AIR CONTROLLED

Aero-matic

AUTOMATIC PROPELLER

Model 220

Automatic Variable-Pitch Propeller

Service Manual

UNIVAIR

UNIVAIR AIRCRAFT CORPORATION

PLANT, OFFICES AND WAREHOUSES: RT. 3, BOX 59, AURORA, COLORADO 80011

TELEPHONE: (303) 364-7661

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GENERAL DESCRIPTION

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PRINCIPLES OF OPERATION

General:

The Aeromatic Propeller utilizes the natural forces acting on the blades and counterweights to accomplish automatically the desired change in blade pitch for varying conditions of flight.

The automatic operation represents a continuous state of balance between the pitch changing tendencies of the aerodynamic force components of thrust an torque, the blade centrifugal and the counterweight centrifugal forces acting on the blade.

Design:

The flange of the Aeromatic Propeller is designed to hold the blade at a fixed angle from the blade pivot axis, about which the blade is allowed to turn to change its pitch. The flange is so arranged in the hub that the blade describes an arc of a cone, forward of the plane of rotation toward low pitch or describes an arc of a cone rearward of the plane of rotation toward high pitch, or any intermediate position. The range of pivoting or the range of blade angle change is governed by predetermined low and high pitch stops.

With the blades free to pivot, the thrust force acting on the center of pressure of the blades tends to turn the blades forward to the low pitch position. The torque force acting on the blade tends to keep the center of pressure of the blade in the plane of rotation, but its effect is relatively small.

The centrifugal force acting on the blade has the following effects:

1. The centrifugal torsion force tends to flatten or reduce the pitch of the blade in all forward and rearward positions with respect to the plane of rotation.

2. The centrifugal displacement force tends to increase the blade pitch when the blade is forward of the plane of rotation and to reduce the blade pitch when it is rearward of the plane of rotation.

The counterweight arms and weights are positioned in front of the plane of rotation at a fixed angle with respect to the blade.

The centrifugal force acting on the weights tend to move the counterweight arm toward the plane of rotation, which in turn causes the blade to move to a higher pitch.

The net centrifugal force acting on the blade and the counterweight tends to increase the blade pitch.

OPERATION IN FLIGHT

The stability of the Aeromatic Propeller is obtained by balancing the pitch decreasing effect of the aerodynamic force against the pitch increasing effect of the net centrifugal force acting on the combined masses of the blade and counterweights.

At take-off, the pitch decreasing forces are greatest, and will therefore move the blades forward to low pitch to permit the engine to develop full take-off power.

During the initial climb, maximum power is made available without overspeed of the engine because the blade pitch increases as the forward speed of the airplane increases.

By maintaining given cruising RPM, constant horsepower of the engine is available at altitudes up to cruise critical (Full throttle at cruising RPM) altitude.

The Aeromatic Propeller tends to govern the RPM of the engine at a fixed power setting, through a wide range of airspeeds of the airplane.

The Aeromatic Propeller load curve (Cube Curve) follows the calculated propeller load curve relationship as shown by the engine manufacturers power specifications, therefore the power RPM and manifold pressure will bear a fixed relationship to the throttle setting.

No additional controls or instruments are required for the operation of this propeller. A manifold pressure gauge is desirable although not required.

STARTING ENGINE:

No special procedure is required to start the engine other than that recommended by the engine manufacturer.

TAKE–OFF AND CLIMB:

Full throttle will make available approximately rated take-off RPM and power. If the indicated power is less at static condition, it will become available before the end of take-off run.

During the climb any percentage of rated power is available and can be selected by throttle setting. A natural loss of power will be expected due to decrease of air density.

CRUISE:

The airplane can be cruised at any altitude up to cruise critical since rated cruise power will be available by adjusting the throttle to cruise RPM.

From a level flight attitude, the airplane can be put into a power glide at a speed in excess of cruising speed, without the engine exceeding its RPM tolerance. While descent is made in this manner, the manifold pressure will increase as altitude is reduced and, therefore, the throttle should be reduced to maintain cruise power without excessive RPM. This condition is very desirable during let-down on cross country flights.

APPROACH AND LANDING:

During the landing approach with throttle closed, the engine will idle in a normal manner. In event of overshooting the landing, the throttle should be opened to maximum position and the blades will then assume low pitch position, thus permitting the engine to develop maximum RPM and power.

ALTITUDE CONTROL UNIT:

The altitude control unit has been designed and produced for the purpose of controlling the propeller RPM above 5,000 ft. altitude, or at an altitude where the desired cruising RPM is not available without a change in the amount of counterweights on the counterweight arm.

The unit may be attached on any Model 220 propeller which is installed on a standard AN 20 spline crankshaft. All control unit parts are interchangeable, except the mounting flange which is designed to fit a particular engine model or make. The weight of the complete unit is approximately 11 lbs.

Operation is accomplished by a push-pull control cable operated from the cockpit or cabin. The arrangement is so that the cable is "Push to increase R.P.M.". Fifteen to eighteen pounds pull is required to operate the unit through its complete range. A model 220 propeller with the Altitude Control Unit attached is identified as a model 220 H.

CONSTRUCTION:

HUB:

The Model220 Aeromatic Hub is a two blade propeller designed to fit a standard SAE No. 20 Spline Shaft.

The Hub Model Number is described as follows:

220 H-1

- 1 — Modified flanges
- H — Altitude control unit
- 20 — SAE Shaft Spline (20)
- 2 — Number of Blades

The hub is fabricated from nickel-chrome molybdenum steel by welding process. The cross tube is welded into the hub barrel and bosses are welded on the side of the barrel to accommodate blade stop bolts. A synchronizer shaft boss is welded to the side of the hub barrel 90° from the cross tube and opposite the blade stop bolt bosses. A preload radial bearing boss is welded to each side of the cross tube at the exact center of the hub barrel bore to locate and preload the blade flange assembly.

A standard SAE-20 spline is broached in the bore of the cross tube. Front and rear cone seats are ground at a 15° angle on the rear cone seat and a 30° angle on the front cone seat. A groove is provided in the front end of the cross tube to accommodate a snap ring for the purpose of pulling the hub from the engine shaft. Snap ring grooves are milled near the end of each barrel bore to accommodate large Tru-Arc Snap Rings which retain the entire blade flange assembly in the hub.

BLADES:

Each Aeromatic blade is clearly identified by a model number and a serial number. The blade model number is described as follows:

O – 85 A

- A — Change in basic blade design
- 85 — Propeller Diameter in inches
- O — Aeromatic blade shank size

The blades of the Aeromatic Propeller are made of thin laminations of selected Maple or Birch, bonded together with thermo-setting resin glue to provide a structure stronger than natural wood blades. The laminations are splayed at alternate angles, approximately 15° from the center line of the blade. This type of construction adds to the rigidity of a curved blade, thus substantially eliminating blade warpage.

An external right hand threaded metal ferrule is pressed on the shank end of the blade after the shank is sealed against moisture penetration. The ferrule is retained on the blade by means of 12 - 5 1/2 inch long and 6 - 6 inch long special lag screws per blade. Each lag screw is tightened with a torque of 150 inch pounds. This load may diminish to 130 inch pounds in service and still be considered ample. When the torque load is below this amount, the screws should be again tightened to 150 inch pounds.

The blade is covered with Aeroloid plastic covering, pressure-bonded to the entire surface. The Aeroloid is .030 inches in thickness and will withstand severe abrasion and moisture. Nicks and small cracks in the Aeroloid plastic covering can be repaired by the use of the Aeromatic Plastic Repair Kit - Part No. 20011. Complete instructions for its use accompanies each kit.

The leading edge metal tipping is manufactured in two pieces. The long piece is termed the leading edge tipping and the small section at the extreme tip is called the cap tipping. The leading edge tipping is provided with scarf cuts every few inches to provide and control stress cracks in the metal, whick may occur due to bending and twisting loads on the blade. The cap tipping is stainless steel and reinforced on the inside to withstand shock from sand, water spray and gravel during taxiing and flight operations.

