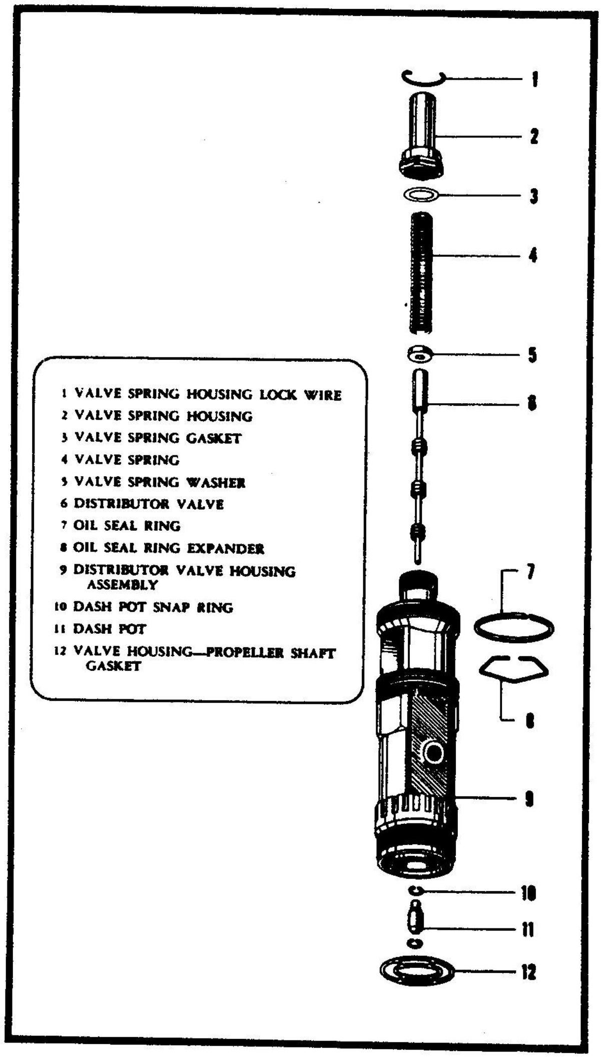


Figure 57—Distributor Valve Assembly for Models 24E60, 23F60, and 24F60

cams with the standard track were employed.

(d) The model 24E60-159 only incorporates a new type of piston which has a toroid gasket instead of the former T-shaped gasket. No nut is needed on the new piston. Otherwise, this dome assembly is identical to that illustrated.

(5) DISTRIBUTOR VALVE ASSEMBLY.

(a) A dome-dumping type distributor vâlve is used in the models 24E50 and 24E60 propellers. As shown in figure 56, the 24E50 valve is made small enough on the inboard end to fit into a standard SAE 50 propeller shaft, and large enough on the outboard end so that the dome assemblies between the models 24E50 and 24E60 propellers will be interchangeable. The dome-dumping action takes place at a blade angle of about 20 degrees above the minimum low pitch blade angle setting on the 24E50 type, and about 30 degrees on the 24E60. A 24E60 valve is shown in figure 57.

(b) These distributor valve assemblies do not incorporate an oil transfer plate or plate-shaft gasket, but are fitted into the propeller shaft with one copper gasket between the base of the housing and the shaft itself.

(6) ENGINE SHAFT EXTENSION ASSEMBLY.

(a) FOR SINGLE-ACTING PROPELLERS. —An engine shaft extension assembly is merely a shortened distributor valve housing with the valve mechanism omitted. The resulting part incorporates

one passage for governor oil to the inboard side of the piston, and one for engine oil to the outboard piston side. A valve is required only on feathering installations where it is necessary to reverse the passages through the distributor valve assembly in order to lead the auxiliary oil to the outboard piston side. On non-feathering installations, this reversal of pressures is not required, and consequently an engine shaft extension which incorporates the two passages previously described is used. The engine shaft extension assembly used with model 24E50 propellers is shown in figure 58, and figure 59 shows the 24E60 type.

(b) FOR DOUBLE-ACTING PROPELLERS. (See figure 60.)

1. The 24E60 model has also been adapted for double-acting operation, which requires another type of engine shaft extension assembly. This extension incorporates a check valve (comprised of a steel ball, backed

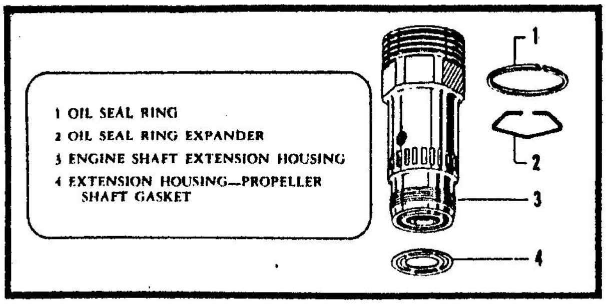


Figure 58—Engine Shaft Extension Assembly for Single-Acting Model 24E50

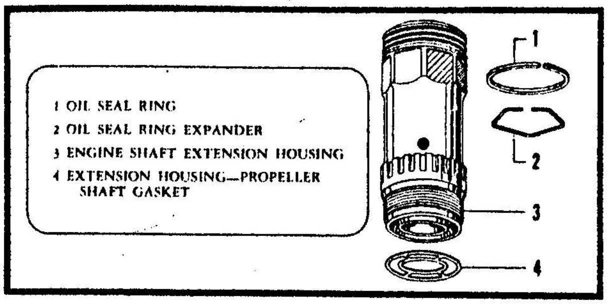


Figure 59—Engine Shaft Extension Assembly for Single-Acting Models 24E60, 23F60, and 24F60

up by a spring and plug, and safetied with a lock wire) which prevents excessively high oil pressure from building up on the outboard side of the piston during unfeathering. There are two oil passages which supply governor oil pressure to either side of the piston, as required. Engine oil does not enter the propeller on double-acting applications.

2. The extension housing is fabricated of aluminum alloy threaded on the inboard end to fit the propeller shaft threads. Just outboard of these threads are locking slots and a wrench hex is located just inboard of the inboard set of oil seal rings.

3. Two sets of oil rings, flanking the port to the check valve, form the oil seal between the outboard and inboard sides of the dome piston.

(7) DE-ICING DEVICE ASSEMBLY. (See figure 61.)—The de-icing devices for these propellers are standard in that they incorporate the same parts in form and general construction that are used on any other Hydromatic model.

b. MODEL 23F60. (See figure 62.)—The model 23F60 is in reality the largest version of the basic 23E50 model. It incorporates three "F" shank blades, and the inner bore of the spider is splined to match with the size 60 involute type propeller shaft spline. The average total *blade* angle range is 80 degrees with a constant speed *blade* angle range of 30.8 degrees. The parts used in the model 23F60 are about the same as those in the basic

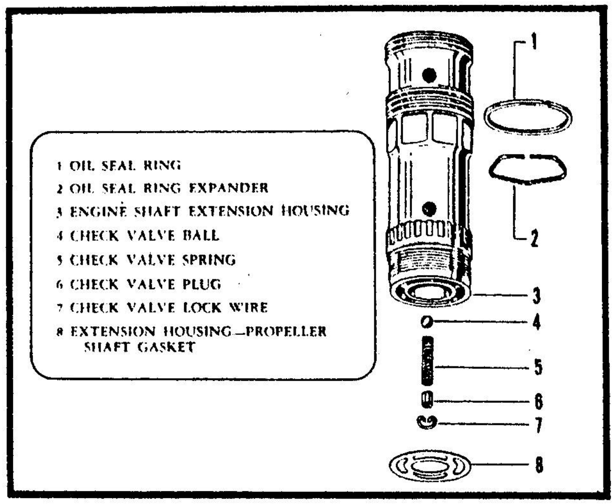


Figure 60—Engine Shaft Extension Assembly for Double-Acting Models 24E60, 23F60, and 24F60

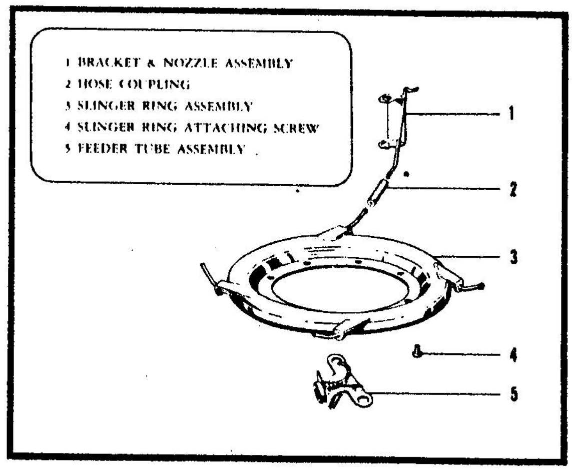


Figure 61—De-Icing Device Assembly for Models 24E50 and 24E60

23E50 model. Slight modifications are made in the parts to account for the difference in size between the two models. The front cone, the propeller retaining nut, and hub snap ring arrangement used are the same as the 23E50 type. However, in the model 23F60, the propeller retaining nut lock wire fits between the propeller shaft and the retaining nut, and locks both the nut and the valve to the shaft.

(1) BARREL ASSEMBLY. (See figure 63.)—This barrel is the same as that used in the 23E50 propellers in that the size of some parts is proportionately larger. Either chevron or toroid type blade packings may be used, although not together in a single propeller.

(2) BLADE ASSEMBLY. (See figure 64.)

(a) "F" shank blades when incorporated in the model 23F60 propeller use the conventional horizontal

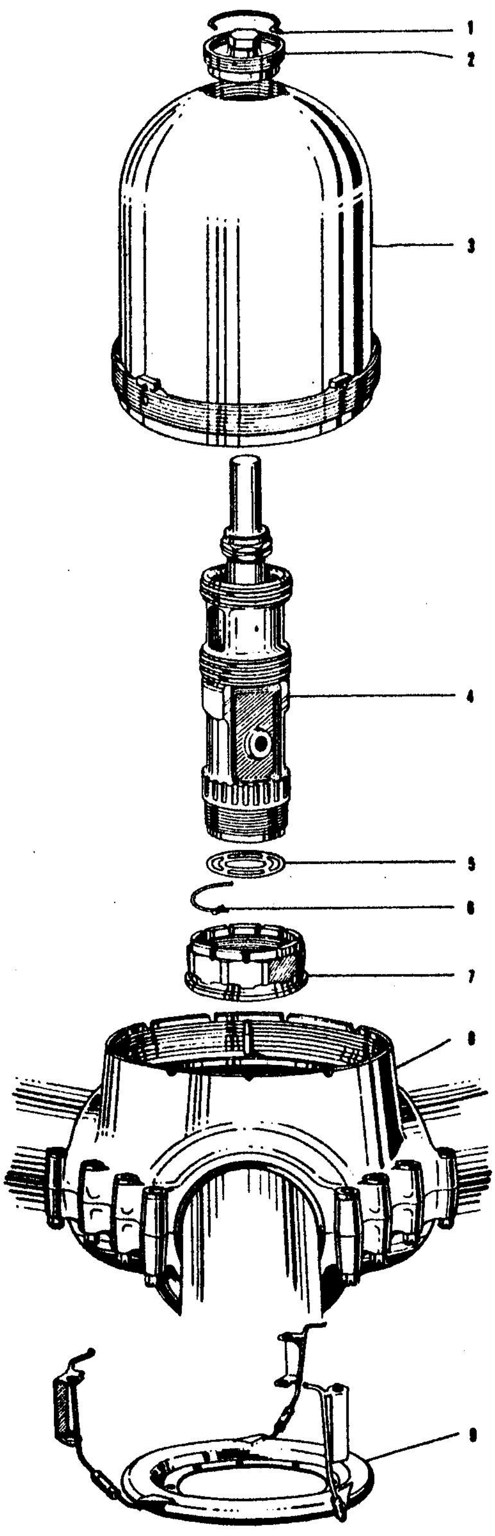


Figure 62—Complete Model 23F60 Propeller

type spring packs between the blade gear segment and the blade bushing. Two of these spring packs are offset to establish the required preload force between the teeth of the rotating cam and the blade gear segment teeth. "F" shank blades are interchangeable between the models 23F60 and 24F60; however, in the latter model vertical spring packs are incorporated.

(b) As previously mentioned, "F" shank bushing drive pins do not incorporate shim plate drive pins. An extended section is incorporated on the bushing drive pin which locates the spider shim and shim plate. The blade gear segment used on the model 24F60 incorporates vertical spring packs and fits directly over the blade bushing face. The shim plate drive pin is fitted into the segment (as in the case of the models 24E50 and 24E60), and two 1/2-inch holes are incorporated 90 degrees from the shim plate drive pin holes to provide clearance for the extended portion of the bushing drive pin. This arrangement makes it possible to use an "F" shank blade without modification in either a 23F60 or 24F60 propeller.

(3) DOME ASSEMBLY. (See figure 65.)—The dome assembly used with the model 23F60 is no different from the basic 23E50 type except for changes in size of the various parts; however, a washer is not used in the dome breather hole in the 23F60 type. The ratio between the rotating cam gear teeth and the blade gear segments is 1.26 to 1, with a total *cam* range of about 100 degrees, and a constant speed cam range of 38.8 degrees. This *cam* ratio establishes the *blade* constant speed range of 30.8 degrees. Indexing the blade (gear segment) one tooth with respect to the rotating cam changes the blade angle 10.6 degrees.

(4) DISTRIBUTOR VALVE ASSEMBLY. (See figure 57.)—There are four minor variations between the distributor valve used with the model 23F60 propeller and the basic 23E50 propeller. First, the valve is built to fit into an SAE 60 propeller shaft; second, it does not use an oil transfer plate; third, it is a dome-dumping valve rather than a dome relief valve type; and fourth, the dash pot is held in the valve sleeve by snap rings rather than tab lock gasket.

Nomenclature for Figure 62

1 DOME BREATHER HOLE NUT LOCK WIRE
2 DOME BREATHER HOLE NUT
3 DOME ASSEMBLY
4 DISTRIBUTOR VALVE ASSEMBLY
5 VALVE HOUSING-PROPELLER SHAFT GASKET
6 PROPELLER RETAINING NUT LOCK WIRE
7 PROPELLER RETAINING NUT
8 HUB ASSEMBLY
9 DE-ICING DEVICE ASSEMBLY

1 FIXED CAM LOCATING DOWEL
2 WELCH PLUG
3 BARREL BOLT (SHORT)
4 BARREL BOLT (LONG)
5 OUTBOARD BARREL HALF
6 HUB SNAP RING
7 FRONT CONE
8 SPIDER-SHAFT SEAL RING
9 SPIDER-SHAFT SEAL
10 SPIDER-SHAFT SEAL WASHER
11 SPIDER
12 BARREL SUPPORT SHIM
13 BARREL SUPPORT
14 SPIDER SHIM PLATE
15 SPIDER SHIM
16 BLADE GEAR SEGMENT
17 SPRING PACK SHIM
18 SPRING PACK SPRINGS
19 SPRING PACK RETAINER
20 CHEVRON TYPE BLADE PACKING
21 TOROID TYPE BLADE PACKING
22 SPIDER RING
23 SPIDER-BARREL PACKING
24 REAR CONE
25 BARREL HALF SEAL
26 INBOARD BARREL HALF
27 BARREL BOLT NUT
28 COTTER PIN

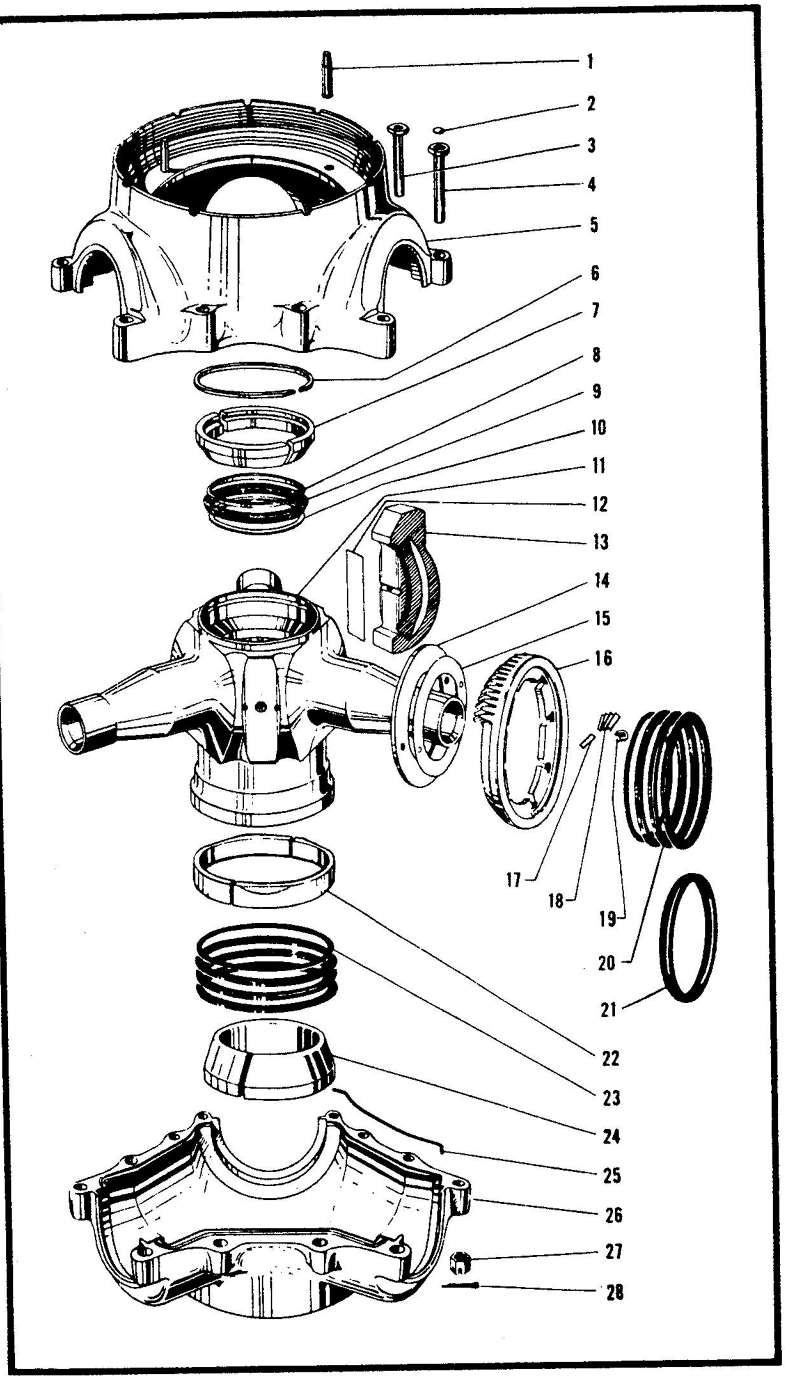


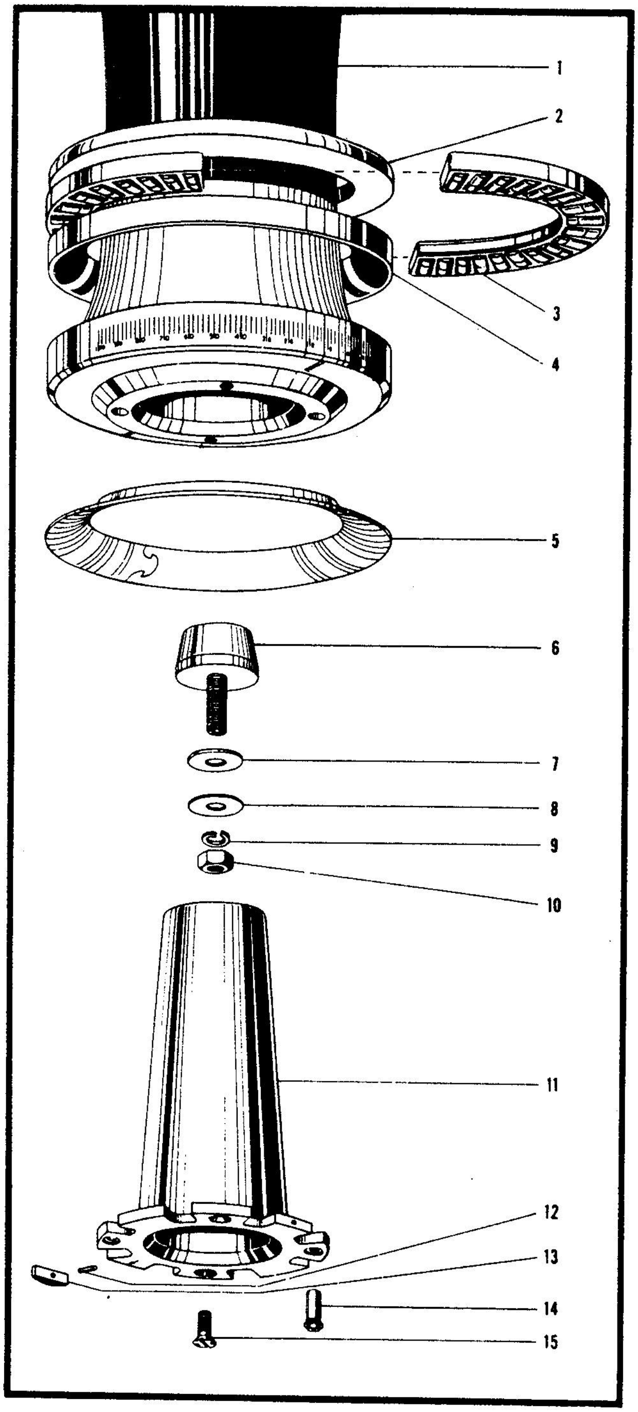
Figure 63—Barrel Assembly for Model 23F60

action takes place at a blade angle of about 25 degrees above the minimum low pitch blade angle setting. The distributor valve used with the model 23F60 propeller is directly interchangeable with valves of the same assembly number used on the 24E60 and the 24F60 models.

(5) ENGINE SHAFT EXTENSION ASSEMBLY.

(*a*) FOR SINGLE-ACTING PROPELLERS.—As yet, an engine shaft extension, which on non-feathering installations replaces a distributor valve, has not been used on the 23F60 model.

(*b*) FOR DOUBLE-ACTING PROPELLERS. (See figure 60.)—For both feathering and non-feathering installations of the double-acting 23F60 model, an engine shaft extension assembly incorporating a check valve (comprised of a steel ball, backed up a spring and a plug, and safetied with a lock wire) is used.



1 BLADE
2 THRUST BEARING FLAT WASHER
3 THRUST BEARING RETAINER
4 THRUST BEARING BEVELED WASHER
5 BLADE CHAFING RING
6 BALANCING PLUG
7 BALANCING WASHER (THICK)
8 BALANCING WASHER (THIN)
9 LOCK WASHER
10 NUT
11 BLADE BUSHING
12 THRUST PLATE PIN
13 BUSHING THRUST PLATE
14 BUSHING DRIVE PIN
15 BUSHING SCREW

Figure 64—"F" Shank Blade Assembly

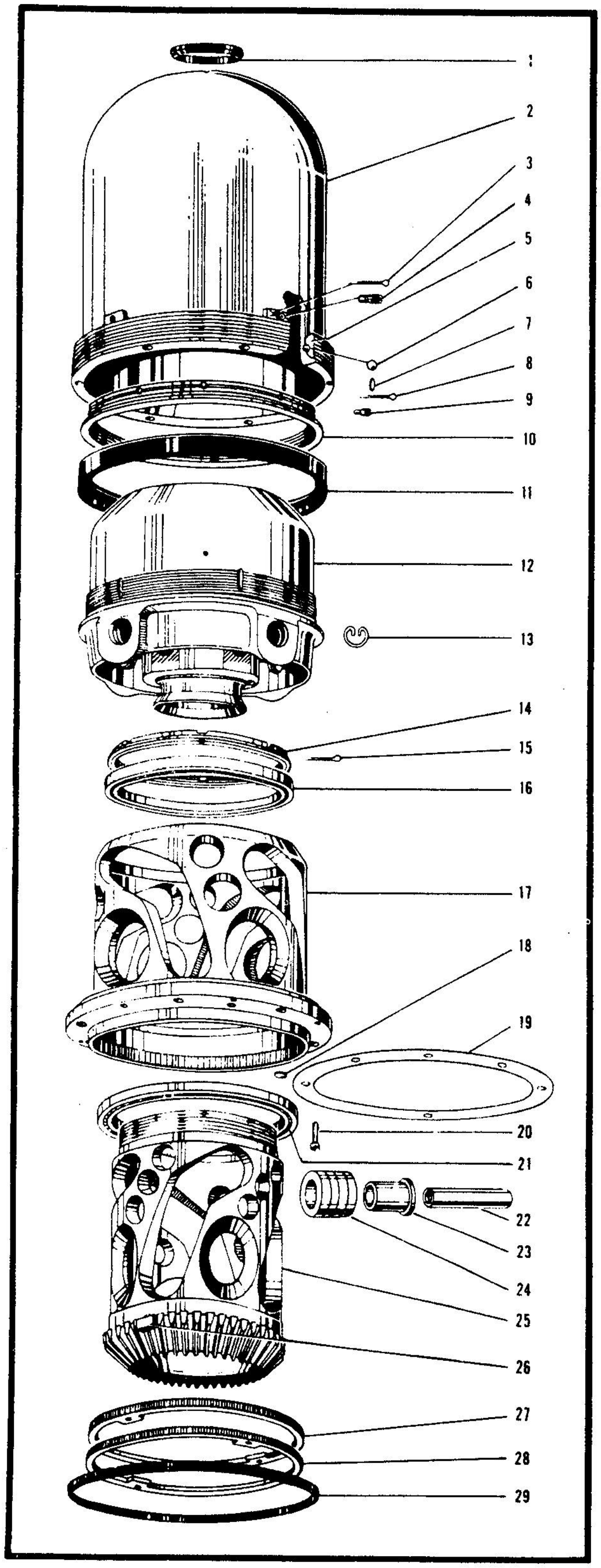
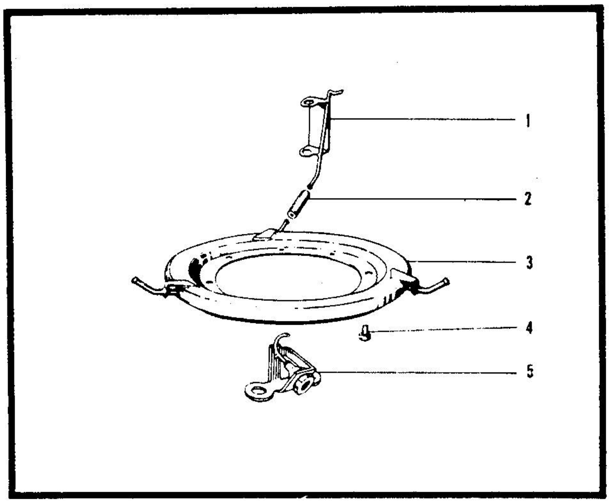


Figure 65—Dome Assembly for Model 23F60

Nomenclature for Figure 65

1 DOME BREATHER HOLE SEAL
2 DOME SHELL
3 COTTER PIN
4 DOME RETAINING NUT LOCK SCREW
5 DOME RETAINING NUT
6 BALL
7 WELCH PLUG
8 COTTER PIN
9 PISTON GASKET NUT LOCK SCREW
10 PISTON GASKET NUT
11 PISTON GASKET
12 PISTON ASSEMBLY
13 CAM ROLLER SHAFT LOCK WIRE
14 CAM BEARING NUT
15 COTTER PIN
16 OUTBOARD CAM BEARING
17 FIXED CAM
18 WELCH PLUG
19 GEAR PRELOADING SHIM
20 DOME SHELL RETAINING SCREW
21 INBOARD CAM BEARING
22 CAM ROLLER SHAFT
23 CAM ROLLER BUSHING
24 CAM ROLLERS
25 ROTATING CAM ASSEMBLY
26 STOP LUG
27 LOW PITCH STOP RING
28 HIGH PITCH STOP RING
29 DOME-BARREL SEAL

(6) DE-ICING DEVICE ASSEMBLY. (See figure 66.)—The de-icing device used with this propeller is standard in that the parts and assemblies are identical with the type used on the basic 23E50 model.



1 BRACKET & NOZZLE ASSEMBLY
2 HOSE COUPLING
3 SLINGER RING ASSEMBLY
4 SLINGER RING ATTACHING SCREW
5 FEEDER TUBE ASSEMBLY

Figure 66—De-Icing Device Assembly for Model 23F60

i. MODEL 24F60 (See figure 67.)—The model 24F60 is the largest of the Hydromatic type. As indicated in the designation, this propeller incorporates four "F" shank blades and the inner bore of the spider is splined to fit a standard involute type SAE 60 spline. This model propeller has a *blade* angle range from 10 degrees low pitch to 90 degrees high pitch measured at the blade reference station, with a constant speed *blade* range of 30.8 degrees. For all practical purposes, the model 24F60 is much the same as any other except for minor changes in size and form of the parts to fit the requirements of four large blades. A complete propeller assembly includes the barrel, blades, dome, distributor valve (on feathering installations), or engine shaft extension (on non-feathering installations), and, if used, the de-icing device. There are smaller parts used at installation, such as the propeller retaining nut, lock wire, dome breather hole nut, and dome breather hole nut lock wire. The engine shaft extension or distributor valve used in the model 24F60 propeller does not incorporate an oil transfer plate and plate gasket. The valve is installed directly into the shaft with a gasket between the base of the housing and the propeller shaft.

(1) BARREL ASSEMBLY. (See figure 68.)

(*a*) This large hub is quite similar in design to the 24E60 model. Compression type packings, identified by two red marks, fit between the barrel halves. The follower ring of the spider-barrel packing is identified by a red stripe.

(*b*) The supports which fit between the barrel halves and the spider are made of aluminum in the model 24F60 propeller. The center section is cut out of each support to provide clearance for the blade gear segments. Small steel dowels are driven into each support to locate it on the spider support seat, and shims are included between the dowel and the support seal on the spider to adjust spider-barrel concentricity and squareness. A small section of the top and bottom of the shim is bent over. These edges should fit along the sides of each support at assembly.

(*c*) Vertical spring packs are used in the model 24F60 in place of the horizontal type incorporated in most other models. The spring pack assembly consists of the horseshoe retainer which fits into the bushing, a number of spring leaves, and a circular retainer which fits into the blade gear segment. These spring pack assemblies provide a spring loaded eccentric gear mounting for preload purposes.

(*d*) The shim plate drive pins are incorporated directly in the blade gear segment. To make "F" shank blades interchangeable, each segment incorporates two 1/2-inch holes which provide clearance for the bushing drive pins.

