T H E S I S

on

The Induction Motor.

Submitted to the Faculty

of the

O R E G O N A G R I C U L T U R A L C O L L E G E

for the degree of

Bachelor of Science

by

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THE DESIGN AND CONSTRUCTION OF A TWO-PHASE INDUCTION MOTOR.

INTRODUCTION.

The problem of the economical transmission of power has long been a serious one to the engineer. Formerly the power had to be generated on or near the spot where it was to be used, but now the advance that has been made in Electrical Engineering has largely done away with this and a power-plant may be situated far away in the hills by some mountain torrent whose power may be harnessed and transmitted with very little loss, many miles and there made to turn the wheels of mills and factories and light our streets and houses. Thus we see that it can be generated cheaply while it would be nearly impossible to generate the power at the point where it is to be used by the use of a steam engine or other power.

Where the electric energy is to be reconverted into mechanical power it is necessary to use some sort of a motor. The simplest and most efficient of these is the continuous current shunt wound motor; but as it is practically impossible to generate direct current at a high potential, and the alternating current can be transformed to any desired pressure, it is used for long distance transmission, thus we see that some sort of an alternating current motor must be used.

EVOLUTION OF THE INDUCTION MOTOR.

The direction of rotation of a direct current motor, whether shunt or series wound, is independent of the direction of the current supplied there to; that is if the current be reversed in the machine the direction of rotation remains the same. Thus theorectcally any direct current motor should operate on alternating current.

In this case the field as well as the armature must be built of laminations to prevent eddy currents, also the field and armature currents must reverse simultaneously.

The most simple way to secure this result is obviously to use a series wound motor; the main objection being that it is not a constant speed machine, the speed varying with load. Also the self induction is very high and consequently the power factor very low. The commutator also sparks viciously. The shunt motor has the objection that the armature current is energy current and the field current magnetizing current and therefore lagging nearly 90° behind the E.M.F., thus the field and armature currents would be out of phase with each other. To overcome this difficulty the field may be excited from a separate E.M.F. differing 90° in phase, thus the field may be connected to one phase and the armature to the other phase of a two phase circuit, and thus the current in field and armature be brought approximately into phase.

This system has the objection that one phase will be more heavily loaded than the other. This can be remedied by connecting two motors in the system with the field of one and the armature of the other in one circuit and vise versa.

But the vicious sparking at the commutator still remains. This can be entirely overcome by producing the current in the armature by closing the armature coils upon themselves and surrounding it by a coil at right angles to the field exciting coils, instead of leading it in by commutator and brushes. Such motors have been built, consisting of two structures, each containing a magnetizing circuit acted upon by one phase and an energy circuit acted upon by the other phase of a two phase system. These two structures may be combined into one by having each of the two coils serve the double purpose of magnetizing the field and inducing current in the armature which is acted upon by the field produced by the other phase.

Obviously instead of just two phases, any number may be used. This leads up by gradual steps from the continuous current shunt motor to the alternating current polyphase induction motor.

DESCRIPTION

The induction or non synchronous motor as it is sometimes termed, is a type of alternating current machine in which as stated above the rotor receives its currents by induction from the field current instead of by conduction from the line.

These machines like most other types both direct and alternating current machines consists essentially of two parts; the stator or field and the rotor or armature.

The field is built up of thin sheets, or laminations of soft iron, in the shape of a ring, which are slotted on the inside to receive the windings (Plate 2. Fig. 2. shows a section of lamination) This field ring is keyed into a cast frame which forms the base of of the machine; this in turn is bolted down to a cast bed plate. (Bed plate shown in first photograph).

The field windings are usually formed into coils, and well taped and insulated before being placed in the slots. These windings are so arranged that when the current is turned on there is a rotating field set up. This field makes as many revolutions per minute as the number of alternations divided by the number of pairs of poles.

THE ROTOR

The rotor which revolves inside of this field is built up of laimnations which are keyed onto a cast iron spider. (Plate 3 Fig. 2.) The spider is keyed to the steel shaft (Plate 3 Fig. 1.) The rotor laminations are slotted around the edge to receive the rotor bars or windings. In small machines these windings consist of large copper bars bolted at the ends to large copper short circuiting rings.

In starting such a motor an auto-transformer is used in the our side circuit, thus the machine is started at a low voltage. This prevents excessive currents in the rotor windings whilestarting. When the machine is brought up to speed this transformer is cut out and the machine runs on the full voltage of line.

In larger machines, however, the windings are generally connected to an outside resistance at starting which cuts down the excessive currents in the windings. This resistance is cut out when the machine is brought up to speed. Another way to prevent excessive currents is to place in series with the rotor windings a few turns of large wire which at the high frequency which the E.M.F. has when the rotor is at rest, has a great amount of self induction but as the machine comes up to speed and the frequency decreases to nearly zero the coil has very little impedence and the rotor is nearly the same as on dead short circuit.

The rotor shaft turns in self oiling bearings which are held in the end plates which in turn are bolted to the frame.

RUNNING OF INDUCTION MOTOR.

In general behavior the induction motor is like the continuous current shunt motor, It operates at approximately constant magnetic density, and at fairly constant speed, slowing down slightly with increase of load. The main difference being that the armature receives its currents by induction instead of being passed in through commutator and brushes. The primary circuit of the induction motor fulfills the double function of exciting circuit corresponding to the field exciting circuit of the direct current shunt motor and a primary circuit inducing a secondary current in the rotor by electro magnetic induction.

As the magnetic field revolves the lines of force are cut by the rotor bars thus inducing a current in them and they in turn reacting on the field produce rotation.

THE ACTION OF INDUCTION MOTOR.

Since the rotor receives its currents by induction the action of an induction motor is essentially the same as that of a transformer, the difference being that in a transformer the secondary is fixed with regard to the primary and the electrical energy of the secondary is used, while with the former, the secondary is m movable with regard to the primary and the mechanical force between the two is utilized.

In consequence of this rotation the frequency of the secondary is not the same as that of the primary and as a rule is very much less; varying from that of the latter when rotor is at rest to zero at synchronism.

The ratio of the E.M.F's is equal to the ratio of the product of turns and frequency. Hence at synchronism the frequency becomes zero and the rotor will have no torque. Therefore the machine will slow down. Thus we see that in practice the speed of the motor will never reach synchronism. This lag is called slip. This slip seldom reaches 15%. Taking due consideration of the difference of frequency the theoretical consideration of the induction motor is best treated as a transformer, the electric output of the latter corresponding to the mechanical output of the former. The secondary being considered as two or more circuits differing in phase relation so as to form a closed winding. The primary consisting of two or more circuits.