The cap tipping is held on the blade by phospher-bronze rivets. The leading edge tipping is also held on by rivets at the thin section of the blade, but at the heavier section, wood screws are used.

Two methods of blade finish have been used. Earlier production blade surfaces were wet-sanded untill smooth, then dipped in a solution of acetone and butyl acetate to bring out a bright lustre finish. Presently the blades are sprayed with a DuPont lacquer instead of being dipped in the above solution.

Three suggested methods of blade refinishing are as follows:

1. Wash blades with soap and water. Wet sand with #220 grit paper. Then dip blades momentarily in a solution of 75% acetone and 25% butyl acetate. If, after the first dipping, the Aeroloid plastic has not returned to its original color, dip again after the first application has been allowed to dry 2 or 3 hours. Allow the blades to dry 48 hours before final balancing of the propeller assembly.

2. Wash blades with soap and water. Wet sand with #220 grit paper. Then mask the leading edge and cap tipping with masking tape. Spray with one coat of black lacquer. If imperfections in the spray appear, another coat may be applied. If the finish is not glossy, it may be polished with rubbing compounds similar to Simonize Cleaner and then waxed with Simonize wax or equivalent. Refer to Aeromatic Service Bulletin No. 18 for detailed instructions.

3. Clean the blade with carbon tetrachloride or Simonize cleaner and polish with wax or wipe with an oily cloth. This method will not eliminate any discoloration in the plastic covering.

   Method No. 1 or No. 2 should be used if the blades have become discolored due to exposure of strong sunlight for a period of time.

Spare blades are kept in stores, and also shipped to Aeromatic Authorized Service Stations with a detachable tag stating the horizontal moment (*) of the respective blade.

In production assembly of propellers, the blades are matched in pairs according to the horizontal moment of the blades. These are grouped in three catagories of horizontal moment (*) values for each particular model blade. Therefore, it is important when Aeromatic Authorized Service Stations order blades to match blades in their stock, that the Serial and Model Numbers of the blade to be matched are given to the factory on the original order.

(*) <u>NOTE:</u> - The horizontal moment (H.M.) is equal to the weight of the blade multiplied by the radial distance from the center of rotation to the center of gravity of the blade.

Blades are supplied to Aeromatic Authorized Service Stations, either in matched pairs or a single blade to match a blade of known horizontal moments.

All blades are shipped without the ferrule being drilled for the Counterweight Arm Locating Screw. Refer to section describing "Counterweight Arm Locating Screw".

Spare blades are shipped in a heavy paper carton with special partitions to hold two blades in each carton. They should be stored in these cartons untill they are installed in propellers. The cartons will protect the finish, which will age if exposed to bright light.

BLADE FLANGE ASSEMBLY:

The Blade Flange is made of nickel-chrome molybdenum steel, heat treated and ground on the bearing surfaces. It is machined so as to form an angle between the hub barrel axis and the blade axis called the lag angle. It is right-hand threaded on the inside bore to match the threads on the blade ferrule.

The outer end of the flange bore is smooth and has four milled slots spaced 90° apart. This allows the clamping action of the counterweight arm to hold the blade ferrule against rotation in the flange.

The threaded section holds the blades against centrifugal load. On the innermost part of the flange a circular recess is provided to hold the preload bearing. At the base end of the threaded section a seal seat is provided in which a synthetic rubber seal is placed and backed-up with a seal plate. This plate is held in position with a Tru-arc Snap Ring fitted into a groove provided for it in the flange.

Large thrust bearings are fitted to the ground surface on the flange. The flange seal packing assembly is placed on the outboard side of the thrust bearing on the outer circumference of the blade flange.

An integral gear segment is machined on the base of the flange, into which the synchronizer gear is engaged. Diametrically opposite the gear segment an integral lug is machined on the flange to serve as part of the high and low pitch stop mechanism.

A machined groove is provided on the extreme outer end of the flange to accommodate a snap ring which retains the counterweight arm against centrifugal force.

Locating holes are provided on opposite sides of each blade flange in order to locate the flange in the plane of rotation while setting the blade angle (termed phase angle) and the counterweight arm angle.

SYNCHRONIZER ASSEMBLY:

A synchronizer gear is employed to coordinate the motion of both blades and to maintain the angular relationship between them. A synchronizer shaft acts as a pivot for the synchronizer gear. The synchronizer shaft is hollow for the purpose of filling the hub with Aeromatic lubricant. This hole is sealed with a 1/8 inch pipe plug called the lubricant plug.

The synchronizer shaft screws into the boss provided on the side of the hub for this purpose. The synchronizer gear meshes with the integral gear segment of the blade flanges. The depth of this gear mesh is adjusted by means of a laminated shim, called the synchronizer shaft shim, which is placed between the flanged portion of the synchronizer shaft and the boss on the hub. This shim also acts as a gasket to prevent lubricant leaks. A good grade of gasket cement is recommended for use on the shim. The synchronizer shaft is secured by safety wire attached to a safety screw placed in a drilled and tapped hole adjacent to the shaft.

BEARING ASSEMBLIES:

Two types of ball bearings are used in the Aeromatic Propeller - a thrust bearing and a preload bearing.

1. The thrust bearings are especially designed for the most efficient and friction-free action. They have a special radius ground into the ball races. The ball are held in place by special wire cage spacers. These spacers require a minimum amount of space, thus affording the maximum number of balls to be located in the given space. These bearings carry the centrifugal load of the blade assemblies on the outside diameter of the outer race of each bearing. A special chamfer on the outside edge of the outer race serves as a space to retain a synthetic rubber seal which prevents lubricant leaks around the outer diameter of the bearing.

   The inside edge of the outer race is also chamfered to allow installation of the flared shim of the flange seal packing assembly. The inner race of the thrust bearing is shaped to fit securely to the radius of the blade flange so that the centrifugal load is evenly transferred from the blade flange to the thrust bearing.

2. The preload bearings are of the radial thrust type, capable of receiving a side load in one direction only. By loading this bearing against the thrust bearing, the end shake and side play in the blade is eliminated.

PRELOAD ASSEMBLY:

The Preload Assembly consists of four parts:

(a) Preload lock spring
(b) Bearing preload lock
(c) Bearing preload screw
(d) Preload bearing sleeve

The screw, lock and spring all fit inside of the boss, provided on the cross tube of the hub and are located in the exact center of the hub barrel bore.

The sleeve fits over the outside diameter of the boss and serves as a pivot for the preload bearing which is placed over it.

The purpose of this assembly is to tighten the blade flange assembly in the hub against the thrust bearing retainer plate and snap ring.

To tighten the preload, a special preload tool is inserted into the center bore of the bearing preload screw. The tool is pushed in to compress the preload lock spring and release the bearing preload lock. The tool is then turned in a counterclockwise direction, causing the bearing preload screw to press outward against the preload bearing sleeve, which in turn presses against the preload bearing. To loosen the preload, the same procedure is used, turning the preload tool in a clockwise direction. When the tool is removed, the preload lock spring forces the bearing preload lock into the bearing preload screw, locking the assembly.

SEALS AND PACKING:

Two types of synthetic rubber seals and one flange seal packing assembly are used to seal the hub and prevent lubricant leaks.

The first type is the flange plate seal, which is a circular ring having a rectangular cross section. It is located between the seat in the inner bore of the blade flange and the flange plate and seals of the inner bore of the blade flange. It is held in position by a snap ring on the outer side of the flange plate and must be compressed before the snap ring can be inserted.

The second type is the thrust bearing seal, which is an "O" ring type of very thin cross section. Its purpose is to seal the lubricant and prevent leaks along the hub barrel at the thrust bearing. It is located in the chamfer of the outer thrust bearing outer race.

