TECHNICAL NOTES

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METHOD OF CONSTRUCTION.

By F. W. Caldwell and N. S. Clay.

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METHOD OF CONSTRUCTION.

By F. W. Caldwell* and N. S. Clay**.

In manufacturing micarta propellers the methods differ considerably from those employed with wood propellers on account of the hardness of the material. The propellers must be formed accurately to size in a mold and afterwards balanced without the customary trimming of the material from the tips.

A press used in forming micarta propellers is shown in Figure 3. Two main rams are provided which may be connected to one of three hydraulic systems to give the molding pressure desired. One pullback ram is provided for opening the press and two stripping rams for removing the propeller from the mold. The platens are designed to withstand a concentrated load of 600 tons in the center, giving under this condition a deflection of less than one-thousandth of an inch. Uniform travel of the head is maintained by a rack and pinion at each end.

Press and Mold for Micarta Propellers.

In constructing the mold, because of the peculiar shape of an airplane propeller, considerable handwork is necessary. For this reason a metal was selected which can be readily chipped,

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filed, scraped and polished and at the same time have sufficient hardness to give the mold satisfactory life. A high grade phosphor bronze was tried and has proved very satisfactory. The high heat conductivity of this material gives the mold quick heating and cooling properties.

The mold is heated with steam and cooled with water. It is of sectional construction to permit insertion of the brass heating pipes and also to facilitate machining. A cross-section of the mold for the Liberty propeller is shown in Figure 4.

Liberty Propeller Mold - Cross-Section 30 Inches from Hub Center.

Since cotton duck has been used with most micarta propellers produced, the description of the manufacturing operations will be confined to this material. The description will also be limited to propellers of conventional design and will not include the detachable blade type.

The cotton duck is received in rolls containing approximately 250 yards. It is first run through a heated chamber to drive off most of the moisture, then immediately passed through an alcoholic solution of the phenolic resin, and then through a heated chamber again to drive off the solvent. The treated cloth is now dry and may be handled or stored for considerable time without damage.

With the aid of paper or metal templets the shape of each lamination is traced on the treated duck which is afterwards cut on a band saw. For convenience a number of sheets are stacked and sawed at the same time. The material cut from between the laminations is subsequently ground and forms a patented molding mixture from which switch bases, airplane pulleys, and other parts are made.

The laminations are next built up in correct sequence on a board from which they can be readily transferred to the mold. In Figure 5 is shown the stacked material for a Liberty propeller compared with the molded propeller.

Stacked Treated Duck for Micarta Propeller Compared with Molded Propeller.

Some micarta propellers have a steel wire molded into the leading edge to improve the flight characteristics. The shape of this wire as used with the Liberty Micarta propeller is also shown in Figure 5. The wire is sewed to one of the duck laminations to hold it in place during the molding operation.

The laminations are transferred from the stacking board directly to the mold which is then closed and heat and pressure applied. The pressure used and the time of baking depends upon the size and shape of the propeller. After baking the required length of time, cooling water is circulated through the mold and when the mold is cold the propeller is removed.

The propeller after removal from the mold requires the following operations:

(1) Filing edges.

(2) First boring of the propeller boss.

(3) Preliminary balancing.

(4) Final boring of boss.

(5) Cutting keyways.

(6) Installing hub.

(7) Curing.

(8) Final balancing.

(9) Finishing.

Filing

The edges of micarta propellers are molded square as can be seen in Figure 4, to avoid sharp edges on the mold pressing blocks. The material is readily filed to the correct shape and polished with emery cloth.

First Bore

The propeller is placed in a fixture on the table of a vertical milling machine and centered from the molded taper hole in the boss. The blade angles and the track of the two blades are then equalized by means of the fixture and a straight cylindrical hole bored in place of the taper, the diameter being less than the finished diameter. The set-up for this operation is shown in Figure 6.

Micarta Propeller Boring Operation.

Preliminary balancing.

In balancing wood propellers, it is customary to remove material from the heavy blade. This is not desirable with the micarta propellers because of the hardness of the material and the thin blades. The method adopted is to locate the hub hole at the center of the gravity of the propeller. The position of this point can be readily determined by measuring the amount and direction of unbalance. For convenience the unbalance is measured in two directions, first, with the longitudinal axis of the propeller horizontal; and second, with it vertical (Figure 7).

If

W = Weight of propeller.

