

THE DESIGN AND CONSTRUCTION OF
AN AIR PROPELLERED BOAT

BY

SAMUEL K. HODGSON

A THESIS SUBMITTED FOR
THE DEGREE OF BACHELOR OF SCIENCE
MECHANICAL ENGINEERING COURSE

University of Tennessee

1926

TABLE OF CONTENTS

Section	I	Introduction	Page	1
"	II	General Survey of the Field	"	2
"	III	Purpose	"	3
"	IV	General Theory	"	4
"	V	Construction	"	6
"	VI	Calculations	"	10
"	VII	Test	"	12
"	VIII	Conclusions	"	13
"	VIX	Bibliography	"	14
"	X	Appendix		
		Plate I - Fusilage	"	115
		" II - Fusilage Section	"	16
		" III - pontoons	"	17
		" IVV--Cranking Sprocket	"	18
"	XI	Photographs	"	19
"	XII	Approval	"	23

INTRODUCTION

The idea of using air blades for boat propulsion is one that has received considerable attention but has not been very widely applied. Several problems of design are peculiar to this type of boat. The motor, being of a rotary type, offered still further complications.

The thesis was written and worked out under Professor R. C. Matthews. Frequent consultations were made and the problems solved as the construction progressed.

There is little written on this method of boat propulsion, and the materials and construction of this boat are quite unusual for such a use.

GENERAL SURVEY OF THE FIELD

No information could be found on this subject in the library. A very careful search was made but only a little description about the power plant was obtained.

This idea seems to be undeveloped. There is a possibility of a fast boat incorporating this idea but using a specially designed hull. The advantages are not so numerous as the disadvantages but notwithstanding this fact there is a thrill in this kind of a boat that a water propelled boat does not have. The type as outlined in this thesis would hardly have any commercial possibilities for several reasons that will be enumerated in the following pages.

PURPOSE

The writer had the motor in his possession and as nothing could be found regarding boats of this kind he was curious to find out how one would perform and if it would act as the calculations indicated. Several shapes of hull were considered but the one selected was unusual and quite different from ones in use. This hull and the method of propulsion seemed to fit together well so a hull as will be described was used. Many interesting problems presented themselves in the course of construction but from the test it may be seen that each one was solved and its operation was satisfactory.

GENERAL THEORY

The motor could not be mounted in the original engine bed in the fusilage because the propeller would not clear the water. A stand was constructed as shown in Photograph No. 1. The center being 2 ft. 11" above the original bed. The crosswires fastened to the top take part of the stress and insure rigidity when the motor is running. The motor being so far above the water gave too high a center of gravity for the boat. It would be unstable in this condition so a pontoon was mounted on each side near the front as shown in Photograph No. 2. These pontoons are described under Section V - Construction. The fact that the pull of the propeller, being exerted so far above the water, would cause a tendency for the boat to go down in front was given consideration but a rough estimate of all forces involved caused the conclusion that the boat would not dive down in front when in motion also the upward curvature of the bottom was expected to cause a lifting effect. The same is true for each pontoon.

From Section VI - Calculations, the motor torque was found to be 195 foot pounds. This torque produced by a counter-clockwise rotation of the motor (looking aft) resulted in a clockwise tendency for the boat to turn over sidewise. This turning effect was really about balanced by the weight of the left pontoon and its distance from the center of the boat. This would not be enough to insure safety so the other pontoon was required. Both pontoons were also needed because in turning there

is a tendency to overturn towards the outside of the curve.

The pontoon were also placed far enough out to each side so that the maximum dead weight moment of the motor to overturn, or 251 pounds x 4 ft.- 2" - 1045 foot pounds, would be taken care of by the supporting power of the pontoon. Each pontoon will support 300 pounds easily. By placing the pontoons 5 ft.- 3" out from the center of the boat the maximum load to be carried by either of them on this account is 251 foot pounds / 5.25 feet - 199 pounds. In this calculation it was assumed that the motor was 15° from the upright thus giving a moment arm of 1 ft.