The flange seal packing assembly consists of the following parts:

(a) Flange seal packing shim (flared)
(b) Flange seal packing shim (inner)
(c) Flange seal packing
(d) Flange seal packing spring
(e) Flange seal packing shim (outer)

The flared shim fits tightly over the blade flange in the inner chamfer of the thrust bearing outer race. The inner shim, or shims, serves the purpose of a spacer to obtain the correct compression on the flange seal packing assembly. The flange seal packing is made of synthetic rubber and is of a modified chevron type of seal. The flange seal spring holds the packing tightly against the blade flange outer diameter and is located in a "V" shaped groove provided in the packing. The outer shim serves as a wearing surface between the packing and the thrust bearing retainer plate. All shims are made of brass.

COUNTERWEIGHTS AND COUNTERWEIGHT ARMS:

The outer ends of the counterweight arms extend toward the front of the propeller at an angle which is determined by the factory. The base of the counterweight arm serves as a clamp to secure the blade ferrule from unscrewing in the flange. A groove for a snap ring is provided at the outside end of the flange to retain the counterweight arm. A clamping action is provided by a bolt held firm by a castle nut and cotterpin which passes through the counterweight arm.

On the outer or small end of the counterweight arm, a 7/16" bolt and nut is provided to hold the counterweights, which vary in size according to the requirements of the horsepower setting. The head of the bolt is located on the outside of the counterweight arm. The counterweights are provided in several weight catagories and are used for flight RPM regulation of the propeller. The counterweights are identified as follows:

Part No.	Weight
2965-1	.25 oz.
2965-2	.05 oz.
2965-3	1.0 oz.
2965-4	2 oz.
2965-7	5 oz.
2965-8	10 oz.

NOTE: - Counterweights control only the flight RPM
Remove weight to increase RPM
Add weight to decrease RPM

In order to measure the counterweight arm angle and set both angles identically, two flats are ground on one side of the arm; one flat on the large diameter and one flat at the small end. These flats are located on the leading edge side of the arm when the propeller is assembled. The angle which these flats form to the centerline of the arm is stamped on the extreme end of each arm. In most cases, it is 16°. Procedure for setting this arm will be described later.

On the centerline of the arm at the large end, a hole is drilled and tapped into which is fitted and safetied the counterweight arm locating screw. Adjacent to this screw, a hole is drilled and tapped to accommodate the counterweight arm safety screw to which the counterweight arm locating screw is safetied.

COUNTERWEIGHT ARM LOCATING SCREW:

In order that the propeller may be disassembled for seal or bearing replacement and be reassembled to its original angles, without the use of a protracter and checking table, the counterweight arm locating screw is installed. This screw has a pilot on the end of it about ¼" long and protrudes through the counterweight arm, the blade flange, the blade ferrule and into the wood of the blade. Before the locating screw can be properly re-installed, it is necessary to align the holes in the counterweight arm, blade flange and the blade ferrule. After completely reassembling the blade into the hub, a check for static balance is desirable if balancing equipment is available. If not, it may be omitted.

On new propeller assemblies or when new blades are installed, it is necessary to insert a drill bushing in the counterweight arm locating screw hole and drill a hole (using a No. 13 drill- .185 inch) through the counterweight arm, blade flange and blade ferrules. When new blades are installed in an old hub, the drilling of blade ferrules only is required. Detailed instructions of this operation will be found under paragraph - "Propeller Assembly".

When the propeller is converted for use on a different installation from what it was originally built which would require different settings, the counterweight arm, blade flange and blade are located by means of a smaller counterweight arm locating screw located at another position. For details of this procedure, refer to Aeromatic Service Bulletin No. 13.

BALANCE WEIGHTS AND BALANCE BAND ASSEMBLY:

Final static balance for the entire propeller assembly is obtained by the balance weight band assembly located around the outer ends of the hub barrel and fastened with a clamping action of a bolt. Horizontal balance is obtained by adding or removing small lead balance weights, which are fitted on the inside of the balance weight lugs and held firmly in position by a spiral compression spring also contained in the balance weight lug.

Vertical balance correction is made by adjusting the position of the balance weight band assembly around the circumference of the hub barrel.

SNAP RINGS AND SNAP RING LOCK:

Three different size snap rings are used in the Model 220 Propeller. These are: Flange plate snap rings, counterweight arm snap rings and thrust bearing retainer snap rings. The purpose of each is as follows:

The flange plate snap ring (Tru-arc ring) is fitted in a groove in the inner bore of the blade flange to hold the flange plate and flange plate seal in position, sealing the inside of the blade flange against lubricant leakage.

The counterweight arm snap ring has a round cross section, it is fitted in a groove in the extreme end of the blade flange and rests against a recess in the counterweight arm. Its purpose is to hold the counterweight arm in position against centrifugal force.

The thrust bearing retainer snap ring is of the Tru-arc type, designed to create equal pressure outward at all points on its circumference. It is located in the milled groove at the outer ends of the bore of the hub barrel and rests against the thrust bearing retainer plate. Thus, it holds the entire blade flange assembly in the hub barrel. The centrifugal load on this snap ring becomes very high and it is very important that the ring be properly seated in the hub groove. The open ends of the snap ring are always placed at a position 45 degrees counterclockwise from the vertical centerline of the hub. This position is marked on the hub by means of a transfer marked "Snap Ring Opening". As a further assurance that the snap ring will remain in position at all times, a special safety lock called a "thrust bearing snap ring lock" has been designed to prevent any possibility of the snap ring springing out while under load and vibration.

The lock is a curved piece of metal of proper length so that it will fit snugly between the open ends of the snap ring when it is installed in the hub. By means of a special tool, this curved lock is pressed outward at the center of the curve untill it becomes almost straight, thus forcing the ring tightly into the bottom of the groove and also holding it firm at that position.

On disassembly, the lock is removed by the use of a small, sharp punch. After the lock has once been compressed, it should not be reused.

HIGH AND LOW PITCH STOP BOLTS:

In order to limit the pitch changing range, adjustable stop bolts are provided on the side of the hub. These stop bolts are screwed into the hub at right angles to the plane of rotation in the special bosses provided for that purpose. The depth to which the stop bolt may be screwed into the hub is regulated by means of laminated shims placed under the head of the stop bolt. By this procedure the pitch range of the propeller is adjusted.

The integral lug on the end of the blade flange diametrically opposite to the integral synchronizer gear segment is arranged to rotate between the high and low pitch stop bolts which protrude into the hub.

The stop bolts are hardened at the extreme tip where they make contact with the hardened lug on the blade flange.

Holes are provided through the head of these bolts for safety wire. Stop bolts are provided in various lengths in order to accommodate the adjustment of any desired high and low pitch angle.

Each bolt is marked to correspond with the boss into which it is fitted. The boss is also marked; for example; No. 1 blade low pitch stop bolt marked 1L, likewise all other bolts are marked, 2L, 1H and 2H.

BLADE FLANGE LOCATING HOLES:

Accurately located holes are provided on the opposite side of each blade flange for the purpose of placing the flange in the plane of rotation when setting the blade angle and the counterweight arm angle during propeller assembly. By use of a special fixture, the "Assembly Fork", the blade flange is held rigid during this operation. The assembly fork is attached by adjustable locating pins which fit into the blade flange locating holes.

PHASE ANGLE AND HOW MEASURED:

The blade angle measured at the datum station when the center line of the blade is in the plane of rotation is termed the "Phase Angle".

Due to the lag angle in the blade flange construction, the blade tips are forward of the plane of rotation when the blades are in low pitch, and rear of the plane of rotation when in high pitch. In order to hold the blade flange stationary in the plane of rotation, the assembly fork is attached to the blade flange as described above.