W_a = Weight required to balance with longitudinal axis horizontal.

W_b = Weight required to balance with transverse axis horizontal.

L = Length of balance arm.

a = Distance hub hole must be shifted longitudinally.

b = Distance hub hole must be shifted in transverse direction.

then

$$W \times a = W_a \times L$$

$$A = \frac{W_a \times L}{W}$$

In like manner $b = \frac{W_b \times L}{W}$

It is necessary to determine the values W_a and W_b very accurately to secure a well-balanced propeller. The balancing is done with accurately ground ways and mandrels in a room free from air currents. One of the balancing stands is shown in Figure 8.

Propeller Balancing.

Final Bore

The propeller is again placed in the fixture on the milling machine and centered from the machined hole. The table is then shifted in the direction of the horizontal and transverse axes, the amounts determined by the balancing operations. The hole is rebored with its center at the desired location, which is the center of gravity of the propeller. The final bore is of sufficient diameter to include the hole first machined as shown in Figure 7. The hole is next reamed to give a .005 inch press fit on the propeller hub.

Balancing and Machining Chart.

Cutting Keyways.

The keyways are cut either on a slotter or with a broaching press. The width is made slightly less than that of the key so as to insure solid bearing on both keyways.

Installing Hub

The latest style of hub used with micarta propellers is shown in Figure 9. This hub is first forged roughly to shape, then accurately machined and finally zinc-plated. A high grade of chrome vanadium steel is used.

The hole in the propeller boss is painted with a thick solution of a phenolic resin and the metal hub pressed in. This requires a pressure of approximately 3 tons.

Micarta Propeller Hub.

Curing.

As micarta propellers are not baked a sufficient length of time in the mold to convert the resin to its final infusible stage, a further curing operation is necessary. The propeller is placed in a fixture similar to that shown in Figure 10, and baked for 20 hours at a temperature slightly over 100°C. At this temperature the material does not soften to an appreciable extent but internal strains are removed and the angles of the blades gradually conform to those of the curing fixture. Slight differences in the angles of the two blades due to distortion after removal from the mold or from errors in machining the hub hole can be corrected in the curing operation. The angles cannot, however, be changed materially from their molded values.

Curing Fixture.

Final Balancing and Finishing.

The propeller as received from the curing operation is ready for the final balancing operation. The longitudinal unbalance can be easily taken care of with a little extra paint or varnish on the tip of the light blade. The transverse unbalance, if too great to be taken care of by painting, is compensated by a metal plate attached to the light side of the propeller boss. Two or more brass machine screws, the holes for which are drilled and tapped into the micarta are used to hold the plate.

Micarta propellers are finished with two coats of gray or maroon paint (the latter for night flying) and two coats of clear varnish. A narrow stripe of red paint, in case of the gray, and black with the maroon finish, is placed on the leading edge. As this wears off in service, it can be replaced without seriously unbalancing the propeller.