The location of the water line on the hull was a trial and error problem. On a drawing drawn to 1/5 scale trial water lines were drawn. See Plate I. The volume displaced both in front and in rear of the center of gravity was calculated. The sum of these two volumes equaled the total displacement of the boat and were equal to each other. The volumes were calculated in Section VI - Calculations.

CONSTRUCTION

The boat was made from a JN4D Curtiss airplane fusilage. The fusilage used was one that had fallen and had been broken in two just in rear of the rear cockpit. The first thing done was to clean up the fusilage by stripping off all the material and fittings that were of no benefit. The ends were spliced and fitted together, but turning the rear end upside down from its regular position in a plane so that a straight bottom was formed. One section had to be left out as the wood was split. This made the fusilage about 4 feet shorter than it originally was. A 10" diagonal glued splice was used with two wood screws thru it and the entire joint was taped and coated with airplane "dope".

Strips of $3/4"$ x $1\ 5/8"$ pine were placed crosswise every foot of the fusilage and extended up the sides to a strip of the same material that ran lengthwise at an average height of about 15" from the bottom. See Plate II. Screws were used thru out the stripping. Cypress boards, $7/16"$ x $3\ 1/2"$, were screwed to these strips on the sides. The edges of the boards were slightly beveled so as to form a groove for calking. These side boards extended from the top lengthwise strip to the bottom of the hull, so the bottom boards would extend over them. The bottom was made of three $5/8"$ x 10" pine boards put on in the same manner as the side boards. A 2" x 4" piece was screwed on the rudder post of the fusilage forming a rear post to which the side boards were screwed. Cotton waste was used as calking. It was forced down each groove, or joint, and hot Jefferys Marine glue was poured in on top of the calking. A hot soldering iron was run along this glue and in this way it was melted into the wood

and calking. The hull was then painted having a good deal of turpentine in the first coat. A second coat was thick and was more carefully applied. This completed the hull. Two airplane seats were put in the fusilage. One in the regular rear cockpit and one in another cockpit arranged in the section in rear of the rear cockpit or in the section that was spliced. In the section in rear of the rear seat two 15 gallon Buick gasoline tanks were installed, one on top of the other and connected by a 5/16" copper pipe. The gasoline line from the motor was also a 5/16" pipe and was connected to the bottom of the bottom tank. An air line of 1/4" copper pipe was connected to the top tank. Pressure was maintained by a hand pump connected on this line thru a tire valve. On this line there is also an air pressure gage. A pressure of 2.5 pounds gage is sufficient to force the gasoline up to the motor.

The motor was a 50 H.P., 7 cylinder, air cooled, Gnome rotary airplane engine made in France. It was purchased from a dealer of war surplus materials for \$36.00. It was new and complete. It was mounted on a stand constructed of angle iron and pipe as can be clearly seen from Photograph No. 1. The center was placed high enough for an 8 foot propeller to clear the water about 6 inches. From the top of this stand two cross wires were run to the fusilage being fastened in front of the front cockpit. Turnbuckles were provided on each wire so that the proper tension could be maintained. This arrangement made a rather stable stand for the motor and yet was light and strong.

The pontoons were made by sawing an Old Town canoe in half

and closing the back end of each half forming a square back. See Plate III. These pontoons were supported by outriggers made of $3/4$ " pipe. There were two brackets to each canoe. the pipe formed a triangle out to each canoe on each bracket the top piece of pipe on each bracket was threaded and sawed in half for a distance of about 4", a coupling screwed on this end, and when the end rods were put in the pipe this adjustable joint was easily locked by screwing up the coupling thus forcing the split pipe together. A wire was run from the front and rear of each pontoon to the main hull to resist any tendency to force the pontoons out of position longitudinally. This arrangement of pontoon outriggers may be seen in Photograph No. 3 and 4. The open tops of the pontoons were covered with canvas having first installed oak boards to hold the pipe outriggers. See Plate III. Canvas was also put on the main hull from the top of the side boarding to the top of the fusilage. All this canvas was coated with airplane "dope" while the second and third coats were applied mixed with aluminum powder. This gave the canvas an aluminum color and drew the cloth up tight. A 1" strip was put on over the seam of the canvas and boarding.