The magnetism may be considered as two fluxes in quadrature, as revolving field or as an alternating flux of equal intensity in all directions. Thus we have led from the direct current shunt; to the polyphase induction motor.

When a two-phaser is running light, if one is cut out the other will take the full current and continue to run. Thus we see that a single phase machine will work satisfactorly, at the same time a transformation takes place, the second or magnetizing phase being produced from the impressed E.M.F. by the rotation of the armature which carries it into quadrature with the inducing current. Thus the field is identical with that of the polyphase machine.

The single phase motor has no torque at starting and consequently must be brought up to speed by some outside means and consequently they are not very extensively used in large sizes.

USES OF INDUCTION MOTOR.

These motors need very little attention and consequently can be used in places where other motors cannot. They are also sparkless and can be used in mills and places where a spark might cause fire.

Altho they are not quite so efficient as the synchronous motor they are more satisfactory for some purposes and are coming more into use.

Description of Two Phase $7\frac{1}{2}$ H.P. Induction Motor

This motor stands about 21 inches high over all and occupies a floor space of 18x30 inches.

It is $7\frac{1}{2}$ H.P. two phase, 100 volt 7,200 alternations four pole and we see from the number of poles that synchronous speed = 1800 R.P.M. The actual speed = 1700 on account of slip.

Rotor

The shaft is $21\frac{1}{2}$ inches long by 1.625 inches in diameter.

The spider is cast and is 6.875 in diameter.

The laminations, which are keyed to the spider, are about 15 mils in thickness and 6.875 in diameter on the inside and 9.625 outside diameter and contain 39 3/8 inch slots to hold the rotor bars. They are built up 3.5 inches in thickness.

These bars are 5/16 inches square and 7.75 inches long. They are insulated and placed in the slots and securely bolted to the short circuiting rings, which are 1/2 by 1.25 inches.

Stator

The field is built up of laminations and is 3.5 inches thick. It has 48 slots, which hold the field windings consisting of 24 coils. These coils are placed 12 in series for each phase. Each coil has

26 double turns of #14 wire.

Frame

The frame is cast in the shape of a ring(Plate I fig I) 16.875 inches in diameter on the outside and perforated for ventilation, this frame stands upon the bedplate

KEY TO BLUE PRINTS.

Plate I.

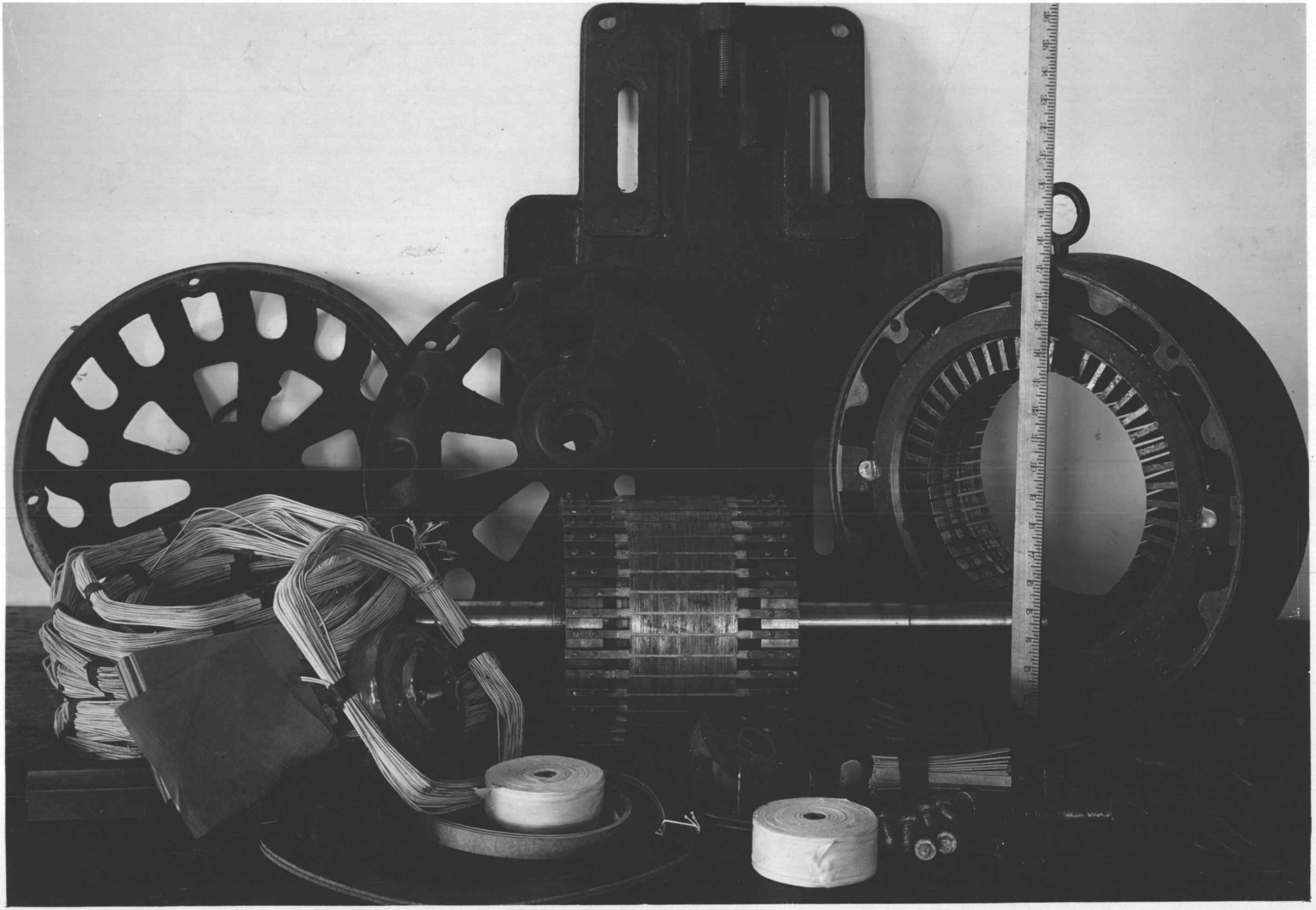
Fig. 1	(A)	--------	End view of field casting.
" "	(B)	--------	Side " " " "
" 2	(A)	--------	End " " end plate.
" "	(B)	--------	Side " " " "