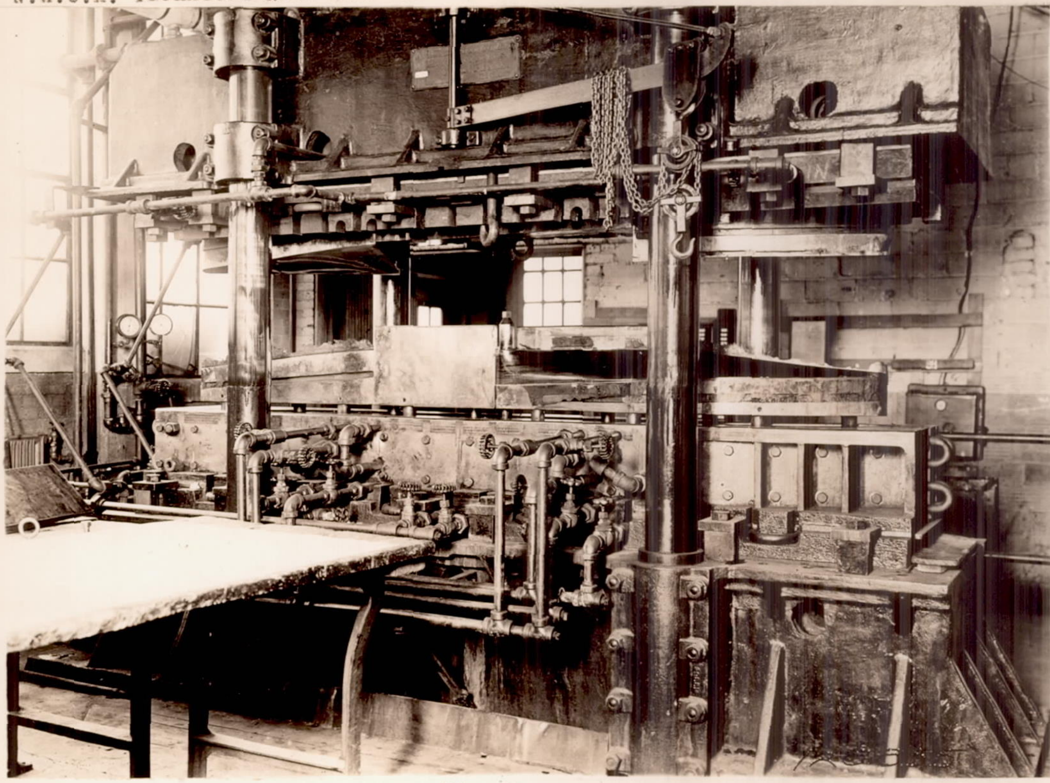

Fig. 3

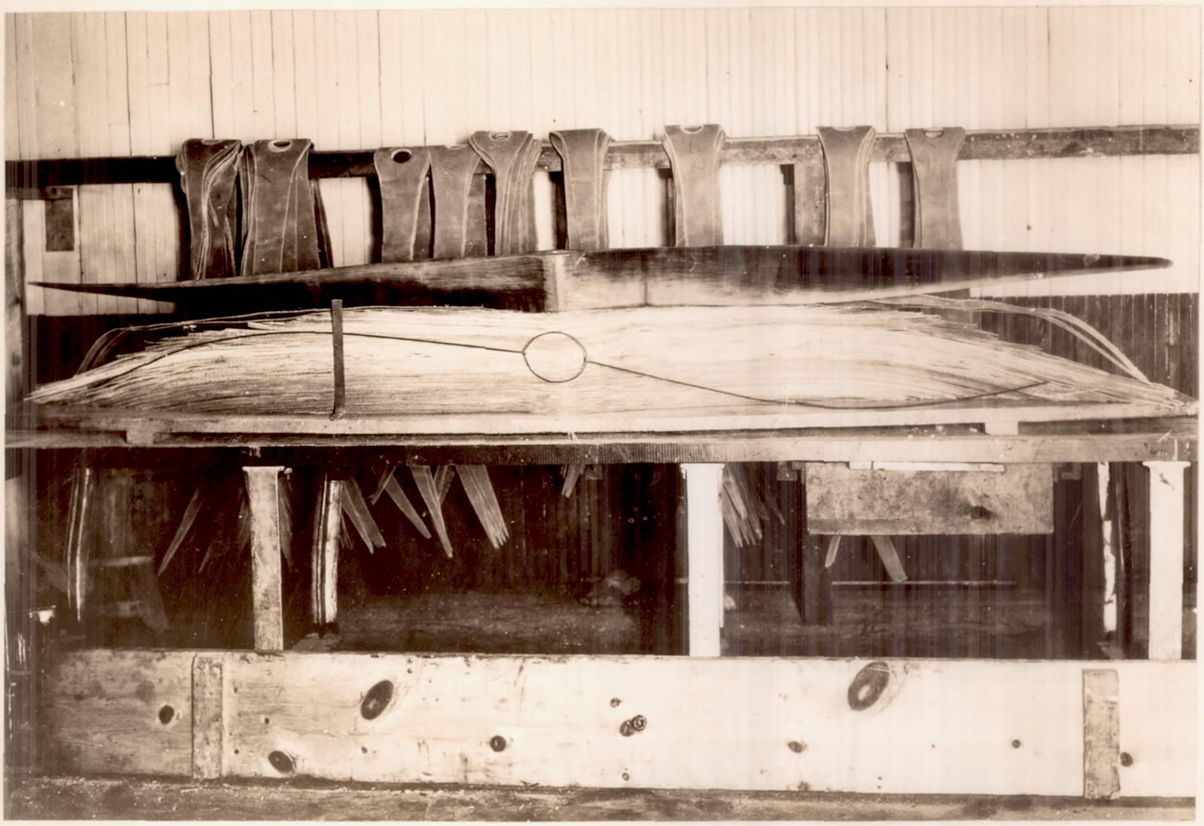

Fig. 5

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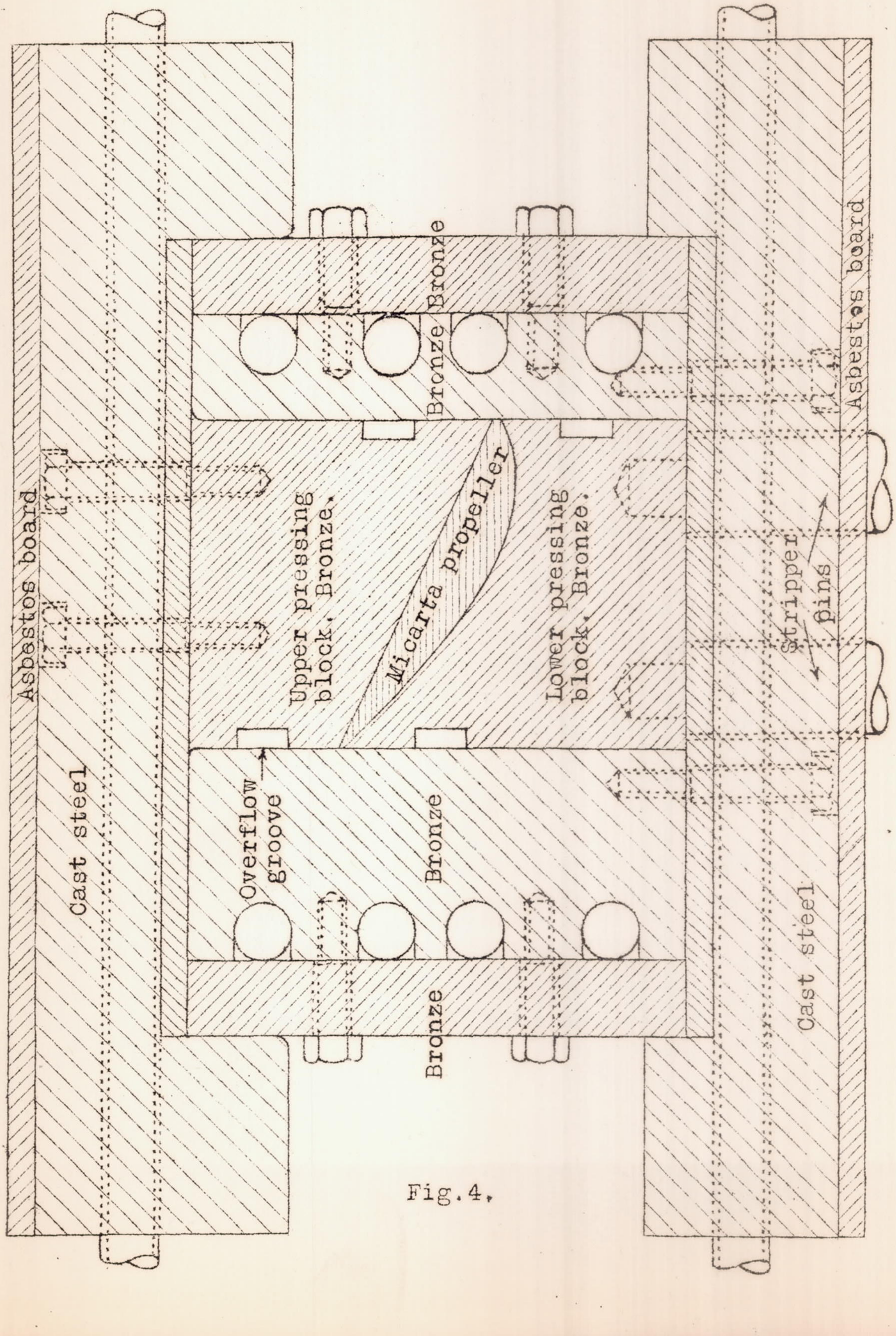
Bronze
Bronze
Asbestos board
Upper pressing block, Bronze.
Micarta propeller
Lower pressing block, Bronze.
Stripper pins
Asbestos board
Cast steel
Overflow groove
Bronze
Cast steel
Bronze

Fig.4.