A cranking mechanism was designed using two 26 tooth bicycle sprockets. One mounted between the propeller and cylinders. The other directly beneath it on the fusilage. This bottom one had a shaft of $3/4$ " pipe extending back to the front cockpit where a crank was put on. The engine sprocket had a ratchet on it so that the sprocket would not turn when the motor ran except in starting. See Plate IV.

The throttle, cut off switch, gasoline cut off, and air gage were mounted on an instrument board installed in the front

cockpit.

A rudder post was put thru the hull using the tail skid bracket that was already in the fusilage as a support. This post is a $3/4$ " pipe extending up thru the hull about a foot. The rudder was made up of a $3/4$ " rod having two $1/8$ " x 5" x 17" peices of sheet steel rivited on each side and brought together at the ends. This gave a sturdy construction and was easily made. There was an arm mounted on the rudder rod and this arm was connected to the rudder foot bar in the front cockpit by cables having turnbuckles in them to take up slack. This completes the description of how the boat was made up.

CALCULATIONS

Total weight -

Motor, stand and propeller	251#
Fusilage, and hull	189#
2 Persons	300#
30 Gal. gasoline and tanks	180#
Ballast	100#
Rudder and equipment	<u>30#</u>
	1050#

The pontoons were not included because they were adjusted so that they supported their own weight.

Resultant weight position of application -

The total resultant weight of the hull was found by taking moments of all the forces about the rear end as a center of moments. This equation gives the results. See Plate I.

$$19 \times 30 \nearrow 30 \times 100 \nearrow 74.5 \times 180 \nearrow 102 \times 150 \nearrow 136 \times 150 \nearrow 156.5 \times 189 \nearrow 244 \times 251 = 1050 \times$$

$$\text{or } X = 134" \text{ from rear end.}$$

To find the displacement of the boat.

Total weight/ weight of 1 cubic foot of water = displacement

$$\text{or } \frac{1050}{62.4} = 16.85 \text{ cubic feet.}$$

To find the torque created by the motor tending to roll the boat over sidewise in a clockwise direction (looking aft)

$$\text{H.P.} = \frac{\text{Pr} \times 2 \times n \times \pi}{33000}$$

But Pr = T , Torque

$$T = \frac{\text{H.P.} \times 33000}{2 \times n \times \pi}$$

The motor is rated as 50 H.P. at 1350 R.P.M.

therefore

$$T = \frac{50 \times 33000}{2 \times 1350 \times 3.1416}$$

$$= 195 \text{ foot pounds.}$$

To find the water line. -

The procedure and method of finding the water line was given under Section IV - General Theory. The calculations are.

$$\frac{5.25 \times 19 \times 2.5}{1728} = 0.145$$

$$\frac{13.8 \times 20.75 \times 3.5}{1728} = 0.580$$

$$\frac{19.2 \times 24 \times 4.7}{1728} = 1.250$$

$$\frac{5.95 \times 26.5 \times 22.8}{1728} = 2.080$$

$$\frac{8.5 \times 6 \times 25.6}{1728} = 0.755$$

$$\frac{7.5 \times 34 \times 24.9}{1728} = 3.680$$

8.480 cubic feet - volume of
rear section

$$\frac{8.8 \times 33 \times 27}{1728} = 4.550$$

$$\frac{8.1 \times 56 \times 27}{1728} = 3.540$$

8.09 cubic feet - volume of
front section

8.480
8.090
16.57 cubic feet Total volume.

These two volumes were as accurate as our measurements so they were satisfactory. Their sum nearly equalled the calculated displacement. It also was considered near enough.