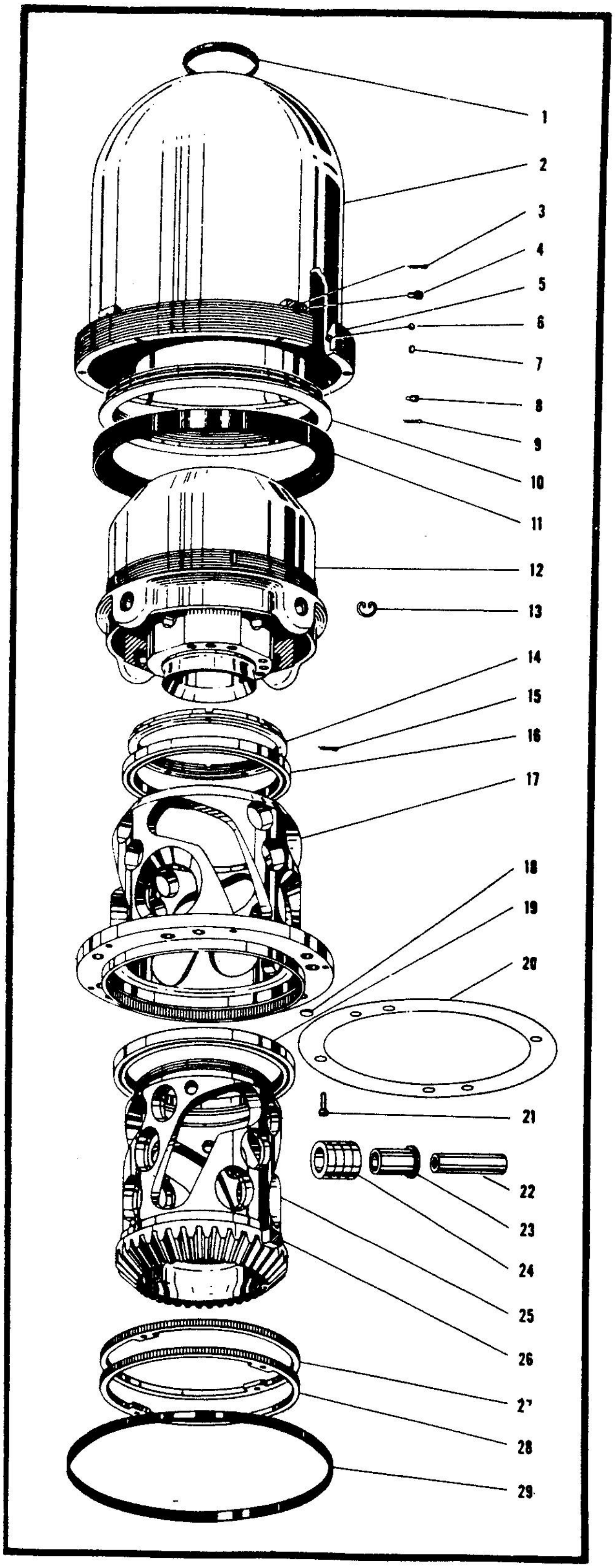
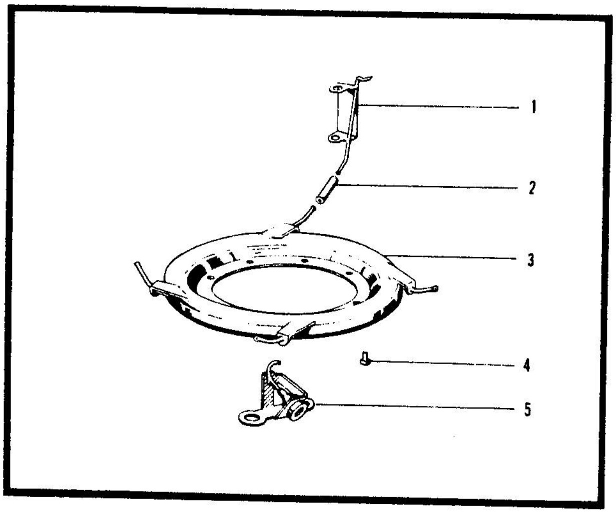


Figure 69—Dome Assembly for Model 24F60

Nomenclature for Figure 69

1 DOME BREATHER HOLE SEAL
2 DOME SHELL
3 COTTER PIN
4 DOME RETAINING NUT LOCK SCREW
5 DOME RETAINING NUT
6 BALL
7 WELCH PLUG
8 PISTON GASKET NUT LOCK SCREW
9 COTTER PIN
10 PISTON GASKET NUT
11 PISTON GASKET
12 PISTON ASSEMBLY
13 CAM ROLLER SHAFT LOCK WIRE
14 CAM BEARING NUT
15 COTTER PIN
16 OUTBOARD CAM BEARING
17 FIXED CAM
18 WELCH PLUG
19 INBOARD CAM BEARING
20 GEAR PRELOADING SHIM
21 DOME SHELL RETAINING SCREW
22 CAM ROLLER SHAFT
23 CAM ROLLER BUSHING
24 CAM ROLLERS
25 ROTATING CAM ASSEMBLY
26 STOP LUG
27 LOW PITCH STOP RING
28 HIGH PITCH STOP RING
29 DOME-BARREL SEAL



1 BRACKET & NOZZLE ASSEMBLY
2 HOSE COUPLING
3 SLINGER RING ASSEMBLY
4 SLINGER RING ATTACHING SCREW
5 FEEDER TUBE ASSEMBLY

Figure 70—De-Icing Device Assembly for Model 24F60

4. MODEL VARIATION SUMMARY.

a. The following model variation summary lists in tabular form the various differences which distinguish one propeller model from another. Insofar as possible, each model is compared with another similar model and the minor variation described.

b. The following code system is used to simplify the tabulation.

(1) TYPE OF BREATHING.—The letter "C" indicates that the engine is crankcase breathing and the letter "S" indicates that the engine breathes through the propeller shaft.

(2) TYPE OF DE-ICING DEVICE.—The following tabulation lists the types of de-icing device assemblies.

(*a*) A — Double lug, fixed nozzle bracket & nozzle assembly, slinger ring without shield.

(*b*) B — Double lug, fixed nozzle bracket & nozzle assembly, slinger ring with shield.

(*c*) C — Single lug, bracket & adjustable nozzle assembly.

(*d*) D — Electrical type.

Propeller Model	Type of Cams	Piston Bleed Holes	Feathering	Unfeath. Pressure (p.s.i.)	Type of Chafing Ring	Type of Breathing	Type of De-icing Device	Remarks
22D30-17	Standard	None	Yes	500	Split	C	A	
22D30-19	Standard	None	Yes	500	Split	C	A	Same as -17 except shaft thread diameter is 1$\frac{5}{16}$ inches.
22D30-33	Standard	Two	Yes	600	Split	C	A	Same as -17 except has 600 p.s.i. distributor valve unfeathering setting.
22D30-35	Standard	Two	Yes	600	Split	C	A	Same as -19 except has 600 p.s.i. distributor valve unfeathering setting.
22D40-15	Standard	None	Yes	500	Split	C	A	
22D40-21	Standard	None	Yes	500	Split	C	A	Same as -15 except shaft thread diameter is 2$\frac{3}{8}$ inches.
22D40-31	Standard	Two	Yes	600	Split	C	A	Same as -15 except has 600 p.s.i. distributor valve unfeathering setting.
22D40-37	Standard	Two	Yes	600	Split	C	A	Same as -21 except has 600 p.s.i. distributor valve assembly unfeathering setting.
23D40-31	Standard	Two	Yes	600	Split	C	A	
23D40-35	Standard	Two	Yes	600	Split	C	A	Same as -31 except shaft thread diameter is 2$\frac{3}{8}$ inches.
33D50-101	Standard	Two	Yes	600	Split	C	A	
33D50-105	Standard	Two	Yes	600	Split	S	A	Same as -101 except adapted for crankshaft breathing.
33D50-111	Standard	Two	No	--	Split	S	A	Same as -105 except non-feathering.
33D50-119	Standard	Two	No	--	Split	C	A	Same as -101 except non-feathering.
33D50-135	Standard	Two	Yes	600	Split	C	A	Same as -101 except distributor valve assembly has locking holes requiring locking sleeve.
33D50-137	Standard	Two	Yes	600	Split	S	A	Same as -105 except distributor valve assembly has locking holes requiring locking sleeve.
33D50-143	Standard	Two	No	--	Split	S	A	Same as -111 except shaft extension assembly has locking holes requiring locking sleeve.
33D50-147	Standard	Two	No	--	Split	C	A	Same as -119 except shaft extension assembly has locking holes requiring locking sleeve.
33D50-191	Standard	None	Yes	500	Split	C	A	Same as -101 except has 500 p.s.i. distributor valve unfeathering setting and no bleed holes in piston.
24D50-65	Straight Slope	Two	No	--	Split	C	C	

Propeller Model	Type of Cams	Piston Bleed Holes	Feather-ing	Unfeath. Pressure (p.s.i.)	Type of Chafing Ring	Type of Breath-ing	Type of De-icing Device	Remarks
24D50-87	Straight Slope	Two	No	--	Split	C	None	Same as -65 except has no de-icing device.
24D50-95	Standard	Two	Yes	600	Split	C	C	
24D50-105	Straight Slope	Two	No	--	Split	C	C	Same as -65 except de-icing device has different feeder tube and nozzle.
24D60-25	Standard	Two	Yes	600	Split	C	A	
24D60-27	Straight Slope	Two	No	--	Split	C	A	Same as -25 except dome assembly has straight slope cams.
23E50-107	Standard	None	Yes	500	Molded	S	B	
23E50-109	Standard	None	Yes	500	Molded	C	B	Same as -107 except adapted for crankcase breathing and de-icing device crankcase spacer has been redesigned.
23E50-119	Standard	None	Yes	500	Molded	C	B	Same as -107 except adapted for crankcase breathing.
23E50-137	Fast Acting	One	Yes	500	Molded	C	B	Same as -119 except dome assembly has fast-acting cams.
23E50-155	Fast Acting	One	No	--	Molded	S	B	Same as -137 except non-feathering, crankshaft breathing, and de-icing device uses different nozzle.
23E50-163	Standard	None	Yes	500	Molded	C	B	Same as -119 except barrel is of new design replacing barrel with split blade packing nut.
23E50-179	Standard	None	Yes	500	Molded	S	B	Same as -163 except adapted for crankshaft breathing and dome assembly uses new design piston with cam roller shaft lock wire.
23E50-181	Standard	None	Yes	500	Molded	C	B	Same as -179 except adapted for crankcase breathing and de-icing device crankcase spacer has been redesigned.
23E50-189	Standard	None	Yes	500	Molded	C	B	Same as -179 except adapted for crankcase breathing.
23E50-231	Standard	None	Yes	500	Molded	S	A	Same as -189 except adapted for crankshaft breathing, redesigned de-icing device, and integral stop plate.
23E50-233	Standard	None	Yes	500	Molded	C	A	Same as -231 except adapted for crankcase breathing.
23E50-241	Standard	None	Yes	500	Molded	C	B	Same as -189 except stationary cam and stop ring stop plate are integral.
23E50-247	Fast Acting	One	Yes	500	Molded	C	A	Same as -233 except dome assembly has fast-acting cams.
23E50-285	Standard	None	Yes	500	Split	S	A	Same as -231 except new barrel design with extended packing lip, spider packing of "O" ring type, and removable blade chafing ring.
23E50-287	Standard	None	Yes	500	Split	C	A	Same as -285 except adapted for crankcase breathing.
23E50-301	Fast Acting	One	Yes	500	Split	C	A	Same as -287 except dome assembly has fast-acting cams.
23E50-311	Standard	None	No	--	Split	C	A	Same as -287 except non-feathering.
23E50-315	Standard	None	No	--	Split	S	A	Same as -311 except adapted for crankshaft breathing.
23EX-319	Standard	None	Yes	500	Split	C	None	Slinger ring only.

5

Propeller Model	Type of Cams	Piston Bleed Holes	Feather-ing	Unfeath. Pressure (p.s.i.)	Type of Chafing Ring	Type of Breath-ing	Type of De-icing Device	Remarks
23E50-321	Straight Slope	One	No	--	Split	C	B	Same as -311 except dome assembly has straight slope cams and uses redesigned de-icing device.
23E50-327	Fast Acting	None	Yes	500	Split	C	A	Same as -301 except piston assembly has no bleed holes.
23E50-337	Standard	Two	Yes	600	Molded	C	B	Same as -109 except has two bleed hole piston and 600 p.s.i. distributor valve unfeathering setting.
23E50-341	Standard	Two	Yes	600	Molded	C	B	Same as -119 except has two bleed hole piston and 600 p.s.i. distributor valve unfeathering setting.
23E50-343	Fast Acting	Two	Yes	600	Molded	C	B	Same as -137 except has two bleed hole piston and 600 p.s.i. distributor valve unfeathering setting.
23E50-357	Standard	Two	Yes	600	Molded	S	B	Same as -179 except has two bleed hole piston and 600 p.s.i. distributor valve unfeathering setting.
23E50-359	Standard	Two	Yes	600	Molded	C	B	Same as -181 except has two bleed hole piston and 600 p.s.i. distributor valve unfeathering setting.
23E50-379	Standard	Two	Yes	600	Molded	C	B	Same as -189 except has two bleed hole piston and 600 p.s.i. distributor valve unfeathering setting.
23E50-389	Standard	Two	Yes	600	Molded	S	A	Same as -231 except has two bleed hole piston and 600 p.s.i. distributor valve unfeathering setting.
23E50-391	Standard	Two	Yes	600	Molded	C	A	Same as -233 except has two bleed hole piston and 600 p.s.i. distributor valve unfeathering setting.
23E50-393	Standard	Two	Yes	600	Molded	C	B	Same as -241 except has two bleed hole piston and 600 p.s.i. distributor valve unfeathering setting.
23E50-399	Standard	Two	Yes	500	Molded	S	A	Same as -231 except piston assembly has two bleed holes.
23E50-455	Standard	Two	No	--	Split	C	A	Same as -311 except piston assembly has two bleed holes.
23E50-471	Standard	Two	Yes	600	Split	S	A	Same as -455 except distributor valve assembly for feathering with crankshaft breathing.
23E50-473	Standard	Two	Yes	600	Split	C	A	Same as -471 except distributor valve assembly for crankcase breathing.
23E50-489	Standard	Two	No	--	Split	C	A	Same as -473 except shaft extension assembly for non-feathering. Same as -455 except for different dome breather hole nut lock wir[illegible]
23E50-491	Standard	Two	No	--	Split	S	A	Same as -489 except shaft extension assembly for crankshaft breathing.
23EX-493	Standard	Two	Yes	600	Split	C	None	Same as -319 except piston assembly has two bleed holes, 600 p.s.i. distributor valve setting and has no slinger ring.
23E50-495	Straight Slope	Two	No	--	Split	C	B	Same as -321 except piston assembly has two bleed holes.
23E50-501	Standard	Two	Yes	600	Split	C	C	
23E50-505	Faired Knee	Two	Yes	600	Split	C	A	Same as -473 except dome assembly has faired knee cams.

Propeller Model	Type of Cams	Piston Bleed Holes	Feather-ing	Unfeath. Pressure (p.s.i.)	Type of Chafing Ring	Type of Breath-ing	Type of De-icing Device	Remarks
23E50-543	Faired Knee	Two	No	- -	Split	C	A	Same as -489 except dome assembly has faired knee cams.
23EX-545	Faired Knee	Two	Yes	600	Split	C	None	Same as -493 except dome assembly has faired knee ams.
23E50-563	Standard	Two	No	- -	Split	C	C	Same as -489 except has adjustable de-icer assembly.
23E50-569	Straight Slope	Two	No	- -	Split	C	C	Same as -563 except dome assembly has straight slope cams.
23E50-573	Faired Knee	Two	Yes	600	Split	C	C	Same as -563 except has distributor valve assembly for feathering and dome assembly has faired knee cams.
23E50-575	Faired Knee	Two	Yes	- -	Split	C	C	Same as -573 except has double-acting shaft extension.
23E50-577	Faired Knee	Two	Yes	600	Split	C	C	Same as -501 except dome assembly has faired knee cams.
23E50-579	Standard	Two	Yes	600	Split	C	D	Same as -473 except has electric de-icing device.
23EX-581	Standard	Two	Yes	640	Split	C	None	Same as -319 except distributor valve with double spring operating at 640 p.s.i., no slinger ring assembly, dome assembly has faired knee cams, and piston assembly has two bleed holes.
23EX-583	Faired Knee	Two	Yes	640	Split	C	None	Same as -581 except dome assembly has faired knee cams.
23E50-673	Standard	Two	Yes	600	Molded	C	B	Same as -163 except has two bleed hole piston and 600 p.s.i. distributor valve unfeathering setting.
33E60-13	Straight Slope	One	No	- -	Split	C	A	
33E60-15	Standard	None	No	- -	Split	C	A	Same as -13 except dome assembly has standard cams.
33E60-31	Standard	Two	Yes	600	Split	C	A	Same as -15 except has distributor valve for feathering, and piston assembly has two bleed holes.
33E60-33	Straight Slope	Two	No	- -	Split	C	A	Same as -13 except piston assembly has two bleed holes.
33E60-35	Standard	Two	No	- -	Split	C	A	Same as -15 except piston assembly has two bleed holes.
33E60-41	Standard	Two	Yes	600	Split	C	C	Same as -35 except has distributor valve for feathering, new barrel design, and de-icing device has adjustable nozzle.
33E60-55	Straight Slope	Two	No	- -	Split	C	C	Same as -33 except de-icing device has adjustable nozzle and barrel has spinner attaching parts.
33E60-71	Standard	Two	Yes	600	Split	C	C	Same as -31 except de-icing device has adjustable nozzle.
33E60-73	Straight Slope	Two	No	- -	Split	C	C	Same as -55 except barrel has no spinner attaching parts.
33E60-81	Faired Knee	Two	Yes	600	Split	C	C	Same as -73 except has distributor valve for feathering and dome assembly has faired knee cams.
33E60-83	Faired Knee	Two	Yes	600	Split	C	C	Same as -81 except has spinner attaching parts, de-icing device has new feeder tube assembly, and is used with single-acting governor.

Propeller Model	Type of Cams	Piston Bleed Holes	Feather-ing	Unfeath. Pressure (p.s.i.)	Type of Chafing Ring	Type of Breath-ing	Type of De-icing Device	Remarks
33E60-85	Faired Knee	Two	Yes	——	Split	C	C	Same as -83 except shaft extension is used with double-acting governors for feathering.
33E60-93	Faired Knee	Two	Yes	600	Split	C	A	Same as -81 except fixed nozzle de-icing device.
33E60-95	Straight Slope	Two	No	——	Split	C	C	Same as -73 except de-icing device used is for a 60A nose section.
33E60-123	Faired Knee	Two	Yes	——	Split	C	C	Same as -95 except shaft extension assembly is used and faired knee cams.
33E60-125	Faired Knee	Two	Yes	600	Split	C	C	Same as -83 except has no spinner attaching parts.
24E50-31	Standard	Two	No	——	Split	C	B	
24E50-65	Standard	Two	No	——	Split	C	B	Same as -31 except assembly has been moved forward one inch.
24E50-67	Faired Knee	Two	No	——	Split	C	C	Same as -65 except dome assembly has faired knee cams, and de-icing device has adjustable nozzle.
24E60-23	Standard	Two	Yes	600	Split	C	A	
24E60-29	Standard	Two	No	——	Split	C	A	Same as -23 except has shaft extension for non-feathering.
24E60-37	Standard	Two	No	——	Split	C	C	Same as -29 except has de-icing device for 60A nose section and has adjustable nozzle.
24E60-41	Standard	Two	Yes	——	Split	C	C	Same as -37 except shaft extension assembly is used.
24E60-45	Faired Knee	Two	No	——	Split	C	C	Same as -37 except dome assembly has faired knee cams.
24E60-47	Faired Knee	Two	Yes	——	Split	C	C	Same as -41 except dome assembly has faired knee cams.
24E60-159	Faired Knee	Two	No	——	None	C	None	Strengthened barrel and new piston.
23F60-21	Standard	None	Yes	500	Split	C	A	
23F60-35	Standard	Two	Yes	600	Split	C	A	Same as -21 except has 600 p.s.i. unfeathering setting, and piston has two bleed holes.
24F60-11	Standard	Two	Yes	——	Split	C	A	Has shaft extension for use with double-acting governor.
24F60-13	Standard	Two	Yes	600	Split	C	A	Same as -11 except has distributor valve assembly for feathering.
24F60-17	Faired Knee	Two	Yes	600	Split	C	A	Same as -13 except dome assembly has faired knee cams.
24F60-23	Standard	Four	Yes	600	Split	C	A	Same as -13 except piston assembly has four bleed holes.
24F60-25	Faired Knee	Four	Yes	600	Split	C	A	Same as -17 except piston assembly has four bleed holes.
24F60-33	Standard	Three	Yes	600	Split	C	A	Same as -13 and -23 except piston has three bleed holes.
24F60-35	Faired Knee	Three	Yes	600	Split	C	A	Same as -25 except piston assembly has three bleed holes.
24F60-43	Faired Knee	Three	Yes	600	Split	C	—	Same as -35 except de-icing device has no bracket and nozzle assembly.
24F60-73	Faired Knee	Three	Yes	600	Split	C	—	Same as -43 except de-icing device used isfor metal fairedbladeassembly.

SECTION III

INSTALLATION

1. INSTALLATION TOOLS REQUIRED.

NOMENCLATURE	APPLICATION	PART NUMBER	PROPELLER MODELS
Propeller Retaining Nut Wrench	To tighten the propeller retain nut.	HSP2017	23EX
		HSP666	24D50, 23E50
		HSP667	24D60
		HSP1483	22D30
Dome Retaining Nut Wrench	To tighten the dome retaining nut.	HSP346	22D30, 22D40
		HSP455	24D50, 24D60, 23E50, 23EX, 33E60
Distributor Valve Wrench	To tighten the distributor valve or shaft extension.	HSP282	24D50, 24D60, 23E50, 23EX, 33E60
		HSP1482	22D30, 22D40
Dome Lifting Handle	To lift the dome.	HSP1332	23D40, 33D50, 24D50, 24D60, 23E50, 23EX, 33E60

2. GENERAL.

a. Since the installation procedure is similar for all models, detailed instructions are given for the model 23E50 propeller only. The various differences for each of the other models are explained in paragraph 5.

b. Hydromatic propellers, prepared for installation on the engine shaft, consist of three major assemblies; the hub assembly (the barrel & blades assembly), the dome assembly, and the distributor valve assembly (for feathering installations) or the engine shaft extension assembly (for non-feathering or double-acting installations.) The de-icing device assembly, if used, is attached to the hub.

(1) Certain attaching parts are also included in the hub assembly, at installation. These parts are the rear cone, the spider-shaft oil seal group, the front cone, the propeller retaining nut, the hub snap ring, and the retaining nut lock wire.

(2) The attaching parts for the dome assembly are the dome breather hole nut, washer, seal, and lock wire on crankcase breathing installations, or the breather cap, washer, seal, and breather cap lock wire on shaft breathing installations. The dome assembly retaining nut is locked in the hub assembly by the dome retaining nut lock screw which is safetied by a cotter pin.

(3) The attaching parts used at installation of the distributor valve assembly are the valve housing-oil transfer plate gasket, the oil transfer plate, and the transfer plate-engine shaft gasket. These parts are used for both a distributor valve assembly (on feathering, single-acting installations) or an engine shaft extension (on non-feathering or double-acting installations). If the installation is the shaft breathing type, a breather tube assembly with a gasket and a cotter pin is required.

c. To insure proper balance and dome-barrel gear preload, the assemblies of any one propeller should be kept together as a propeller unit. Recent production models incorporate the identical serial number stamped on the dome and the barrel for purposes of identification.

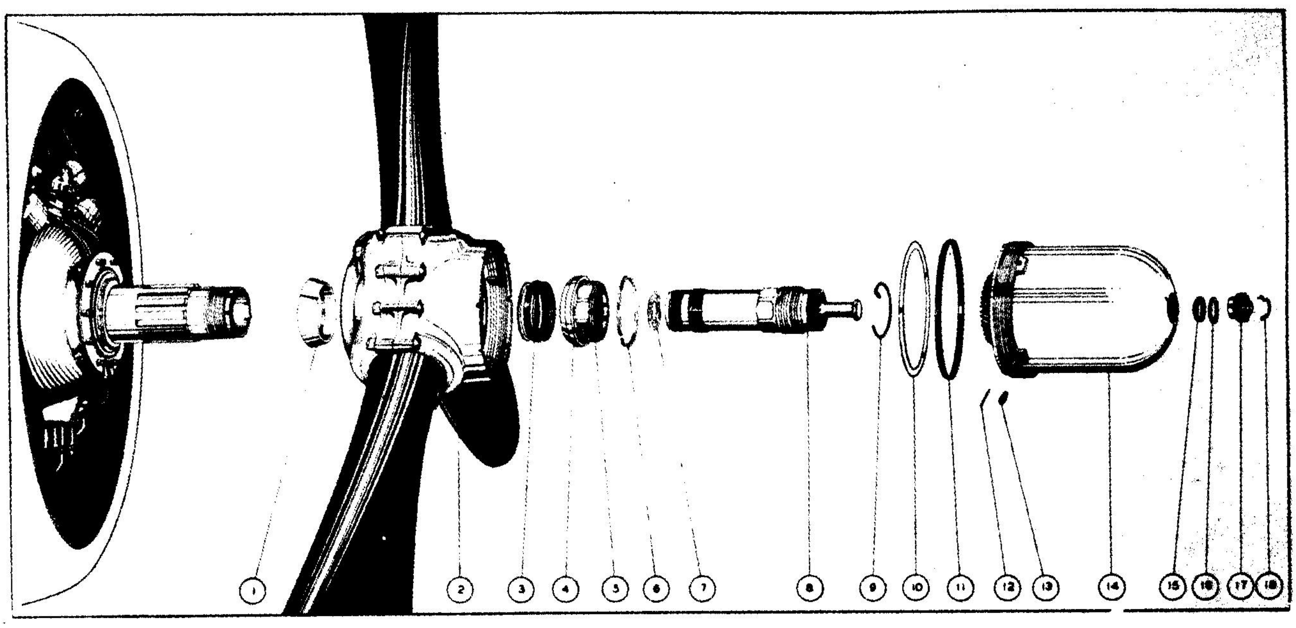
d. Throughout this section references are made to the blade ***high pitch angle***. This angle is the full-feathered angle in feathering installations and the high pitch angle in non-feathering installations. A recent change eliminated the use of assembly stop pins which on earlier models acted as definite blade high pitch stops. The new models incorporate index marks on the barrel and graduations on the blades.

e. It should be noted in this section that the light weight installation tools formerly furnished with the propeller are shown. These tools are entirely satisfactory for occasional use. However, when installation tools are to be used frequently, it is recommended that the heavy duty tools listed in paragraph 1 be used. It should be further noted that manufacture of light weight tools has been discontinued.

f. If the propeller is taken directly from the shipping box and installed, extreme care should be taken that the parts packed separately in the box are not lost. These parts include the dome-barrel seal, the oil transfer plate-shaft gasket, the valve housing-oil transfer plate gasket, the dome breather hole seal, and the spider-shaft seal. In some cases, the barrel half oil seals will be shipped with the propeller. All of these parts are packed in small containers which may be misplaced if carelessly handled.

3. PREINSTALLATION CHECKS.

a. Before installing a propeller, all parts which are accessible without disassembling should be visually examined for damage, and checked for fit and freedom of movement. All traces of corrosion and all raised edges of nicks, burrs, cuts, galling, and scoring on joining surfaces of attaching parts shall be carefully stoned down.



1 REAR CONE
2 HUB & BLADES ASSEMBLY
3 SPIDER-SHAFT OIL SEAL ASSEMBLY
4 FRONT CONE
5 PROPELLER RETAINING NUT
6 HUB SNAP RING
7 OIL TRANSFER PLATE-PROPELLER SHAFT GASKET
8 DISTRIBUTOR VALVE ASSEMBLY
9 PROPELLER RETAINING NUT LOCK WIRE
10 DOME-BARREL PRELOAD SHIM
11 DOME-BARREL SEAL
12 DOME RETAINING NUT LOCK SCREW COTTER
13 DOME RETAINING NUT LOCK SCREW
14 DOME ASSEMBLY
15 DOME BREATHER HOLE SEAL
16 DOME BREATHER HOLE WASHER
17 DOME BREATHER HOLE NUT
18 DOME BREATHER HOLE NUT LOCK WIRE

Figure 71—Propeller Assemblies and Parts Extended Off Propeller Shaft

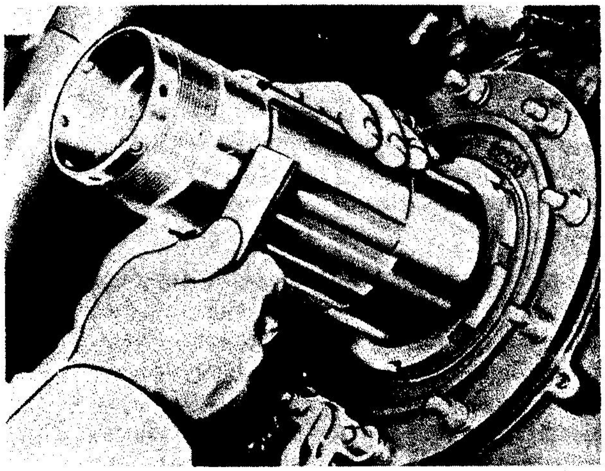


Figure 72—Stoning Down Propeller Shaft

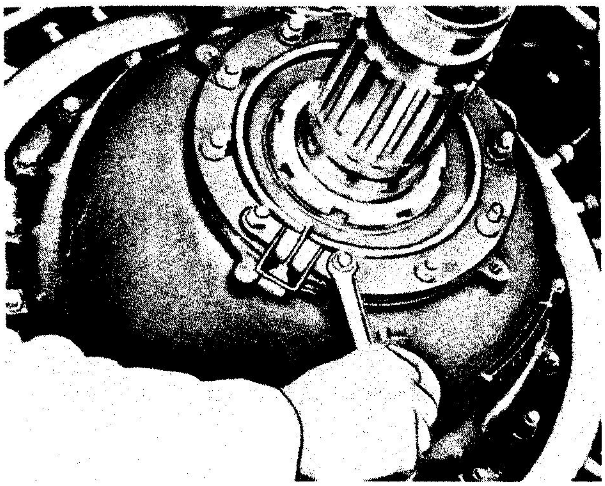


Figure 73—Mounting De-Icing Device Feeder Tube

CAUTION

Remove all small metal particles after any stoning or dressing of propeller parts. If carbon tetrachloride is used make certain all traces are finally removed and the parts thoroughly dried. In order to protect the synthetic rubber seals and packings use either carbon tetrachloride or cleaner, 3-GP-8, but do not use any aromatic fuels for cleaning a propeller.

b. Inspect the propeller shaft splines and threads for nicks, burrs, or similar damage. Dress down any such imperfections with a fine stone and polish with crocus cloth. Wash the shaft with gasoline and allow to dry thoroughly. Then apply a light film of clean engine oil to both the inside and outside of the propeller shaft.

c. It is not necessary to wash down propellers prior to installation in order to remove the corrosion preventive compound (Specification C-27-587). Since the compound is soluble in engine oil, it has no ill effects on either the engine oil or any parts concerned. However, it may be desirable to remove the material from external surfaces to facilitate handling.

d. If a Hydromatic type propeller has been standing idle for a considerable length of time, either in storage or on an airplane, the blade packings may stick to the blade shank. This condition causes high blade torque which is especially noticeable during feathering and unfeathering checks. These sticky packings can be loosened up by working a small quantity of SAE No. 10 oil, or its equivalent, between the blade packing and the blade shank. To facilitate this operation, hold back the blade packing with about a .010-inch blade from a feeler gage, or some other thin piece of shim stock which will not damage the blade or packing, and then work in the oil.