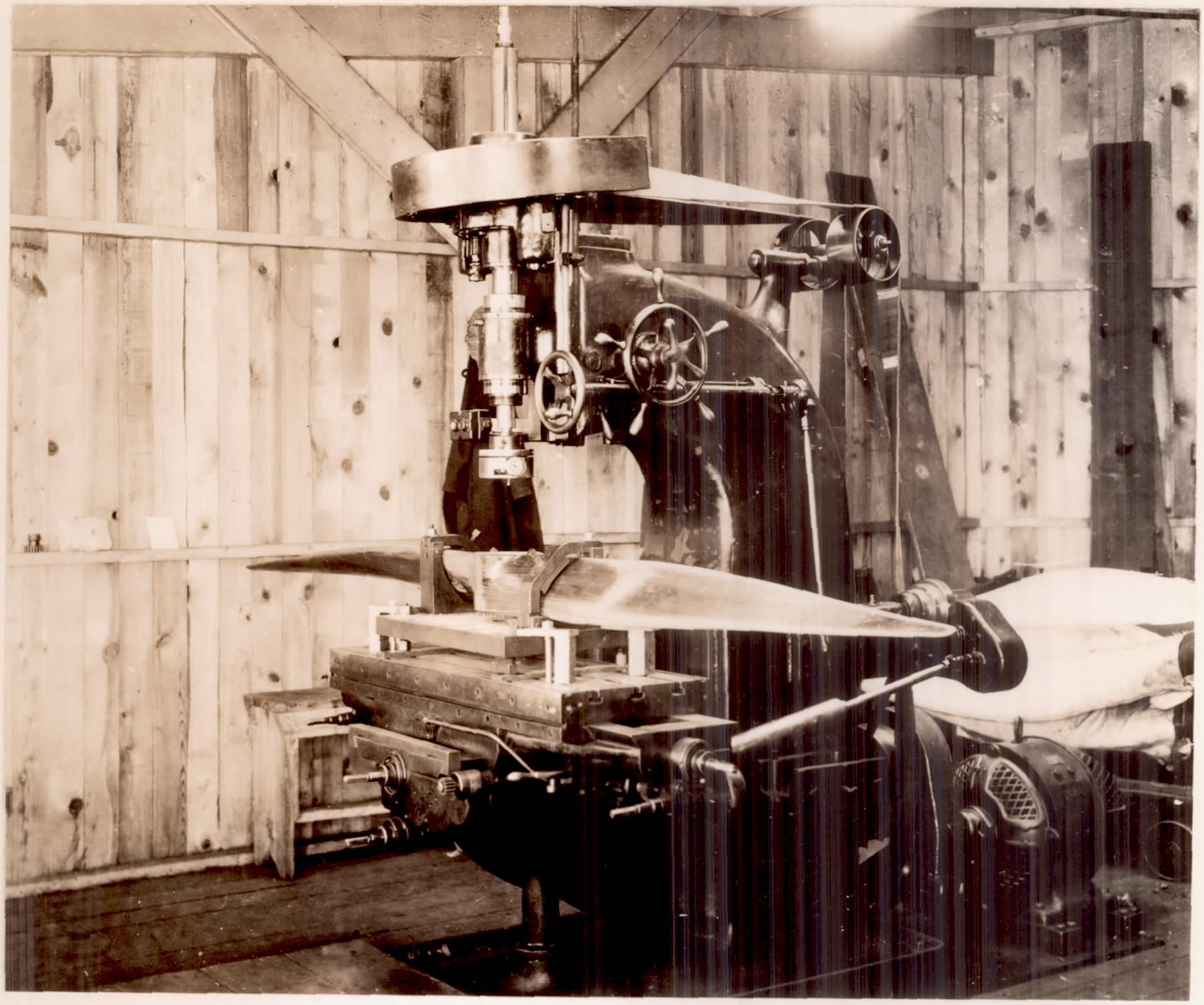

Fig. 6

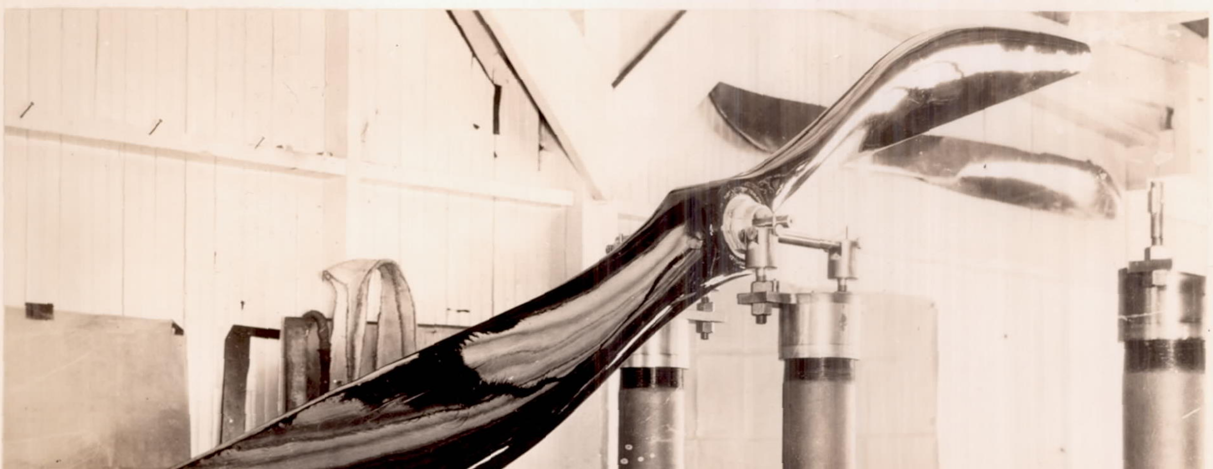

Fig. 8

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