TEST ase

The boat was hauled to the river bank at Central Avenue. The hull and motor were taken down assembled while the pontoons and rudder were put on at the river. There were enough people to help so we could lift the boat out into the water sidewise. Photograph No. 5 shows the boat just after it was launched. It sat almost exactly as the calculations had indicated. Only slight adjustments of the height of the pontoons was necessary. The motor, which had been previously tuned up, was started by the crank and with the propeller turning about 1100 R.P.M. the boat ran nicely and at an estimated speed of from 18 to 20 miles per hour in still water. When the boat was in motion the front end of the hull rose on the water about 6".

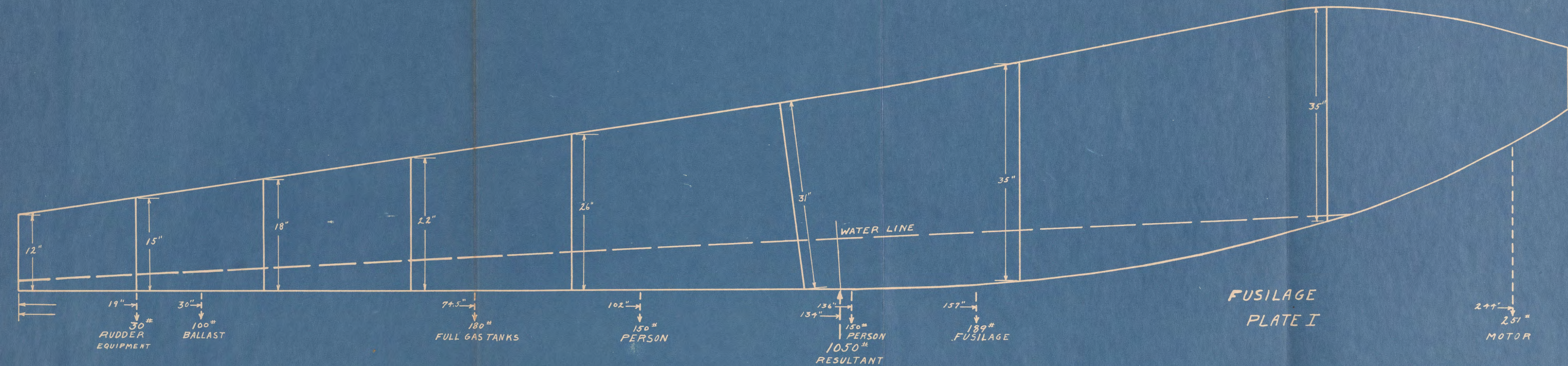
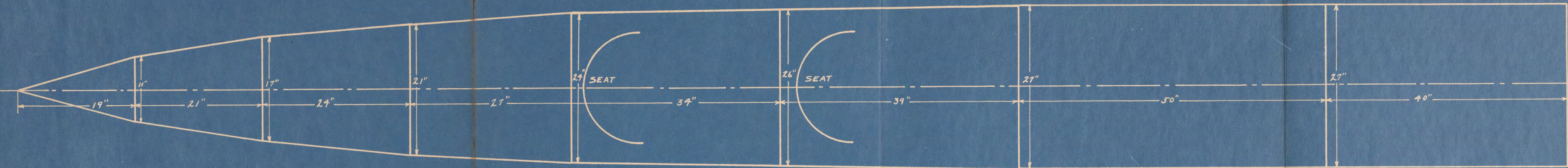
A faint, circular stamp is visible in the lower half of the page. It contains the text "JAPANESE LITHO" in a circular arrangement, with "MADE IN U.S.A." written below it.