ATTACHING PARTS:

Standard AN 20 spline attaching parts are required for most installations. On installations where the standard AN parts are useable they may be substituted by a complete set of similar parts made by Aeromatic which are approved by F.A.A. The main difference between the two sets are that Aeromatic hub retaining nut is made of bronze and the front cone is made in one piece and slotted similar to the rear cone. The Aeromatic parts are interchangeable with the AN standard parts.

On a few applications a special spacer is required between the rear cone and the engine thrust bearing nut. A special retainer nut is used in conjunction with this spacer. On short engine shaft installations, a special retainer nut is provided with the propeller.

NAME PLATE:

The name plate is attached by four aluminum pins on the side of the hub adjacent to the stop bolts. It contains the following information concerning the propeller: Hub serial number, model number, assembly number and production or type certificate number.

A separate assembly number is assigned to each airplane-propeller installation, although the blades may be of the same model. The purpose of this number is to designate the proper blade, counterweight arm, and low and high pitch angles, as well as the amount of counterweights required for a specific FAA approved installation and other pertinent assembly data.

If a propeller is originally set for a certain installation and then is converted to another airplane and engine combination, a new name plate should be attached showing the proper assembly number for the new installation so that in the event another Aeromatic Service Station checks the propeller, it will be checked against the proper assembly data.

LUBRICATION:

The Aeromatic Propeller is lubricated by a special lubricant (Aeromatic Lubricant 5M).

The above lubricant is available at any Aeromatic Propeller Dealer, Distributor, and approved Service Station or may be obtained directly from the Aeromatic Propeller Division, Univair Aircraft Corp., Aurora, Colorado; 80010.

The Aeromatic Propeller Model 220 must be checked for lubricant every fifty (50) hours.

When filling the hub with lubricant (5M), turn the hub so that the filler plug is on the upper side of the hub. Remove the filler plug and fill hub with Aeromatic Lubricant using any type of oil gun or can with a spout.

> NOTE - In case of emergency, a light engine oil may be used temporarily. This substitute should be replaced with the approved type lubricant as soon as possible, otherwise damage may result to the seals, packings, and bearings.

STORING:

Before storing the propeller for any length of time, fill the hub with Aeromatic Lubricant.

Coat all exposed metal parts with exterior surface corrosion preventive conforming to Specification AN-C-52. Coat the plastic surfaces of the blades with Simonize or similar wax. Keep the blades covered or in a dark place, if possible.

When the propeller is in storage, it must be supported by the hub and not supported by the blade. It should be kept in a horizontal position.

SECTION II – PROPELLER DISASSEMBLY:

The following steps should be followed in sequence in making a complete propeller disassembly.

1. Place a 20 spline assembly and balance arbor bushing into the hub.

2. Place the propeller assembly including bushing on the assembly table post.

3. Take a complete reading of all settings, including phase angle, counterweight angle, high and low pitch angles.

4. Remove the counterweight arm locating screw (28) from the counterweight arm (1).

5. Withdraw cotter pins from counterweight arm clamp bolt (8) and loosen counterweight arm clamp bolt nut (17).

6. Remove blades by rotating them in the blade flange (10) in a counterclockwise direction a few turns. Then pull on the blade untill it is removed from the blade flange.

7. Push or tap the counterweight arms (1) with a soft hammer toward the center of the hub far enough to remove the counterweight arm snap ring (25). Then remove the counterweight arms from the blade flanges by pulling radially outward.

8. Remove the flange plate snap ring (26) with a No. 5 Snap Ring Pliers, then the flange plate (11) and the flange plate seal (33).

9. To release the preload from the bearings, insert the Aeromatic preload tool through the blade flange end and insert the serrated part of the tool into the bearing preload screw (31). Then press hard on the tee (44) handle of the tool, which compresses the preload lock spring and releases the preload bearing lock (14). Then while the spring is compressed, rotate the Tee handle of the preload tool in a clockwise direction. This will relieve the preload of the bearings.

10. Remove the thrust bearing Snap Ring Lock (15) with the use of a small sharp punch.

11. The Thrust Bearing Retainer Snap Ring (27) can now be removed with No. 7 Snap Ring Pliers.

12. Remove the blade flange assembly from the hub as far as possible by inserting the preload tool as previously instructed, and rotate in a counter- clockwise direction as far as it will go. Now the thrust bearing retainer plate (23) can be removed. Then remove the thrust bearing seal (34) by the use of a small screw driver or a similar tool. With a slight pull, the blade flange assembly can easily be removed.

13. The bearing preload can now easily be removed by hand.

14. The synchronizer shaft (35) is ready to be removed by use of the special synchronizer shaft tool. This is done by rotating the handle in a counter-clockwise direction.

15. After the synchronizer shaft is removed, the synchronizer gear (12) can be removed through the hub barrel.

16. The stop bolts can now be removed. Care should be used to keep each set of stop bolt shims with their respective bolts.

17. Remove balance band assemblies (2). The hub is now ready for magnaflux inspection.

SECTION III – PROPELLER ASSEMBLY

Start the propeller assembly by fitting a 20 spline assembly and balance bushing into the hub. Then place the unit on the assembly post of the propeller checking table. Install the four stop bolts (45 and 46) with their corresponding shims (49) in their respective hub bosses which are 1H, 2H, 1L and 2L. Do not tighten or safety bolts untill high and low pitch angles have been adjusted.

The angular relationship between the blade assembly and the hub, which is controlled by the position of these stop bolts, is dependent upon a particular engine and airplane combination, cowl, configuration, etc.

If a reassembled propeller is to be used on another type of airplane or on an engine model other than which it was originally assembled, a new shimming arrangement will be required or a different length stop bolt may be used to an advantage. Also the blade and counterweight arm angle may require a change in settings. Refer to Service Station Assembly & Parts List for proper settings.

Next, assemble the preload lock spring (44), preload lock (14), and preload screw (31) into the preload boss bore No. 1. Screw this assembly into the boss as far as it will go, using the special preload tool. Then slide the bearing sleeve (41) over the boss. Repeat the same operation for No. 2 preload assembly.

The following assembly should be made on a bench before placing into the hub, starting with No. 1 blade flange (Part No. 3267). Place the preload bearing (3) in the recess provided for it at the inner end of the flange. Since this bearing is a radial thrust bearing, it is very important that it is properly installed, e.g., place the bearing in the flange so that the lettering "Thrust Here" and numerals on the bearing race are hidden when installed in the blade flange, or another check is that the lettering "Thrust Here" and numerals are to face toward the tip of the blades.

Then turn the blade flange over and place on a clean bench so that the previously installed preload bearing is toward the bench. Place the thrust bearing (4) over the flange (10) so that the inner race with the large radius is first installed. This race should fit solidly on the ground, flat surface of the flange. In order to check this, hold the bearing race tight on the flange, with the thumb and forefinger of each hand, and then hold the assembly up to the light. If properly fitted, no light will be visible between the flange and bearing race. Be sure both surfaces are free from grit, grease or oil during this test.

If light is visible between the two surfaces, the possible causes are that the bearing race radius is too small or the blade flange radius is too large. This condition can be remedied by using another bearing race with a larger radius. Then continue assembly of the ball cage and outer bearing race.

Next, install the flared flange seal packing shim (36) over the blade flange with the flare fitting into the chamber of the bearing race. This shim will require a small amount of pressure to slide it over the flange. Great care should be exercised to avoid cocking or distorting the shim. The race of a discarded thrust bearing is a very convenient tool to use in applying even pressure on the shim while it is being installed. Also be sure that it fits solidly on the outer bearing race when it is in position. A .016" flange seal packing shim (37) should then be placed on the flange, adjacent to the flared shim.

Next, place the flange seal packing (19) over the flange with the feathered edge toward the propeller blade. Before the flange seal packing spring (43) is installed, the following check should be made to adjust for proper flange seal packing compression.