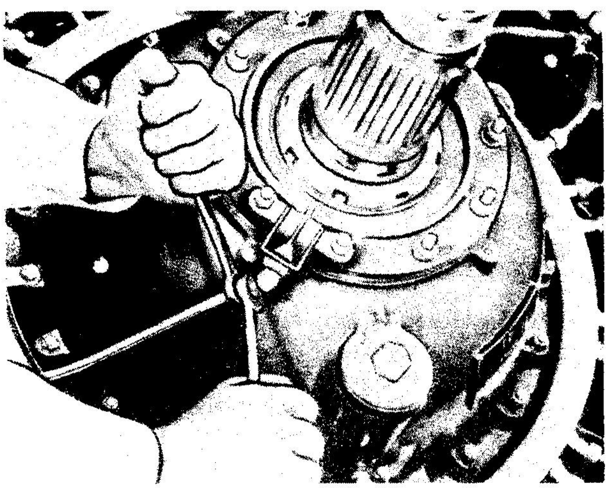


Figure 74—Connecting Feeder Tube Fluid Supply Pipe

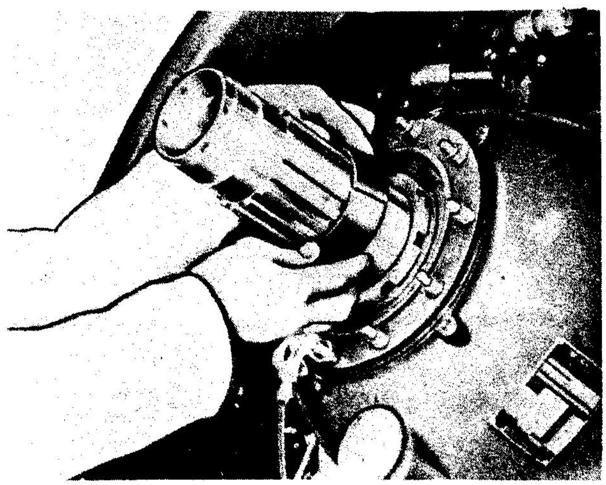


Figure 75—Installing Rear Cone on Propeller Shaft

NOTE

Prior to installation the blade torque shall be checked. If blade torque is satisfactory freeing of the blade packing will not be necessary, should freeing be required care should be exercised to prevent damage to the TEFLON strip (Ref EO 15-30AB-6B/1).

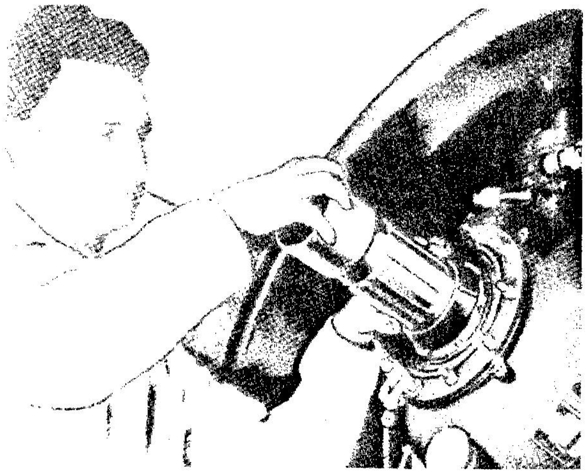


Figure 76—Covering Shaft with Thread Protector

Figure 77—Hoisting Hub Assembly

4. INSTALLATION—MODEL 23E50.

a. DE-ICING DEVICE INSTALLATION.

(1) Before mounting the propeller on the propeller shaft, install the de-icer feeder tube assembly on two studs of the engine thrust plate. On certain engines the feeder tube may interfere slightly with the slinger ring as the propeller is installed. To avoid this, do not tighten the feeder tube snugly until the hub is in position.

(2) Connect the de-icing fluid supply pipe to the feeder tube.

Note

After complete installation of the propeller on the engine, check to see that the feeder tube assembly will direct the flow of de-icing fluid to the de-icing slinger ring.

(3) When connecting the fluid supply pipe to the feeder tube assembly, make certain that all the fittings are tight. The use of *two wrenches* is recommended for this operation. It is further recommended that a short section of flexible hose be used as a part of the supply line to minimize the transmission of vibration through the line, and that some support other than the feeder tube itself be used to hold the line. A later model of the feeder tube is designed so that flexible hose must be used to attach the supply line to the feeder tube.

b. HUB INSTALLATION.

(1) Install the rear cone on the propeller shaft and move it back until it contacts the propeller shaft thrust bearing nut. The shaft is to be lightly coated with engine oil and the rear cone wiped clean of all oil and installed dry. To prevent seizure of the propeller, retaining nut or distributor valve, apply a thin film of Anti-Seize, white lead base, 3-GP-801, to the shaft internal and external threads.

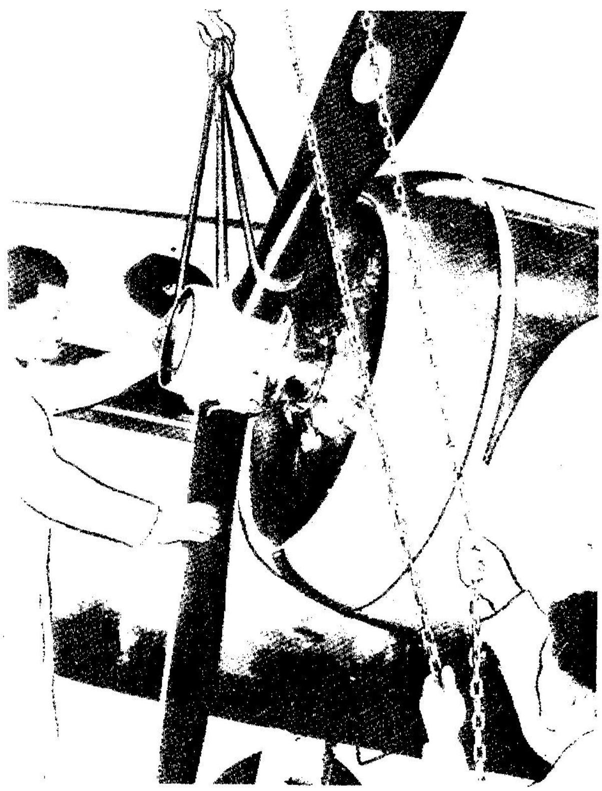


Figure 78—Installing Hub Assembly onto Propeller Shaft

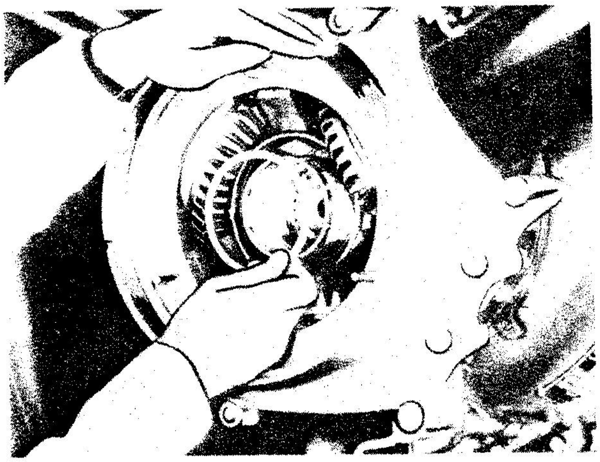


Figure 79—Installing Spider-Shaft Oil Seal Washer

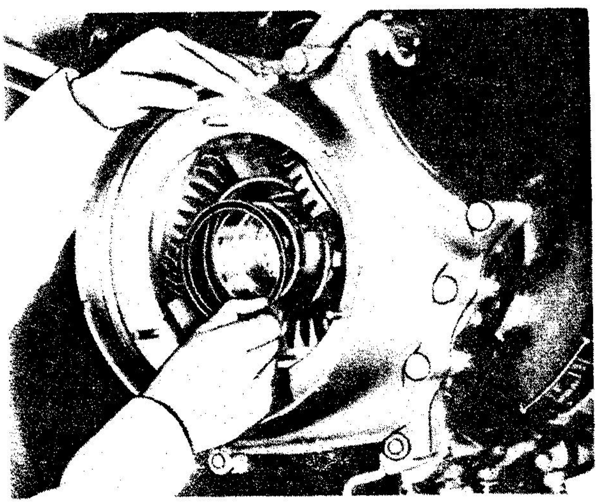


Figure 80—Installing Spider-Shaft Oil Seal

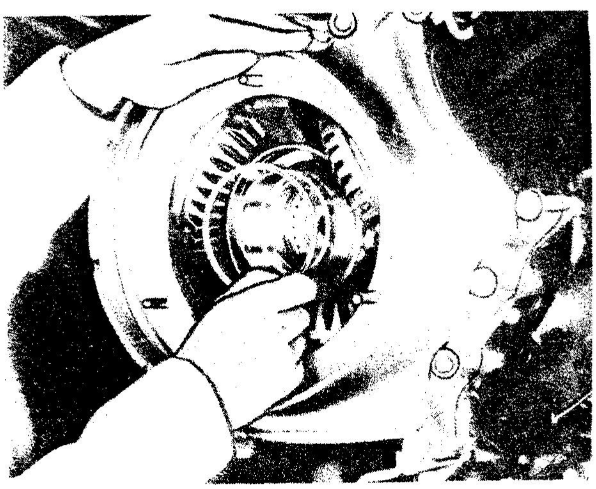


Figure 81—Installing Spider-Shaft Oil Seal Ring

(2) Cover the propeller shaft threads with a thread protector or wrap with tape if a protector is not available. Lift the propeller hub assembly by means of a hoist and strap, making sure that the propeller is held so that the blank spline in the spider is in line with the wide spline on the engine shaft, and that propeller blade clearance is provided for the installation work stand. Install the hub assembly on the propeller shaft.

Note

On most new engines, oil and corrosion preventives are flushed from the cylinders prior to installation of the engine on the aircraft. However, in case this has not been done and the engine is allowed to stand idle for an appreciable time after propeller installation and before engine run-up, the portion of the cylinders wiped clean of protective by rotating the propeller shaft during installation may corrode. In such cases, attach a single hoisting sling to the blade opposite the blank spline of the spider so that at installation the propeller will line up with the engine shaft wide spline (usually left in the top dead-center position) and it will not be necessary to rotate the shaft.

(3) Remove the thread protector (or tape) from the shaft. The spider-shaft seal group consists of the spider-shaft oil seal washer, the spider-shaft oil seal, and the spider-shaft oil seal ring. Install these pieces over the propeller shaft in that order to fit outboard of the propeller spider splines. The open end (or lips) of the seal faces away from the engine. Use some blunt instrument which will not harm the seal to aid in properly seating it.

(4) Apply a thin film of thread lubricant (Specification 3 - GP - 8 0 1) or clean engine oil to the threads on the inner diameter of the propeller retaining nut.

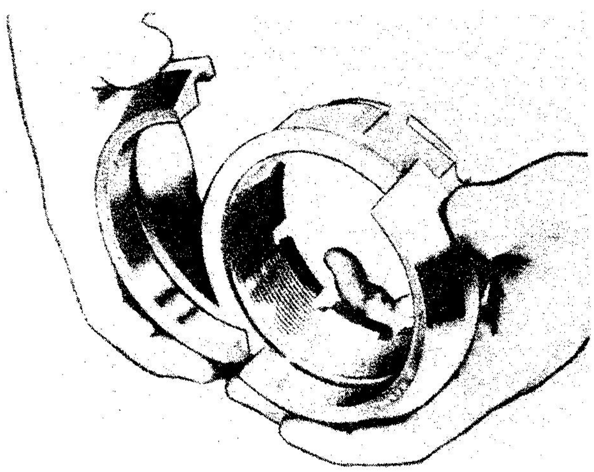


Figure 82—Installing Front Cone Halves

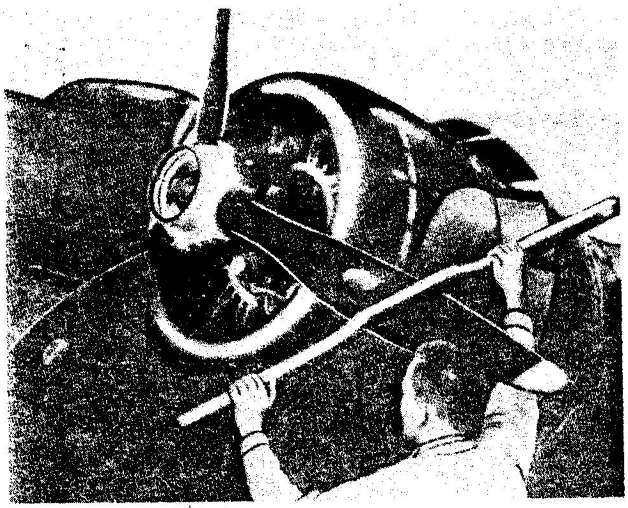


Figure 83—Turning Blades into Reverse Pitch

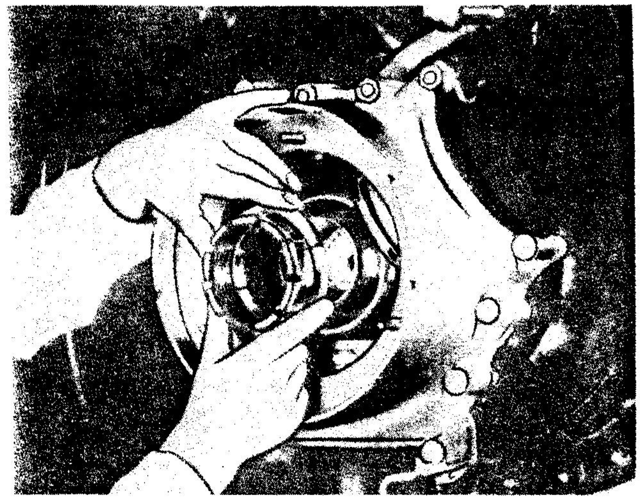


Figure 84—Installing Front Cone and Retaining Nut

Then install the front cone on the propeller retaining nut. These parts are made so that the groove incorporated inside the front cone matches with the flange at the base of the retaining nut. Turn the blades into reverse pitch to move the toothed portion of the blade gear segments down into the hub, thereby providing the necessary clearance which will permit installation of the propeller retaining nut and the attached front cone halves. The ends of the blade gear segments will contact the phenolic spider ring; therefore, do not jam the blades hard, but turn slowly and only far enough to provide clearance. Start the propeller retaining nut and the attached front cone onto the propeller shaft threads by hand.

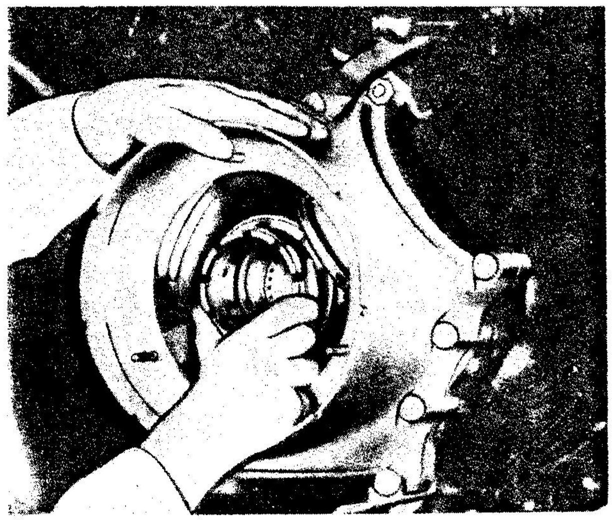


Figure 85—Starting Retaining Nut on Shaft

CAUTION

The propeller retaining nut should advance on the threads without binding or catching. If it does not, recheck both the retaining nut and the propeller shaft threads for burrs, nicks, cross-threading, etc.

(5) Tighten propeller retaining nut on the shaft using the installation wrench in conjunction with the torque kit (DMS 19550-A1) refer to EO 15-30-2 for correct torque.

(6) Determine if one of the locking slots in the retaining nut is in alignment with one of the holes in the propeller shaft. If not continue the tightening operation until one slot and hole are in alignment. Spacing of the slots in the propeller retaining nut with respect to the holes in the propeller shaft is such that alignment of a slot and hole will occur at each five degrees of rotation.

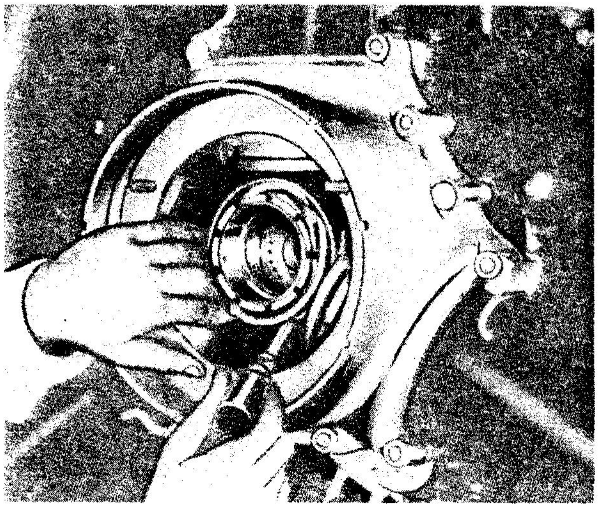


Figure 87—Installing Hub Snap Ring

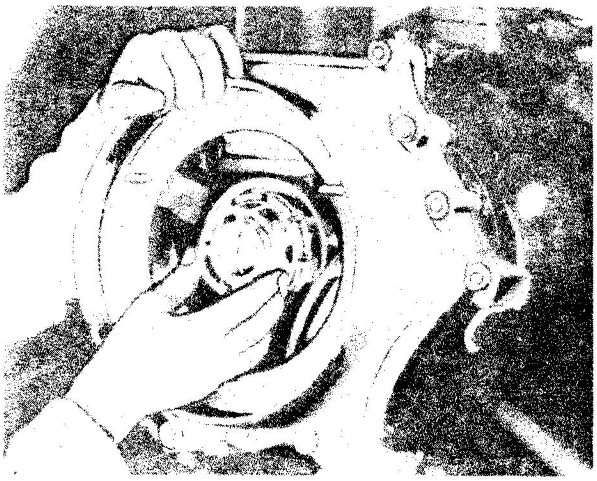


Figure 88—Installing Oil Transfer Plate-Propeller Shaft Gasket

(7) Compress the hub snap ring and install it in the spider snap ring groove.

Note

Removal of the propeller may be extremely difficult if the hub snap ring is not in place.

c. DISTRIBUTOR VALVE INSTALLATION.

(1) CRANKCASE BREATHING TYPE.

(a) Install the correct distributor valve-propeller shaft gasket inside the propeller shaft. Make certain that the engine shipping plug is removed from the shaft.

(b) Check the valve housing oil transfer plate on the base of the distributor valve to be sure that it is the solid center type for crankcase breathing installations, and that the copper gasket is included between the oil transfer plate and the housing.

(c) Apply a thin film of thread lubricant (meeting Specification 3-GP-801) or clean engine oil to the threads on the base of the distributor valve. Screw the valve into the propeller shaft by hand.

CAUTION

The valve should advance into the propeller shaft smoothly and easily. If binding is noticed, remove the valve and check the threads of the propeller shaft and the housing for burrs, damaged threads, cross-threading, etc.

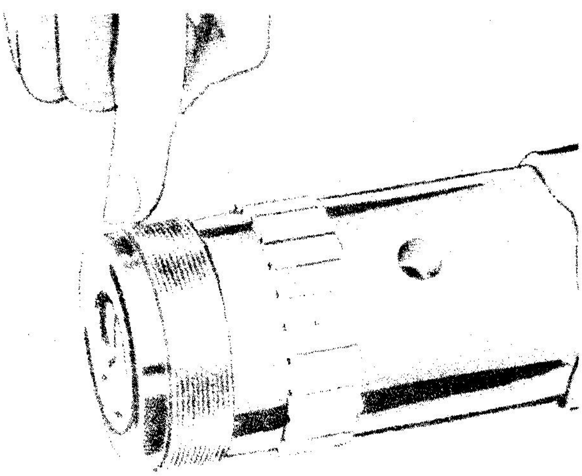


Figure 89—Checking Valve Housing—Transfer Plate Gasket

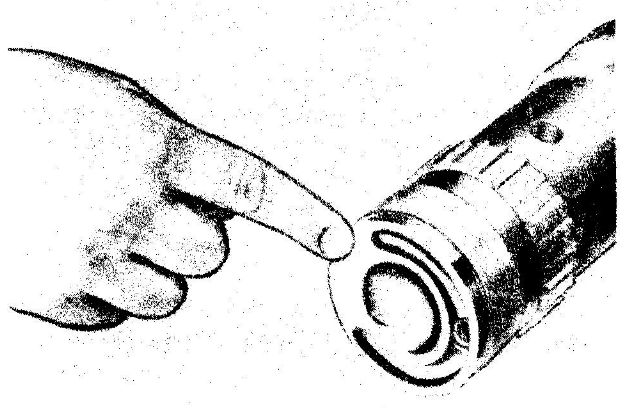


Figure 90—Checking Crankcase Breathing Type Oil Transfer Plate

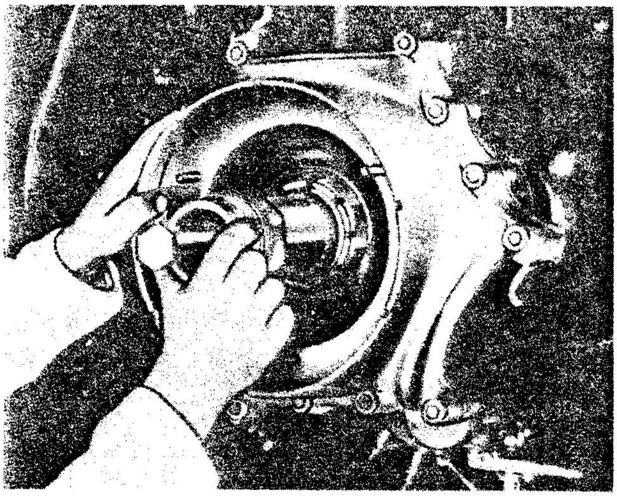


Figure 91—Installing Distributor Valve

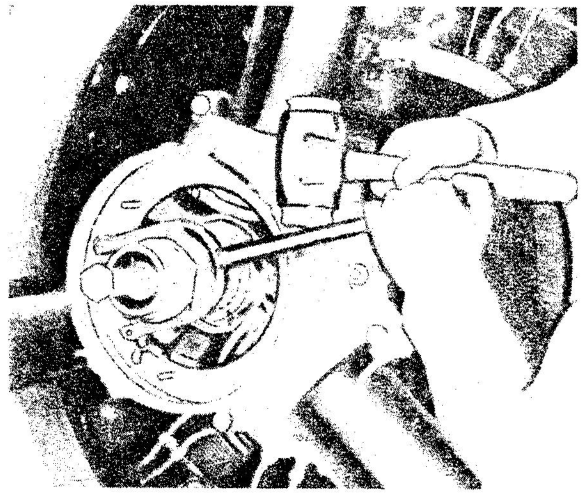


Figure 92—Tightening Distributor Valve

(d) Tighten the distributor valve into the propeller shaft using the proper wrench. Apply a torque of 100-120 pound-feet. While this torque is being applied, lightly strike the bar near the wrench with a hammer weighing not more than 2-1/2 pounds. Repeat this tightening operation until one of the locking slots on the valve housing is in alignment with the same locking hole in the propeller shaft as previously determined for the retaining nut.

CAUTION

Under no conditions should the valve housing be backed off even slightly in order to obtain slot and hole alignment. If this alignment cannot be obtained without exceeding the specified torque, remove the distributor valve and reinstall it, either using a new oil transfer plate-shaft gasket, or reducing the thickness of the first gasket by lapping it slightly. This caution applies as well to the installation procedure described in the following paragraphs on the other types of valves and shaft extensions.

(*e*) Insert the propeller retaining nut lock wire in the lock wire groove of the retaining nut and make certain that the extended portion of the wire fits through the propeller retaining nut and the propeller shaft and locks into a slot in the valve housing.

(2) SHAFT BREATHING TYPE.—On installations which breathe through the propeller shaft, the installation procedure is identical with that described for the crankcase breathing type except for the following:

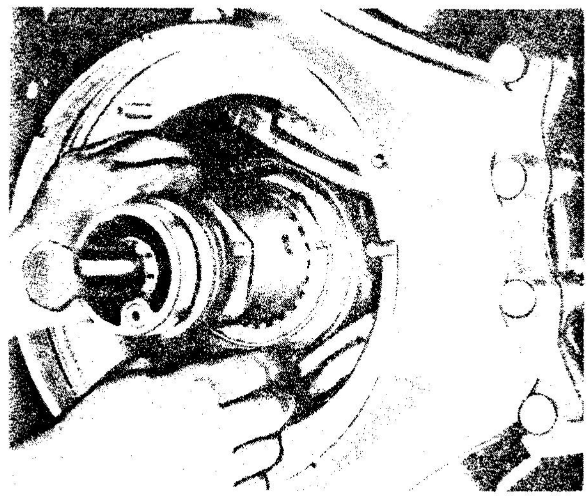


Figure 93—Installing Propeller Retaining Nut Lock Wire

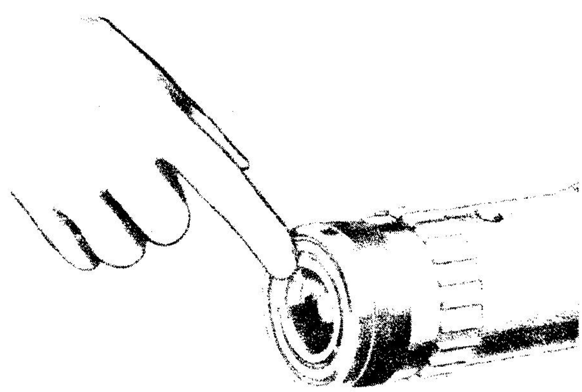


Figure 94—Checking Shaft Breathing Type Oil Transfer Plate

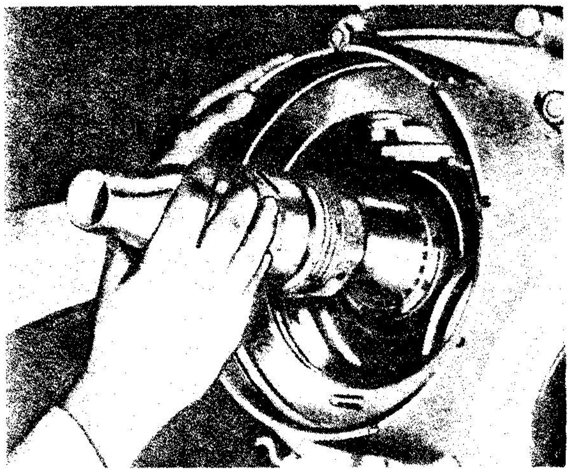


Figure 95—Installing Breather Tube

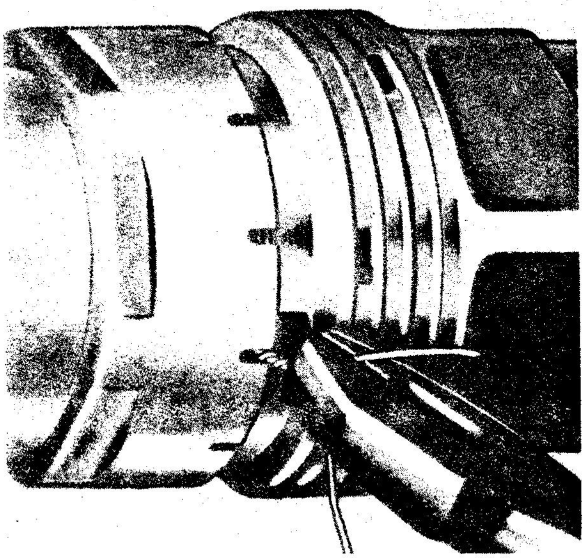


Figure 96—Locking Breather Tube

(*a*) The oil transfer plate used on shaft breathing installations incorporates a 1-1/4 inch hole through the center to provide passage for the breather gases.

(*b*) If the breather tube has not already been installed on the distributor valve, set the breather tube-valve housing gasket in place inside the threaded end of the breather tube. Coat the breather tube threads and the distributor valve housing threads with a light film of thread lubricant or clean engine oil, and then screw the tube onto the outboard end of the distributor valve housing. Tighten the breather tube by applying a torque of 100-120 pound-feet. Lock the breather tube to the valve housing by inserting safety wire through a slot in the skirt of the breather tube into the small hole in the top of the outboard oil port. It is generally easier to install the breather tube onto the valve before valve installation in the shaft.

d. ENGINE SHAFT EXTENSION INSTALLATION.

(1) CRANKCASE BREATHING TYPE.—The installation procedure for an engine shaft extension of the crankcase breathing type is identical with the procedure for installing a distributor valve of the same type.

(2) SHAFT BREATHING TYPE.—The installation procedure for an engine shaft extension of the shaft breathing type is identical with the procedure covering a breather type distributor valve.

e. INSTALLATION OF DOME STOP RINGS.—Prior to dome installation the high and low pitch stop rings must be checked for correct positioning in the dome. It is assumed that the blade angle settings are known for the particular aircraft. Three cases are discussed: one, reinstallation of a propeller previously removed; two, installation of a new propeller; and three, readjustment of the propeller blade angle settings.

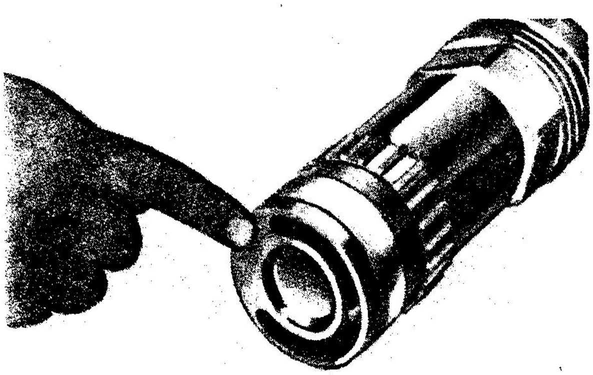


Figure 97—Crankcase Breathing Type Engine Shaft Extension

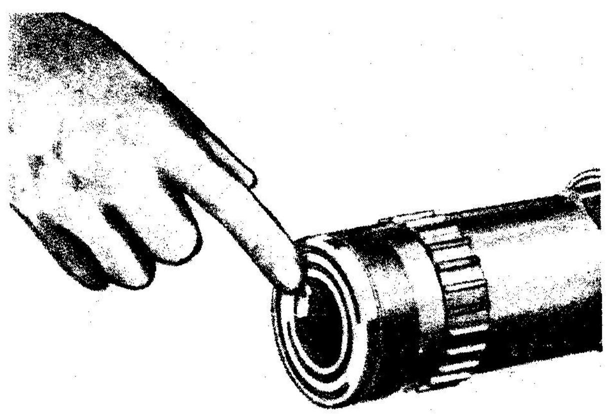


Figure 98—Shaft Breathing Type Engine Shaft Extension

(1) GENERAL NOTES.