CONCLUSION

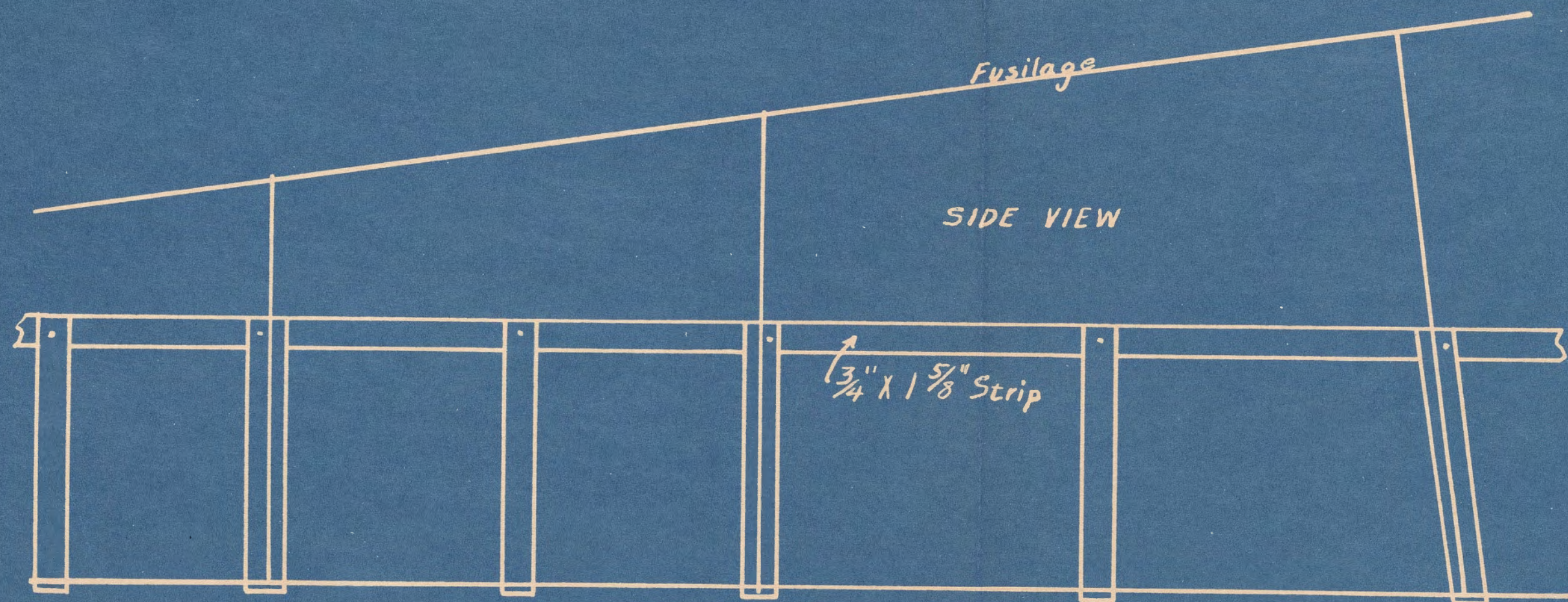
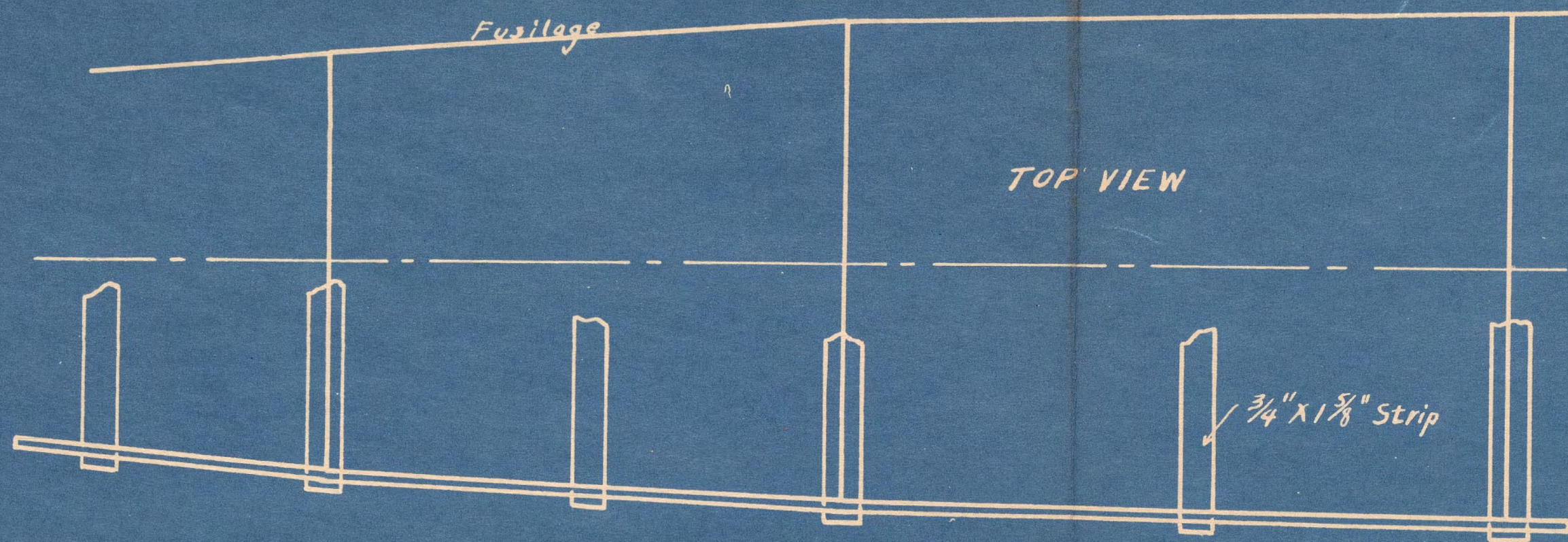
When the boat was tried it was found advantageous to adjust the pontoons so that they would support a larger part of the load on the front end. When the boat was in operation the planing effect was not great enough to raise the pontoons out of the water. This fact made the boat much slower than otherwise.