Place the thrust bearing retainer plate (23) over the entire packing and shim assembly. The weight of the thrust bearing retainer plate on the seal packing should allow a space of approximately .030" air gap between the plate and the outer race of the thrust bearing. If this space is not .030", add shims in increments of .005", which are provided for this purpose. Or if the gap is in excess of .030", remove the .016" shim and substitute two .005" shims.

After the proper clearance is adjusted for compression on the flange seal packing, remove the thrust bearing retainer plate and install the flange seal packing spring (43) in the groove provided for it in the flange seal packing. Then place the outer flange seal packing shim (38) on top of the seal packing. The assembly is now ready for installation in the hub. Place No. 1 assembly in its corresponding hub barrel. A special tool should be used while making this assembly in order to prevent the flared shim from being displaced on the blade flange. It is essential that this shim remain in its proper position, otherwise lubricant leaks may occur at the flange seal packing. This tool may easily be made from a discarded thrust bearing retainer plate by reducing the diameter approximately 1/8" and applying two 10-32 screws to serve as handles for quick removel.

After the above-mentioned assembly tool has been removed, install the thin circular thrust bearing seal (34) in the chamfered groove of the outer race of the thrust bearing at the hub wall. Then place the thrust bearing retainer plate (23) in place, followed by the thrust bearing retainer snap ring (27). Using the snap ring pliers No. 7, compress the snap ring untill it fits inside the end of the hub barrel and place it in the groove provided for that purpose, locating the snap ring openings at a point 45° counter-clockwise from the vertical center line of the hub.

Next, install the snap ring lock (15) between the open ends of the snap ring. By use of the special snap ring lock pliers, this lock should be pressed firmly in place allowing approximately 1/16" of its center portion to extend beyond the ring groove. This extended portion is for removel purposes at the next disassembly.

The preload on the blade flange assembly is now ready to be tightened. Insert the special preload tool through the hole in the center of the base of the blade flange. Push the tool hard enough to compress the preload lock spring (44), thereby relieving the preload lock (14). While holding the preload tool in this "in position", rotate counter-clockwise untill the bearings are loaded and a slight drag is felt on the bearings so that all end play and side motion is removed from the flange when the blade is installed. This adjustment usually requires all the force a man can exert with one hand on the handle of the Tee handle of the tool. When the preload tool is removed, the spring automatically forces the lock into locked position and secures the preload adjustment. Care must be exercised not to confuse seal drag with bearing drag.

As a final check on the preload adjustment. a blade may be screwed into the blade flange and moved sideways while the hub is held rigid on the table post. This adjustment is very critical as excessive preload will cause the bearing to brinell. Too little or loose preload will allow excessive shake in the blade flange and cause lubricant leaks and also allow the bearings to pit or brinell. In either case, the results will be an erratic operating propeller in flight.

Next, install the flange plate seal (33) into the recess provided for it inside the blade flange bore. Then place the flange plate (11) on top of the seal with the small center lug pointing outward.

Apply the flange plate assembly tool and compress the seal untill the flange plate snap ring (26) can be installed in the groove provided for it. The flange plate assembly tool is now ready to be removed.

Now install the synchronizer gear (12). First, mount the hub rigidly on the mandrel, or post, on the assembly table and place the assembly fork on the blade flange No. 1 to engage the locating holes provided for this purpose. While the flange is held in this position, insert the synchronizer gear segment (12) through No. 2 barrel. Hold the gear segment in a horizontal position, or parallel to the assembly table while meshing it into the gear segment of No. 1 blade flange. While in this position, insert the synchronizer shaft (35) with synchronizer shim (39) through the hub boss and synchronizer gear. Screw the shaft in by hand, but do not tighten at this time.

An additional check for the proper location of the synchronizer gear engagement may be made by sighting through No. 2 barrel. One gear tooth of the blade flange gear segment should be showing above the gear synchronizer segment.

NOTE: In setting up a propeller to utilize a very high pitch for semi-feathering, as used on multi-engine installations, the gear segment of the synchronizer and the blade flange gear segment should mesh evenly at the top. This is accomplished by installing the synchronizer gear at a slight angle with the meshing end higher than the synchronizer shaft.

Repeat the same assembly and testing operation for No. 2 flange (3268). When installing flange, hold the two locating holes on the flange as near parallel to the assembly table as possible during this operation to insure the proper synchronizer meshing while No. 1 flange is held rigid by the assembly fork.

As a guide to keep the flange No. 2 in proper position, a piece of welding rod may be passed through the locating holes and extended on both sides of the flange and held parallel to the surface of the assembly table. After the No. 2 flange installation is completed, install the counterweight arms (1) on the blade flanges, push the arms on the flanges far enough to be able to place the counterweight arm snap ring (25) in the groove on the end of the flanges provided for that purpose. Then slide the counterweights toward the end of the flanges untill it rests against the snap ring.

Lubricate the threads on the counterweight arm clamp bolts (8) and nuts (17) with anti-sieze compound, specification AN-C-53 or an equivalent mixture of 70% pure white lead and 30% clean engine oil.

Insert the clamp bolt (8) to the counterweight arm (1) with the threaded end toward the side marked "NUT". Attach the nuts loosely on the bolts untill after the blades have been installed.

Before blades are installed or lubricant is added to the hub, check for leakage by applying 10 lb/sq. in. of air pressure to the hub. While the hub is pressurized, immerse the unit in solvent, kerosene or any clear cleaning fluid to check for air leaks. If leaks occur, remedy them before proceeding with assembly. By the use of air pressure, a leak can be detected; and in the event alterations are required, the hub is free of lubricant. In this procedure the hub is allways empty during static balancing of the propeller assembly.

Blades may be installed now. Coat the threads of the blade shank with anti-sieze compound and screw blades into their respective flanges untill the thread bottom. Place the assembly fork back on No. 1 blade flange. See that the base of the assembly fork fits firmly on the checking table. Then unscrew the blade untill the desired phase angle is obtained at the datum station. This phase angle is given on the assembly data sheet relative to the assembly number of the propeller. In measuring the phase angle, high and low pitch, the protractor adapter should always be used on the protractor arm. In effect, this protractor adapter is a templet which fits all model Aeromatic blades. No blade settings should be made without it.

After setting the blade phase angle, adjust the counterweight arm angle. This is done by measuring the complement angle of a 90^{o} quadrant. Set the protractor to the angle given on the propeller assembly sheet for the respective model.

Place the protractor arm against the base of the counterweight on the side on which the flat surfaces are ground. Holding the base of the protractor firmly on the table with the required angle set, place the protractor arm against the counterweight, rotate the small end of counter-weight arm untill both the base and the counterweight arm tip rest against the protractor, install counterweight arm locating screw (28). Tighten the counterweight arm clamp bolt while counterweight arm is in this position to 55-60 ft. lbs. torque with the use of a torque wrench. After the counterweight arm clamp bolt is tightened, recheck both phase angle and counterweight angle for proper settings, a tolerance of plus or minus $.1^{o}$ is permissible.

While the blade is still held by the assembly fork, measure the height of the blade tip from the assembly table. The same procedure is used in setting No. 2 blade. After this operation is completed, compare the height of both blade tips. This will determine the blade track. A tolerance of 1/8" between the two blades is permissible. The radius of both blades should be also measured; a 1/8" tolerance is permissible.

Remove the assembly fork and set high and low pitch of both blades as prescribed in the applicable Parts Assembly List. Pitch adjustment is made by use of the laminated shims placed under the heads of the stop bolts. The low pitch settings must be correct within a tolerance of plus or minus $.1^{o}$; the high pitch stops within plus or minus $.25^{o}$. When adjusting stop bolts, be sure that each blade rests against the respective stop bolt when measuring either high or low pitch angles. It may simplify this operation to back off the opposite stop bolt while this adjustment is being made on high and low pitch stops.