(a) GENERAL.—The cam track length determines the maximum possible angular travel of the cam bevel gear and consequently the blade *range.* The stop rings determine the actual angular *settings* (operating limits), always somewhat shorter than the maximum possible range. The relationship of blade gear segments to the rotating cam bevel gear determines where the blade angular range is positioned.

(b) GEAR RATIO.—The gear ratio between the cam bevel gear and the blade gear segment may be one-to-one, five-to-four, or some other value depending upon the propeller model. Table I lists the gear ratios for all models. This ratio determines the actual angular travel of the blade for a given angular travel of the cam. For instance, in a propeller having a five-to-four gear ratio, a five-degree movement of the rotating cam produces a four-degree movement of the blades. This ratio also determines the number of serrations in the stop rings.

TABLE I

Propeller Models	Cam Gear — Blade Gear Segment Ratio	Gear Segment Tooth Angle (Degrees)
22D30, 22D40, 23D40, 33D50	4-3	7.5
24D50, 24D60	1-1	8.18
23E50, 23EX, 33E60	5-4	8.0
24E50, 24E60	1-1	10.0
23F60	1.26-1	10.6
24F60	1-1	11.25

(c) GEAR SEGMENT TOOTH ANGLE.—The angle between adjacent teeth (listed in table I) determines the major steps of indexing the blade to the cam. Without changing the position of the rollers on the cam track, the blade range can be shifted the amount of the tooth angle by reindexing the gear segment to the cam bevel gear. This permits selection of various blade angle ranges for the same cam range. The indexing is automatically accomplished by use of stop rings and assembly stop pins (where used) properly selected for the range desired.

(d) STOP RING MARKING.—Each stop ring has certain markings necessary for proper identification and use. One is the part number. (In one earlier method of marking both the high and the low pitch limits were included as dash numbers. In another method either the high or the low limit was stamped as the dash number. Current stop rings eliminate the dash number in order to facilitate spare parts storage.) Two other markings on each ring cover installation directions as to when and how to place the ring. For low pitch stop rings these markings are "ASSEMBLE THIS STOP FIRST" and "SET TO LOW PITCH." For high pitch rings these are "ASSEMBLE THIS STOP LAST" and "SET TO HIGH PITCH". The fourth mark is a line pointing to a tooth or a serration. The position of this line is determined by the basic pitch range used on the particular aircraft installation. A later paragraph describes the method for marking unmarked stop rings taken from storage.

(e) CAUTIONS.

(1) Stop rings must always be used in correct pairs as determined from Table II. As an example, if the pitch settings are to be 18 degrees low and 90 degrees high in a model 23E50 propeller, use either rings 52933 and 52932 marked for the 10-90 range or the same rings marked for the 14-94 range or the same rings marked for the 18-98 range. Do ***not*** use ring 52933 marked for the 18 degree low setting and ring 52932 marked for the 90 degree high setting. The use of two mismatched stop rings will not permit the correct pitch settings to be established.

(2) The blade angles corresponding with the index markings are the high and low limits to which the blade may be set. They are ***not*** necessarily the actual operating settings, although the low limit often is the same as the low pitch setting since it is desirable to use as much of the constant speed portion of the cam track as possible. For example, if the pitch settings are to be 18 degrees low and 90 degrees high in a 23E50 propeller, stop rings for a blade angle range of 18 to 98 degrees should be used. Rings for a range of 14 to 94 degrees or for 10 to 90 could be used, but the 18 to 98 range provides a positioning of the range so that the constant speed portion of the cam track will be best utilized.

(2) SETTING PROCEDURE — REINSTALLED PROPELLERS.—If the stop rings have not been taken out of the dome after removal of the propeller, it is un-

TABLE II

PROPELLER MODELS	TYPE OF CAMS	BLADE PITCH RANGE	DOWEL HOLE PLUGGED	FORMER LOW PITCH STOP	NEW LOW PITCH STOP	ARROW LOCATION	FORMER HIGH PITCH STOP	NEW HIGH PITCH STOP	ARROW LOCATION
22D30, 22D40	Standard	5-88 20-103		54623-5-88 " -20-103	54623-5 " -20	* *	54622-5-88 " -20-103	54622-88 " -103	* *
23D40, 33D50	Standard	10-90 17.5-97.5 25-105		53116-10-90 " -17.5-97.5 " -25-105	53116 " "	—16 —23.5 —31	53114-10-90 " -17.5-97.5 " -25-105	53114 " "	+16 +8.5 +1
	Straight Slope	15-54		53116-15-54	53116	—16	53114-15-54	53114	+16
24D50, 24D60	Standard	10-110 26.4-126.4		55799-10-110 " -26.4-126.4	55799 "	—17 —33.4	55800-10-110 " -26.4-126.4	55800 "	+17 +.6
	Straight Slope	10-65 18.2-73.2 26.4-81.4		55799-10-65 " -18.2-73.2 " -26.4-81.4	55799 " "	—17 —25.2 —33.4	55800-10-65 " -18.2-73.2 " -26.4-81.4	55800 " "	+17 +8.8 +.6
23E50, 23EX, 33E60	Standard	10-90 18-98 26-106		52933-10-90 " -18-98 " -26-106	52933 " "	—15 —23 —31	52932-10-90 " -18-98 " -26-106	52932 " "	+15 +7 —1
	Faired Knee	10-90 14-94 18-98 22-102 26-106 30-110	B A B A B A	52933-10-90 " -14-94 " -18-98 " -22-102 " -26-106	52933 " " " " "	—15 —19 —23 —27 —31 —35	52932-10-90 " -14-94 " -18-98 " -22-102 " -26-106	52932 " " " " "	+15 +11 +7 +3 —1 —5
	Fast Acting	7-82 15-90 23-98		52933-7-52 " -15-90 " -23-98	52933 " "	—7 —15 —23	52932-7-52 " -15-90 " -23-98	52932 " "	+23 +15 +7
	Straight Slope	10-54 18-62 26-70		52933-10-54 " -18-62	52933 " "	—15 —23 —31	52932-10-54 " -18-62	52932 " "	+15 +7 —1
24E50, 24E60	Standard	10-100		55664-10-110 **	55357	—20	55665-10-110 **	55358	+10
	Faired Knee	10-90 20-100	B B	55357-10-90 " -20-100	55357 "	—20 —30	55358-10-90 " -20-100	55358 "	+20 +10
23F60	Standard	10-90		55357-10-90	55357	—20	55358-10-90	55358	+10
24F60	Standard	10-90 21.25-101.25		55357-10-90 " -21.25-101.25	55357 "	—20 —31.25	55358-10-90 " -21.25-101.25	55358 "	+20 +8.75
	Faired Knee	10-90 16-96 21.25-101.25	B A B	55357-10-90 " -16-96 " -21.25-101.25	55357 " "	—20 —26 —31.25	55358-10-90 " -16-96 " -21.25-101.25	55358 " "	+20 +14 +8.75

* The angle graduations are stamped on the stop ring and cannot be changed or marked in the Field.
** These stop rings have recently been changed to use the same rings as the model 23F60 and 24F60 propellers.

necessary to check the stop ring settings before reinstallation of the propeller *on the same aircraft*. If the propeller is to be installed on another type of aircraft, the angle settings shall be carefully checked according to the procedure outlined for a new installation. If the stop rings have been removed from the propeller but are to be reinstalled on the same aircraft, it is necessary only to replace the rings according to the instructions given for initial insertion in a later paragraph.

(3) SETTING PROCEDURE—NEW INSTALLATION.

(a) The determination of the proper stop ring settings is usually made by the aircraft manufacturer in conjunction with the propeller manufacturer. In general, the settings are chosen so that the maximum use is made of the constant speed portion of the cam track, as previously mentioned. This is done by selecting a pitch range whose low limit is equal to or only slightly lower than the low blade angle setting. In an actual situation, reference shall be made to the aircraft log book for the blade angle settings for the particular installation.

(b) After the proper settings have been ascertained, consult Table II for the stop rings to be used. If the range is not given, select for the propeller model being used a blade pitch range in column 3 in which the low limit is equal to or slightly lower than the low angle setting. Then place a ruler across the page at the range selected. Column 6 indicates the low pitch stop to be used and column 7 gives the location of the index mark on that ring. Column 9 gives the high pitch stop and column 10 its index mark location. After the unmarked stop rings (no index mark) have been obtained, index lines must be etched onto the rings, located as called for in columns 7 and 10. As shown in figures 218 and 219, these index lines are positioned either clockwise or counterclockwise from the zero tooth. In columns 7 and 10 clockwise direction is +, and counterclockwise is —. Specific directions are furnished in Section VI, paragraph 5, for such marking. It shall also be noted that propellers with faired knee cams require that certain locating holes in the fixed cam be plugged according to the pitch range used. Failure to plug the right hole will result in incorrect angle settings.

(4) ADJUSTMENTS OF BLADE ANGLE SETTING.—Whenever a stop ring is relocated, a check should be made to insure that the stop ring lugs are still actually limiting cam rotation. When the dome is placed in both the high and low pitch positions, there should be contact between the rotating cam lugs and the stop ring lugs. If there is not, the stop rings have been set beyond the cam track range, and must be reset.

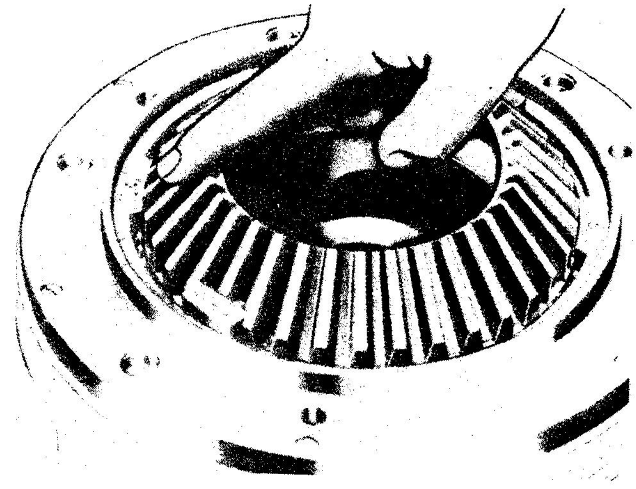


Figure 99—Checking Low Pitch Stop Ring Setting

(a) RESETTING THE LOW PITCH ANGLE.—With any given stop ring (with a basic low pitch setting of 10 degrees, for example) the low pitch setting may be raised any amount but cannot be set below the basic low pitch setting for that particular ring. When the stop ring is set at its basic low pitch setting, the cam rollers are almost at the extreme end of the cam track. Should the stop ring be set at a lower degree (in this case 9 degrees) the cam rollers may contact the end of the cam track which will then act as the stop for cam

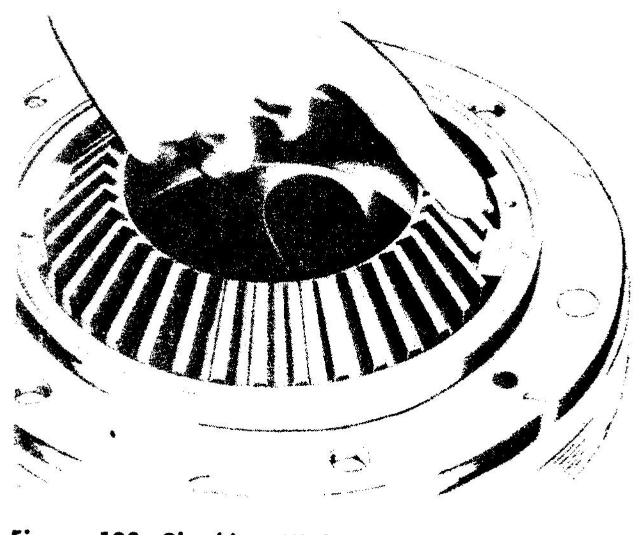


Figure 100—Checking High Pitch Stop Ring Setting

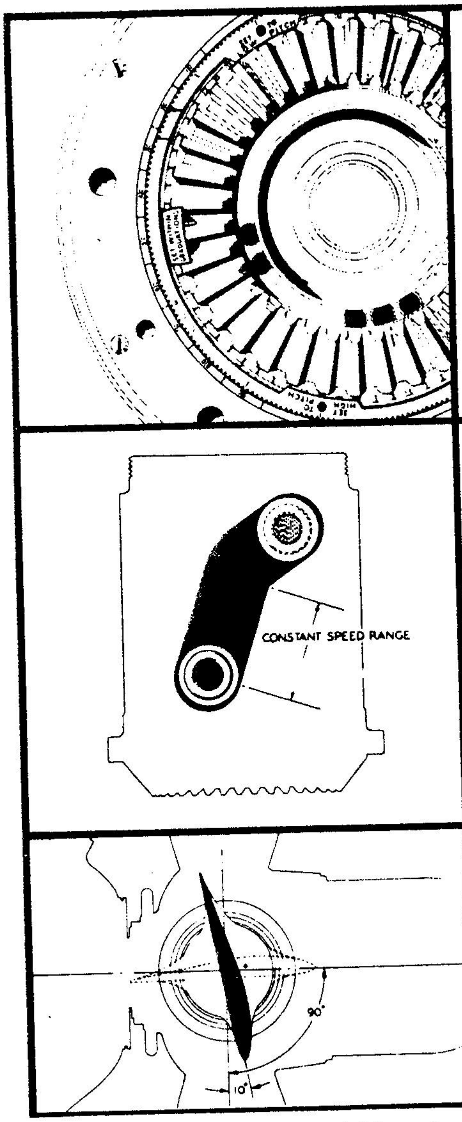


Figure 101—Pitch Setting of 10 and 90 Degrees Using Stop Rings for Pitch Range of 10 to 90 Degrees

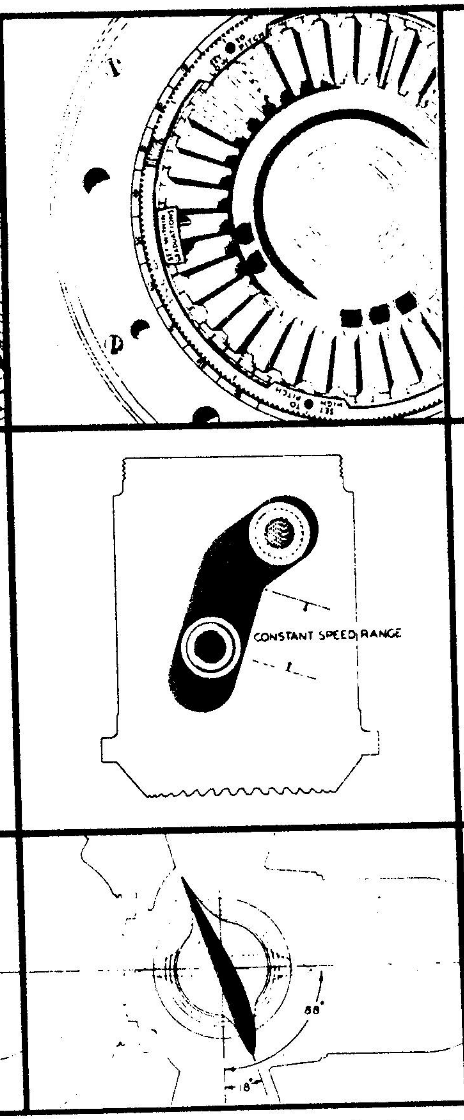


Figure 102—Pitch Setting of 18 and 88 Degrees Using Stop Rings for Pitch Range of 10 to 90 Degrees

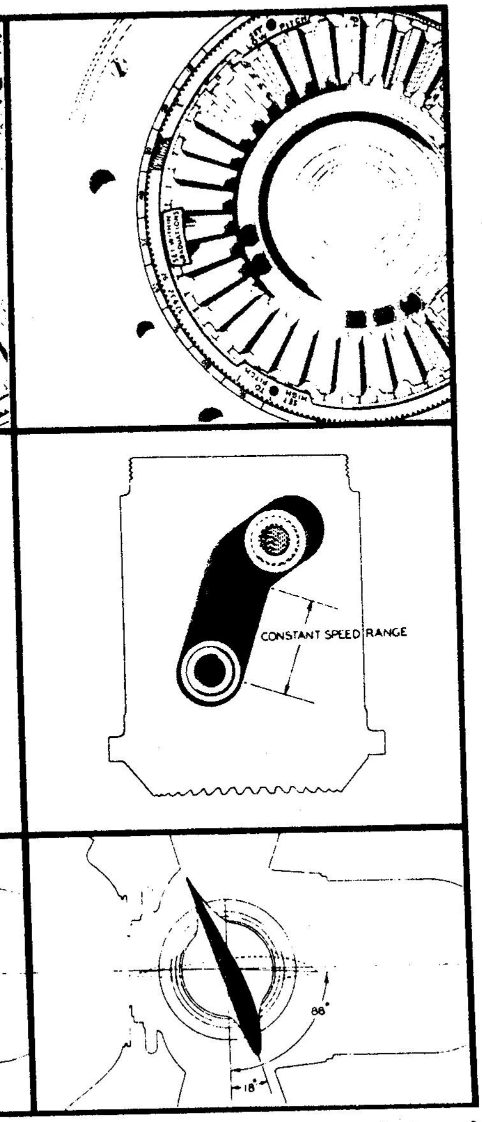


Figure 103—Pitch Setting of 18 and 88 Degrees Using Stop Rings for Pitch Range of 18 to 98 Degrees

rotation. However, the angle may be set higher than the basic low pitch setting. Setting the angle higher effectively shortens the constant speed range of the cam track.

(b) RESETTING THE HIGH PITCH ANGLE.—Resetting the high pitch limit may be necessary in order to prevent rotation of the feathered propeller. Ordinarily, once the high pitch feathered angle has been determined, it is never necessary to change it.

1. The high pitch stop ring can be removed and set at any lower angle but cannot be set to any higher angle than its basic setting because the cam rollers will contact the end of the cam track. In order to set the high pitch stop to a higher angle, it is necessary to relocate the entire angle range as will later be explained.

2. In addition to setting the stop ring to a lower angle, the assembly stop pins (if used) must be changed. If the stop pin is not changed, the blade and dome will not be in alignment prior to assembly. This is done by inserting a new pin in place of the former one, and must be done no matter in which direction the change is made.

(c) REINDEXING THE RANGES.—The blade angle range may be relocated for several reasons. It may be desired to raise the high pitch or to lower the low pitch angle. It is usually done to reindex the position of the cam constant speed range so that the full range can be utilized. As the construction of the cam itself is fixed, and provides only a certain amount of blade angle range, it is only necessary to change the relationship of blade gear segment to cam gear to change the location of the range. There is a definite angle between two adjacent teeth of the blade gear segment. If the blade gear segment is readjusted with respect to the cam gear so that

an adjacent tooth replaces the one formerly used, the blade angle range will have been changed by the amount of the gear segment tooth angle (see table I) in relation to the cam gear range.

1. EXAMPLE.—The following example should serve to illustrate how these settings are made. A 23E50 propeller is adjusted in figure 101 to a low pitch of 10 degrees and a high pitch (feathered position) of 90 degrees. This gives a *blade* constant speed range of 31 degrees. However, it may be desirable to have a higher low pitch angle for take-off and a lower high pitch angle to obtain an effective feathered position. In figure 102 the low pitch stop has been set to 18 degrees and the high pitch to 88 degrees. This shortens the blade constant speed range to 23 degrees which does not take full advantage of the cam track. Therefore, in figure 103 the blade has been reindexed one tooth. The low pitch setting is 18 degrees and the high pitch setting is 88 degrees although the cam permits a high pitch up to 98 degrees. As shown in table II, several pitch ranges are available.

2. CHANGES.—Two operations are necessary when reindexing.

a. The stop rings should be re-marked. Table II indicates the changes to be made on the rings.

b. The assembly stop pins (if used) must be changed the same angular amount to agree with the high pitch setting.

f. DOME INSTALLATION.—After the high and low pitch stop rings have been correctly installed, the dome shall be installed.

(1) CRANKCASE BREATHING TYPE.

(a) Install the required number of preload shims over the fixed cam locating dowels in the hub assembly.

(b) Using the proper tool, move the rotating cam until the cam stop lugs contact the lugs on the high pitch stop ring. This places the dome in the high pitch position. Then place the propeller blades in the same high pitch position by lining up the correct angle stamped on the blade butt with the index line on the inner periphery of the dome-barrel shelf. Be certain that all three blades are at the same angle as the dome. On older models which incorporate assembly stop pins, turn each blade towards high pitch until it contacts the stop pin. This sets the blade at the correct high pitch angle, if the proper assembly stop pins have been used.

CAUTION

When installing the dome assembly on the hub assembly, it is absolutely essential that the cam gear in the dome meshes properly with the blade gear segments. By setting the dome assembly and the blade assemblies at the same high pitch angle, the mating teeth will mesh properly. Make certain that the high pitch angle set in both the dome and the hub assemblies is identical.

(c) Install the dome lifting handle in the dome breather hole at the outboard end of the dome. Carefully inspect the threads on the dome lifting handle to make certain there are no imperfections which might damage the dome breather hole threads. The dome assembly is initially installed on the hub assembly with the correct number of preload shims in place but without the dome-barrel seal. Lift the dome assembly into position and install it over the fixed cam locating dowels in the hub assembly. Make certain that the arrow etched on the base of the fixed cam coincides at installation with the arrow stamped on the dome-barrel shelf of the outboard barrel half. When installing the dome assembly in the hub assembly, make certain that the oil seal rings on the valve assembly are staggered, and that they enter properly into the piston oil seal ring sleeve.

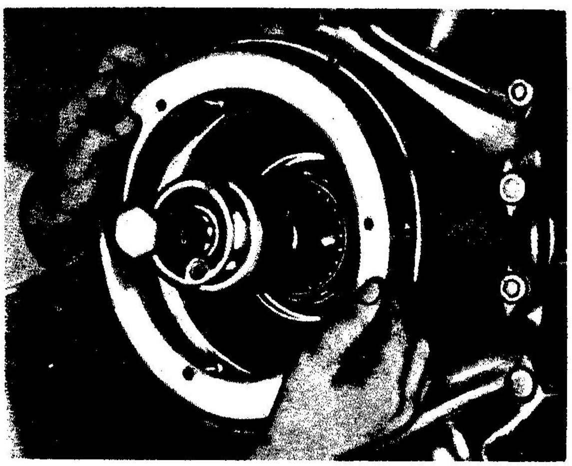


Figure 104—Installing Preload Shim

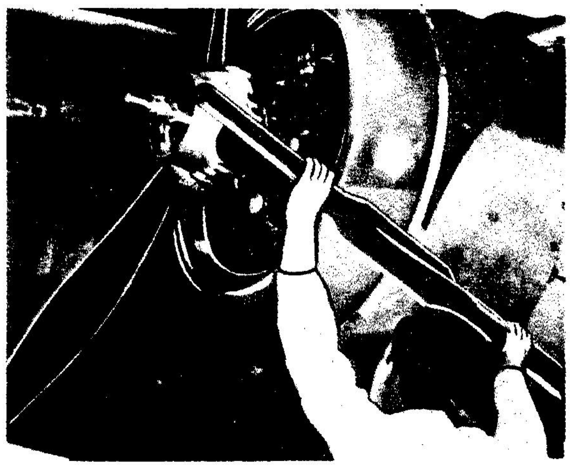


Figure 105—Turning Blades to High Pitch

Figure 106—Installing Dome Lifting Handle

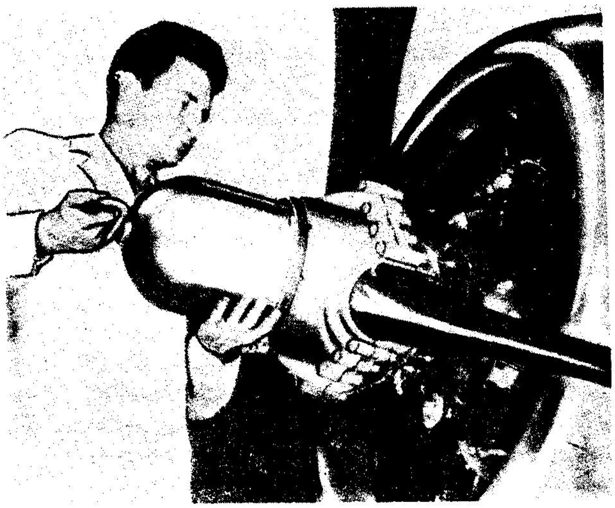


Figure 107—Installing Dome Assembly onto Hub

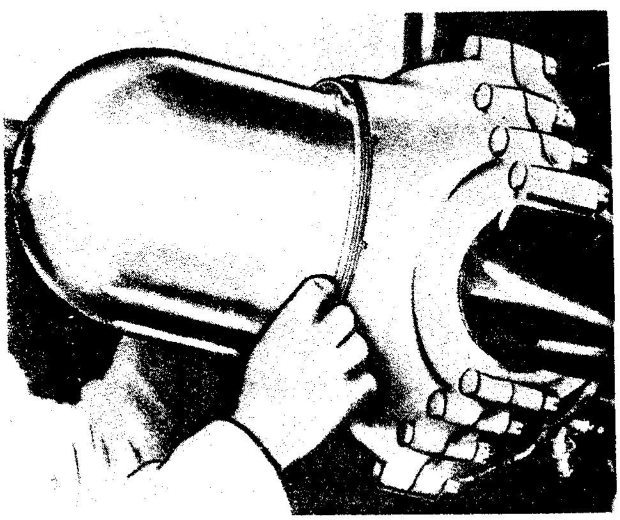


Figure 108—Starting Dome Retaining Nut into Hub

(d) Turn the dome in an anticlockwise direction until the fixed cam locating dowels in the dome-barrel shelf enter the dowel holes in the fixed cam. Start the dome retaining nut into the hub assembly by hand turning the dome retaining nut, and then attach the proper wrench and wrench bar. Tighten the dome retaining nut using a torque sufficient to seat the dome on the barrel shelf (approximately 250 pound-feet). Do not exceed 720 pound-feet. Mark the position of the dome retaining nut with respect to the barrel. Then remove the dome.

Note

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 outboard barrel half. 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-barrel seal. Failure to tighten the dome unit securely in the hub will result in elongation or failure of the dome shell retaining screws, and oil leakage around the dome retaining nut.

(e) To correctly install the dome-barrel seal, apply a light film of oil to both the seal and the surface of the fixed cam on which the seal is to be installed. Then carefully assemble the dome-barrel seal onto the fixed cam, and work it into position. This procedure tends to allow the seal to distribute itself more evenly, and prevents its "bunching up" when the dome assembly is installed in the hub assembly. It should be

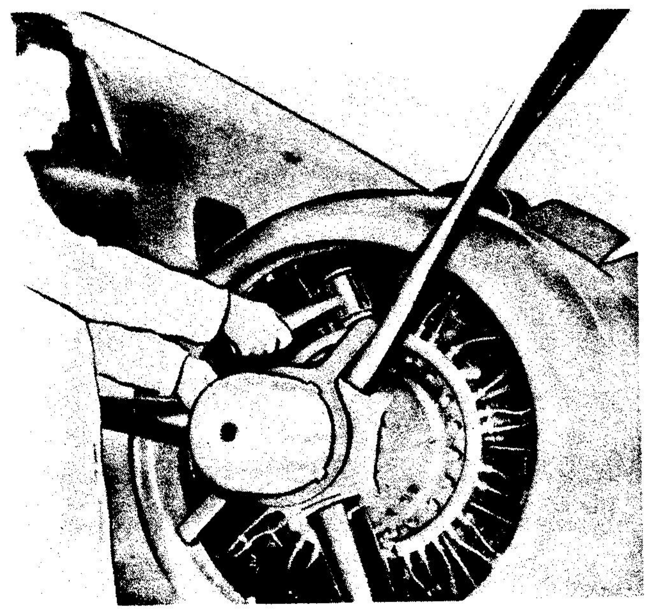


Figure 109—Tightening Dome Retaining Nut

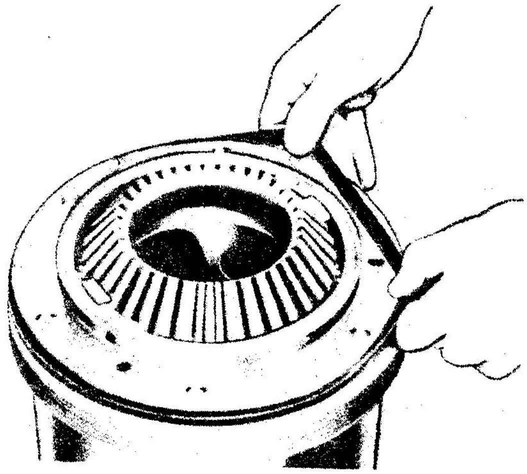


Figure 110—Installing Dome-Barrel Seal

noted that leakage in the vicinity of the dome retaining nut may often be caused by improper installation of this seal.

(f) Reinstall the dome assembly and apply sufficient torque to the dome retaining nut to bring it at least to the position previously marked, and to obtain alignment of the dome retaining nut lock screw with one of the crescent slots in the outboard edge of the barrel. Once the dome retaining nut has been started into the hub, do not back it out until the position previously marked has been obtained. If this procedure is not followed, the dome-barrel seal may catch between the threads when the dome retaining nut is retightened after it has been partially backed out.

(g) Remove the dome lifting handle. Install the dome retaining nut lock screw in the dome retaining nut, and safety this screw with a 1/16-inch cotter pin or lock wire. If lock wire is used, make certain that it is installed in line with the outboard barrel half edge similar to the set-up shown.

(h) Check the high pitch blade angle either by the index line on the blades and the graduations on the barrel blade bore (if the propeller has this feature), or by a bubble protractor at the reference station, and then using suitable blade turning levers, shift the propeller blades into the full low position and check the low blade angle. These angles should be the same as the high and low pitch settings of the stop rings, and this check will insure that the correct relationship between the blade gear segments and the cam gear has been obtained.