When the boat was in motion a considerable lifting of the front end was noticed due to the curvature of the bottom of the hull. This performance was estimated as explained under Section IV - General Theory.

About 220 hours were put in on the construction of the boat. The cost of the motor was \$36.00 while the remainder of it cost about \$74.00 bringing the total to about \$110.00.

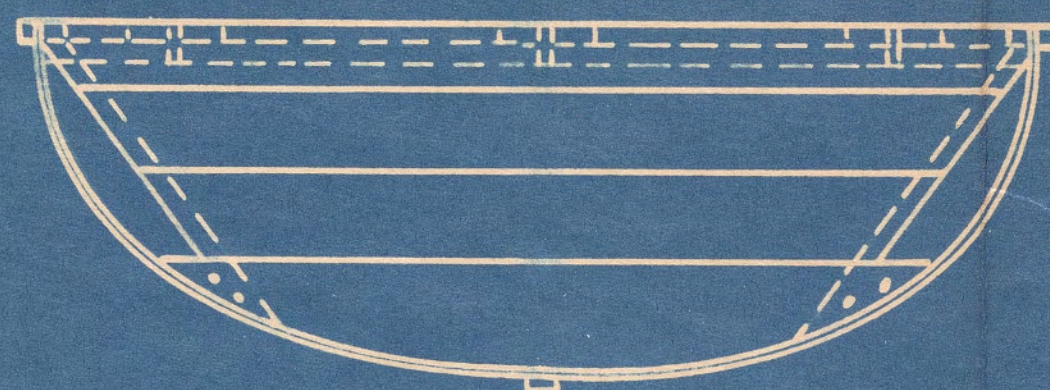


FUSILAGE
PLATE I

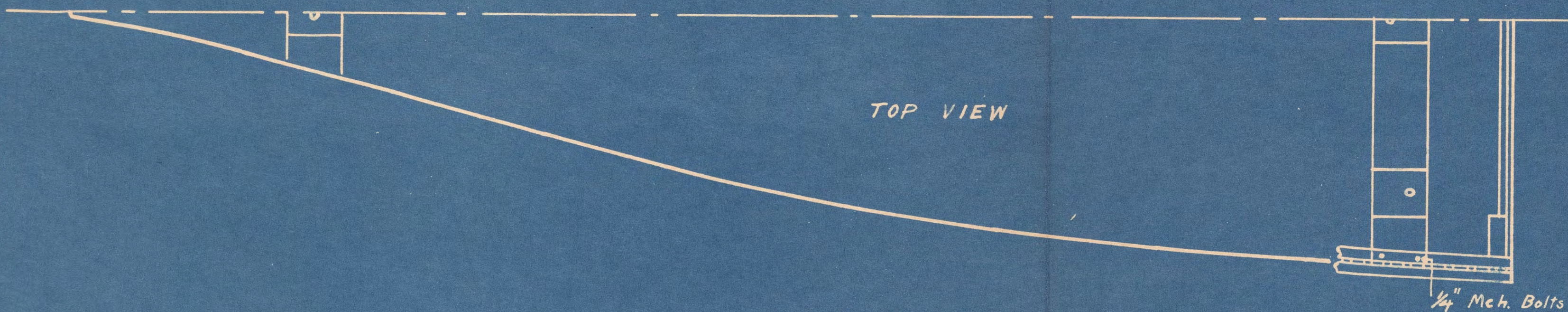


SECTION OF FUSILAGE
Showing Strip Construction

PLATE II



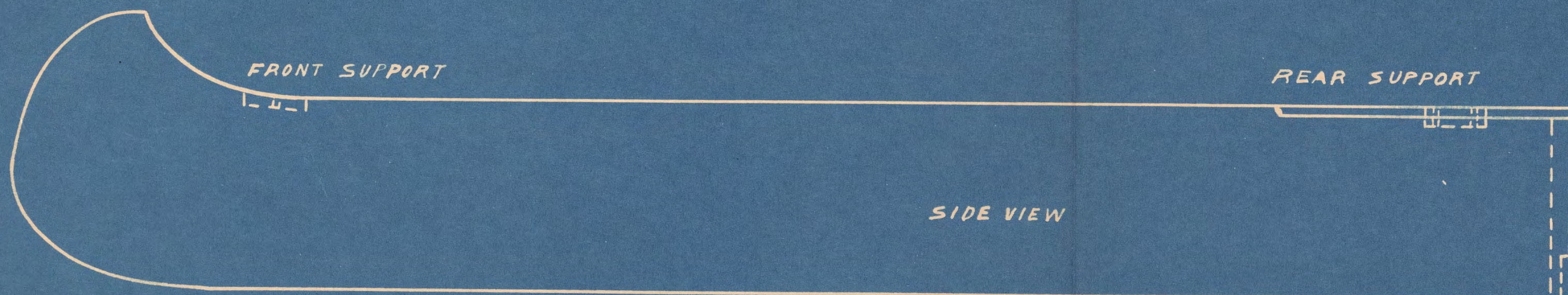
END VIEW
Showing Construction



TOP VIEW

$\frac{1}{4}$ " Mech. Bolts

PONTOONS



FRONT SUPPORT

REAR SUPPORT

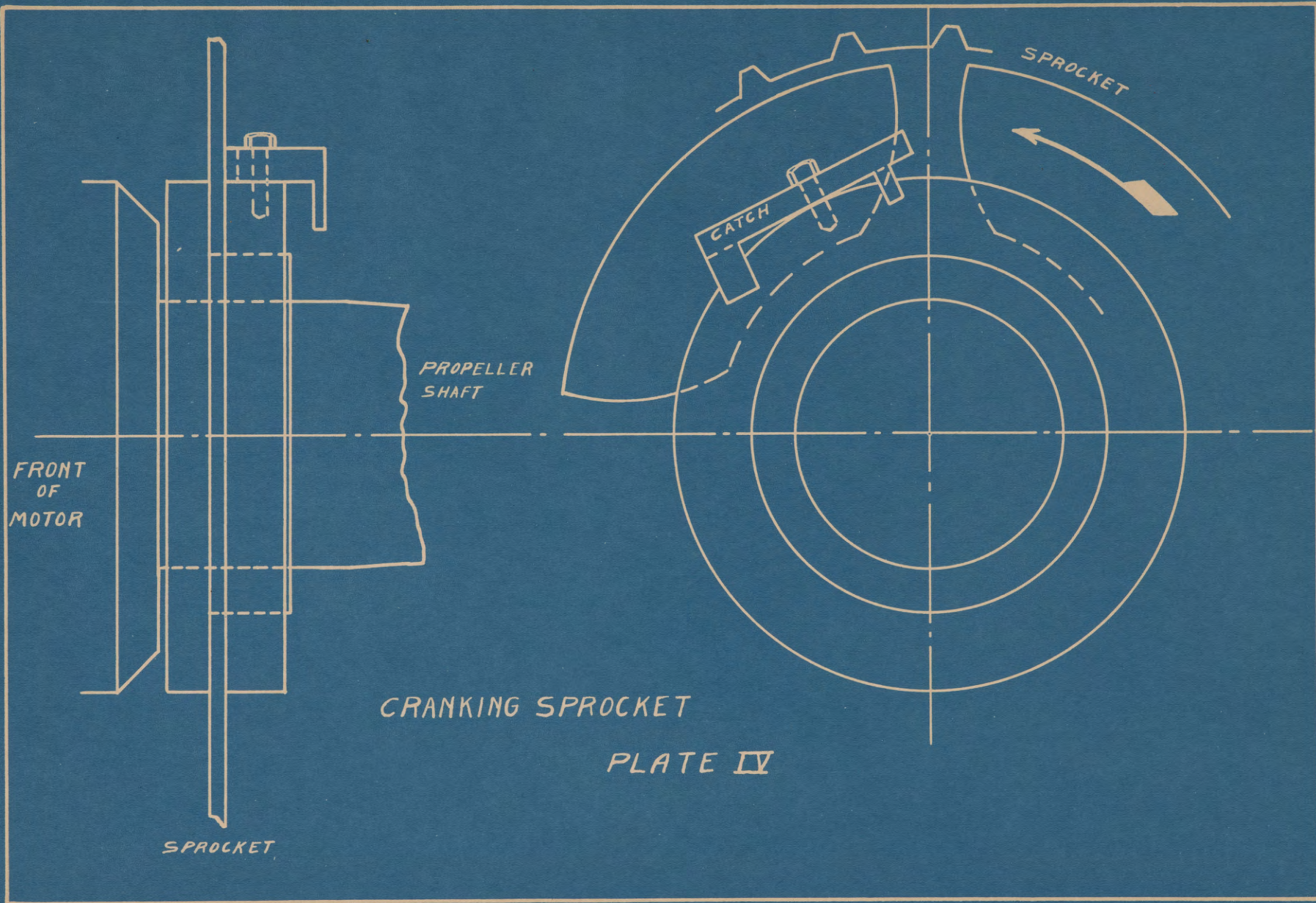
SIDE VIEW

PLATE III

BIBLIOGRAPHY

Airplane Engine Encyclopedia - Glenn D. Angle

Airplane Construction and Design - Rathbun





No. 1



No. 2

2



No. 3



No. 4



No. 5



No. 6



No. 7



No. 8



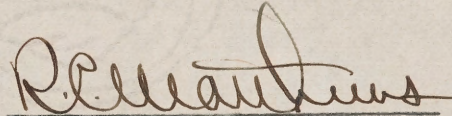
No. 9



No. 10

APPROVAL

The foregoing thesis is hereby approved as a creditable study of an engineering subject, carried out and presented in a manner sufficiently satisfactory to warrant its acceptance as a prerequisite to the degree for which it has been submitted. It is to be understood that by this approval the undersigned does not necessarily endorse or approve any statement made, opinions expressed, or conclusions drawn therein, but approves the thesis only for the purpose for which it is submitted.



Professor of Drawing and
Machine Design

May 1976