The synchronizer shaft (35) can now be tightened and safetied. A special synchronizer assembly tool is provided for this purpose.

After the synchronizer shaft has been tightened, rotate the blades between high and low stops to feel for undue drag or rough spots, which may be felt if the synchronizer gear is meshed too deeply in the flange gear segments. If this should happen, add shims under the head of the synchronizer shaft.

As an additional check, hold one blade stationary and measure the backlash between the two blades. The maximum tolerance is 1^{o}, but $½^{o}$ or less is more desirable.

If no blade replacements were made and the angles of counterweight arm and blade are set, the counterweight arm locating screws (28) with washer (48) attached should be tightened and safetied.

BLADE REPLACEMENT:

When a blade replacement is made, the following procedure for redrilling the blade ferrule should be used.

Screw drill bushing Part No. 2913 into the threaded counterweight arm locating screw hole. Place the round shank end of a Number 13 drill through the drill bushing and into the drilled hole in the blade flange from which the locating screw was previously removed. As an alternate a counterweight arm locating screw may be cut down in length so that it passes through the counterweight arm and blade flange only when in position. The phase angle can be set, and the counterweight bolt tightened before the screw is removed and drill bushing installed.

Set the blade to the proper phase angle, tighten the counterweight arm bolt (8) with the drill shank in this position. Then remove the drill shank. Drill the blade ferrule using the No. 13 drill to a depth of 3/16'' into the new blade. Remove drill bushing, install counterweight arm locating screw (28) with washer (48) attached and safety.

PROPELLER ASSEMBLY BALANCE:

Before lubricant is applied to a rebuilt propeller, the balance should be checked and adjusted if necessary.

Correction for small horizontal out-of-balance conditions is made by adding or removing lead balance weights (51) at the balance band around the hub to the desired position.,

Whenever horizontal balance cannot be corrected by the above method, remove the light blade and add lead wool in the center hole of the blade shank untill balance is obtained. Propellers that have been removed from an airplane to have the balance checked should be completely filled with lubricant before starting the check.

COUNTERWEIGHT ARM CHANGE – PROCEDURE:

Whenever a propeller assembly is converted from one installation to another, in most cases a change in counterweight arm angles will be required and frequently the phase angle requires a change also. A detailed procedure has been established for this operation and is explained in Service Bulletin No. 16 supplied to all Aeromatic Authorized Service Stations.

COUNTERWEIGHTS:

When a propeller is overhauled, the original counterweights (9) should be replaced. When new blades are installed, counterweights should be added as required on the Service Station parts list to correspond with the particular horizontal moment of the new blades. Counterweights are installed on the inner side of the counterweight arm so that the centrifugal force holds them against the arm. By this arrangement, the counterweight bolt (7) is not required to carry the centrifugal load.

INSTALLATION OF ALTITUDE CONTROL UNIT:

1. Remove the front nose cowl from the airplane.
2. Install the control mounting flange No. 3332C on the nose of the engine crankcase making sure that one of the helical slots in its rim is located at the top of the engine. Secure with the four 5/16" by 18 socket head screws No. 20206-10. Washers No. AN960-516L should be placed under the heads of these screws. Safety screws with wire.
3. Next, install the thrust plate and housing assembly No. 3338, which is fastened in place with two housing dowel screws No. 20213 and one control cable anchor screw No. 20214. The two dowel screws require one (1) each washer No. AN960-616. Provision is made to safety these screws to the housing. The cable anchor screw requires a lock washer to secure it. Before assembly, coat the sides of the inclined slots of the mounting flange with Lubriplate No. 110 or with wheel bearing grease. Use the grease freely at this point as the excess grease will remain inside the housing.
4. Install bell crank bracket No. 20283, on the two forward crankcase bolts on right-hand side of engine (from cockpit). Mount the bell crank No. 20284 on this bracket.
5. Drill an 11/16" diameter hole in the fire wall for the control cable. This hole is to be located on the right-hand side (from cockpit) 12 inches from the top of the cowl and 9½ inches horizontally toward the center of the fire wall. A rubber grommet is placed in this hole to prevent chafing of the control cable housing.
6. String the cable housing through the fire wall from the cockpit, secure the cable housing to the engine at the rocker box covers by the use of Adel clamps. Mount the control lock unit on the instrument panel in the hole provided for the "propeller control".
7. Attach the ball joints with the control rod on the bell crank and on the anchor screw on the thrust plate housing.
8. Rotate the thrust plate housing counter-clockwise, looking from the cockpit, untill it strikes the stops. This will be low pitch condition. Then place the instrument panel control handle at the " full forward position". Adjust the yoke on the threaded end of the control cable to proper length, connect the bell crank with clevis pin and safety.
9. Attach the aluminum angle, forming bracket for control spring, on the two upper rocker box screws on No. 6 cylinder with its extended end toward the propeller.
10. Hook the short end of the coil spring in the small hole in end of spring bracket and the other end to the thrust plate housing anchor screw.
11. Replace engine nose cowl.
12. Using the present nose cowl cover plate, enlarge the center hole to 8½" diameter. Then rivet the 1/16" thick circular neoprene gasket to the modified cover plate.
    Be sure that this neoprene seal is centrally located on the cover plate; otherwise, a good fit will not be made around the thrust plate housing.
13. Install the propeller on the shaft in the usual manner, making sure that the hub dowel key fits into the keyway in the thrust plate No. 3334.

SERVICE AND OVERHAUL TOOLS

Tool No.	Nomenclature	Application
	Pliers	Installing lock wires.
	Socket Wrench 3/4 Hex	Tightening counterweight bolts and nuts.
	Machinist's Square	Checking blade track and edge alignment.
	Blade Wrench	Turning blades.
	Torque Wrench	Tightening counterweight bolts and nuts.
4070	Assembly fork	Fixing position of flanges for phase angle measurements.
3290	Lubricant Gun and Fittings	Filling hub with lubricant.
2091	Oil Gun	Filling hub with oil.
4031	Protractor	Measuring blade angles and counterweight angles.
20075	Preload Tool	Adjusting preload.
2805	Preload Tool (old style)	Adjusting preload.
2626-1	Protractor Adapter	Used with Protractor to measure blade angle.
4074	Flange Plate Assembly Tool	Compressing flange seal rings while assembling snap rings.
2871-7	Snap Ring Pliers No. 7	Removing and assembling thrust bearing retainer snap rings.
2871-7T	Tips for No. 7 Pliers	Replacement of worn or broken tips.
2871-5	Snap Ring Pliers No. 5	Removing and assembling flange plate snap ring.
2988	Synchronizer Shaft Assembly Tool	Removing and installing shaft.
	Socket Wrench 7/16 Hex	Adjusting balancing weight assemblies.
	Screw Driver	Installing counterweight saftey screws.
	Allen Head Wrench, 3/16 Hex	Used for removing and installing lubricant filler plug.
2913	Drill Bushing	Drilling counterweight lock screw holes in new blades.
	Soft Hammer	Removing and assembling various tight fitting parts.
20106	Snap Ring Lock Tool	Installing Snap Ring Locks.
3423	Service Station Horizontal Moment checking tool.	Measuring horizontal balance of blade.
3322	Locating screw drill jig-counterweight arm.	Relocating counterweight arm.
3300	Name Plate Assembly Tool	Installing name plate.