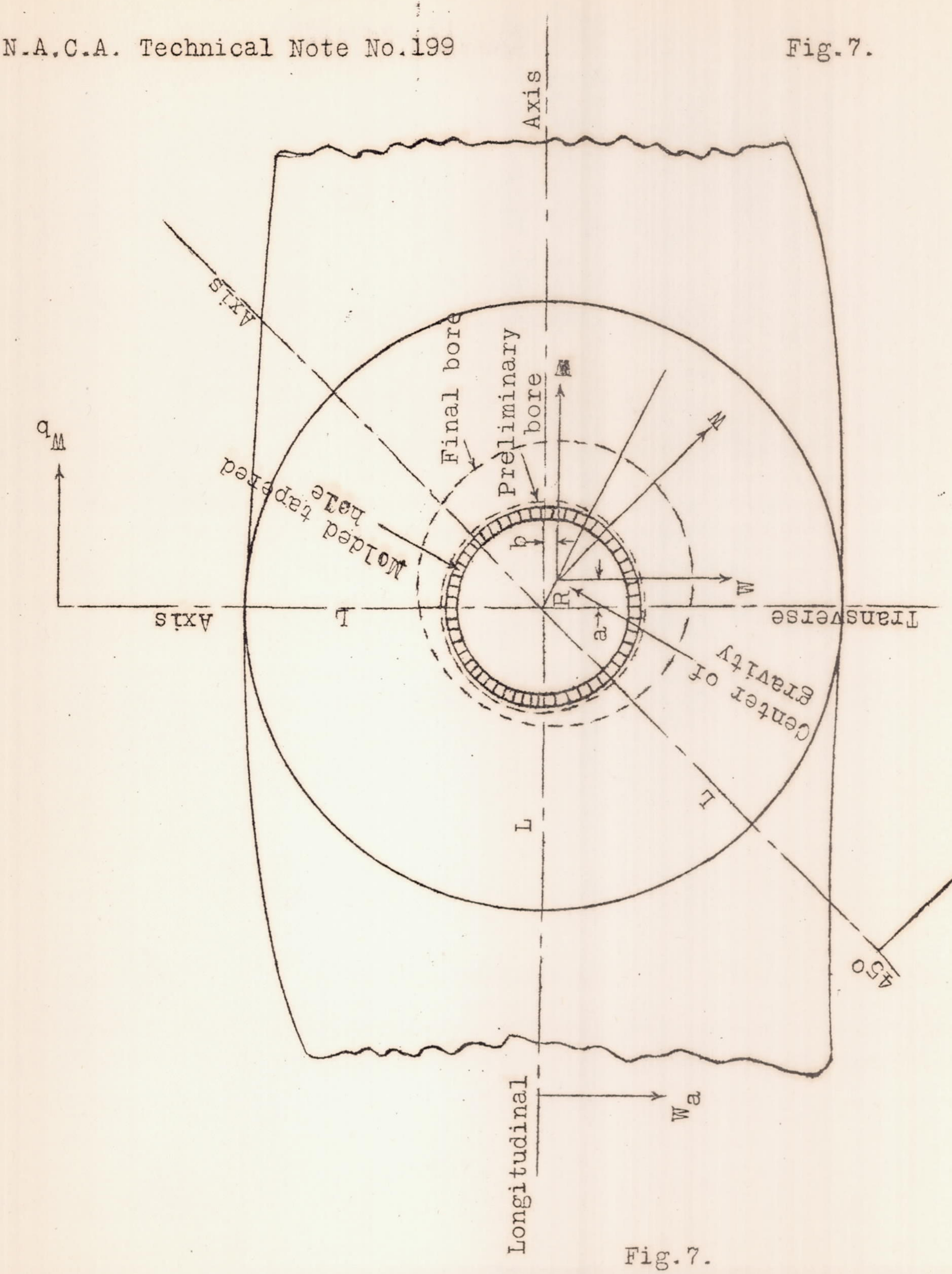
Axis
Axis
Final bore
Preliminary bore
Molded tapered hole
b
R
a
W
Axis
L
Transverse
Center of gravity
L
L
45°
W_x
W_b
Longitudinal
W_a