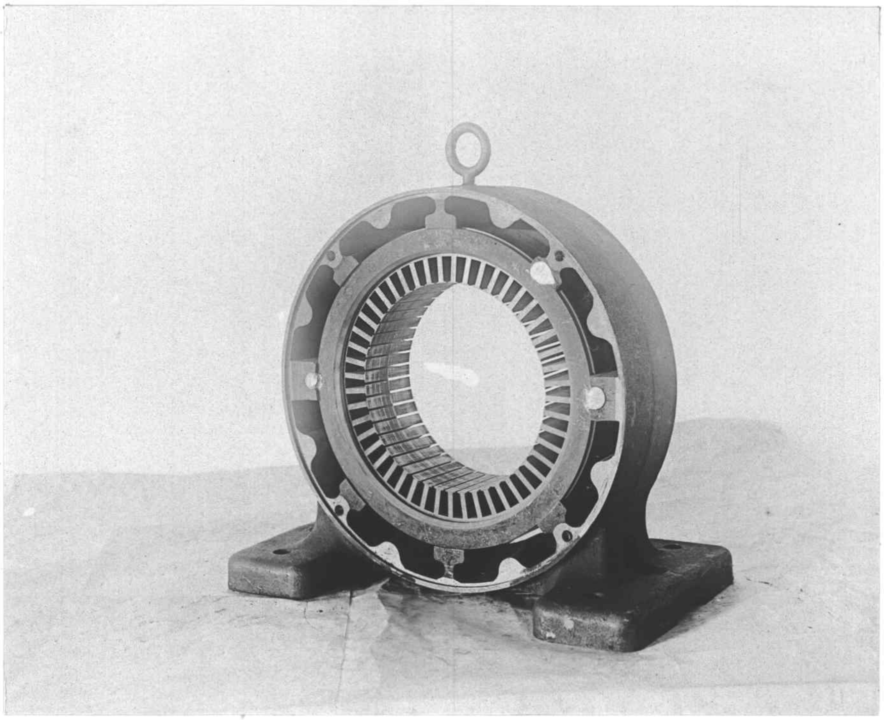
Plate II.

Fig. 1	(A)	--------	End view of rotor lamination.
" "	(B)	--------	Side " " " built up.
" 2		--------	Section of stator lamination.

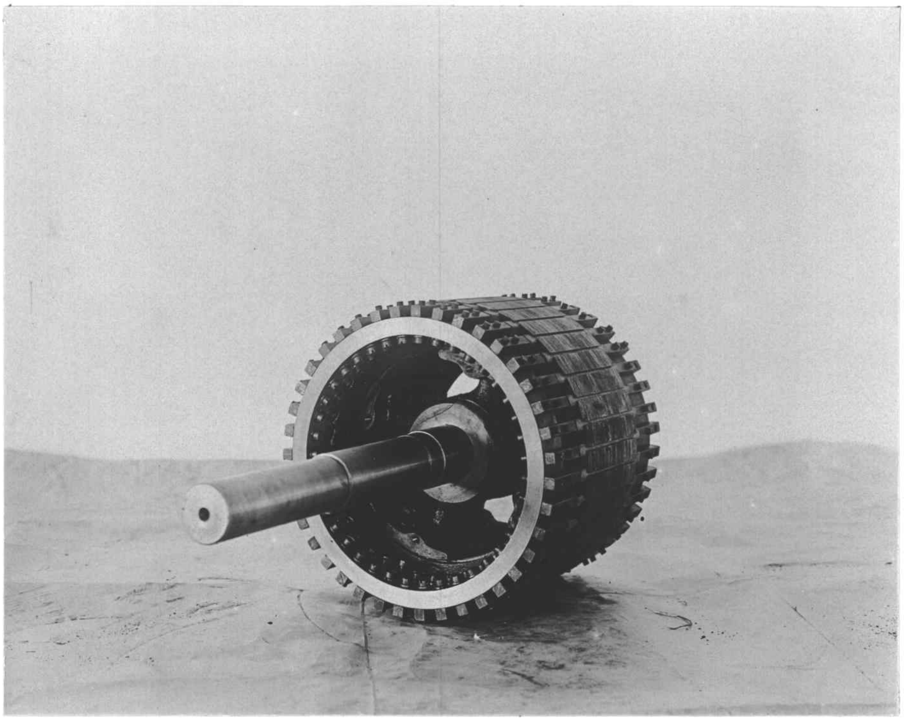
Plate III.

Fig. 1		--------	Shaft.
" 2	(A)	--------	Rotor spider.
" 2	(B)	--------	End view of rotor lamination.
" 3		--------	Rotor bar.





Frame and Field.



Rotor.

End Plate.