TABLE OF FITS AND TOLERANCES:

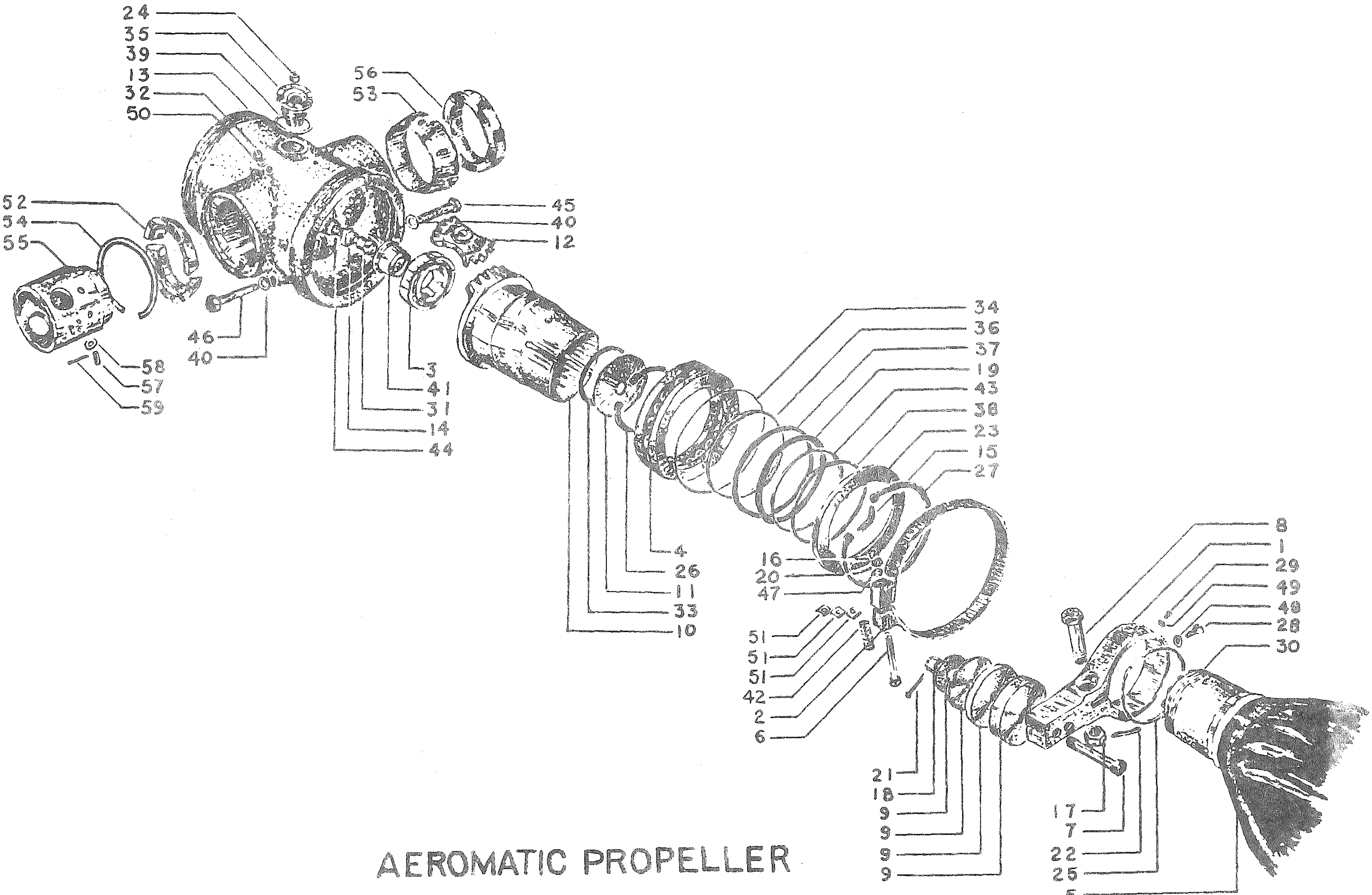
Maximum backlash between blades	1°
Length of flange seal packing spring	7"
Variation between blade angles Low Pitch	$.2^{\circ}$
Variation between blade angles High Pitch	$.5^{\circ}$
Variation between blade angles at Phase angle	$.2^{\circ}$
Static out-of-balance tolerance	2 in/oz.
Out of track (between two blades)	1/8"
Radius (between two blades)	1/8"
Torque on counterweight arm clamp bolt	55-60 foot/pounds
Retaining nut minimum thread engagements (crankshaft)	5½ threads
Minimum clearance between cowl and propeller	¼"
Compression on flange seal packing	.030"
Torque - Blade Retention Lag Screws	140-150 in. lb.
Lubricant leakage air pressure test	10 lb./in.
Minimum propeller diameter below standard	1½"

EXPLODED VIEW – PARTS LIST:

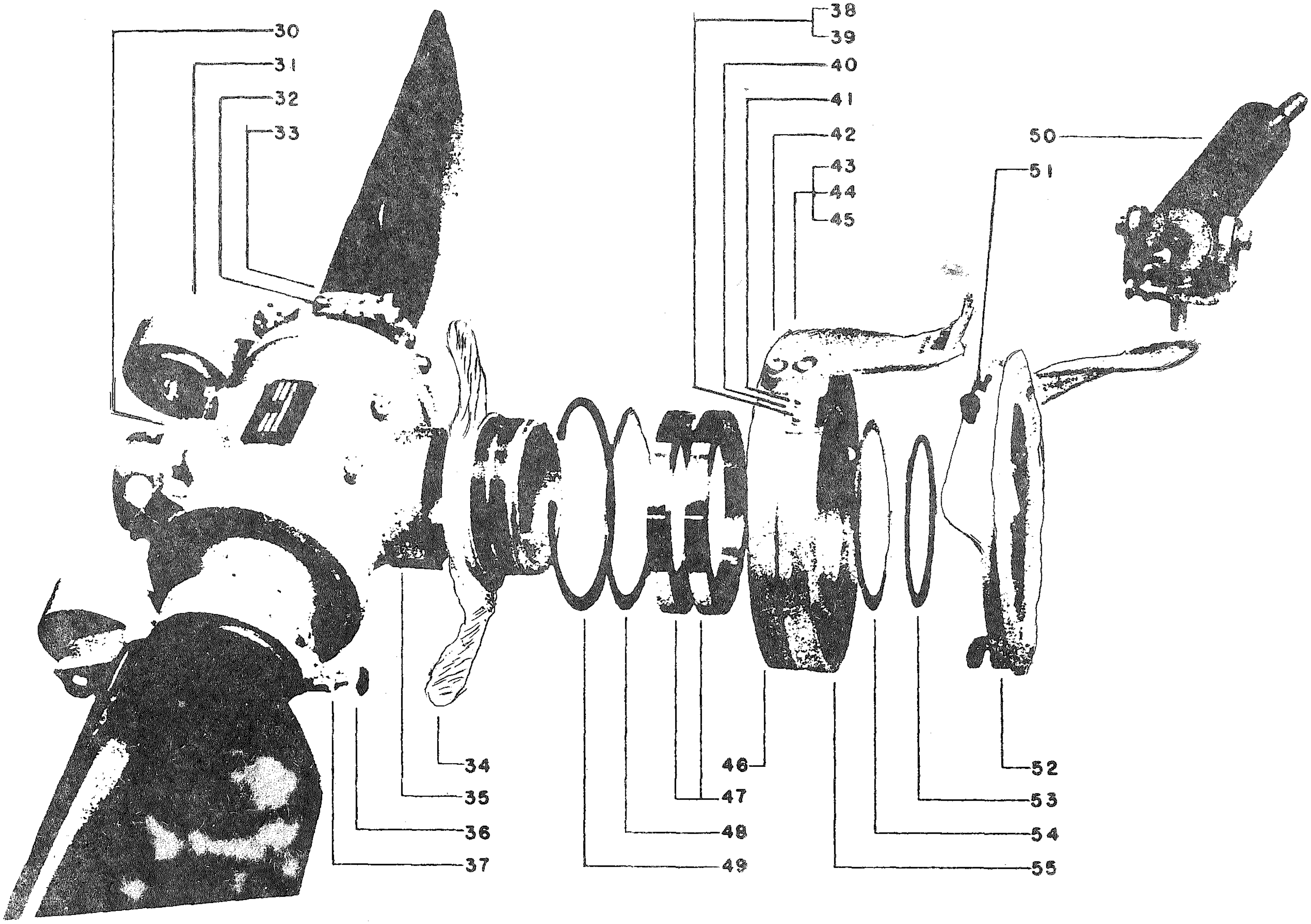
INDEX NO.	PART NO.	PART NAME	NO. REQ'D.
1	3282	Arm-Counterweight	2
2	2848	Band Balance Weight	As Req'd.
3	2856	Bearing-Preload	2
4	2833	Bearing Thrust	2
5	P4986-85	Blade Assembly	2
6	AN4-21	Bolt-Balance Weight Band	2
7	AN7	Bolt-Counterweight	2
8	2167	Bolt-Counterweight Arm Clamp	2
9	2965	Counterweight	As Req'd.
10	3267	Flange-Blade No. 1	1
10	3268	Flange-Blade No. 2	1
11	2644	Flange Plate	2
12	2853	Gear - Synchronizer	1
13	4765	Hub (only)	1
14	20066	Lock -Bearing Preload	2
15	20105	Lock - Thrust Bearing Snap Ring	2
16	AN310-4	Nut - Balance Weight Band	2
17	20042-8	Nut - Counterweight Arm Clamp	2
18	AN310-7	Nut - Counterweight Bolt	2
19	20117	Packing - Flange Seal	2
20	AN380C-2-2	Pin - Cotter (Balance Band Bolt)	2
21	AN380C-3-3	Pin - Cotter (Counterweight Bolt)	2
22	AN380C-4-3	Pin- Cotter (Counterweight Clamp Bolt)	2
23	2859	Plate - Thrust Bearing Retainer	2
24	2740	Plug - Lubricant	1
25	2478	Ring - Counterweight Arm Snap	2
26	2606	Ring - Flange Plate Snap	2
27	2843	Ring - Thrust Bearing Retainer Snap	2
28	2894	Screw - Cwt. Arm Locating (5/16-24)	2
29	AN502-10-4	Screw - Cwt. Arm Safety	2
30	2875	Screw - Lag	36
31	20065	Screw - Bearing Preload	2
32	2934-3	Screw - Synchronizer Safety	1
33	2534	Seal - Flange Plate	2
34	2841	Seal - Thrust Bearing	2
35	2855	Shaft - Synchronizer	1