(i) First install the dome breather hole washer on the dome breather hole nut, then add the seal over the washer onto the nut, and finally, insert and tighten the assembly into the dome shell. This latter procedure will keep the seal lined up on the nut and prevent its catching between the dome shell and dome breather hole

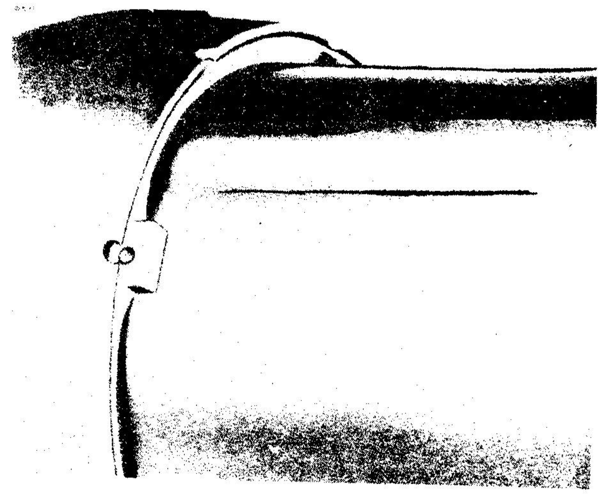


Figure 111—Correct Positioning of Retaining Nut after Tightening

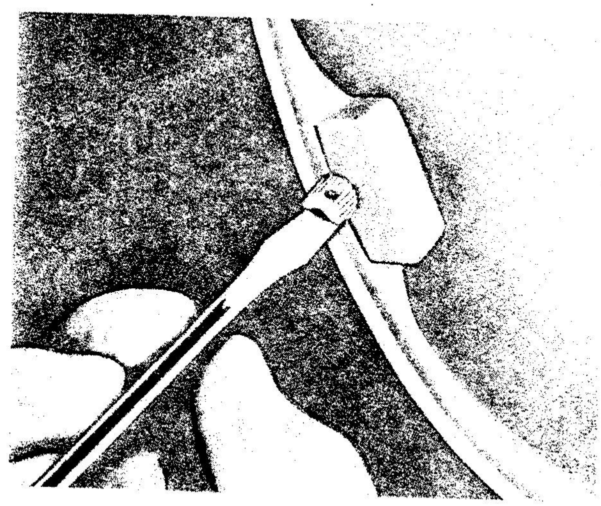


Figure 112—Installing Retaining Nut Lock Screw

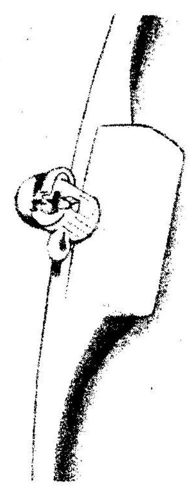


Figure 113—Lock Screw with Cotter Pin Inserted

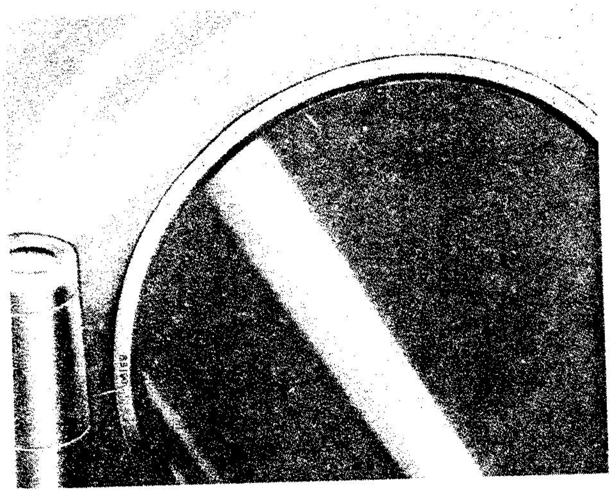


Figure 114—Checking Angle by Scribe Mark

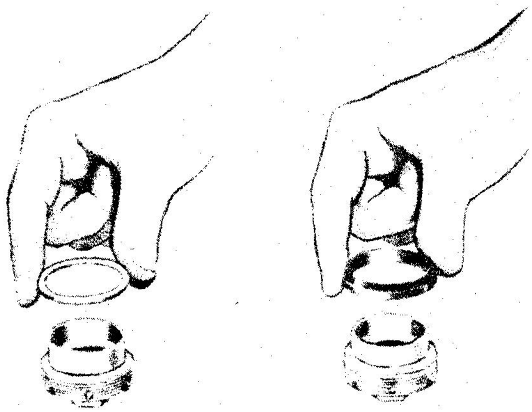


Figure 115—Installing Washer and Seal onto Dome Breather Hole Nut

nut threads. Tighten it into place using a torque of 30-50 pound-feet. Continue this tightening operation until one of the holes in the nut lines up with a slot in the dome shell. Snap the dome breather hole nut lock wire into the groove on the inside of the nut in such a way that the extended portion of the wire rests in the dome shell groove.

Note

A dome breather hole washer is not used on all Hydromatic propeller models. See paragraph 5 for instructions on all models other than the basic 23E50.

(j) Check all external cotter pins and safety wire.

(2) SHAFT BREATHING TYPE.—On installations which breathe through the propeller shaft, the installation procedure for the dome assembly is identical with that described for the crankcase breathing type except for the minor differences listed below:

(a) When the dome assembly is put into position in the barrel assembly, make certain that the valve breather tube enters smoothly into the dome shell breather hole.

(b) After the dome assembly has been installed, tightened, and locked, the dome breather hole seal and washer are put in place around the breather tube. These parts are identical with those used on crankcase breathing installations.

(c) Install the breather cap nut and tighten it into place using a torque of 30 to 50 pound-feet. When tightening, line up one of the lock wire holes with a slot in the dome shell. Put the breather cap nut lock wire in position by inserting its extended prong through the nut into the dome shell slot, and snap the wire into place in the locking groove. Then install the rubber breather

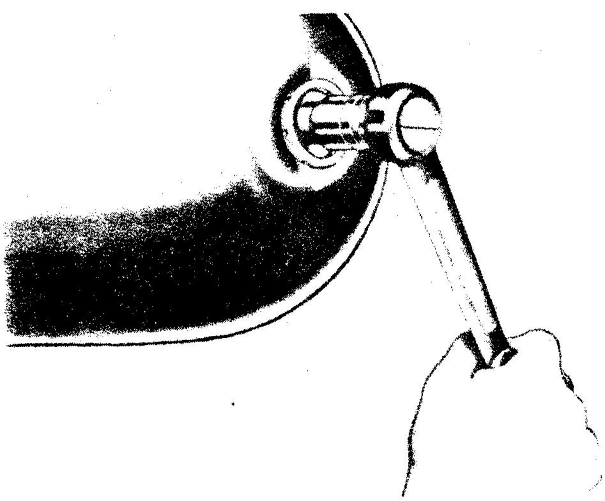


Figure 116—Tightening Dome Breather Hole Nut

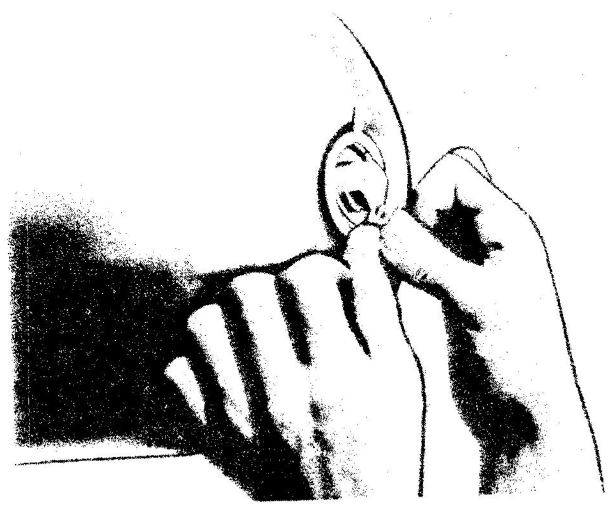


Figure 117—Installing Nut Lock Wire

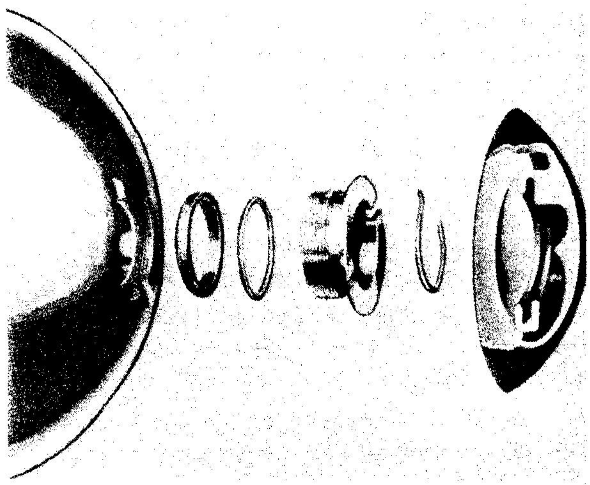


Figure 118—Extended View of Rubber Breather Cap Assembly

cap onto the flange of the nut by hand. Be absolutely certain that the cap fits evenly all the way around with no folding of the bottom lip. Older models use a one-piece steel breather cap which is integral with the nut. It is installed in a similar manner and locked by a wire extending through one of the cap supporting posts into a dome shell slot.

5. INSTALLATION—OTHER MODELS.

Note

Only the variations in installation procedure between the model 23E50 propeller and the particular model under discussion are given in the following paragraphs.

a. MODELS 22D30 AND 22D40.

(1) The installation procedure for these models is very similar to that for the basic model 23E50. The correct installation tools are shown and listed in paragraph 1. However, since these two models do not incorporate a distributor valve oil transfer plate, the only gasket required is the one between the propeller shaft and the base of the valve housing. The recommended tightening torque for this built-up type of distributor valve is 100 pound-feet.

(2) The stop rings are serrated on their ID and fit matching serrations on the OD of the rotating cam teeth. The rings have the degree graduations which are located relative to an index mark on the rotating cam.

(3) Since the dome-barrel seal is the chevron type, it is not necessary to follow the procedure previously described for insuring that the dome is seated. Tightening with a torque of 720 pound-feet is sufficient to seat the dome firmly on the barrel shelf.

(4) The dome retaining nut is locked in place in the hub assembly by a cotter pin fitting through one of the holes in the dome retaining nut into a slot in the outboard barrel half dome retaining nut threads.

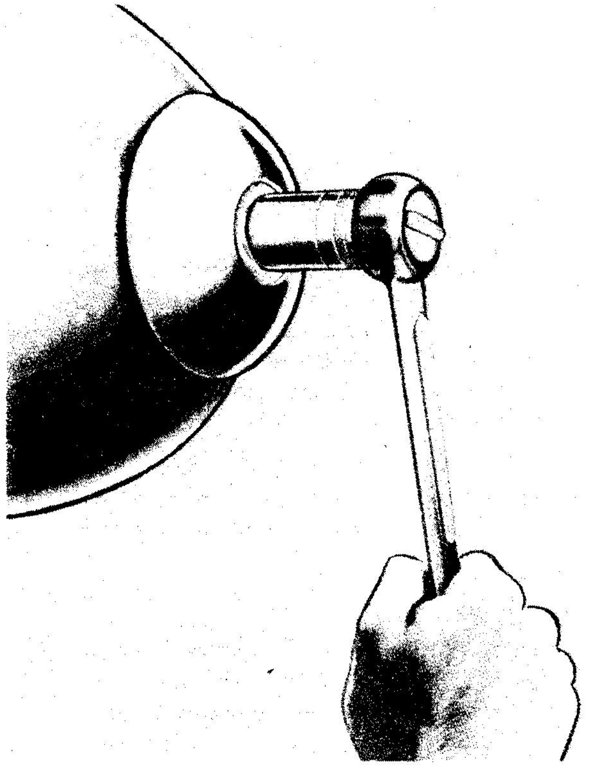


Figure 119—Tightening One-Piece Breather Cap

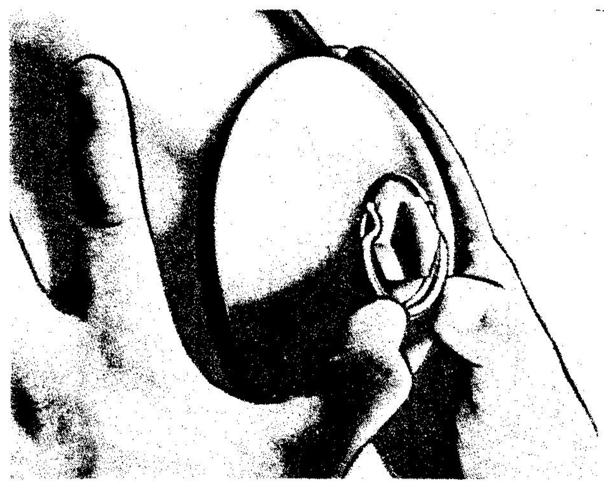


Figure 120—Installing Breather Cap Lock Wire

(5) Since these models are not manufactured in the shaft breathing type, there is no breather hole in the dome shell.

b. MODEL 23D40.

(1) To install this model propeller, follow the general instructions given for the model 23E50. The built-up

type distributor valve incorporates two slots into which fit extensions on the valve housing adapter. This adapter is set into place, and the retaining nut wrench fitted over it. Tightening torque for these built-up valves is 100 pound-feet.

(2) A chevron type dome-barrel seal is used which is inserted with its spacer into a small recess in the barrel adjacent to the outboard side of the dome-barrel shelf. The open lips of the seal face inboard. Since the seal is not compressed, tightening the dome retaining nut with a torque of 720 pound-feet is sufficient to seat the dome firmly, and it is unnecessary to follow the procedure described for the 23E50 model to insure proper seating.

(3) The 23D40 does not include a dome breather hole washer; consequently, this group consists of the breather hole seal, nut, and lock wire, installed in that order.

c. MODEL 33D50.

(1) Again, the 33D50 propeller follows closely the procedure given for the 23E50 model with but slight variations. After installation of the hub assembly has been completed and the retaining nut tightened in place, the hub snap ring is put in place in the hub snap ring groove in the spider. Then the propeller retaining nut lock ring is installed over the nut so that the lugs on the ring lock in the grooves cut in the outboard rim of the spider. This ring is so constructed that alignment between the extensions on the ring and the splines on the retaining nut may be obtained by installing the ring in one of three possible positions. If alignment by this method cannot be obtained, the retaining nut should be further tightened to properly index with the retaining nut lock ring.

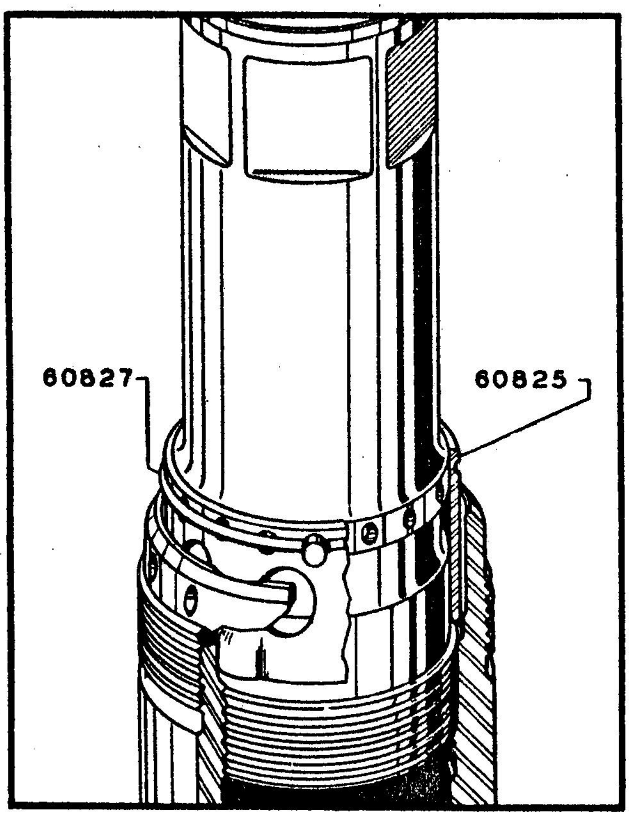


Figure 121—Sleeve Type Housing Lock on Model 33D50

(2) After the lock ring has been set in place, the propeller retaining nut lock ring lock wire is installed on the retaining nut outboard of the nut lock ring.

(3) The installation procedure for the distributor valve and the shaft extension differs somewhat from that for the model 23E50. The earlier model 33D50 has a valve (and shaft extension) which is locked to the propeller shaft by a lock wire set between the housing and the shaft. After alignment between a valve slot and a propeller shaft locking hole has been obtained, this wire is installed so that its pin fits into the locking slot on the valve and through the hole in the shaft.

(4) Later models of the valve and shaft extension are locked by means of a separate sleeve which has two projections diametrically opposite on the inboard end to match two grooves on the ID of the propeller shaft. The outboard end has 14 equally spaced locking holes. The retaining wire assembly, consisting of a wire with a free-fitting bushing at right angles, is fitted into a groove on the sleeve OD with the bushing extending inward through a hole in the sleeve into a hole in the housing as shown. Since the sleeve has 14 locking holes and there are 13 in the housing, it is sometimes possible to obtain alignment by reinserting the sleeve 180 degrees from its former position in the shaft.

DELETED

(5) Since a chevron type dome-barrel seal is used, installation of the dome assembly follows the procedure previously outlined for the model 23D40. A dome breather hole washer is not used in model 33D50 propellers.

d. MODELS 24D50 AND 24D60.

(1) These models have never incorporated assembly stop pins. Consequently, the blades must be set to high pitch prior to dome installation by lining up the proper degree mark on the blade butt with the index line on the inner periphery of the dome-barrel shelf, or by using a protractor at the blade reference station.

(2) On the 24D60 model only, the retaining nut should be tightened with a torque of 1500 pound-feet.

e. MODEL 23EX.

Note

Since this propeller is used only on British aircraft, it is recommended that the procedure described be used only as a reference and not in place of instructions issued by the British for any given aircraft installations.

(1) The installation procedure for a model 23EX propeller is quite similar to that described for the basic 23E50 model; however, prior to installation of the distributor valve, the sleeve is inserted inside the propeller shaft with the smaller diameter end entering first. The distributor valve, and the attached tube and gasket, are then installed inside the propeller shaft and the sleeve with a soft copper gasket fitting between the base of the housing and the outside rim of the sleeve. When the distributor valve is tightened, this gasket forms the oil seal between the housing and the sleeve, and the sleeve also serves to locate the valve in the shaft. Tightening torque for this distributor valve is 100 pound-feet, and it should be remembered that the inboard end of the tube incorporates a left-hand thread.

(2) The propeller retaining nut lock wire is installed in the retaining nut after alignment between the retaining nut, a locking slot on the valve housing, and one of the locking holes in the propeller shaft has been attained. The pin on the lock wire fits through the retaining nut and the propeller shaft into a locking slot on the valve housing, and locks the hub and distributor valve assemblies.

f. MODEL 33E60.

(1) After the propeller retaining nut has been tightened in place with a torque of 1500 pound-feet, the serrated retaining nut lock ring is fitted over it and locked in the slots in the outboard rim of the spider. The ring in turn is held in place by a retaining wire which fits in a groove incorporated near the outboard end of the retaining nut. This part of the installation is complete after the hub snap ring has been installed in the spider snap ring groove.

(2) The valve is next installed with the gasket fitting between the base of the valve housing and the propeller shaft. No oil transfer plate is used with either a 33E60 distributor valve or engine shaft extension. To lock the valve in place, line up one of the locking slots on the base of the housing with a locking hole in the propeller shaft. Then insert the valve lock wire between the housing and the shaft in such a way that the locking pin on the wire extends into the locking slot and also through the locking hole in the propeller shaft.

g. MODELS 24E50 AND 24E60.

(1) The distributor valve or engine shaft extension assembly is installed in the propeller shaft with a copper gasket fitting between the base of the housing and the shaft. No oil transfer plate is used with these propellers.

(2) The retaining nut torque for the 24E60 is 1500 pound-feet, and an adapter plate, listed in paragraph 1, should be used in conjunction with the wrench.

(3) The propeller retaining nut and the valve assembly are locked by a propeller retaining nut lock wire which fits around the outside of the nut, through a locking hole in the propeller shaft, and into a locking slot on the housing.

(4) No steel washer is used with the dome breather hole nut or cap on 24E50 or 24E60 propellers.

h. MODEL 23F60.—To install the model 23F60 propeller, follow the instructions given in paragraph 4, with the exception that the propeller retaining nut lock wire is installed between the propeller shaft and the retaining nut with the small end of the locking pin fitting through a locking hole in the shaft and the large end into a locking spline on the valve housing. A washer is not used in the dome breather hole. The retaining nut torque is 1500 pound-feet. Use the adapter plate in conjunction with the propeller retaining nut wrench.

i. MODEL 24F60.—To install a model 24F60 propeller, follow the instructions given in paragraph 4, with the exception that one gasket is fitted between the base of the valve housing and the propeller shaft, and the valve oil transfer plate and gasket are omitted. The retaining nut torque is 1500 pound-feet. Use the adapter plate together with the propeller retaining nut wrench.

6. REMOVAL—ALL MODELS.

Note

In general, the procedure for removing the propeller is the reverse of the installation procedure.

a. DOME AND DISTRIBUTOR VALVE REMOVAL.

(1) Take out the dome breather hole nut lock wire (on crankcase breathing installations), or the breather cap lock wire (on shaft breathing installations).

(2) Remove the dome breather hole nut (on crankcase breathing installations), or the dome breather cap nut (on shaft breathing installations). Using blade persuaders, turn the blades into the full high pitch position. The dome is usually filled with engine oil. Some provision should be made to take care of this oil both at removal of the dome plug and when the dome assembly is disconnected from the hub assembly.

(3) Install the dome lifting handle. Take out the dome retaining nut lock screw cotter pin, and then remove the nut lock screw.

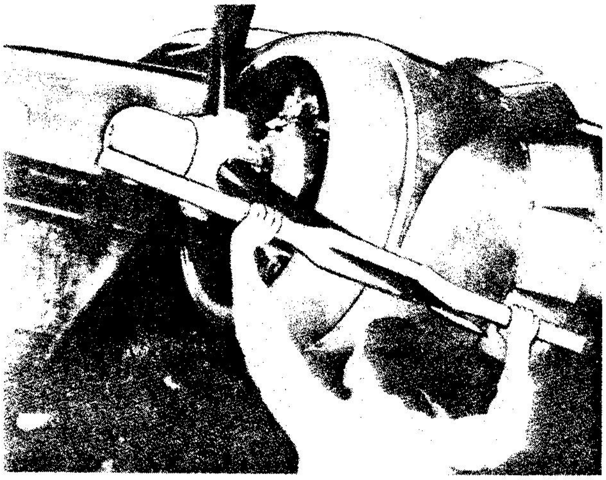


Figure 122—Turning Blades to High Pitch

(4) Back off the dome retaining nut, and then lift off the dome assembly on a line parallel with the shaft. Be careful not to damage the distributor valve during removal of the dome assembly.

(5) Take out the propeller retaining nut lock wire.

CAUTION

Unless the propeller retaining nut lock wire is removed before the valve is turned, the locking splines on the valve will be damaged.

(6) Using the proper wrench, remove the valve from the propeller shaft.

b. HUB REMOVAL.

(1) Install the propeller hoisting sling.

(2) Back off the propeller retaining nut and the attached front cone. When the propeller retaining nut is backed off the propeller shaft, the outboard ledge of the front cone will contact the hub snap ring and jack the propeller hub assembly off the rear cone.

(3) Cover the propeller shaft threads with a thread protector, or wrap with tape if the protector is not available.

(4) Remove the spider-shaft oil seal ring, seal, and washer. The seal can be removed in good condition if the propeller is first moved back on the shaft, and the seal carefully guided over the propeller shaft threads.

(5) Remove the propeller from the propeller shaft.

(6) If another propeller is not to be installed immediately, clean, oil, and then cover the propeller shaft.

(7) If the propeller is to be left in storage for any length of time, EO 05-1-9 should be consulted for correct preservation procedure.

SECTION IV
OPERATION

1. PRINCIPLES OF OPERATION—MODEL 23E50

a. GENERAL.

(1) Operation of the Hydromatic propeller is determined by the type of governor used. When a single-acting type of governor is used, the propeller is called "single-acting." Likewise, a "double-acting" propeller has a double-acting governor. The propeller mechanism is exactly the same for both except that the double-acting type does not require a distributor valve, but uses an engine shaft extension similar to that used with the non-feathering, single-acting propeller.

(2) Since the single-acting type of propeller is the most widely used, the following detailed description of operation is based on that type. However, a brief description of operation for the double-acting type is included in paragraph 1e.

(3) In the following description of propeller operation, it is also assumed that the individual, electric motor driven pump feathering system shown diagrammatically in figure 126 is used. In this type of installation, a motor-pump unit, which is usually installed in each engine nacelle, supplies oil (from the engine oil tank) to the Hydromatic propeller. With any other type of feathering system, consult the aircraft manufacturer for details of its operation.

(4) In engines which incorporate a propeller shaft constructed as shown in the operating diagrams, an air separator plug is used. This plug allows air, which may collect at the center of the shaft after propeller installation, to be bled from the system through 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 initial engine run-up. 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 lost from the shaft and move the blades to a higher angle.

(5) The engine oil pump supplies oil to the propeller governor and the single-acting propeller at the prevailing engine pressure.

b. CONSTANT SPEED OPERATION.
(See figure 123.)

(1) PROPELLER MECHANISM.

(a) Three fundamental forces, described fully and shown in section II, are utilized to control the blade angle variations required for "CONSTANT SPEED" propeller operation. These forces are:

1. Centrifugal twisting moment, a component of the centrifugal force acting on a rotating blade which tends at all times to move the blade into low pitch;

2. Oil at engine pressure on the outboard piston side which is introduced to supplement the blade centrifugal twisting moment toward low pitch; and

3. Oil, taken from the engine supply and boosted in pressure by the engine driven propeller governor, supplied to the inboard piston side to balance forces *1* and 2, and used to move the blades toward high pitch.

(b) The pitch changing mechanism, by means of which oil forces are translated into blade twisting moments, consists essentially of a piston *(2)* operating in a cylinder, a pair of coaxial, cylindrical cams *(4)* and *(5)*, and bevel gears. The piston and cylinder transform the hydraulic force into mechanical force, and the cams transmit this force to the blades through the bevel gears.

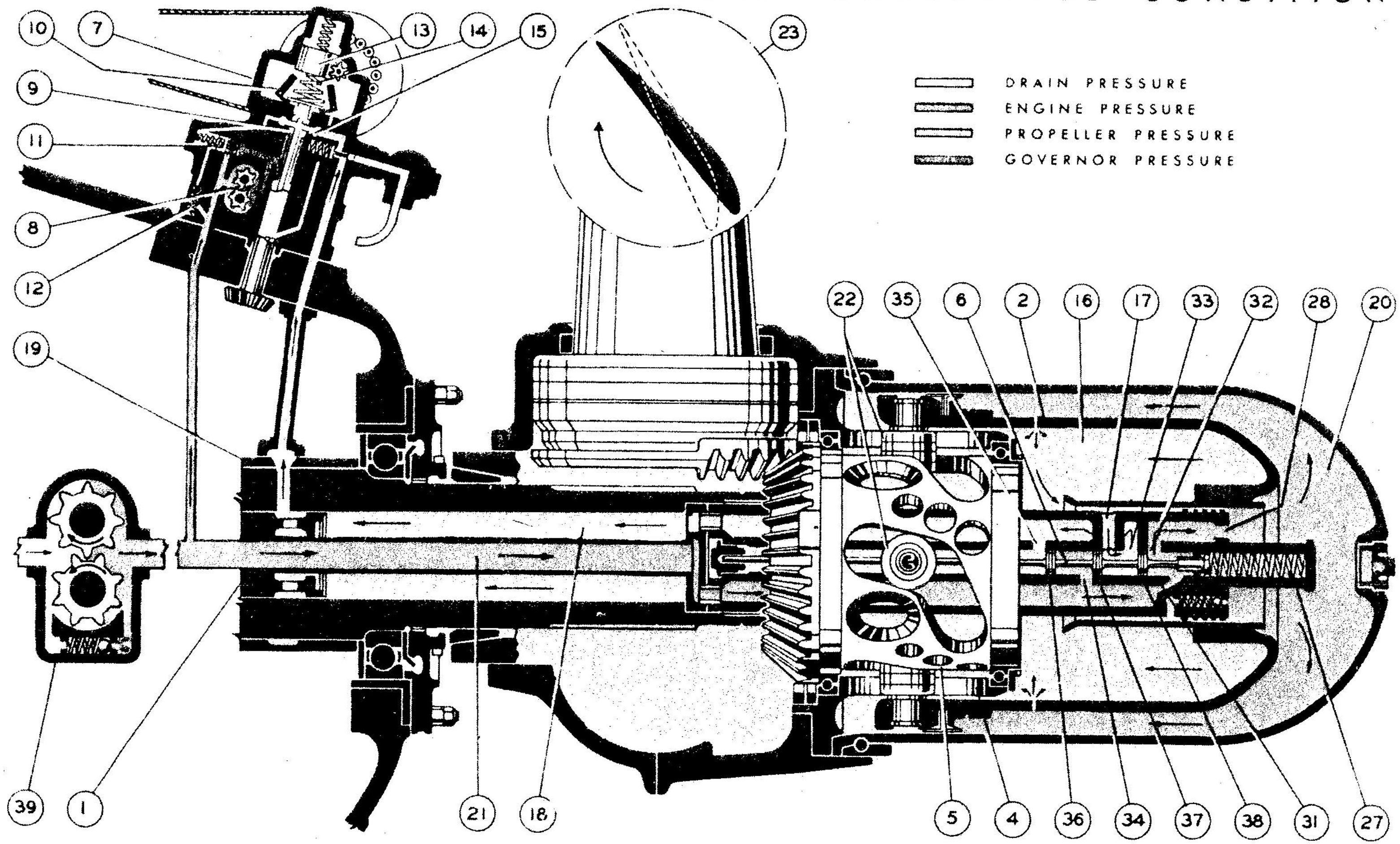
(c) Only the steep portion of the cam tracks between the inboard end and the break in the track profile is used during constant speed operation. As an example, this portion of the cam track for one cam design provides a blade angle range of 33 degrees; normally from 10 degrees low pitch to 43 degrees measured at the blade reference station. The slope of this portion of the cam track is such that the resulting mechanical advantage of the piston-cams arrangement is relatively high.

(d) The distributor valve *(6)* does not shift during the constant speed and feathering operations. The assembly serves merely to provide passages for the oil flow to and from the propeller dome.

(2) GOVERNOR MECHANISM.

(a) The propeller constant speed control unit *(7)* is an engine-driven governor of the centrifugal fly-weight type. It incorporates a gear pump *(8)* which boosts the engine oil to the pressure required for propeller operation; a pilot valve *(9)* actuated by the fly-weights *(10)* that controls the flow of oil through the governor; and a relief valve system *(11)* and *(12)* which regulates the operating pressures in the governor. The required balance between the three control forces is maintained by the propeller governor (constant speed control unit) which, in addition to boosting the engine oil pressure, meters to or drains from the inboard side of the propeller piston the exact quantity of oil necessary to maintain the proper blade angle for constant speed operation.