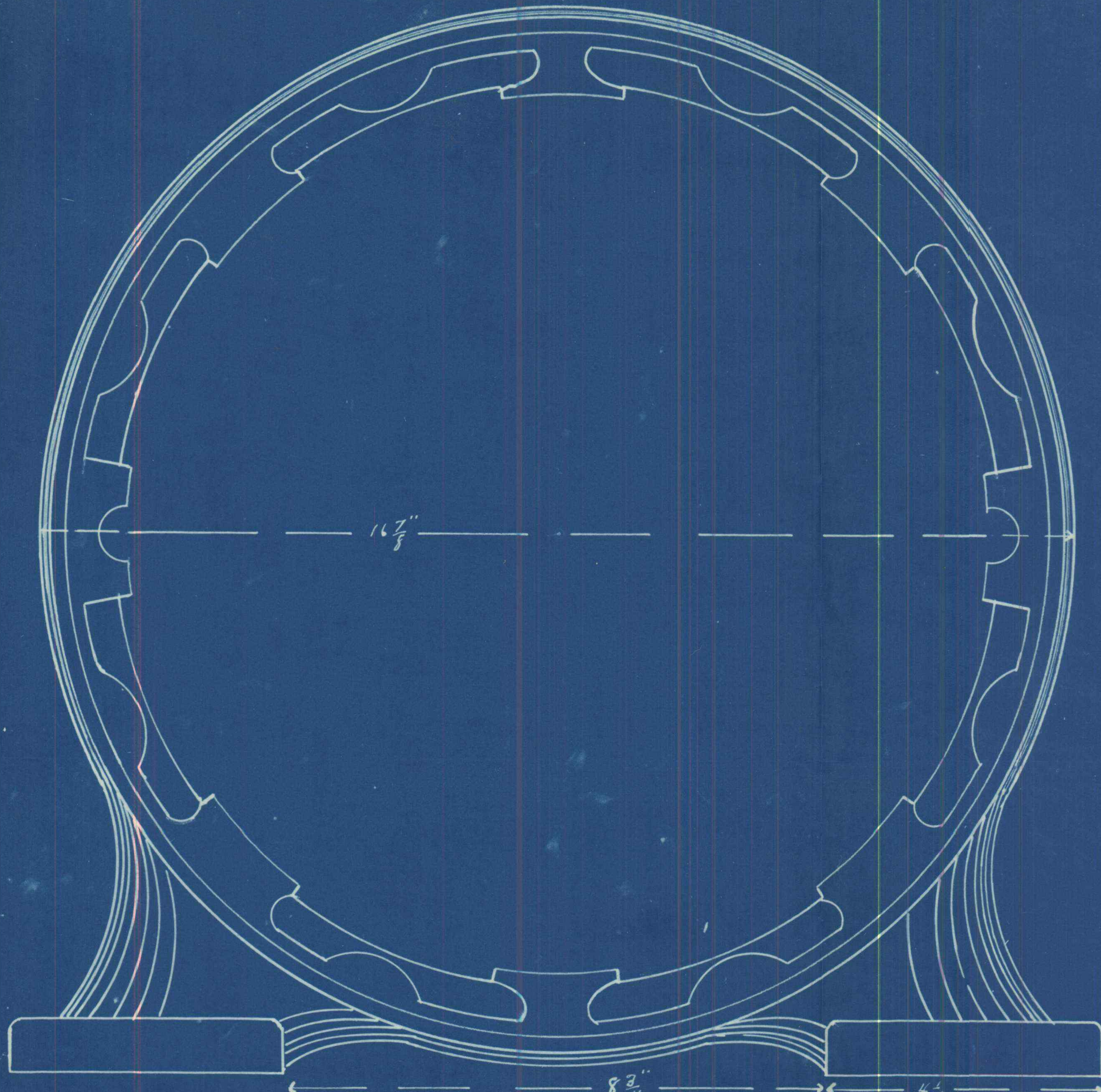


Fig I A

Scale 1/2

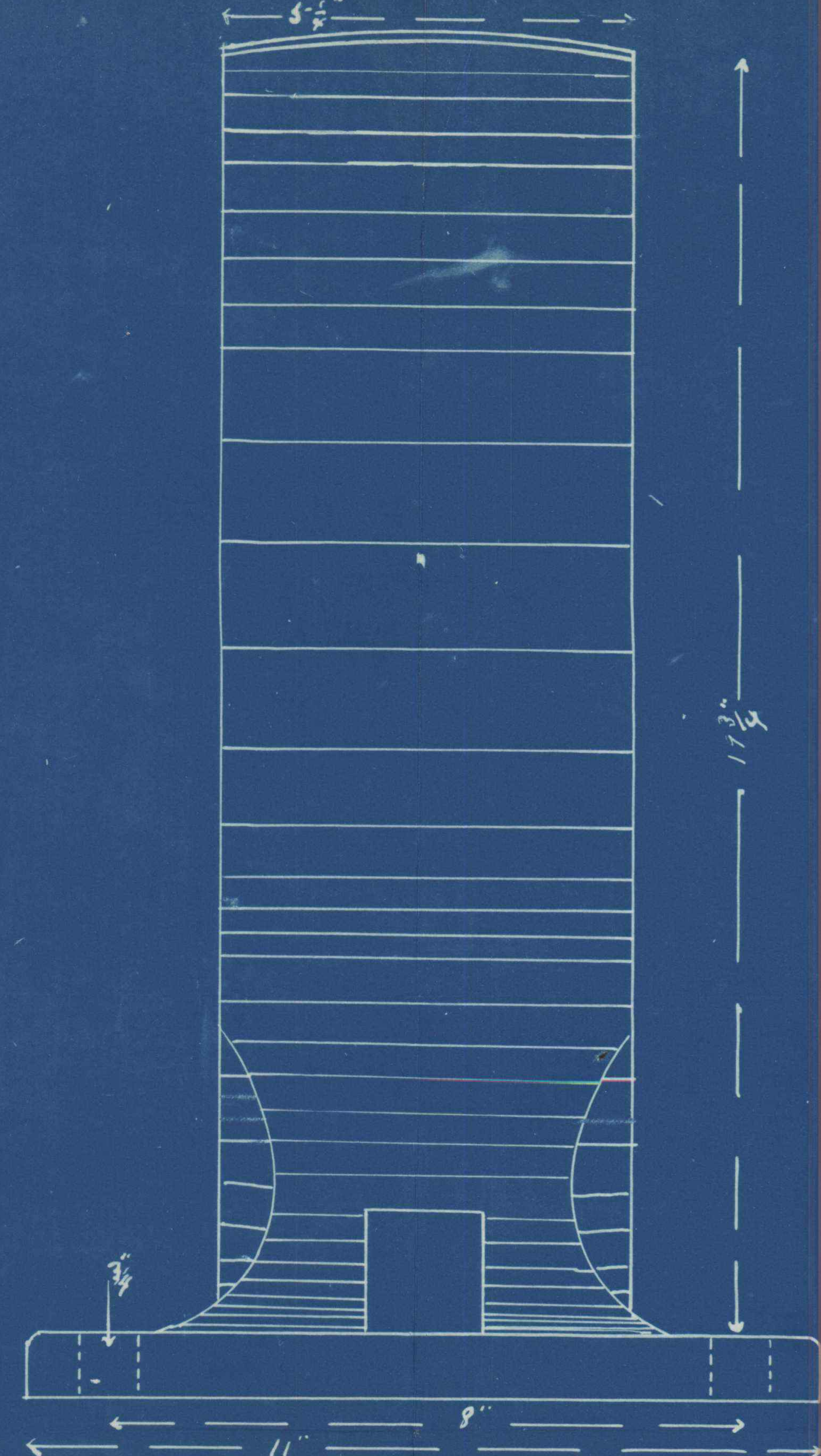


Fig I B