EXPLODED VIEW -- PARTS LIST (Cont'd)

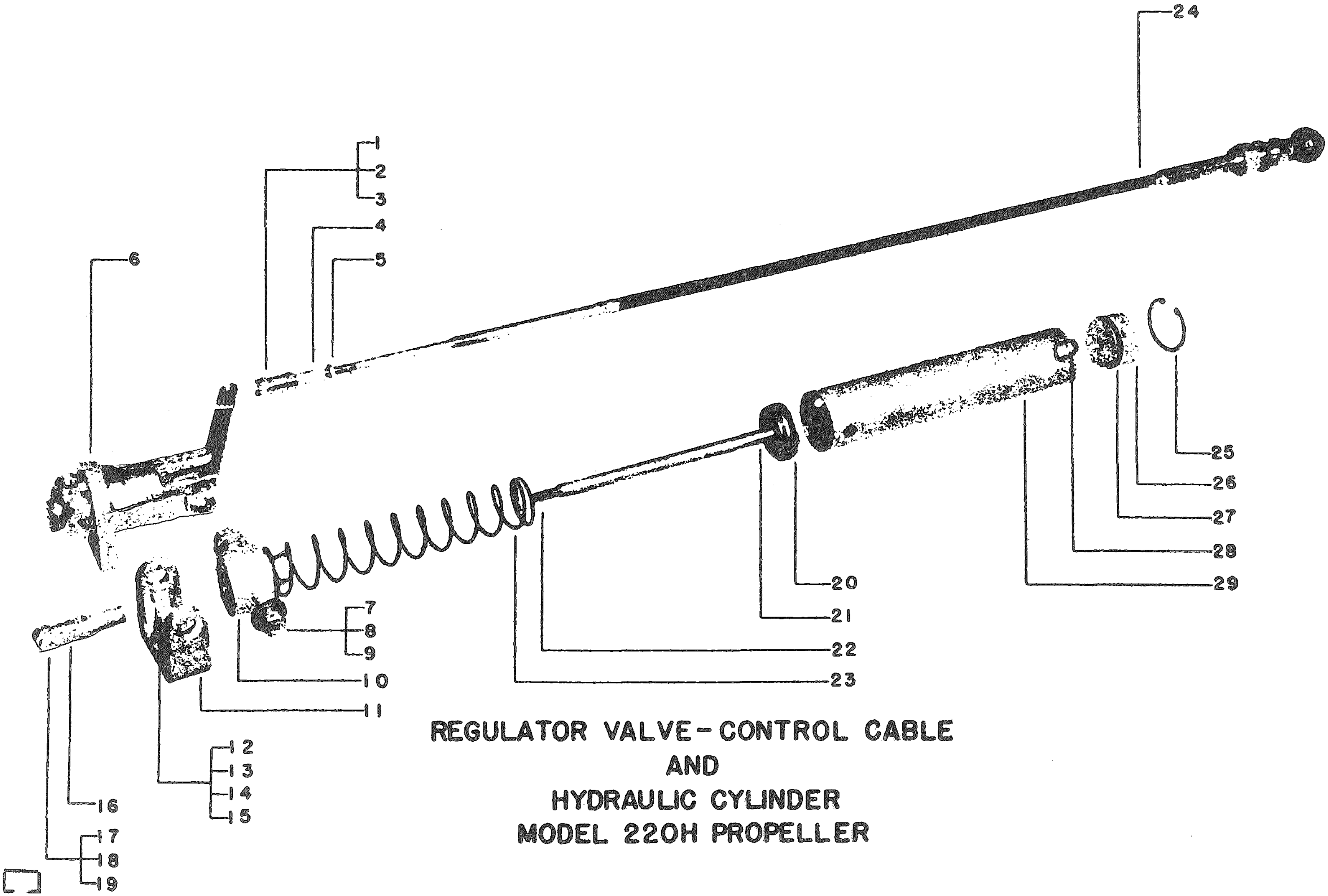
INDEX NO.	PART NO.	PART NAME	NO. REQ'D.
36	20102	Shim - Flange Seal Packing (Flared)	2
37	2996	Shim - Flange Seal Packing (Inner)	2
38	20062	Shim - Flange Seal Packing (Outer)	2
39	2854	Shim - Synchronizer Shaft	As Req'd.
40	2660	Shim - Stop Bolt	As Req'd.
41	2857	Sleeve - Preload Bearing	2
42	2621	Spring - Balance Weight	As Req'd.
43	2995-1	Spring - Flange Seal Packing	2
44	20070	Spring - Preload Lock	2
45	2659-60	Stop Bolt - High Pitch	2
46	2659-49	Stop Bolt - Low Pitch	2
47	AN960-416 L	Washer - Balance Band Bolt	2
48	2714-3	Washer - Cwt. Arm Locating Screw	2
49	AN960-10	Washer - Cwt. Arm Safety Screw	2
50	2934-3	Washer - Synchronizer Safety Screw	1
51	2888	Weight - Balance	As Req'd.
52	2400	Front Cone	1
53	2989	Rear Cone	1
54	20013-20	Snap Ring	1
55	2746	Retainer Nut	1
56	2542-10	Spacer	1
57	AN394-19	Flat Head Pin	1
58	AN960-416	Washer	1
59	AN380C-2-3	Cotter Pin	1



AEROMATIC PROPELLER
MODEL 220



AEROMATIC HI-CRUISE PROPELLER
MODEL 220H ASSEMBLY



REGULATOR VALVE-CONTROL CABLE
AND
HYDRAULIC CYLINDER
MODEL 220H PROPELLER