Fig.7.

135

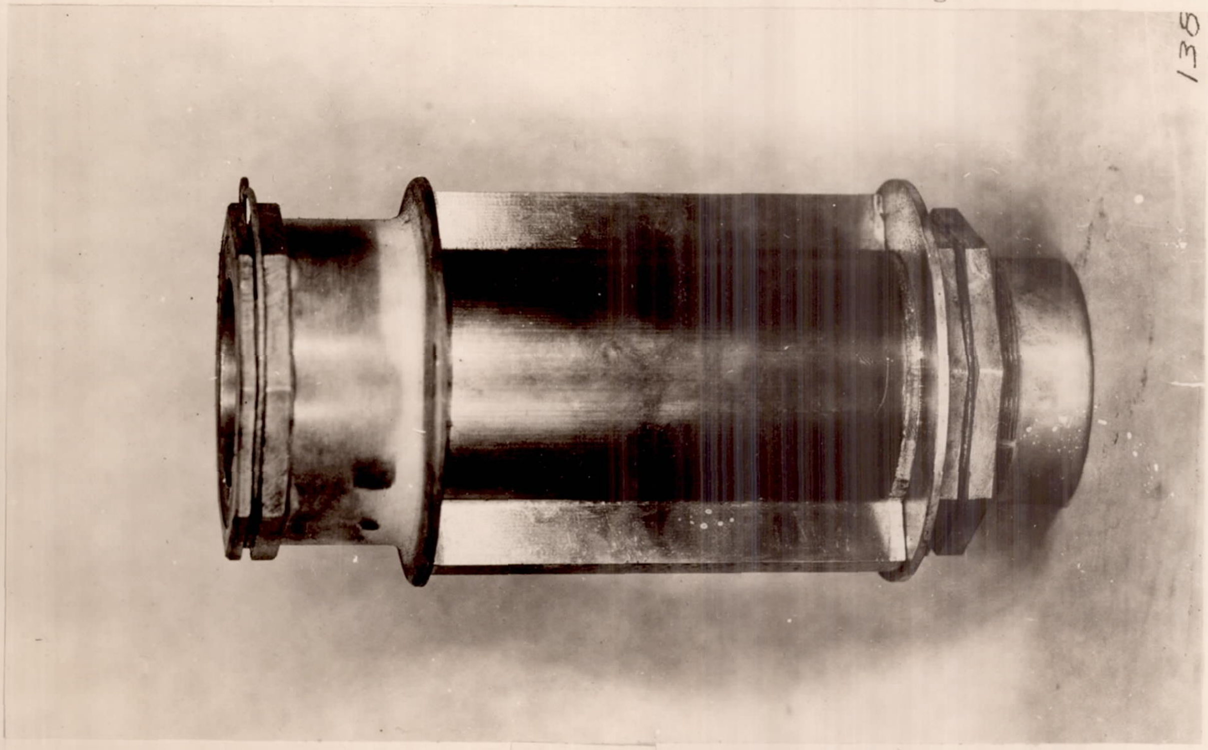

Fig. 9

Fig. 10

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