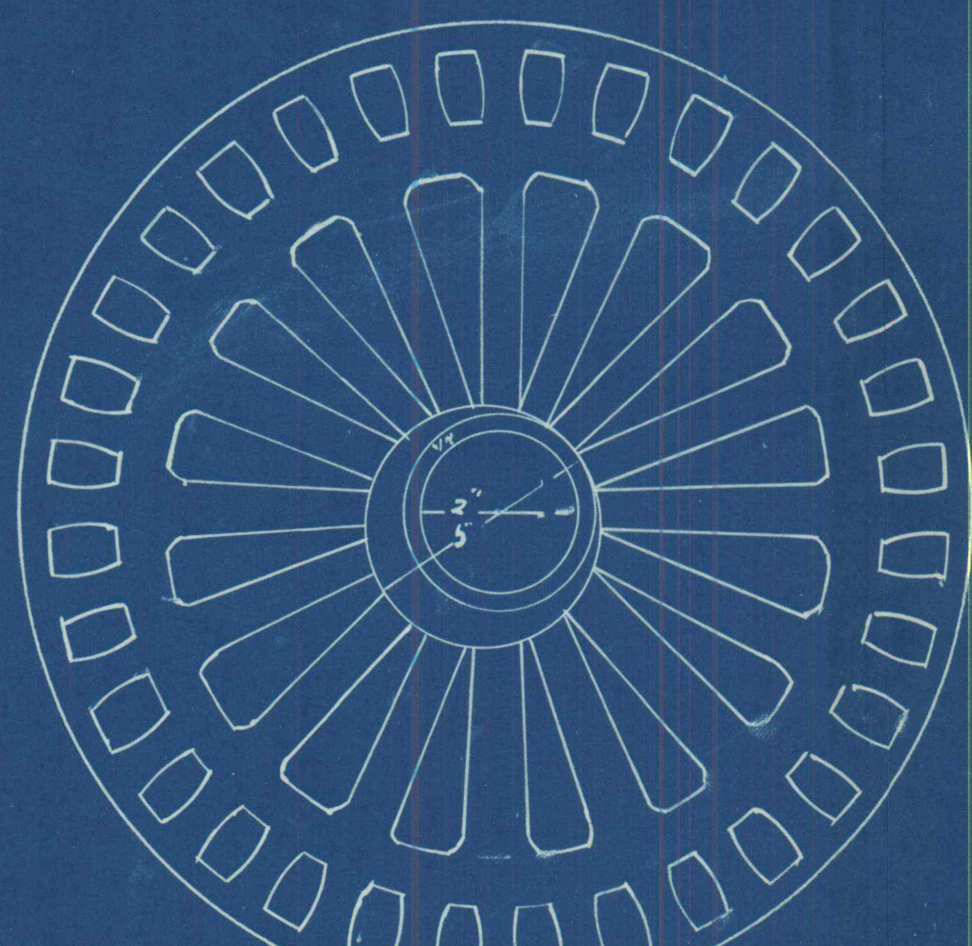


Fig II A

Scale 1/4

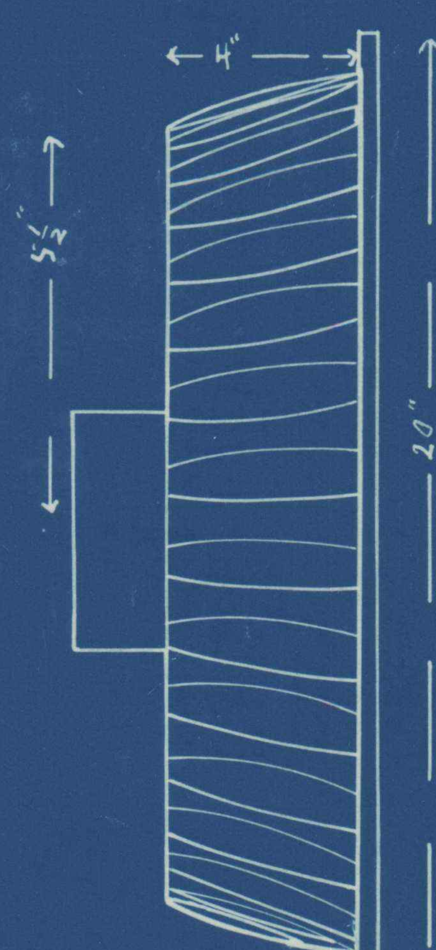


Fig II B

PLATE I.