SCHEMATIC OPERATING DIAGRAM—UNDERSPEED CONDITION



No.	NAME
1	Air Separator Plug
2	Double Acting Piston
4	Fixed Cam
5	Rotating Cam
6	Distributor Valve
7	Constant Speed Control Unit (or Governor)
8	Governor Booster Gear Pump
9	Governor Pilot Valve
10	Governor Fly-Weights
11	Governor Relief Valve
12	Governor Dump Valve
13	Governor Rack
14	Governor Speeder Spring
15	Propeller-Governor Metering Port
16	Inboard Piston End
17	Distributor Valve Inboard Outlet & Inlet
18	Propeller Shaft Governor Oil Passage
19	Propeller Shaft Oil Transfer Rings
20	Outboard Piston End
21	Propeller Shaft Engine Oil Passage
22	Cam Rollers
23	Blade Angle Schematic Diagram
27	Distributor Valve Spring
28	Distributor Valve Outboard Outlet & Inlet
31	Distributor Valve Port
32	Distributor Valve Port
33	Distributor Valve Port
34	Distributor Valve Port
35	Distributor Valve Port
36	Distributor Valve Land
37	Distributor Valve Land
38	Distributor Valve Land
39	Engine Oil Pump

Figure 123—Propeller Operating Diagram—Underspeed Condition

(*b*) The rpm at which the propeller will operate is adjusted in the governor head. The operator can change this setting by changing the position of the rack (*13*) through the governor cockpit control arrangement. As the rack is lowered, the compression in the speeder spring (*14*) is increased. This means the engine speed necessary to maintain a balanced relationship between the fly-weights' centrifugal force and the speeder spring force (a state of equilibrium which establishes the on-speed condition) is also increased. If the operator raises the rack (*13*), the compression in the speeder spring (*14*) is lessened and the engine rpm necessary to establish a balance between the fly-weights' centrifugal force and the speeder spring force is decreased.

(*c*) The position of the pilot valve (*9*) with respect to the propeller-governor metering port (*15*) regulates the quantity of oil which will flow through this port to or from the propeller.

(*d*) A spring is included above the rack which, in case of governor control system failure, returns the rack to an intermediate position approximating cruising rpm.

(3) UNDERSPEED. (See figure 123.)—As shown in the blade angle diagram (*23*), underspeeding results when the blades (solid black section) have moved to a higher angle than that required (shown as a dotted line section) for constant speed operation. The arrow in (*23*) represents the direction in which the blades will move to reestablish on-speed operation.

(*a*) OIL FLOW.

1. When the engine speed drops below the rpm for which the governor (*7*) is set, the resulting decrease in centrifugal force allows the fly-weights (*10*) to move inward under the force of the speeder spring (*14*) thus lowering the pilot valve (*9*) which opens the propeller-governor metering port (*15*) to drain. This allows oil to flow from the inboard piston end (*16*), through the distributor valve inboard inlet (*17*), between distributor valve lands (*37*) and (*38*), through valve port (*33*), into the propeller shaft governor oil passage (*18*). From there the oil moves through the propeller shaft oil transfer rings (*19*), up to the propeller-governor metering port (*15*), and then through the governor drive gear shaft and pilot valve arrangement (*9*) to drain in the engine nose case. The oil is recovered from the engine nose case and returned to the oil tank by the engine scavenging pump.

2. The distributor valve does not shift during the constant speed (or feathering) operations. During the underspeed condition, engine oil entering through port (*34*) is trapped between distributor valve lands (*36*) and (*37*) balancing that portion of the valve, while oil at drain pressure applied to lands (*37*) and (*38*) cancels out. The only force present which tends to shift the valve is drain pressure applied through port (*35*) against the inboard end of land (*36*); however, this force is very small as compared with the combined forces of engine oil and distributor valve spring (*27*) acting on the outboard end of land (*38*).

(*b*) PROPELLER ACTION. — As the oil is drained from the inboard piston end (*16*), engine oil flows through the propeller shaft engine oil passage (*21*), through distributor valve ports (*31*) and (*32*), and emerges from the distributor valve outboard outlet (*28*) into the outboard piston end (*20*). In conjunction with blade centrifugal twisting moment, this oil moves the piston (*2*) inboard. The piston motion is transmitted through the piston rollers (*22*) operating in the oppositely inclined cam tracks of the fixed cam (*4*) and the rotating cam (*5*) into blade twisting moment through the beveled gears. As indicated in the blade angle schematic diagram (*23*), the blades are moved to a lower angle.

(*c*) RESULT.—As the blades assume a lower angle (shown as a dotted line section), the engine speed increases, and the pilot valve (*9*) is raised by the increased centrifugal force exerted by the governor fly-weights (*10*). This action gradually closes off the propeller-governor metering port (*15*), which in turn decrease the flow of oil from the inboard piston end. This decrease in oil flow also decreases the rate of blade angle change toward low pitch, and when the engine has reached the rpm for which the governor is set, the pilot valve (*9*) will have assumed a neutral position (closed) in which it prevents any appreciable oil flow to or from the propeller. (The pilot valve never completely closes off the propeller-governor metering port (*15*). For an explanation, see ON-SPEED.) The valve is held in this position because the fly-weight centrifugal force just equals the speeder spring force. The control forces are now in equilibrium and the propeller and governor are operating on-speed.

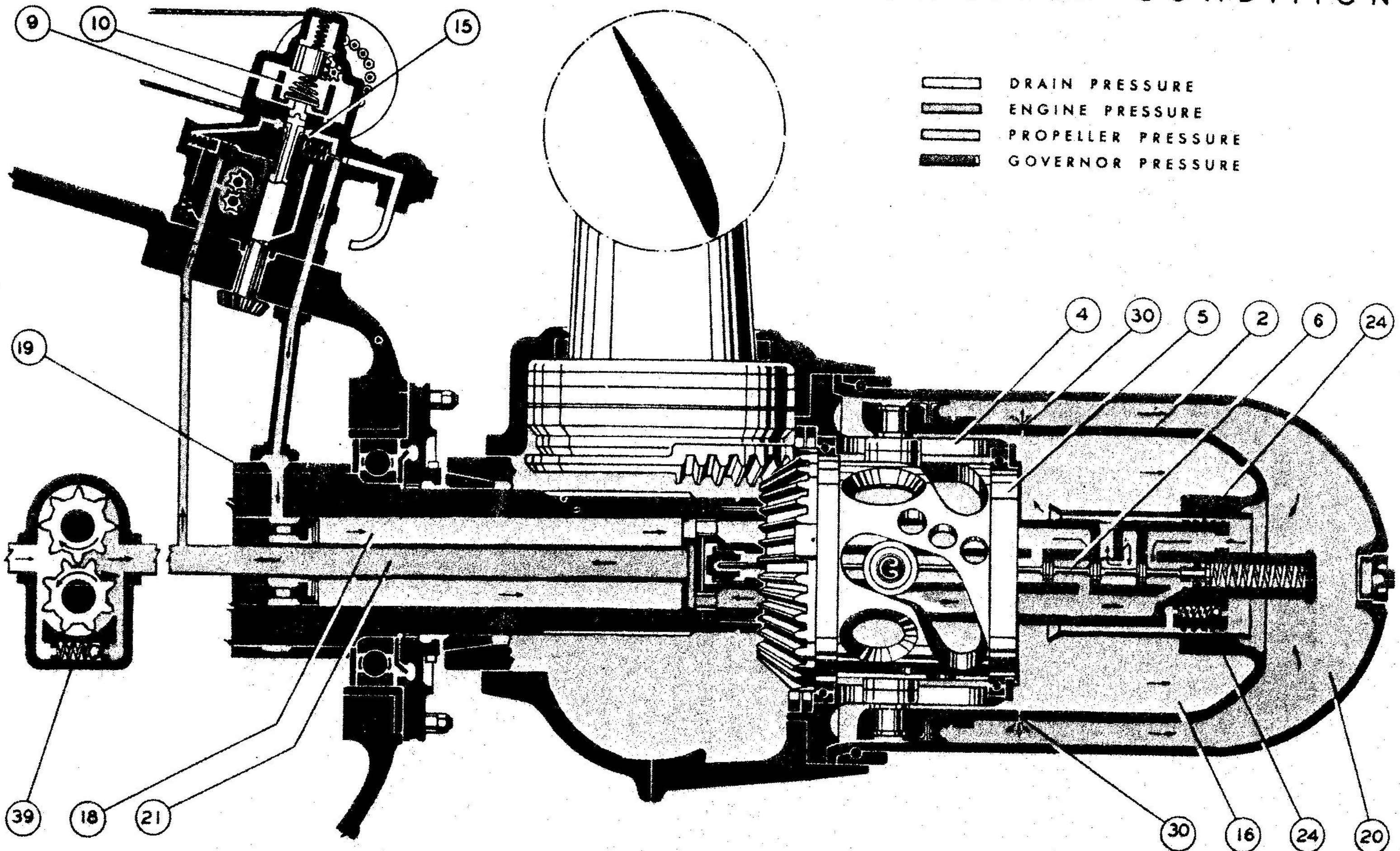
(*d*) During underspeed operation, the relief valve (*11*) opens and by-passes oil from the booster pump (*8*).

(*e*) Some governor installations incorporate a dump valve as shown at (*12*). During underspeed operation, this valve remains closed.

(4) ON-SPEED. (See figure 124.)—In the on-speed condition the propeller and governor forces are in equilibrium. The governor fly-weights (*10*) are in a position which permits the pilot valve (*9*) to close the propeller-governor metering port (*15*) completely except for a small bleed flow which replaces oil passed through the piston bleed holes (*30*), past the distributor valve oil seal rings (*24*), and the propeller shaft oil transfer rings (*19*).

(5) OVERSPEED. (See figure 125.)—If the propeller is operating below the rpm for which the control is set, the blades will be in a lower angle shown as a

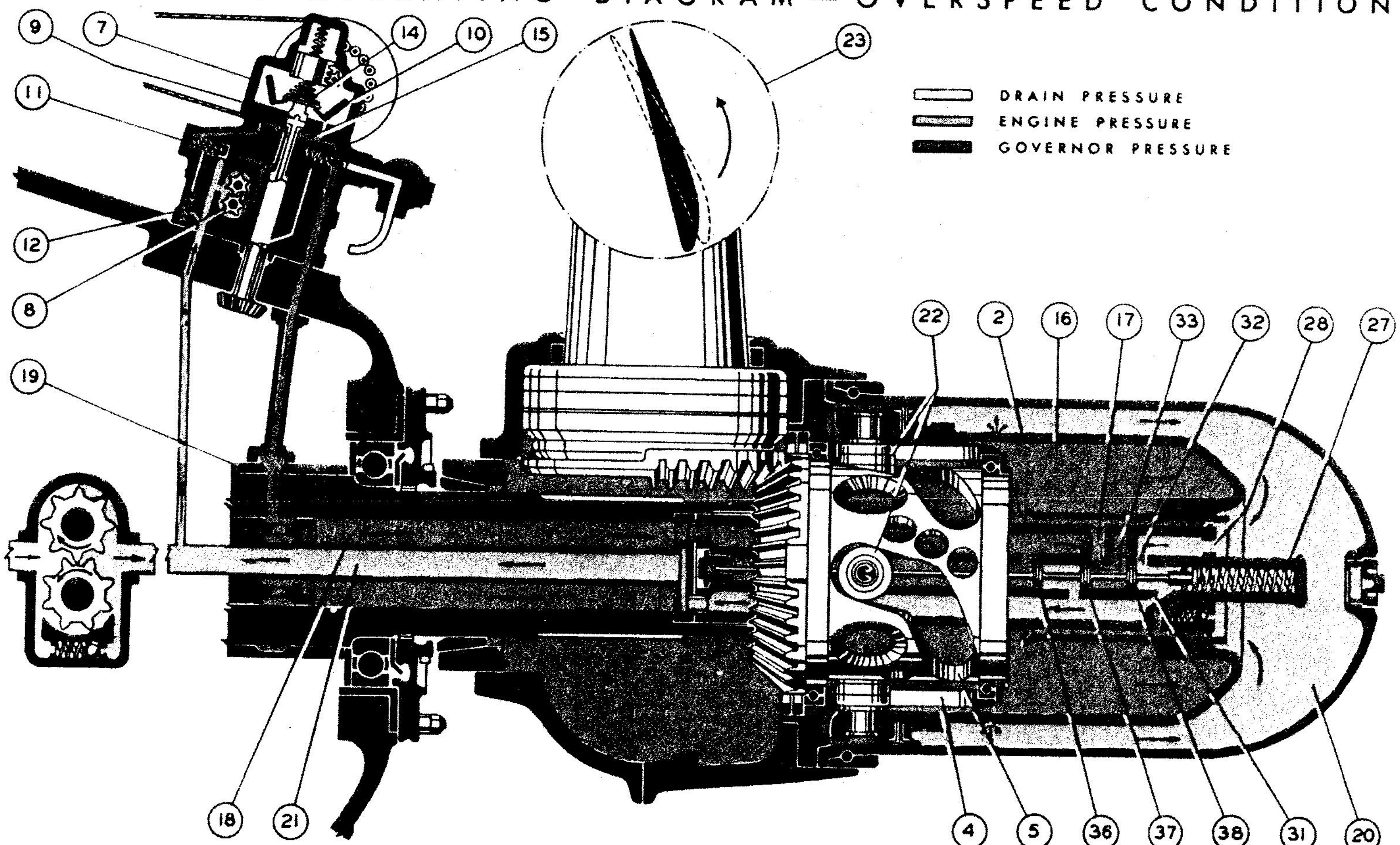
SCHEMATIC OPERATING DIAGRAM—ON-SPEED CONDITION



No.	NAME	No.	NAME	No.	NAME
2	Double Acting Piston	10	Governor Fly-Weights.	20	Outboard Piston End
4	Fixed Cam	15	Propeller-Governor Metering Port	21	Propeller Shaft Engine Oil Passage
5	Rotating Cam	16	Inboard Piston End	24	Distributor Valve Oil Seal Rings
6	Distributor Valve	18	Propeller Shaft Governor Oil Passage	30	Piston Bleed Hole
9	Governor Pilot Valve	19	Propeller Shaft Oil Transfer Rings	39	Engine Oil Pump

Figure 124—Propeller Operating Diagram—On-Speed Condition

SCHEMATIC OPERATING DIAGRAM — OVERSPEED CONDITION



No.	NAME	No.	NAME	No.	NAME
2	Double Acting Piston	14	Governor Speeder Spring	23	Blade Angle Schematic Diagram
4	Fixed Cam	15	Propeller-Governor Metering Port	27	Distributor Valve Spring
5	Rotating Cam	16	Inboard Piston End	28	Distributor Valve Outboard Outlet & Inlet
7	Constant Speed Control Unit (or Governor)	17	Distributor Valve Inboard Outlet & Inlet	31	Distributor Valve Port
8	Governor Booster Gear Pump	18	Propeller Shaft Governor Oil Passage	32	Distributor Valve Port
9	Governor Pilot Valve	19	Propeller Shaft Oil Transfer Rings	33	Distributor Valve Port
10	Governor Fly-Weights	20	Outboard Piston End	36	Distributor Valve Land
11	Governor Relief Valve	21	Propeller Shaft Engine Oil Passage	37	Distributor Valve Land
12	Governor Dump Valve	22	Cam Rollers	38	Distributor Valve Land

Figure 125—Propeller Operating Diagram—Overspeed Condition

solid black section in *(23)* than that required as shown by the dotted lines. The arrow in *(23)* represents the direction in which the blades will move to bring the propeller on-speed.

(a) OIL FLOW.—When the engine speed increases above the rpm for which the governor *(7)* is set, the fly-weights *(10)* move outward against the force of the speeder spring *(14)* raising the pilot valve *(9)* which opens the propeller-governor metering port *(15)*. This allows governor oil to flow from the governor booster pump *(8)*, through the propeller-governor metering port *(15)*, into the engine oil transfer rings *(19)*. From the rings the oil passes through the propeller shaft governor oil passage *(18)*, through the distributor valve port *(33)*, between distributor lands *(37)* and *(38)*, and then into the inboard piston end *(16)* entering from the distributor valve inboard outlet *(17)*.

(b) PROPELLER ACTION.—As a result of this flow, the piston *(2)* and the attached rollers *(22)* move outboard, and the rotating cam *(5)* is turned by virtue of the cam track arrangement previously described. As the piston moves outboard, oil is displaced from the outboard piston end *(20)*. This oil enters the distributor valve outboard inlet *(28)*, flows through distributor valve port *(32)*, past the outboard end of valve land *(38)*, through port *(31)*, into the propeller shaft engine oil passage *(21)*. From that point it is dissipated into the engine lubricating system. The same balanced forces exist across the distributor valve during overspeed correction as during underspeed, except that oil at governor pressure replaces oil at drain pressure on the inboard end of valve land *(36)*, and between lands *(37)* and *(38)*.

(c) RESULT.—Outboard motion of the piston moves the propeller blades toward a higher angle, which in turn decreases the engine rpm. A decrease in engine rpm brings about a corresponding decrease in the rotating speed of the governor fly-weights *(10)*. As a result, the fly-weights are moved inward by the force of the speeder spring *(14)*, the pilot valve is lowered, and the propeller-governor metering port *(15)* is closed. Once this port has been closed, oil flow to or from the propeller practically ceases, and the propeller and governor operate on-speed.

Note

The net pressure available for moving the blades to a higher angle is the difference between the pressure on the inboard piston end *(16)* and the outboard piston end *(20)*. This net pressure could vary considerably as a result of variations in engine pressure. To provide for this, the governor relief valve *(11)* is backed by engine oil pressure which supplements the force of the relief valve spring. In this way, the net

Note—Continued

pressure conditions across the propeller piston *(2)* are duplicated across the governor relief valve *(11)*, and adequate oil force to move the piston is assured. Similar compensating engine oil pressure is applied to the outboard end of the distributor valve.

(d) DUMP VALVE ACTION.—If the propeller mechanism reaches its limit of travel (in a non-feathering installation) without satisfying the requirements for on-speed operation, or is somehow prevented from going to a higher pitch, the pressure in the propeller line will build up until it is sufficient to open the governor dump valve *(12)*. At a flow of about 2-1/2 quarts per minute (approximately .52 Imp. gal. per minute), a pressure drop results in the line connecting the spring chamber of the governor relief valve *(11)* to the output of the booster pump which is somewhat greater than the pressure equivalent of the relief valve spring. This produces a pressure differential across the relief valve sufficient to cause the valve to open against the spring and the major portion of the pump output is bypassed.

c. FEATHERING OPERATION.
(See figure 127.)

(1) OPERATION OF FEATHERING ACCESSORIES.—A typical Hydromatic propeller feathering accessory installation is shown in figure 126. When the feathering push-button switch is depressed, the low current circuit is established from the battery through the push-button holding coil, and from the battery through the solenoid relay. As long as the circuit remains closed, the holding coil keeps the push-button in the depressed position. Closing the solenoid establishes the high current circuit from the battery into the feathering motor-pump unit. The feathering pump picks up engine oil from the oil supply tank, boosts its pressure (if necessary, to the relief valve setting of the pump), and supplies it to the governor high pressure transfer valve connection *(25)*, shown in figures 127 and 128.

(2) GOVERNOR AND PROPELLER OPERATION.

(a) Auxiliary oil entering the high pressure transfer valve connection *(25)* shifts the governor transfer valve *(26)*, which hydraulically disconnects the governor from the propeller, and simultaneously opens the propeller-governor oil line to auxiliary oil.

(b) The oil flows through the engine transfer rings *(19)*, through the propeller shaft governor oil passage *(18)*, through distributor valve port *(33)*, between lands *(37)* and *(38)*, and finally to the inboard piston end *(16)* entering from the valve inboard outlet *(17)*.

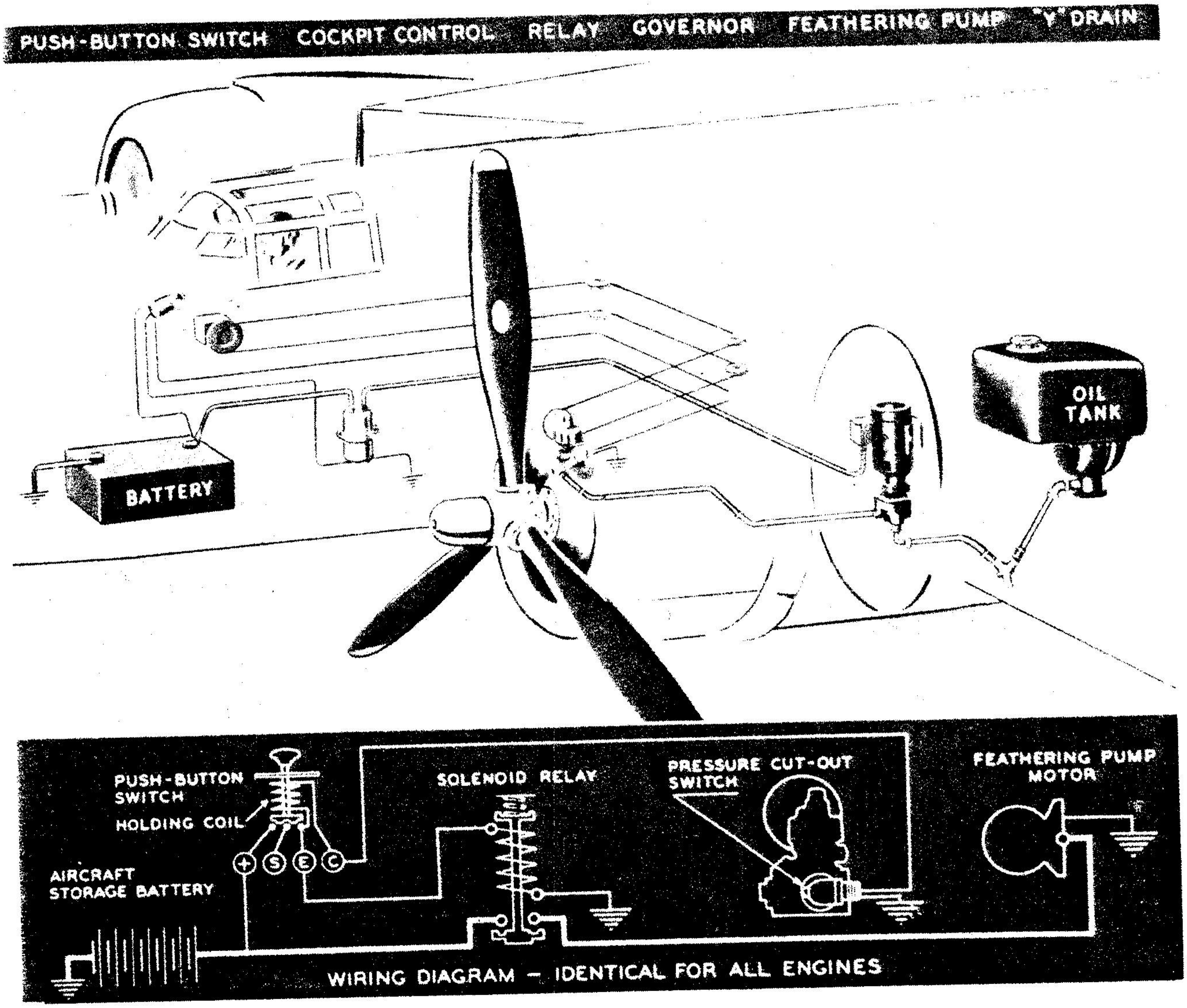


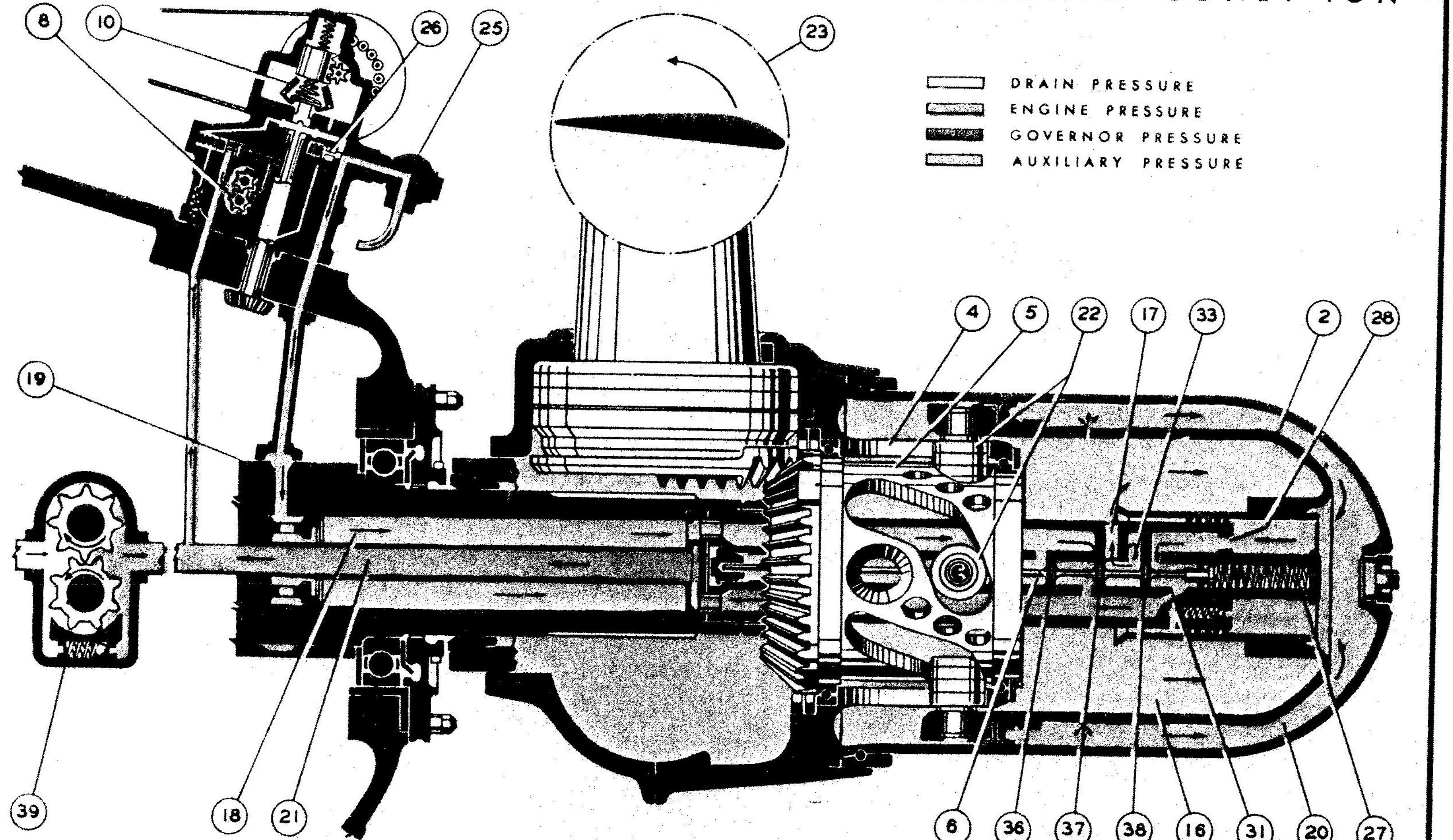
Figure 126—Typical Feathering Installation

Note

The distributor valve *(6)* does not shift during the feathering operation. It merely provides oil passages to the inboard piston end for auxiliary oil, and the outboard piston end for engine oil. The same conditions as described in UNDERSPEED exist in the distributor valve except that oil at auxiliary pressure replaces drain oil at the inboard end of land *(36)*, and between lands *(37)* and *(38)*. The distributor valve spring *(27)* is backed up by engine oil pressure which means that at all times the pressure differential required to move the piston will be identical with that applied to the distributor valve.

(3) PROPELLER ACTION.—The propeller piston *(2)* moves outboard under the auxiliary oil pressure at a speed proportional to the rate at which oil is supplied. This piston motion is transmitted through the piston rollers *(22)* operating in the oppositely inclined cam tracks of the fixed cam *(4)* and the rotating cam *(5)* into blade twisting moment through the bevel gears. Only during feathering (or unfeathering) is the low mechanical advantage portion of the cam tracks which lies between the break and the outboard end of the track profile used. Oil at engine pressure displaced from the outboard piston end *(20)* flows through the distributor valve outboard inlet *(28)*, past the outboard end of land *(38)*, through port *(31)*, into the propeller shaft engine oil passage *(21)*, and is finally delivered into the engine lubricating system. As indicated in the blade cross-section diagram *(23)*, the blades move toward the full high pitch, (or feathered) angle.