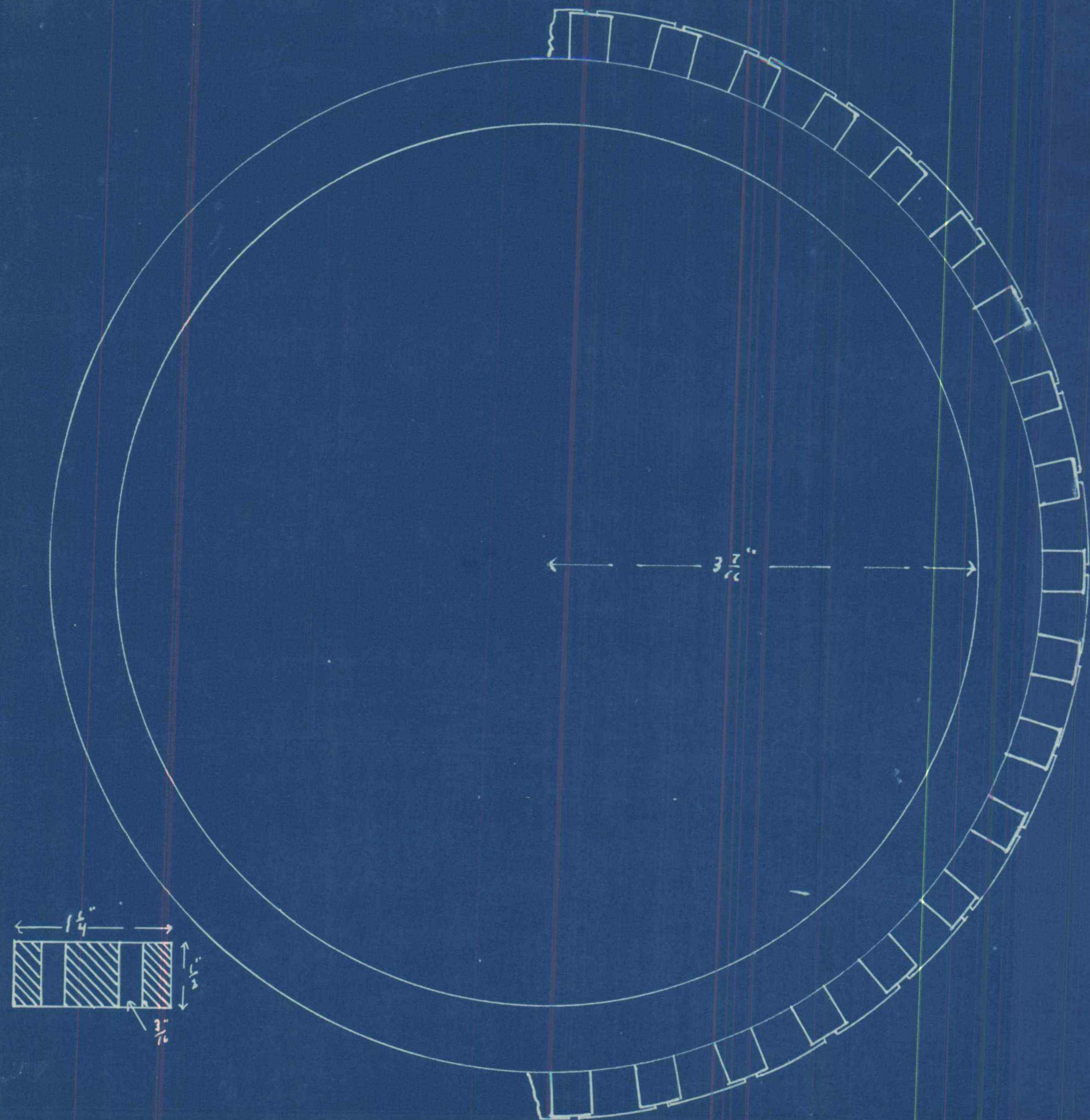


Fig. I. A.

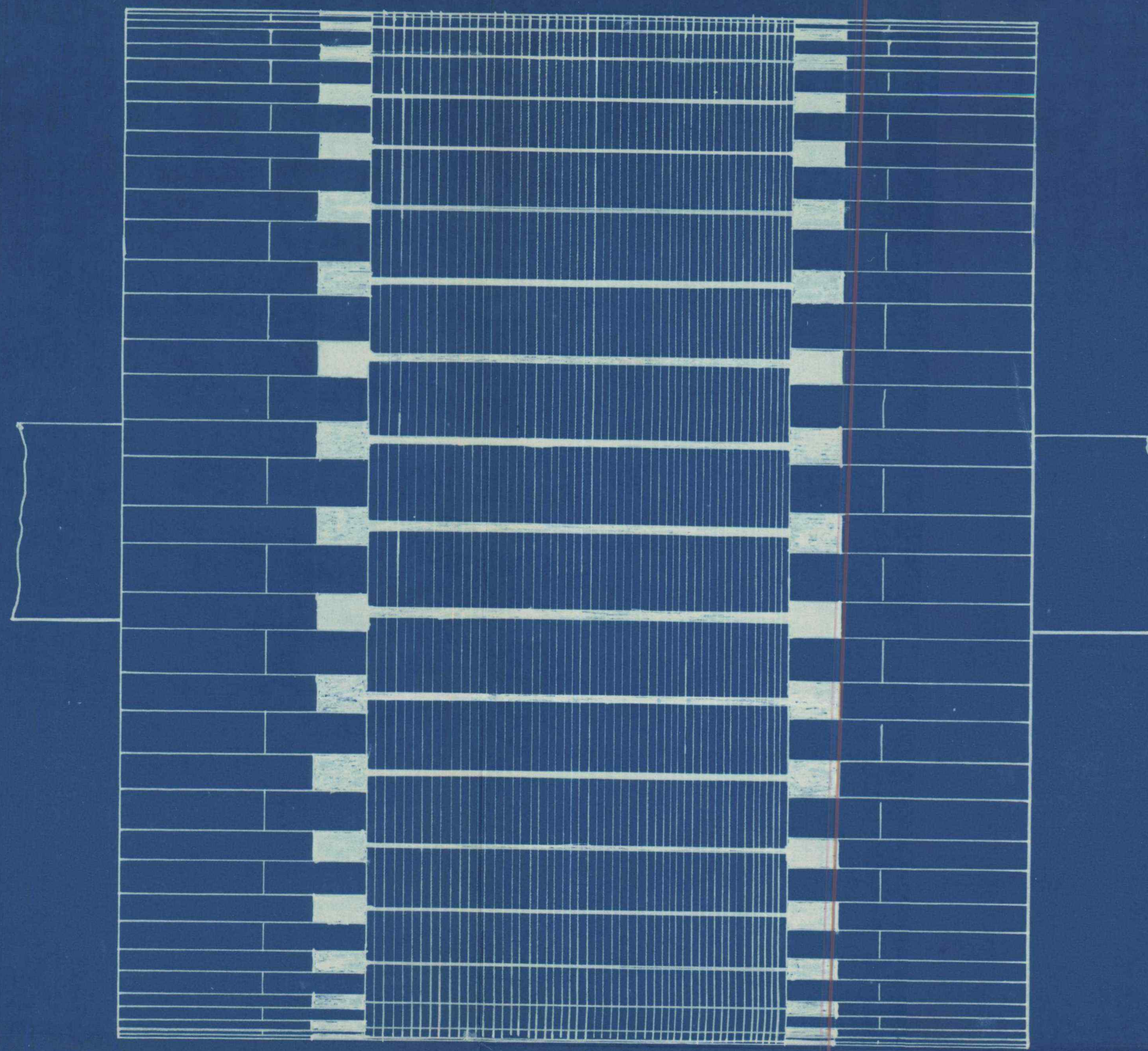


Fig. I. B.

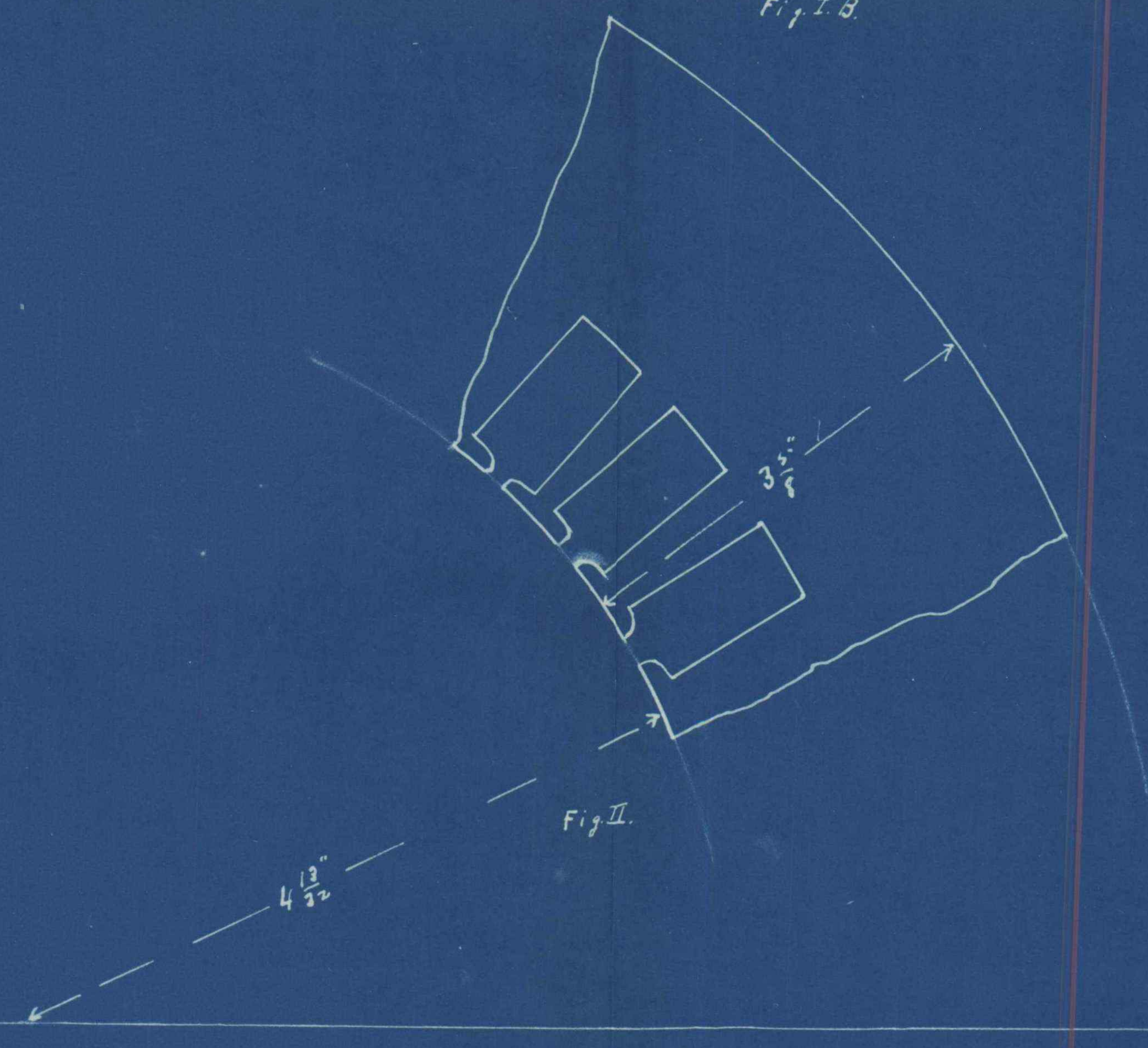
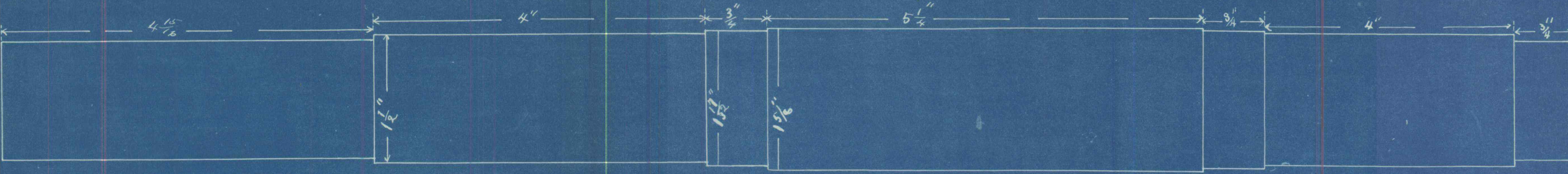
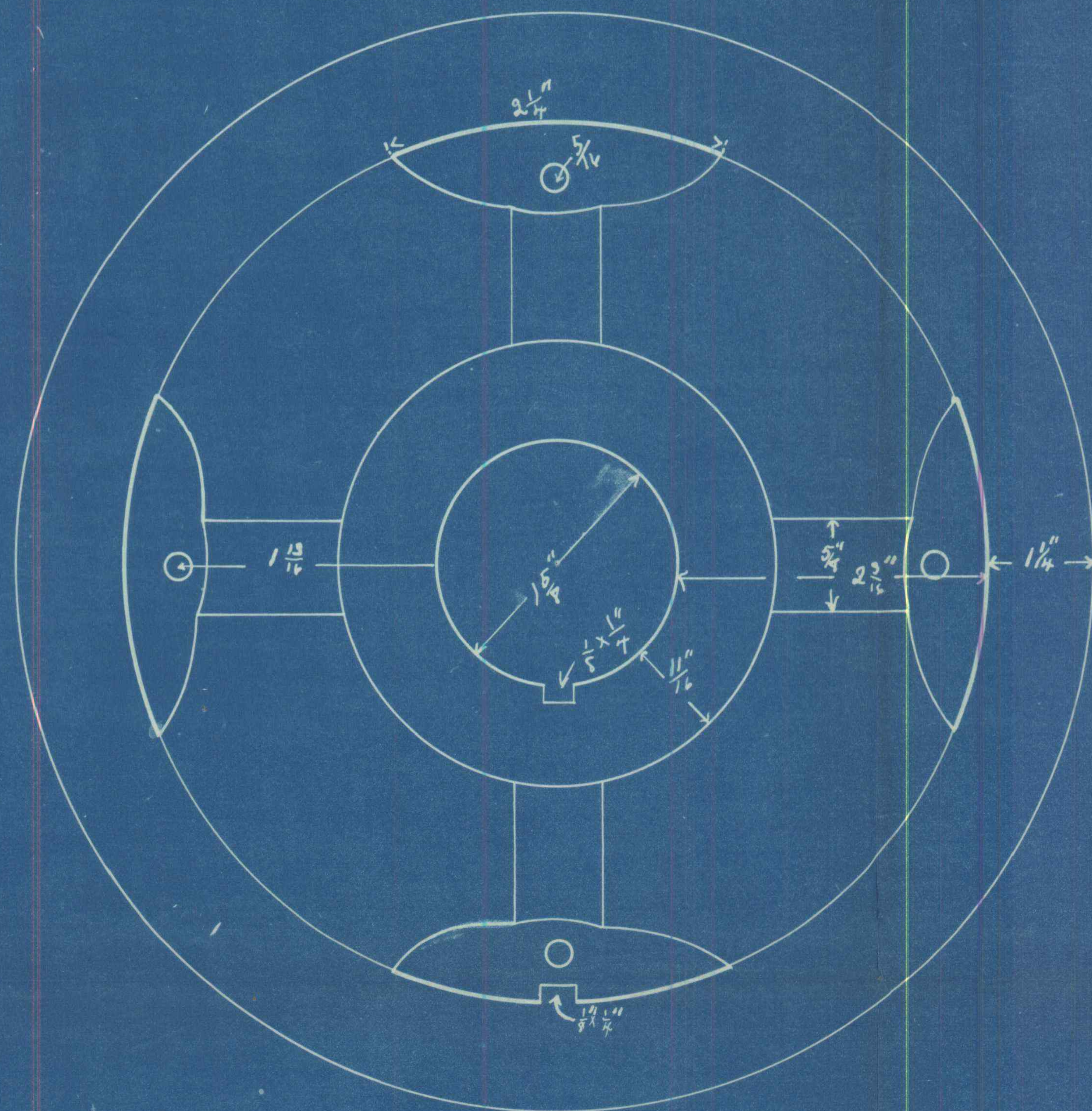