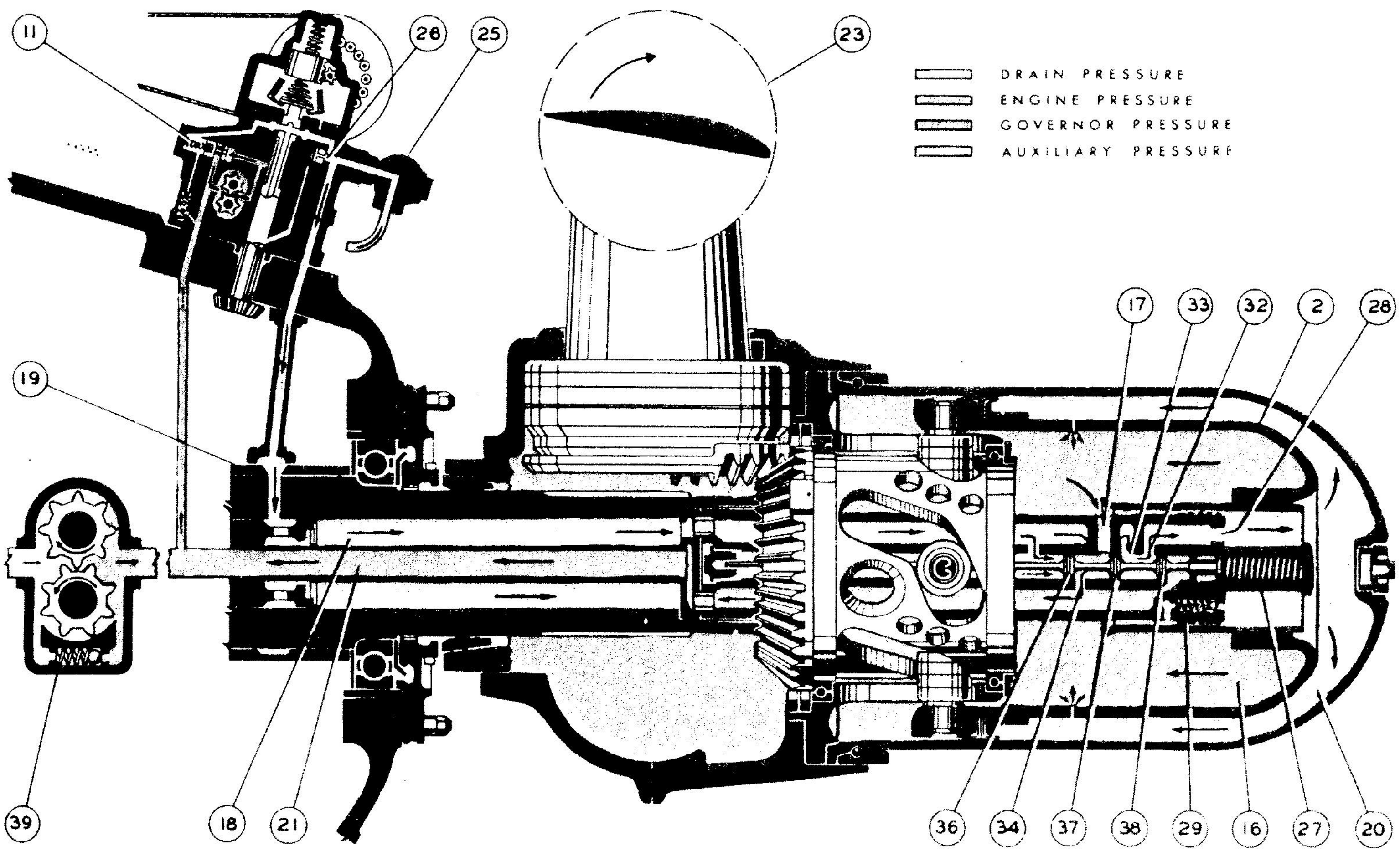
SCHEMATIC OPERATING DIAGRAM—FEATHERING CONDITION



No.	NAME	No.	NAME	No.	NAME
2	Double Acting Piston	18	Propeller Shaft Governor Oil Passage	27	Distributor Valve Spring
4	Fixed Cam	19	Propeller Shaft Oil Transfer Rings	28	Distributor Valve Outboard Outlet & Inlet
5	Rotating Cam	20	Outboard Piston End	31	Distributor Valve Port
6	Distributor Valve	21	Propeller Shaft Engine Oil Passage	33	Distributor Valve Port
8	Governor Booster Gear Pump	22	Cam Rollers	36	Distributor Valve Land
10	Governor Fly-Weights	23	Blade Angle Schematic Diagram	37	Distributor Valve Land
16	Inboard Piston End	25	Governor High Pressure Transfer Valve Elbow	38	Distributor Valve Land
17	Distributor Valve Inboard Outlet & Inlet	26	Governor High Pressure Transfer Valve	39	Engine Oil Pump

Figure 127—Propeller Operating Diagram—Feathering Condition

SCHEMATIC OPERATING DIAGRAM — UNFEATHERING CONDITION



No.	NAME	No.	NAME	No.	NAME
2	Double Acting Piston	21	Propeller Shaft Engine Oil Passage	32	Distributor Valve Port
11	Governor Relief Valve	23	Blade Angle Schematic Diagram	33	Distributor Valve Port
16	Inboard Piston End	25	Governor High Pressure Transfer Valve Elbow	34	Distributor Valve Port
17	Distributor Valve Inboard Outlet & Inlet	26	Governor High Pressure Transfer Valve	36	Distributor Valve Land
18	Propeller Shaft Governor Oil Passage	27	Distributor Valve Spring	37	Distributor Valve Land
19	Propeller Shaft Oil Transfer Rings	28	Distributor Valve Outboard Outlet & Inlet	38	Distributor Valve Land
20	Outboard Piston End	29	Dome Relief Valve	39	Engine Oil Pump

Figure 128—Propeller Operating Diagram—Unfeathering Condition

(4) RESULT.—Having reached the full-feathered position, further movement of the mechanism is prevented by contact between the high angle stop ring in the base of the fixed cam *(4)* and the stop lugs set in the teeth of the rotating cam *(5)*. The pressure in the inboard piston end *(16)* now increases rapidly, and upon reaching the pressure for which the electric cut-out switch shown in figure 126, is set, the switch automatically opens. This pressure is less than that required to shift the distributor valve. Opening of this switch de-energizes the holding coil and releases the feathering push-button control switch. Release of this switch breaks the solenoid relay circuit which in turn shuts off the feathering pump motor. The pressure in both the inboard end *(16)* and the outboard end *(20)* of the piston drops to zero, and the propeller blades remain in the feathered position by virtue of balanced aerodynamic forces. The governor high pressure transfer valve *(26)* shifts to its normal position once the pressure in the propeller-governor line drops below that required to hold the valve in the open position.

d. UNFEATHERING OPERATION.
(See figure 128.)

(1) OPERATION OF ACCESSORIES DURING UNFEATHERING.—To unfeather a Hydromatic propeller, the pilot depresses ***and holds in*** the feathering switch push-button control switch. As in the case of feathering a propeller, this completes the low current control circuit from the battery, through the holding coil, and also from the battery through the solenoid. Closing the solenoid establishes the high current circuit from the battery through the motor-pump unit, and the pump supplies oil at a high pressure to the governor transfer valve.

(2) GOVERNOR AND PROPELLER OPERATION.—Auxiliary oil entering through the high pressure transfer valve connection *(25)* shifts the governor transfer valve *(26)* and disconnects the governor from the propeller line and in the same operation auxiliary oil is admitted. The oil flows through the engine oil transfer rings *(19)*, through the propeller shaft governor oil passage *(18)*, and into the distributor valve assembly.

(3) PROPELLER ACTION.

(a) When the unfeathering operation begins, the piston *(2)* is, of course, in the extreme outboard position, and the oil enters the inboard piston end *(16)* through the distributor valve inboard outlet *(17)*. As the pressure on the inboard end of the piston increases, the pressure against distributor valve land *(36)* builds up, and when it becomes greater than the combined opposing force of the distributor valve spring *(27)* and the oil pressure behind this spring, the valve shifts. Once the valve shifts, the passages through the distributor valve assembly to the propeller are reversed. Shifting the valve opens a passage from port *(33)*, between lands *(37)* and *(38)*, through port *(32)*, to the outboard piston end through distributor valve outlet *(28)*.

(b) As the piston moves inboard under the auxiliary pressure, oil is displaced from the inboard piston end *(16)* through inlet *(17)*, between lands *(37)* and *(36)*, through port *(34)*, and into the propeller shaft engine oil passage *(21)* where it is discharged into the engine lubricating system.

(c) At the same time the pressure at the cut-out switch (see figure 126) increases and the switch opens. However, the circuit to the feathering pump and motor unit remains complete so long as the pilot holds in the feathering switch.

(4) RESULT.

(a) With the inboard end of the propeller piston connected to drain, and auxiliary pressure flowing to the outboard end of the piston, the piston moves inboard, unfeathering the blades as indicated in the blade cross-section diagram *(23)*. As the blades are unfeathered, they begin to windmill assisting the unfeathering operation by the added force toward low pitch brought about by centrifugal twisting moment. When the engine speed has increased to approximately 1000 rpm, the operator manually releases the feathering switch, and in doing so shuts off the feathering pump motor. The pressure in the distributor valve and at the governor transfer valve *(26)* decreases, allowing the distributor valve to shift under the action of the valve spring *(27)*, and allowing the transfer valve to shift under the action of the governor high pressure transfer valve spring. This action reconnects the governor with the propeller, and establishes the same oil passages through the distributor valve as are used during constant speed and feathering operations.

(b) The dome relief valve *(29)* is designed to prevent excessive pressures in the outboard cylinder end should the propeller be unfeathered to a point where the mechanism is against the positive low angle stop. This condition occurs when the pilot continues to hold the push-button control switch in after the propeller is unfeathered. The dome relief valve is set at a pressure which is adequate to allow unfeathering the propeller under all conditions, but is considerably less than the maximum pressure capable of being supplied by the feathering pump. As in the case of the distributor valve spring *(27)*, the dome relief valve *(29)* is backed up by engine oil pressure which insures adequate oil pressure for unfeathering regardless of the back pressure set up when the piston displaces oil into the engine lubricating system. Should the mechanism be unfeathered against the low pitch stops, the dome relief valve *(29)* opens and allows the high pressure oil to flow from the outboard piston end *(20)* to the inboard piston end *(16)*.

e. DOUBLE-ACTING PROPELLER OPERATION.—Basically, double-acting propeller operation is very similar to that of the single-acting type, the difference being that governor oil is directed to either side of the propeller piston in the double-acting type as the operating condition requires. This makes necessary two lines from the governor, one to each side of the piston. No distributor valve is used since direction of oil flow is determined within the governor for all operating conditions. Propeller return oil goes back to the governor and is used over again, rather than going into the engine oil system. Consult the applicable Handbook for a detailed description of the governor.

(1) UNDERSPEED.—If the engine speed drops below the rpm for which the governor is set, the speeder spring moves the pilot valve downward. Oil on the inboard side of the propeller piston is drained to the intake side of the governor pump while governor pump oil, through the *outboard* governor-propeller line, is directed to the outboard side of the propeller piston. This action moves the piston in an inboard direction, the blades are turned to a lower angle (with the assistance of the centrifugal twisting moment force), and the propeller is returned to on-speed operation.

(2) ON-SPEED.—During on-speed operation the oil is held in the propeller to maintain a constant blade angle. The governor supplies to the propeller only enough oil to equalize that lost through normal internal leakage.

(3) OVERSPEED.—If the engine speed increases above the rpm for which the governor is set, the increased centrifugal force of the fly-weights raises the pilot valve. Oil on the outboard side of the propeller piston is drained to the intake side of the governor pump while oil at governor pump pressure is directed to the inboard side of the propeller piston through the *inboard* governor-propeller line. This action moves the piston in an outboard direction, the blade angle is increased, and the propeller is returned to on-speed operation.

(4) FEATHERING.—In order to feather the propeller, the feathering switch button is *pushed in*, operating the auxiliary pump which delivers high pressure oil to the inboard side of the propeller piston, through the *inboard* governor-propeller line, after first raising the pilot valve to an artificial overspeed position. Oil on the outboard side of the piston drains, through the outboard governor-propeller line, to the intake side of the governor pump. This permits the governor pump oil to assist the high pressure oil in moving the piston in an outboard direction, which continues, beyond the constant speed range, until mechanically stopped when the blades reach the predetermined feathering angle. The auxiliary pump is stopped when the cut-out switch opening pressure is reached.

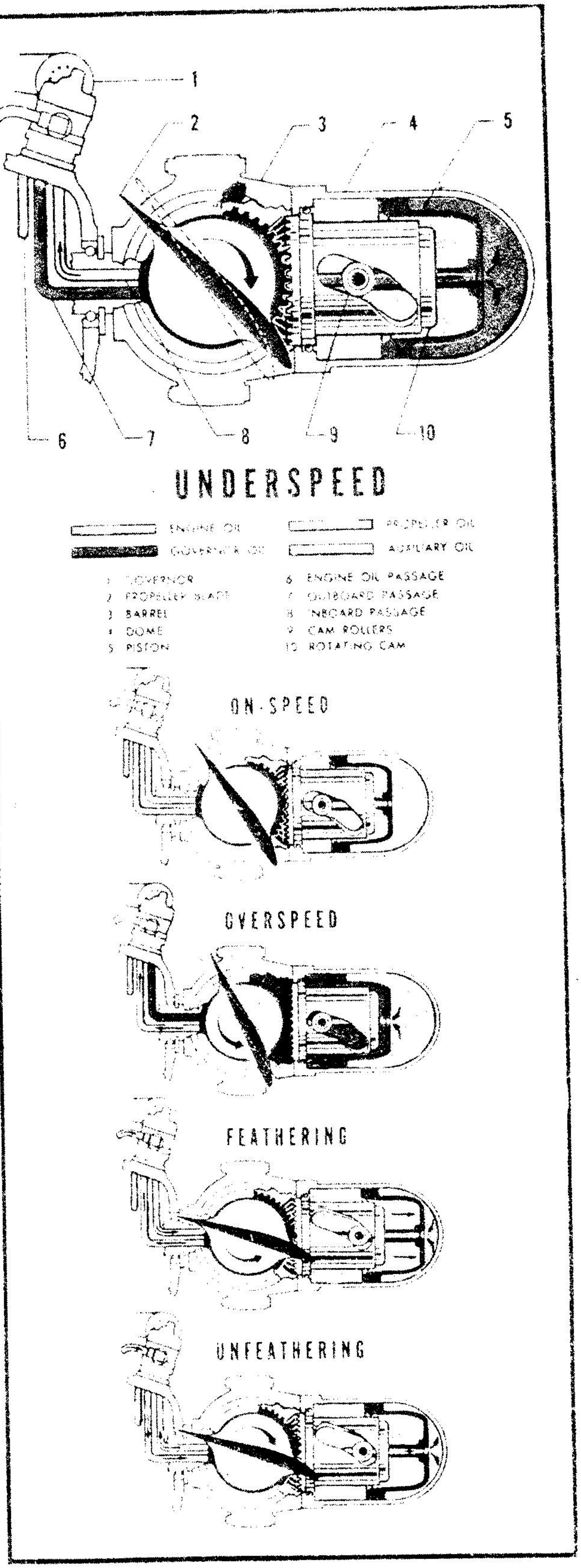


Figure 129—Double-Acting Propeller Operating Diagrams

(5) UNFEATHERING.—Unfeathering is accomplished by *pulling out and holding out* the feathering switch button, thereby operating the auxiliary pump which delivers high pressure oil to the outboard side of the propeller piston, through the *outboard* governor-propeller line. Oil on the inboard side of the piston drains, through the *inboard* governor-propeller line, to the intake side of the governor pump. This causes the piston to be moved in an inboard direction and the blades to be turned toward low pitch. As soon as the propeller starts to rotate, the governor pump oil assists the auxiliary high pressure oil in unfeathering the propeller. When the rpm has reached approximately 1000, the feathering switch button should be released in order to stop the auxiliary pump motor and return the propeller to governor operation.

2. PRINCIPLES OF OPERATION—OTHER MODELS.

a. GENERAL.—The principles of operation of all other models is identical with those described in paragraph 1 for the 23E50 model except that a "dome-dumping" type of distributor valve is used. Operation of the dome-dumping valve is described in the following paragraph.

b. OPERATION.

(1) DESCRIPTION.—The piston oil seal ring sleeve incorporates (toward the outboard end) a series of holes which extend completely around the periphery of the sleeve. These holes are identified by the letter (D) in figures 130, 131, and 132. Dump type valves include two sets of oil seal rings. The three inboard rings separate governor oil on the inboard piston side from engine oil on the outboard piston side during constant speed operation and feathering. During unfeathering, the two outboard rings separate auxiliary oil on the outboard piston side from engine oil on the inboard side. The outboard set of rings is identified as (B), and the inboard rings as (A) in the drawings mentioned above. The valve also includes a port between these rings which is identified here as (C).

(2) CONSTANT SPEED. (See figure 130.)—During constant speed operation the holes *(D)* in the piston oil seal ring sleeve operate within the outboard rings *(B)* and the inboard rings *(A)*. With the sleeve holes in this position, the dump port *(C)* in the distributor valve (which is connected to the engine oil passage inside the valve) is open to engine oil on the outboard side of the piston. Under these conditions, oil pressure is equalized on both sides of the dump port and no oil flow takes place.

(3) FEATHERING. (See figure 131.)—During propeller feathering, the holes *(D)* in the piston sleeve pass over the outboard oil seal rings *(B)* and close off the

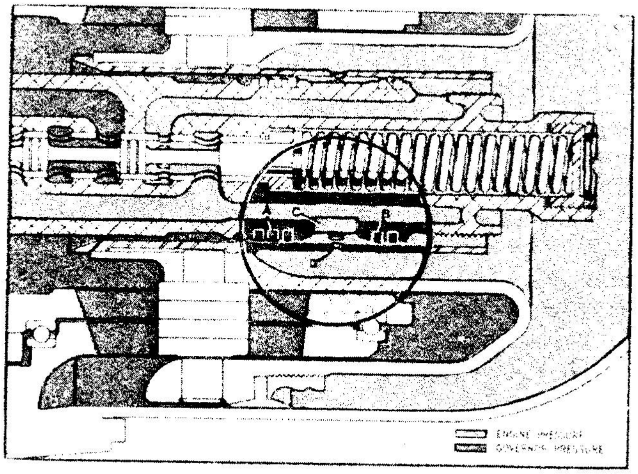


Figure 130—Dome-Dumping Type Distributor Valve Operating Diagram—Constant Speed Condition

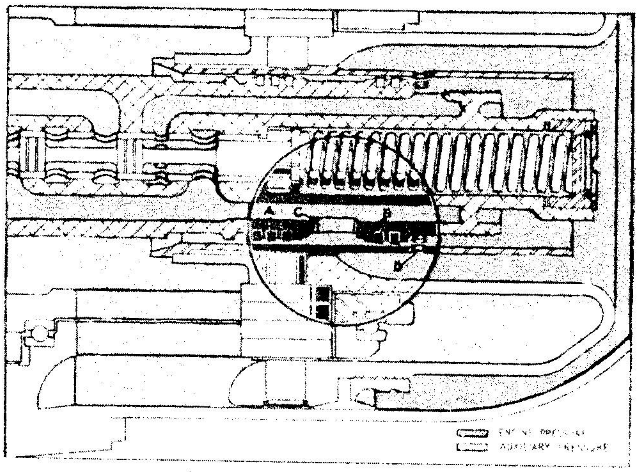


Figure 131—Dome-Dumping Type Distributor Valve Operating Diagram—Feathering Condition

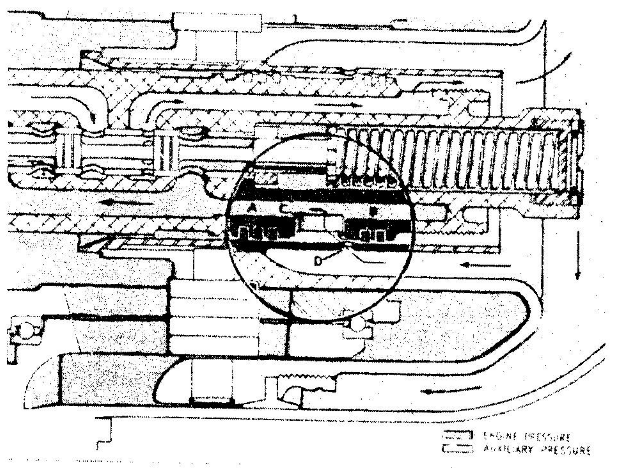


Figure 132—Dome-Dumping Type Distributor Valve Operating Diagram—Unfeathering Condition

dump port. This arrangement makes the dump valve inoperative during feathering operation of the propeller.

(4) UNFEATHERING. (See figure 132.)—When the propeller is unfeathered, the holes *(D)* in the oil seal ring sleeve move inboard and pass the rings *(B)*. This opens a passage from the outboard side of the piston, through the dump port *(C)*, into the engine oil passage in the distributor valve. The resulting oil flow, which takes place at a blade angle of about 25 degrees above the minimum low pitch setting, drains sufficient oil from the outboard piston side to protect the low pitch stop ring lugs from excessively high loads which would result if the piston were allowed to move to the full low pitch position under auxiliary unfeathering pressure.

3. OPERATION INSTRUCTIONS.

a. GROUND TESTS.—The procedures outlined in this paragraph are *suggestions* for operation of the Hydromatic propeller. To account for various changes in this procedure which are peculiar to any given installation, consult the engine or aircraft manufacturer's Handbooks.

(1) GOVERNING ACTION.

(a) After completion of propeller installation, move the blades into low pitch by means of blade persuaders. Before any tests are run, make certain that the correct angular relationship between the rotating cam gear and the blade gear segments has been established. This can be checked by using a protractor at the blade reference station, or by noting whether the scribe mark on the shank of each blade is aligned with the correct low pitch angle degree mark stamped on the external lip of the barrel blade bore. This low pitch angle should agree with the low pitch stop setting in the dome assembly.

(b) Set the cockpit governor control to the high rpm position, and then start the engine and warm it up in accordance with the engine operating instructions for the installation. When the engine is started, the outboard end of the propeller dome will fill with engine oil at normal engine pressure for a single-acting governor and with governor pump oil for a double-acting governor. This pressure, in conjunction with the blade centrifugal twisting moment, will hold the blades against the low pitch stops. With the propeller blades in full low pitch, and the actual engine rpm lower than that for which the governor is set, the engine rpm will vary with engine horsepower output. Under this condition, the magnetos may be checked at suitable power by watching the tachometer for a drop in rpm as the magneto switch is turned.

(c) After completing the engine warm-up period, advance the throttle to some intermediate (65 to 70 percent of normal rated) engine speed; for example, 1800 rpm. Move the governor cockpit control to the minimum rpm position. At this control setting, the engine will be turning faster than the speed for which the governor is set, and the governor will supply oil to the inboard side of the propeller piston. In 35 to 45 seconds, the inboard end of the propeller dome will have been filled with oil, and the propeller blades will move toward a higher pitch. This action will change the engine rpm to the minimum governor setting.

(d) After the inboard and outboard ends of the dome have been filled with oil, move the governor control several times between the minimum and the maximum settings (allowing time for the engine speed to follow the propeller control) to eliminate trapped air from the propeller system. Care must be taken that engine operating temperatures are not exceeded.

(e) Then move the governor control to the high rpm position, advance the throttle, and make the customary check of manifold pressure against engine rpm.

(2) FEATHERING AND UNFEATHERING TESTS.—The test procedure for feathering and unfeathering a propeller on the ground, described in this section, is based on the assumption that an individual, electrically driven feathering pump is used. If any other system is used in the aircraft, consult the aircraft manufacturer's operating handbook for specific instructions.

(a) Complete the ground test of governing action as just outlined. With the engine operating at approximately 1500 rpm and 22 inches Hg. manifold pressure, depress the feathering switch. When the propeller has reached the full-feathered position, the switch will automatically open, and the engine rpm will have decreased to approximately 500.

Note

Torching at the exhaust outlet may occur with some engines. Usually the engine will continue to run after the propeller has been completely feathered on the ground. In this case, engine oil pressure maintained on the outboard piston side may be sufficient to unfeather the propeller without assistance from the feathering pump. This condition will be evidenced by a slow but steady increase in rpm.

(b) Immediately after the feathering test has been satisfactorily completed, again depress the push-button switch, and hold it down while the propeller is being unfeathered until the engine rpm increases to approximately 1000. With the double-acting propeller, the switch is *pulled out* and *held out* to unfeather.

(c) Release the push-button switch. The engine will return to the control of the governor.

CAUTION

To avoid overloading the engine sump, do not repeat the feathering and unfeathering test until the engine has run for at least two minutes at approximately 1000 rpm.

(d) The above method of testing the feathering operation with the engine running has several important advantages not attainable when feathering is carried out with the engine stationary. They are: one, it is *not* necessary to drain the engine sump after a feathering cycle (to avoid loading the engine with oil) since the engine scavenge pumps return the excess oil to the tanks; two, the oil is hot and the propeller feathers and unfeathers faster and on a lower pump pressure, thereby reducing the load on the electrical system; three, the hot oil and rotating engine parts allow a lower engine oil back pressure during feathering and unfeathering (this back pressure is caused by the displacement of approximately three quarts (.625 Imp. gals.) of propeller oil into the engine lubricating system when the propeller is feathered or unfeathered); and four, the feathering test is made with oil of relatively low viscosity which approaches more closely the conditions under which the propeller would be feathered in flight.

b. FLIGHT TESTS.—This procedure again assumes that the individual, electric motor driven feathering pump system is used. If any other type of auxiliary pressure supply is incorporated in the installation, the procedure should be modified in accordance with the engine and airplane maufacturers' specifications.

(1) FEATHERING PROCEDURE.—Operating the controls in accordance with the procedure outlined below will permit feathering the propeller in the shortest possible time. If the throttle is closed before the feathering push-button switch is operated, the propeller will move to a lower pitch which increases the time required for the blades to reach the full-feathered position. However, if the governor control is moved to a lower governing speed before the feathering push-button switch is actuated, the blades would assume a higher angle, but at a rate somewhat slower than if the propeller were operated by the feathering pump. Again, the net time to feather the propeller will be longer.

(a) EMERGENCY FEATHERING PROCEDURE.

1. Depress feathering switch.

2. Turn off auxiliary supercharger.

3. Turn off fuel booster pump.

4. Move throttle to "CLOSED" position.

5. Set mixture control to "IDLE CUT-OFF" position.

6. Turn off fuel supply to engine whose propeller is being feathered.

7. Turn off ignition switch after propeller has stopped turning.

8. Turn off generator switch of the engine with feathered propeller.

(b) PRACTICE OR TEST FEATHERING PROCEDURE.—To avoid hydraulic lock and excessive oil cooling in the lower engine cylinders, keep to a minimum the length of time the propeller is left in the feathered position during these tests.

1. Turn off auxiliary supercharger.

2. Reduce rpm and manifold pressure.

3. Depress feathering switch.

4. Turn off fuel booster pump.

5. Move throttle to "CLOSED" position.

6. Set mixture control to "IDLE CUT-OFF" position.

7. Shut off fuel supply to engine whose propeller is being feathered.

8. Turn off ignition switch after propeller has stopped turning.

9. Turn off generator switch of the engine with feathered propeller.

(c) Relevant aircraft EOs should be consulted for feathering procedures for specific aircraft.

Note

In the case of centrifugal booster pumps and positive displacement pumps with integral relief valves, the fuel supply may be shut off before the booster pump is stopped without damage; however, in the case of positive displacement pumps without integral relief valves, failure to turn off the pump before shutting off the fuel supply may lead to dangerous pressures in the fuel system.

(2) UNFEATHERING PROCEDURE. — Caution should be taken regarding unfeathering in cases where the propeller was feathered because of a damaged engine, as returning the engine to operation may result in further damage. Under such conditions, it may prove impossible to feather the propeller again due to damage to oil passages in the engine. Army Air Forces activities will unfeather propellers following emergency feathering only when use of the engine is required for landing or continued flight.

(a) Move governor control to minimum rpm position.

(b) Crack throttle open to approximate starting position.

(c) Depress feathering button and hold it in place until engine speed is approximately 1000 rpm. With a double-acting propeller, the switch is *pulled out* and *held out* for unfeathering.

(d) Turn on ignition switch after propeller has turned at least three revolutions.

(e) Turn on fuel supply.

(f) Turn on fuel booster pump.

(g) After fuel pressure is attained, move mixture control to "AUTO-RICH" and adjust throttle to proper manifold pressure for engine warm-up.

(h) When engine reaches approximately 1000 rpm, turn on generator and release feathering push-button switch.

(i) Allow engine to warm up at low rpm.

(3) GENERAL CAUTIONS.—In connection with the feathering and unfeathering operations of the propeller, the following points are important:

(a) Starting the feathering auxiliary pump, or otherwise applying high pressure oil to the system for feathering or unfeathering the propeller, automatically disconnects the single-acting type governor from the system by means of a pressure-actuated transfer valve in the governor. (In the double-acting governor the auxiliary oil acts directly on the pilot valve to position it for either feathering or unfeathering. Pump output oil supplements the auxiliary oil. A check valve prevents reverse flow through the pump.) Upon reopening the feathering 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 rpm, at the time when the high pressure is discontinued, is sufficient to provide adequate control forces toward low pitch (approximately 500 rpm minimum).

(b) The operation of the distributor valve (used on single-acting propellers only) is such that the blades cannot be unfeathered, *by means of auxiliary high pressure oil*, until they have *first* reached the full-feathered position. Thus, after an interruption in the flow of high pressure oil, a reapplication of the auxiliary pressure will cause the propeller to move toward the feathered position regardless of whether its direction of motion, prior to the interruption, was toward feathering or unfeathering.

(c) From the two preceding paragraphs, it is evident that should the feathering switch be closed (or the high pressure oil applied) inadvertently, the feathering action can be stopped, and the propeller returned to governor control by manually reopening the push-button switch (or discontinuing the high pressure supply) providing the rpm has not been reduced below about 500. If the accidental operation of the feathering switch has resulted in complete (or nearly complete) feathering, the propeller should, of course, be unfeathered in the normal manner.

(d) Oil pressure is not required to hold the blades in the full-feathered position. Proper setting of the high pitch (or feathered) stop can be checked by noting any tendency for the propeller to rotate. Once the blades have been feathered and rotation stopped, torque-producing, aerodynamic forces are in equilibrium and the propeller will not windmill.

(e) Due to viscous oil in the propeller system at low temperatures, difficulty may be encountered with the pressure at the cut-out switch reaching the operating pressure of the switch before the propeller reaches the fully feathered position. This causes the feathering switch to release prematurely. If this condition is encountered, the feathering switch should be depressed each time it releases. The switch should not be held in continuously as the pressure may then build up sufficiently to shift the distributor valve and cause the propeller to start to unfeather before reaching the feathered position.

(f) If, for any reason, the feathering switch fails to release when the propeller reaches the feathered position, the distributor valve will shift to the unfeathering position and an increase in engine rpm will be noted. In such cases, the feathering switch should be pulled out immediately. After a delay of two or three seconds, to allow the valve to shift back to the feathered position, the switch should again be depressed. When the feathered position is reached as indicated by cessation of propeller windmilling, or by the rpm reaching a minimum, the feathering switch should be manually pulled out to avoid unfeathering.

c. FLIGHT OPERATION.

(1) TAKE-OFF.—Move the propeller control into the full take-off rpm position. Advance the throttle and adjust the manifold pressure to the take-off rating recommended for the installation.

(2) CLIMB.—For the climbing operation immediately following take-off, first reduce the manifold pres-

sure and then the propeller control to the climbing condition specified for the engine.

(3) HIGH SPEED.—Set the propeller and throttle controls in the maximum allowable positions for continuous operation.

(4) ECONOMICAL CRUISING.—Once the engine rmp has been adjusted, it will be held constant by the propeller governor. Since changes in the attitude and altitude of the aircraft, as well as changes in the engine manifold pressure, can be made without altering the rpm, any changes required in the cruising rpm or manifold pressure settings are to be made by first setting the propeller control to the desired rpm and then adjusting the manifold pressure.

(5) MAXIMUM ENDURANCE.—Reduce the rpm to the lowest permissible for the manifold pressure required to maintain the selected air speed. Adjust the throttle and mixture control.

(6) POWER DESCENT.—Power descent operation in which the power absorption limits of the propeller are not exceeded is fully taken care of by the constant speed control unit; that is, as the air speed increases in the descent, the governor will move the propeller blades to a higher pitch in order to hold the rpm at the desired value. Set the governor control to obtain the correct rpm for the power selected.

(7) POWER DIVE.—Move the propeller-governor control and throttle into the desired position. Manifold pressure should not be allowed to exceed the maximum power rating.

(8) APPROACH AND LANDING.—Set the propeller-governor control to approximately the maximum cruising position, and move the mixture control to the automatic rich position. With these settings, the power output of the engine is controlled by the throttle during the approach and glide. Advance the throttle and propeller controls evenly and smoothly during all operations.

(9) STOPPING ENGINES.—Move the propeller-governor control to the maximum rpm position. Follow the procedure outlined in the applicable technical publication to shut down the engines.

(10) DE-ICING OPERATION.—For de-icing, the cockpit control should be operated to admit the de-icing fluid to the propeller as directed by the operating instructions for the installation.

d. EMERGENCY OPERATION.

(1) OVERSPEEDING.—Care should be taken to distinguish between the momentary overspeeds which may occur in violent maneuvers (or if the manifold pressure is increased suddenly) and true run-aways in which the propeller is uncontrollable and may reach extremely high speeds. The former are due to the time lag required for the governor to react and the propeller to change pitch. The increase in rpm over the governor setting is not large, and after a brief period, the rpm returns to the governor setting. With regard to a run-away propeller, several causes should be kept in mind.