Fig. II.

PLATE II.



Shaft
Fig. 1



Rotor spider.
Fig 2 A

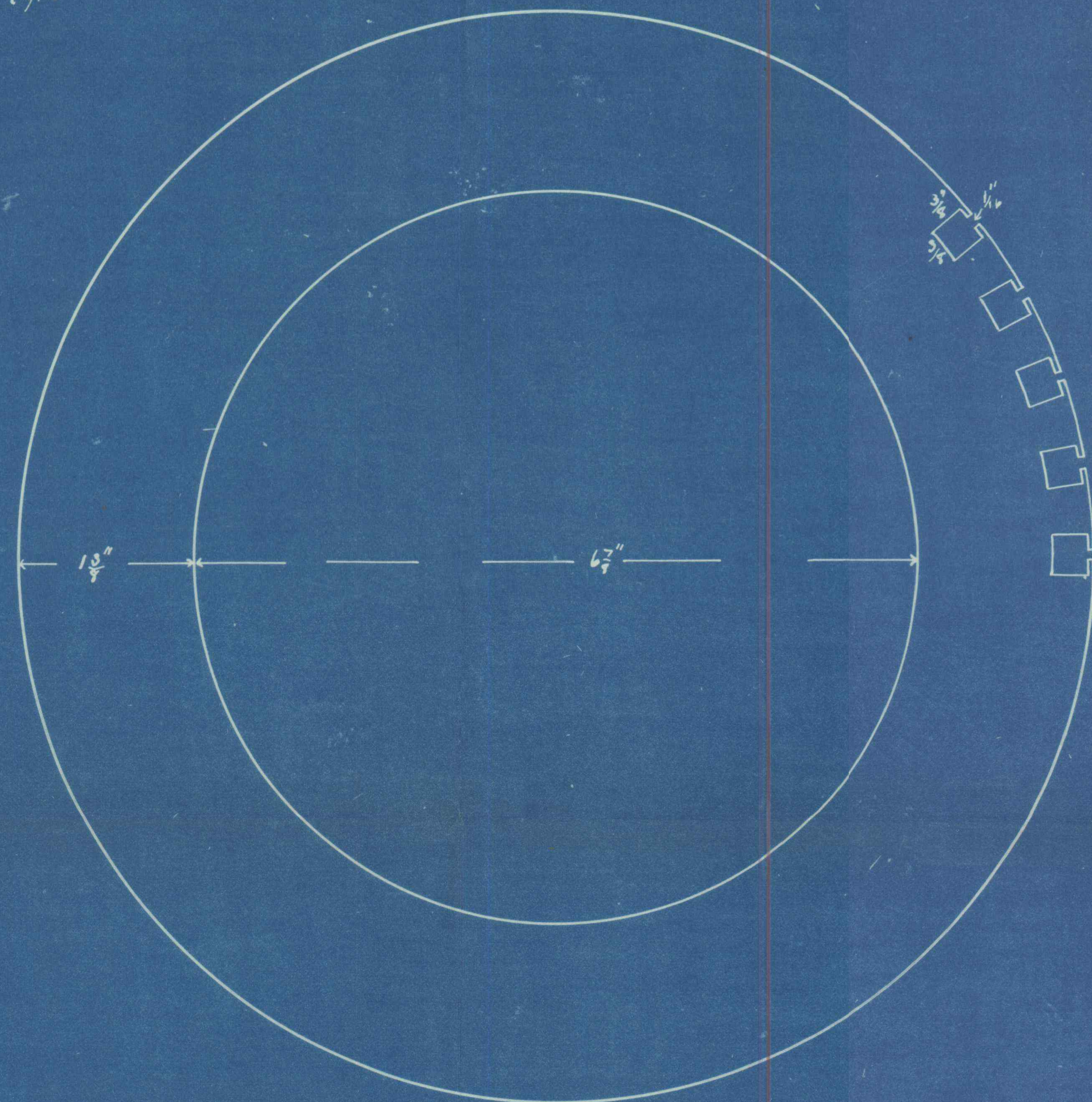
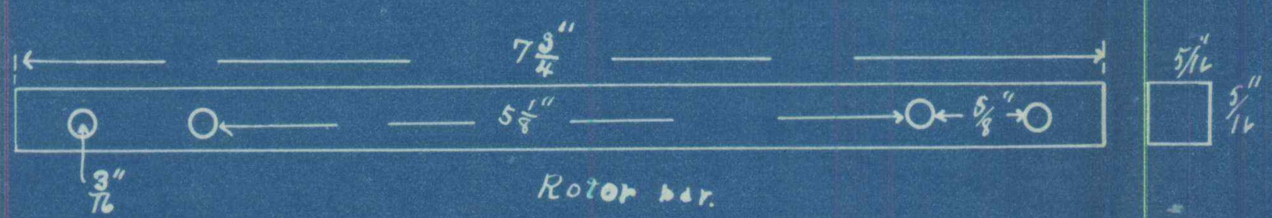


Fig 2 B



Rotor bar.

PLATE III H Tuber