(a) While ordinarily a run-away propeller on a multi-engine aircraft should be promptly feathered, under certain critical flight conditions such as during take-off, it may be advisable to continue the propeller in operation by reducing the manifold pressure in order to utilize all possible power, or even to allow the rpm to reach high values until the immediate emergency is passed. The proper procedure to be followed in most cases depends upon a number of conditions, such as the aircraft type, and attention should be given to the pilot's operating instructions in the applicable technical Handbooks. If severe vibration of any part of the aircraft occurs, the propeller should immediately be feathered.

(b) A slow increase in rpm at high altitude usually is indicative of insufficient oil supply to the propeller. When this condition is noted, the manifold pressure and speed should be reduced to prevent a further increase in rpm. If reducing the manifold pressure does not prevent an increase in rpm, the propeller should be feathered and the altitude decreased to the level where proper propeller operation last occurred.

(c) Discharge of a large quantity of oil, usually at high altitude, from the engine breather is indicative of cavitation of the engine oil pump. If this occurs, an attempt should immediately be made to feather the propeller, and altitude of the aircraft should be decreased to the level where proper functioning of the propeller last occurred.

Note

Loss of a small quantity of oil through the breather sometimes occurs during normal flight operation, and it is not necessarily an indication of scavenging pump cavitation. If the discharge through the breather assumes appreciable quantities, or if a small loss persists for a long period of time, the altitude of the aircraft should be decreased.

(2) FAILURE TO FEATHER.—If, due to combat damage or other causes, it is impossible to feather the propeller, an attempt should be made to windmill the propeller at the lowest possible rpm. As the windmilling rpm is proportional to the air speed, it is desirable to fly at not more than 20 to 30 mph above the stalling speed. The controls on the windmilling engine should be placed in the following positions.

(a) Propeller control in full "DECREASE RPM".

(b) Mixture control in "IDLE CUT-OFF".

(c) Ignition switch "OFF".
(d) Throttle fully "CLOSED"
(e) Fuel supply "OFF".
(f) Cross feed "OFF".

Note

If severe vibration occurs, it should be reduced or minimized by flying at the minimum air speed practicable. In cases where it is necessary to fly at higher air speeds than previously noted, in order to maintain position and formation for security reasons, the controls should be placed in the positions described.

e. COLD WEATHER OPERATING INSTRUCTIONS.—When operating under conditions requiring dilution of the engine oil system, diluted oil should be provided to the propeller dome and feathering system, in accordance with the following procedure, during the last two minutes of the dilution.

(1) With feathering propellers, close the propeller feathering switch long enough to produce a drop of 400 engine rpm. Pull the switch out to release and allow the rpm to return to normal. Repeat this operation three times. In the case of aircraft provided with separate dilution switches for the feathering system, care should be taken to close these switches during the period the feathering switch is depressed.

(2) With non-feathering propellers, operate the propeller control to obtain a change of approximately 400 rpm. Repeat this procedure three times.

SECTION V

SERVICE INSPECTION, MAINTENANCE, AND LUBRICATION

1. SERVICE TOOLS REQUIRED.

Note

The tools required for service, with full description and complete information for proper application, are listed in Section III, Paras. 1 to 4.

2. MINOR INSPECTION

NOTE

The following inspection detail is to serve as a guide in carrying out propeller maintenance. Relevant aircraft EOs should be consulted for the latest approved propeller maintenance.

PREFLIGHT INSPECTION

Perform preflight inspection as specified in the Handbook for the aircraft.

With the engine running at reduced throttle, operate the propeller control three or four times through its entire range. The propeller should respond to movement of the governor control (as indicated by the tachometer) within the power limit of the reduced throttle setting. This test serves to expel air which might have been trapped in the propeller system, and at the same time it will show up improper operation of the propeller, governor, or engine.

For all Hydromatic propellers, with the propeller control in the full increase rpm position, advance the throttle until the engine speed reaches 2000 rpm. Move the propeller control toward the decrease rpm position until the engine speed drops approximately 200 rpm. Return the propeller control to the full increase rpm position and note that the engine speed returns to 2000 rpm.

For feathering propellers, after completing the preceding test, depress the feathering button. When the engine speed has dropped approximately 200 rpm, pull the button out. Note that the engine speed returns to 2000 rpm.

DAILY INSPECTION

Inspect all blades for bends, nicks, cracks, raised edges, etc. If a more complete check for cracks is considered necessary, apply local etching. See paragraph 3 for minor blade repair procedure.

In the case of aircraft operated near salt water, wash the blades thoroughly with clean (fresh) water, dry completely, and then apply a thin film of clean engine oil.

The exterior of the propeller hub will be carefully examined for any evidence of damage.

Visually check for oil leakage at the dome breather hole, dome retaining nut, barrel blade bores, barrel halves parting line, and at the rear cone.

Note

If the propeller has just recently been installed, residual oil may show up. This should not be misinterpreted as propeller leakage.

Check the propeller installation for security of mounting. This includes all external cotter pins and safety wire.

If propeller vibration has been reported, check all blade angle settings by the scribe mark on the blade shank and the angle graduations stamped on the external surface of the blade bore lip, or by using a bubble protractor at the blade reference station. If necessary, check the track of each blade.

Note

The following inspection checks apply only to propeller blade design No. B6521A-6.

Check for indication of fairing slippage. This can be readily determined by examining the metal fairing for indication of buckling, twisting, etc. If such slippage is indicated, replace the blade.

Tighten fairing screws as necessary.

MINOR INSPECTION

The exterior of all parts of the propeller will be examined for cracks, 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 during this inspection, and when necessary, perform local etching according to the procedure outlined in paragraph 3.

Check for deterioration of markings on both the propeller blades and hub.

If the blades incorporate fairings, check for damage to these, and, if necessary, repair according to the procedures outlined in paragraph 3.

MAJOR INSPECTION

Remove the dome assembly from the propeller according to the procedure outlined in section III. Partially disassemble the dome by removing the stop rings and dome shell. The piston and cams will not be disassembled. The cams, piston, and the inside of the dome shell will be washed in cleaner, 3-GP-8 to remove carbon and sludge deposits. The dome assembly will then be reassembled and reinstalled on the propeller. Refer to Table 11 page 68 and paras. (3)(a)(b), (4)(a)(b) of Section III paragraph 4 page 69.

Check the propeller retaining nut for looseness. Each check will be made with the proper wrench and the nut tightened as required and properly safetied. If repeated tightening of the nut is necessary to maintain the proper tightness, the propeller shall be removed and the cause ascertained.

Note

The following inspection checks apply only to propeller blade design No. B6521A-6. Make the same checks after 200 hours.

Check for indication of fairing slippage.

Tighten fairing screws as necessary.

Inspect exterior of blade fairing casting support assemblies for indications of cracks, bends, etc. When condition of entire blade assembly warrants local etching with caustic soda and nitric acid, do not contaminate bond area with the soda and acid.

ENGINE CHANGE INSPECTION
(For B6521A-6 blades only)

Remove blade fairing by removing fairing screws.

Tighten inboard and outboard support assembly bolts and nuts if necessary. Also check for slippage, cracks, bends, and other objectionable defects.

Check blade fairing for cracks, nicks, etc.

Check deicing tube assembly for split tubing, cracks at the brazed joint, satisfactory assembly of the deicing rubber tube, and tightness of the tube brackets.

Replace self locking nuts and fairing deicing tube grommet if defective.

SPECIAL INSPECTIONS

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

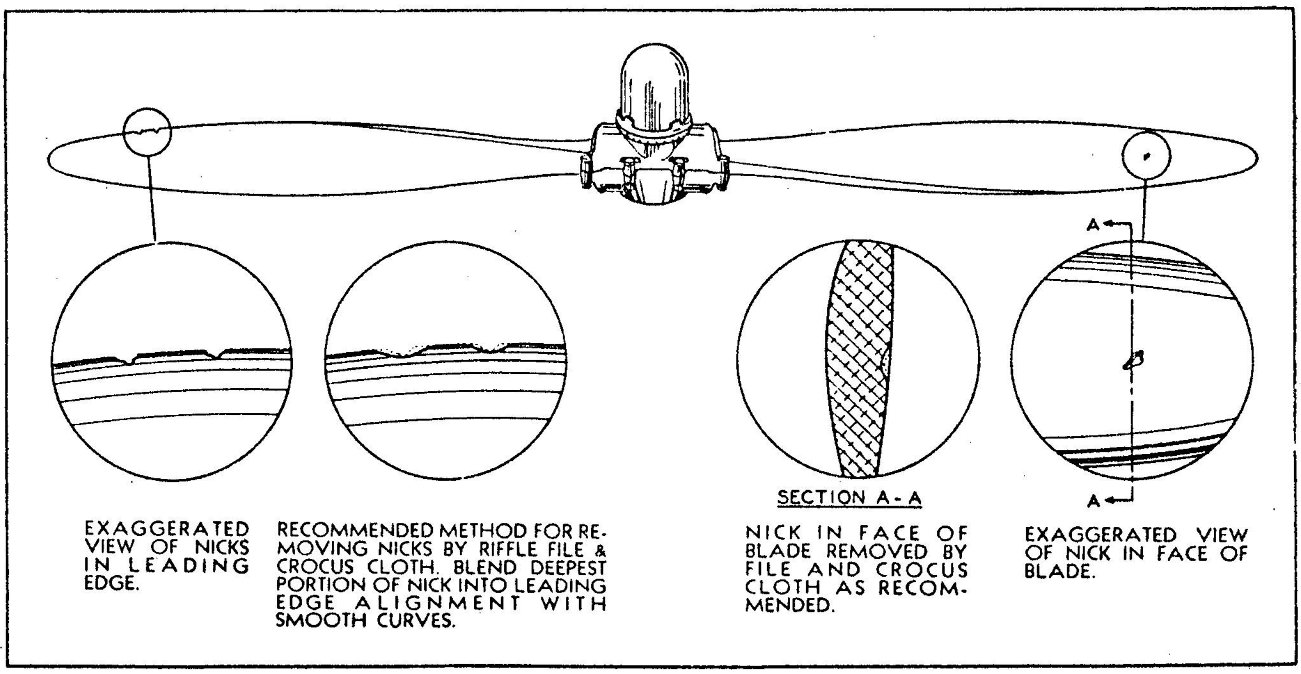


Figure 133—Typical Nicks and Methods of Removal

and misalignment. Steel parts will be inspected by an approved magnetic inspection method. The aluminum alloy blades, if otherwise serviceable, will be tested by anodic treatment or by any other approved method for detecting cracks.

If, for any reason, the propeller is removed prior to the specified overhaul period, the propeller hub cone seats, cones, and other attaching parts will be inspected for galling, wear, bottoming, proper fit, etc. Any defects will be corrected before reinstallation of the propeller.

3. MAINTENANCE.

a. MINOR BLADE REPAIR.—Aluminum alloy blades which are bent or otherwise damaged beyond the minor repair limits set up in this paragraph shall be sent to an approved blade overhaul base for repair.

CAUTION

Blades having design numbers 6801 and above are processed by cold rolling the blade fillet and shank area to approximately the 8-inch station, and shotblasting from the 7-inch to the 36-inch station. These operations establish initial compressive stresses in the blade which shall not be removed. Minor repair shall be permitted in the shot-blasted and tip areas only. In the shot-blasted area, nicks shall be removed by the use of emery and crocus cloth; files shall not be used. After the nick has been saucered out, the surrounding area must be shotblasted. The area to be shotblasted shall not be less than one inch in diameter, and at least three times the repaired area.

(1) LOCAL ETCHING.—Caustic solution for local etching will be prepared locally by adding one pound of commercial technical-grade caustic soda to a gallon of water. The quantity of solution will depend on the amount of etching to be done. With No. 00 sandpaper or crocus cloth, clean and smooth off the area containing the apparent crack. Apply a small quantity of caustic solution to the suspected area with a swab or brush. After the area is well darkened, thoroughly wipe it off with a clean (dampened) cloth. Too much water may entirely remove the solution from a crack and spoil the test. If a crack extending into the metal exists, it will appear as a dark line or mark, and by using a magnifying glass, small bubbles may be seen forming in the line or mark. Immediately upon completion of the final checks, all traces of the caustic solution will be removed with a solution of one part of concentrated technical-grade nitric acid and five parts of water. Wash the blade thoroughly with clean

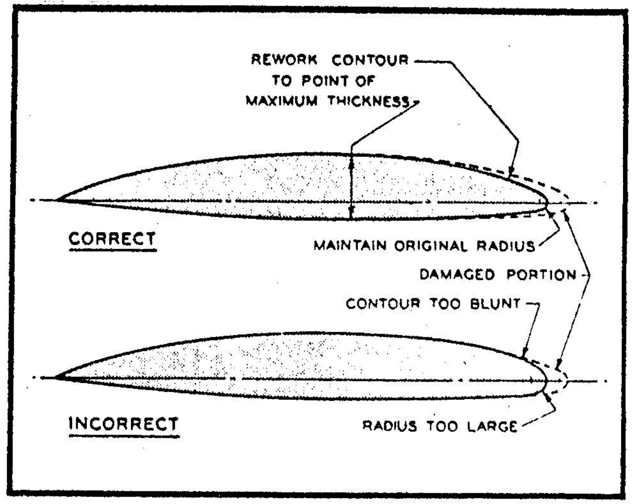


Figure 134—Repair of Leading Edge

(fresh) water. The blade will then be dried and coated with clean engine oil.

(2) BLADE REPAIR PROCEDURE.

(a) To avoid dressing off an excessive amount of metal, check by local etching at intervals during the process of removing cracks and double-backed edges of metal. Suitable sandpaper or fine cut files may be used for removing the necessary amount of metal. In each case, the area involved will be smoothly finished with No. 00 sandpaper, and each blade from which any appreciable amount of metal has been removed will be properly balanced before it is used.

(b) Raised edges of cuts, scars, scratches, nicks, etc. will be removed; however, if their removal or treatment takes the blade below the allowable repair limits, the blade shall be retired from service.

(c) The metal around longitudinal surface cracks, narrow cuts, and shallow scratches will be removed in such a way that shallow saucer-shaped depressions as shown in figure 133 are formed. Blades requiring the removal of metal which would form a finished depression more than 1/8 inch in depth at its deepest point, 3/8 inch in width, and one inch in length, will be sent to an approved overhaul base.

(d) The metal at the edge of wide scars, cuts, scratches, nicks, etc. will be rounded off and the surfaces within the edges smoothed out as shown in figure 133. 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 will be sent to an approved overhaul base or depot.

CAUTION

The only acceptable methods of repairing cuts, nicks, cracks, etc. in blades are those by which metal containing and adjacent to the damage is removed from the blade to leave a smooth well-faired surface. Methods which attempt to relocate metal by cold-working to cover or conceal the defect rather than remove the damage are not acceptable.

(e) With the exception of cracks, it is not necessary to completely remove or "saucer out" all of a comparatively deep nick unless it has a sharp bottom. Since it is essential that no metal be removed unnecessarily, properly rounding off the edges and smoothing out the surface within the edges is usually sufficient.

(f) A reasonable number of repairs per blade may not be dangerous (if within the limits specified) unless their location with respect to each other is such as to form a continuous line of repairs that would materially weaken the blade.

(g) Blades that have the leading edges pitted from normal wear may be reworked by removing sufficient material to eliminate the irregularities. The metal will be removed by starting at approximately the thickest section, and working forward over the leading edge camber so that the contour of the reworked portion will remain substantially the same. In all cases, avoid abrupt changes in section or blunt edges.

Note

The following procedure applies to propeller blade design No. B6521A-6.

(h) Examine fairing support assemblies with magnifying glass. Do not use local etching process unless etchants can be definitely kept from the bond areas between the blade and the castings.

1. Check fairing support assemblies for nicks, scratches, etc. and remove provided removal can be accomplished using 150 grit sandpaper with a minimum amount of work.

2. Check leading and trailing edges of inboard casting for indication of bends.

3. If heat is required to straighten blade, remove fairing and return blade to service without fairing, being sure to identify blade as design No. 6521A-6.

Note

Propellers must consist of four blades with fairings or four blades without fairings. Never mix the two types of blades on the same propeller.

4. Repair of defects in the blade fairing shall be limited to the use of No. 380 to No. 400 abrasive cloth. Repair of the dents, which are not detrimental to the life of the fairing, may be made by using a rubber or leather mallet.

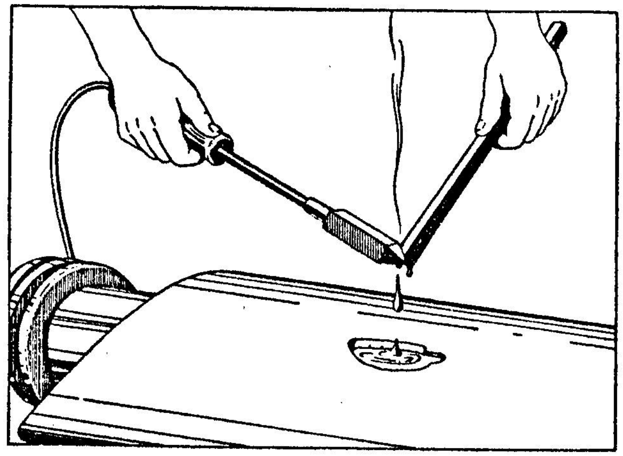


Figure 135—Patching Blade Fairing

(3) MOLDED FAIRING REPAIR PROCEDURE. —Molded blade fairings are sometimes damaged by accidents in handling or by flying stones on the field. It is recommended that such damage be repaired by means of Fairing Patching Compound. The repair of areas greater than three square inches is not recommended. The patching compound supplied in stick form has the advantages of being kept indefinitely and of being quickly applied with simple tools.

(a) Remove loose particles from the damaged area and undercut the cover stock slightly. The cavity must be dry and free from oil.

(b) Melt the stick compound into the cavity. A hot soldering iron may be used conveniently. If a flame is used, be careful not to ignite the fairing itself. Be sure the patching compound is really molten in the cavity so that it may fill small pores and adhere well to the cavity surface. A hot nail or knife blade will help to accomplish this.

(c) Fill the hole completely and allow to cool. When the patch is cool, file and sand the patching compound into a surface which blends with the fairing itself.

(d) Repaint the blade, and then return it to service.

Note

The compound is resistant to hot oil and gasoline, but will be attacked slowly by hot solvent degreasers and lacquer thinners.

D E L E T E D

(4) PAINTING.

(a) GENERAL - Blades may be painted while assembled in the propeller hub if facilities for disassembly, balance, and reassembly are not available. Some provisions should be made to seal off the blade bore during the painting operation.

(b) Materials - The following materials (to latest revision) or their equivalent shall be used. Materials shall be prepared in accordance with applicable technical instructions. Care shall be taken that the materials are thoroughly mixed when being applied.

1. A primer aircraft metal zinc chromate, Spec. 1-GP-132, RCAF Ref. 33A/529. Thinner Spec. 1-GP-70, RCAF Ref. 33A/119.

2. Top coat, lacquer pigmented, Spec. 1-GP-134, RCAF Ref. 33A/440 (yellow). DTD 754A, RCAF Ref. 33A/396 (black). Thinner 1-GP-136 RCAF Ref. 33A/553.

(c) APPLICATION.

1. Preparation of the blades prior to painting, shall have been balanced and given the standard satin finish, unless otherwise specified.

2. Cleaning - To ensure that the paint materials will adhere properly to the blades, it is imperative that all surfaces to be painted shall be thoroughly and carefully cleaned directly before application of the priming coat, using one of the following solvents: benzol, carbon tetrachloride, petroleum fractions such as low boiling naphtha or trichlorethylene. Since rubber fairings are subject to deterioration by prolonged exposure to organic solvents, faired blades shall be cleaned by hand with one of the above solvents and given a final rinse with clean unused solvent. Likewise for the application of the top coat, care shall be taken that the priming coat does not become soiled.

3. Extent of Application - The painting and marking of propellers varies with each aircraft. A particular aircraft may have several different painting and marking schemes to which the propeller has to conform. EO 05-1-2U, Aircraft Finish Schemes and Markings, list drawing numbers for all RCAF aircraft. If these drawings have specific instructions for painting and marking the propeller they should be followed, otherwise the following three classes of general application are to be adhered to:

4. Hydromatic propellers used in single engine installation, and counter-weight propellers: Blade thrust faces painted black with yellow tips.

5. Hydromatic propellers incorporating non-surface-treated blades used in multiple engine installation: Blades in this group are painted black with yellow tips.

NOTE

Hydromatic propellers 22D30 used in Expediter installation are to have blade tips painted yellow on the camber side only. Face side of black tips shall be painted black.

6. Hydromatic propellers incorporating surface-treated blades (shot-peened) as used in North Star and C5 installation: Blades are satin finished but unpainted except for the yellow tips.

(d) In general, except for the additional application of topcoat lacquer to achieve balance, the blade shall be given a three-coat application, consisting of one priming coat and two lacquer topcoats. The total thickness of the three coats shall be .002 plus or minus .0004 inch. Those portions of the blade which are not to be painted shall be shielded or masked by any appropriate method. Blade roots shall not be painted in the region listed in Table XXII. Four inches of the blade tip for propellers 15 feet in diameter or less and six inches for propellers greater than 15 feet in diameter shall be painted on both sides with yellow lacquer topcoat unless otherwise specified. A strip of

TABLE XXII

COUNTERWEIGHT BLADES (inch)		HYDROMATIC BLADES (inch)	
B Shank	2.4-2.6	D Shank	3.1-3.3
D Shank	2.7-2.9	E Shank	3.3-3.5
E Shank	3.0-3.2	F Shank	3.8-4.0

non-specular or glossy orange yellow paint shall be applied on the face side of the blade at the reference station. This strip shall be painted over one coat of zinc chromate primer if the surface is not already painted, or over the last coat if the surface is already painted. The strip shall be 1/8 plus or minus 1/32 inch wide and 2 plus or minus 1/4 inch long. The difference in distance from the blade reference station to each side of the strip shall not be more than 1/8 inch, and the difference in distance from the blade.

b. DELETED.

c. CLEANING OF PROPELLERS - Except in the case of etching, caustic material will not be used on a propeller. The removal of enamel and varnish from propeller parts will be accomplished by the use of approved lacquer thinners and solvents. As soon as possible after a propeller has been subjected to salt water, all traces of salt on all parts of the propeller will be flushed off with fresh water and the propeller then thoroughly dried and coated with clean oil.

NOTE

No petroleum type solvents shall be used for cleaning B6521A-6 blades, particularly in the area where the fairing is bonded to the blade.

(1) STEEL HUBS - Steel hubs will be cleaned with soap and fresh water, cleaner, Spec. 3-GP-8 sene. Use 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.

(2) ALUMINUM ALLOY BLADES - Warm fresh water and soap, cleaner, Spec. 3-GP-8, and suitable brushes or cloth, as may be available and practical, will be used for the cleaning of aluminum alloy blades. 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 blades. In special cases where a high polish is desired, a responsible party may authorize the use of a good grade of metal polish provided that upon completion of the polishing all traces of polish are immediately removed and the blades cleaned and coated with a thin film of clean engine oil.

d. 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.

e. PROPELLER MARKINGS.

(1) HUB AND DOME - The propeller serial number and model number are acid etched on the outside surface of the barrel. The serial number is also etched on the lower surface of the fixed cam so as to facilitate keeping the dome with the proper hub. The required amount of preload shims is marked on the dome-barrel shelf. Other identifying markings are located at various points on the hub and dome.

(2) BLADE MARKINGS.

(a) Each blade shall have the following marking stamped with a rubber stamp or painted with the aid of a suitable stencil on the camber side of the blade approximately between the 18- and 24-inch stations and approximately on the mid-chord position, using letters and numerals 1/2 inch high. The markings shall be applied approximately parallel to the longitudinal center line of the blade in such a way as to be read from the trailing edge. In no instance will such markings be indented or cut into the metal.

1. Serial number.

2. Part or Drawing number.

3. Blade angle settings.

4. Date of repair or overhaul.

(b) On unpainted blades, black ink shall be used. On blades painted black, white ink is to be used. Black Matthews Vulcan Ink or its equivalent and White Matthews No. 550 ink or its equivalent have been found best for the purpose. After the ink dries, the lettering shall be covered with a coating of stencil varnish or clear lacquer to protect it, except on unpainted anodized blades.

(c) In addition to the above ink marking, the manufacturer's identification decalcomania shall be affixed approximately midway out on the camber side of each blade so as to be read from the trailing edge.

f. VIBRATION - If propeller vibration has been reported, check all blade angle settings by using a bubble protractor at the blade reference station. The blade angles should be within 0.2 degree of each other and with 0.5 degree of the specified high and low pitch settings when turned to those positions. If necessary check the track of each blade. This can be accomplished by fixing a rigid pointer on the aircraft fuselage, wing or engine nacelle, extending to the face of the propeller blade near the extreme tip. Rotate the propeller and measure the distance from the end of the pointer to a point near the tip of each blade. For propellers having a nominal diameter of 14 feet or less, the blades shall track within 1/8 inch. For propellers having a nominal diameter greater than 14 feet, the blades shall track within 3/16 inch.

4. LUBRICATION.

Since the Hydromatic propeller is a hydraulic mechanism operating with engine oil, no other lubrication is required.

5. SERVICE TROUBLES AND REMEDIES.

The following information in its condensed table form lists the troubles, the probable causes, and the remedies most frequently encountered in Field servicing. This information supplemented by a thorough understanding of the principle of operation of the propeller and the functions of the parts involved should make trouble-shooting relatively simple. Careful and accurate determination of the troubles and their related causes and remedies will reduce to a minimum the time required for servicing and will aid in extending the service life of the propeller.

TROUBLE	PROBABLE CAUSE	REMEDY
LEAKAGE		
At breather cap (shaft breathing installations)	Incomplete engine scavenging or excessive blow-by.	Consult engine manual.
	Loose distributor valve.	Tighten distributor valve or engine shaft extension. See section III.
	Damaged gaskets.	Replace gaskets. See section III
	Malfitting engine shaft breather parts.	Consult engine manual.
At dome breather hole (crankcase breathing installations)	Damaged seal.	Replace seal. See section III.
	Washer missing.	Install washer. See section III.
	Loose nut.	Tighten nut. See section III.
At dome retaining nut.	Damaged dome-barrel seal.	Replace seal. See section III.
	Loose nut.	Tighten nut. See section III.
	Too many preload shims.	Check preload.

TROUBLE	PROBABLE CAUSE	REMEDY
At barrel blade bore.	Damaged packing or molded chafing ring.	Replace packing. Remove molded chafing ring and replace with split-type chafing ring.
	Damaged split-type chafing ring.	Replace chafing ring.
At barrel half parting line.	Damaged seals.	Replace seals.
	Improper closure of barrel halves.	Remove burrs from parting surfaces of barrel halves.
	Undetermined cause.	Use cement in conjunction with barrel half seals.
In rear cone vicinity.	Damaged spider-barrel packing.	Replace packing.
	Damaged or incorrectly installed spider-shaft seal.	Replace seal. See section III.
	Engine thrust plate seal.	Consult engine manual.
	Loose master spline locating screw.	Tighten screw in shaft.
ROUGHNESS	Ice on propeller.	Increase rpm for short time, and start de-icing fluid if available.
	Propeller unbalance.	Land and check balance. (Effect will be greater at high rpm.)
	Blade angles vary among blades.	Check blade angles with protractor or blade scribe mark.
	Blade out of track.	Check blade track.
	Spark plug or ignition.	Replace spark plugs and check wiring.
	Engine part failure.	Feather propeller if feathering installation, otherwise reduce rpm to minimum.
	Unknown cause (resulting in excessive vibration).	Feather propeller for continued flight if feathering installation, otherwise reduce rpm to minimum.
POOR SYNCHRONIZATION	Ignition trouble.	Check with ignition tester.
	Poor carburetion.	Consult engine or carburetor manual.
	Excessive engine transfer ring leakage.	Replace rings according to engine manufacturer's specifications.
	Sludge in governor pilot valve or relief valve.	Disassemble and clean.
	Sticky piston action in propeller dome assembly.	Remove dome shell, clean and lubricate piston gasket. If gasket is badly damaged, replace. If piston contact area of dome is scored, polish with wetordry No. 300 or fine crocus cloth.
	Loose piston gasket.	Tighten piston gasket nut.
	Backlash in governor control system.	Rerig or adjust control system.
	Air in propeller system.	Operate controls two or three times between high and low rpm during run-up. See section IV.
INABILITY TO ATTAIN TAKE-OFF RPM ON THE BLOCKS Note With take-off manifold pressure, it is impossible in some installations to obtain take-off rpm on the blocks.	Wrong setting of governor or incorrect rigging of control system.	Reset governor or rerig and adjust control system.
	Improper installation of low pitch stop in propeller dome assembly.	Reset low pitch stop ring. See section III.
	Low engine power.	Consult engine manual.
	Erroneous reading tachometers or manifold pressure gages.	Calibrate instruments.

TROUBLE	PROBABLE CAUSE	REMEDY
OVERSPEEDING ON TAKE-OFF	Wrong setting on governor.	Reset governor.
	Insufficient exercise of propeller mechanism prior to take-off.	Move control several times through constant speed range with engine running. See section IV.
	Too rapid opening of throttle.	Advance throttle evenly and slowly.
	Damaged gasket between distributor valve and propeller shaft.	Install new gasket. See section III.
	Damaged or incorrect gasket between governor base and engine mounting pad.	Install correct new gasket.
	Sticky governor pilot or relief valve.	Disassemble and clean.
	High engine transfer ring leakage.	Replace rings according to engine manufacturer's specifications.
	Erroneous reading tachometers or manifold pressure gages.	Calibrate instruments.
FAILURE TO FEATHER	Aircraft batteries low.	Recharge or replace batteries.
	Faulty aircraft electrical system.	Check wiring system pertaining to feathering pump and control circuit.
	Failure of push button to remain engaged.	Check battery and low pressure setting of cut-out switch.
	Failure to remain feathered with push button failing to disengage.	Reset cut-out switch and check electrical control circuit.
	Windmilling of propeller in high pitch angle.	Reset high pitch stop ring. See section III.
	Sheared coupling in feathering pump.	Replace coupling.
	Restricted oil supply to feathering pump.	Check feathering pump inlet lines for foreign material and bleed line.
	Defective feathering pump.	Replace pump.
Due to excessive leakage.	Improper distributor valve installation.	Reinstall distributor valve. See section III.
	Damaged or incorrect gasket between governor base and engine mounting pad.	Replace gasket.
	Engine transfer rings.	Replace rings according to engine manufacturer's specifications.
FAILURE TO UNFEATHER	Batteries low.	Change or recharge batteries.
	Faulty electrical system.	Check control and power circuits of feathering system.
	Sheared coupling in feathering pump.	Replace coupling.
	Restricted oil supply to feathering pump.	Check feathering pump inlet lines for foreign material, and bleed line.
	Defective feathering pump.	Replace pump.
Due to excessive leakage.	Engine transfer rings.	Replace rings according to engine manufacturer's specifications.
	Improper distributor valve installation.	Reinstall distributor valve. See section III.
	Damaged or incorrect gasket between governor base and engine mounting pad.	Replace gasket.