1493

THE DESIGN AND CONSTRUCTION

of

A MAGNETIC SEPARATOR.

R.R.White,

C.E.Davis.

THE DESIGN AND CONSTRUCTION OF A MAGNETIC SEPARATOR.

It requires no little amount of care and time to avoid the mixing of iron with brass filings in the machine shop, especially where diversified work is done on the same machines. The brass filings are quite valuable but are useless when mixed with iron since the brass filings cannot be recast in the presence of the iron filings without the iron being mixed through the casting, unmelted. It is a laborious task to separate these metals with the hands or by means of a magnet; hence the necessity of a magnetic separator in the machine shop.

In designing a magnetic separator our object was that of magnetizing a rotating cylinder, thus holding the iron filings on it's surface while the brass, being non-magnetic, falls off due to gravity as the drum rotates. Every one who has gained any knowledge of electricity has learned that when a current is passed through a coil of wire wound about a piece of magnetic material, this material will attract and hold other magnetic materials. By Plate II one can see that eighty four electro-magnets have been set into an iron hub, the design of which is represented in Plate III. If we pass a current through the coils of the magnets they will become magnetized and retain any particals of iron which might come in contact with them.

One may wonder how a current may be passed through the coils while rotating. By having two copper bars insulated from each other and from the frame of the machine, impressing a voltage over them, no current will flow until they are electrically connected. Now, if we have two brushes between which are the magnet coils, these brushes being insulated from each other and from the frame of the machine, then when these brushes are in contact with the bars it is evident that the coils are in the circuit. The two copper bars are circular and fastened to the frame of the machine, while the brushes are fastened to the drum, rotate with it and rub on these bars.

The solving of this problem presented another. Must the flow of mixed filings, falling on the drum, be stopped, the brass which has fallen off removed and the circuit broken to remove the iron? We saw at once that this operation was quite undesirable and devised a plan whereby we could let the mixed flow of filings continue, catch the brass in a bin as they fell from the front side of the drum and, as the magnets started upward on the back side, demagnetize them, thus releasing the iron which falls into another bin.

By reference to Plates I and IV, it will be noticed that two rows of magnets are in series thus requiring one set of brushes for each two rows of magnets. When any set of brushes comes in contact with the copper bars the two rows of magnets, connected to that set, are magnetized. By noticing the length and position of the bars it will be seen that the magnets go into the circuit just before the brushes reach their top position, remaining in the circuit until the

upward motion has fairly begun.

Over the magnets is placed a copper cylinder with holes through which the magnets project permitting the iron to come into direct contact with the magnets. If we should not have the magnets projecting through the plate much loss of energy would be occasioned due to the great reluctance of the copper plate. Not only this but there would be a great amount of leakage between the magnets under the plate. When the filings once touch the magnets an easy path for the lines of force is made over the surface of the drum.

By Plate II we see that the drum is composed of two main parts, the hub and the cores of the magnets. These parts are of such a shape as to offer the least possible reluctance to the magnetic lines of force. The reluctance of a magnetic circuit depends, first, upon the length of the circuit and the density of the lines of force, second, upon the material composing the circuit and, third, upon the joints.

The first point is gained by placing the magnets as illustrated in Plate II. It will be seen that the inner end of the magnet cores are close together thus making the path through the yoke or hub quite short. This hub is of such proportions as to be worked at a very low density thus making the reluctance in this part of the circuit very small. By far the greatest reluctance in the magnetic circuit is in the air gap. This gap was minimized by enlarging the outer ends of the cores. This pole face also serves as a collar for the winding, as a support for the copper cylinder and to distribute the magnetic lines of force more evenly over the drum.

As to the second point, it is found by experiment that the softer the iron the less the reluctance and the better the magnetic properties. Practice has shown that the softest castings are obtained from using nothing but pig iron. In casting the cores and hub, a gray foundry pig without any additions of scrap iron or chemicals was used.

In making the joints a large area of contact with a minimum air space is desirable. The first point was gained by making an enlargement on the inner end of the core similar to the outer end which fits snugly on the hub and also serves as a collar for the winding. The cores are screwed into the hub for a length of one and one fourth inches thus forming an ample contact. The air space can be made very small by good machine shop work.

This machine is designed for a 220 volt circuit. In Foster's wiring tables sufficient data is given for winding the magnets. The magnets must be wound so that the wire on them will offer such a resistance that the current through the wire will not be too great. A resistance in the circuit would accomplish the same purpose for most any voltage, but this would occasion a loss of energy due to the resistance. The size of wire, its length, permissible amperage and depth of winding must be considered for any particular impressed voltage.

Having a certain space on each magnet to fill with wire by knowing the diameter of the wire the number of turns can be calculated. First, a certain size of wire may be assumed and a trial calculation made. By a few trials, the proper size of wire, to fulfill all conditions, will be found.

Assume Number 26 (B.S.G.). Double cotton covered copper wire.

Diameter .026"

Depth of winding space .5"

This will allow twenty layers (Permissible by table)

Length of winding space 2.94"

Which allows 122 turns

Total number of turns 2440

Mean length 5.1"

Total length per spool 1036'

Resistance per foot .0475 (by table)

Resistance per spool 49 ohms.

There are 14 spools in series, hence resistance per circuit 686 ohms

$$C = \frac{E}{R} = \frac{220}{686} = .32 \text{ amperes}$$

which is permissible by table in Foster.

Pounds of wire, by table, 14.

It is necessary, in order that no grounds occur, to insulate the winding from the cores. This is done by placing on the cores alternate layers of shellac and silk to a depth of 1/16". The magnets are wound separately in the same direction leaving the ends of the wires projecting about three inches. After the magnets are screwed into the hub, these ends are connected so that the current will pass around adjacent cores in opposite directions thus forming north and south poles alternately, both longitudinally and circumferentially.

By a simple test in which a hopper with a variable opening was used, the flow of filings was found to be irregular for an aperture small enough to let the right amount pass. The filings would clog especially if large shavings and pieces of metal were mixed with the filings. By a test in which the hopper mouth was placed so close to a drum that it could be left large enough to eradicate clogging, it was found that large pieces such as nails would not pass and were apt to scar the copper cylinder. The final conclusion of these tests was that a pan below the mouth of the hopper shaking back and forth across it would eliminate the difficulty. The reason is easily explained. The pan may be at considerable distance from the mouth of the hopper thus allowing large particles to pass. The pan carries the filings to the drum and causes a steady flow.

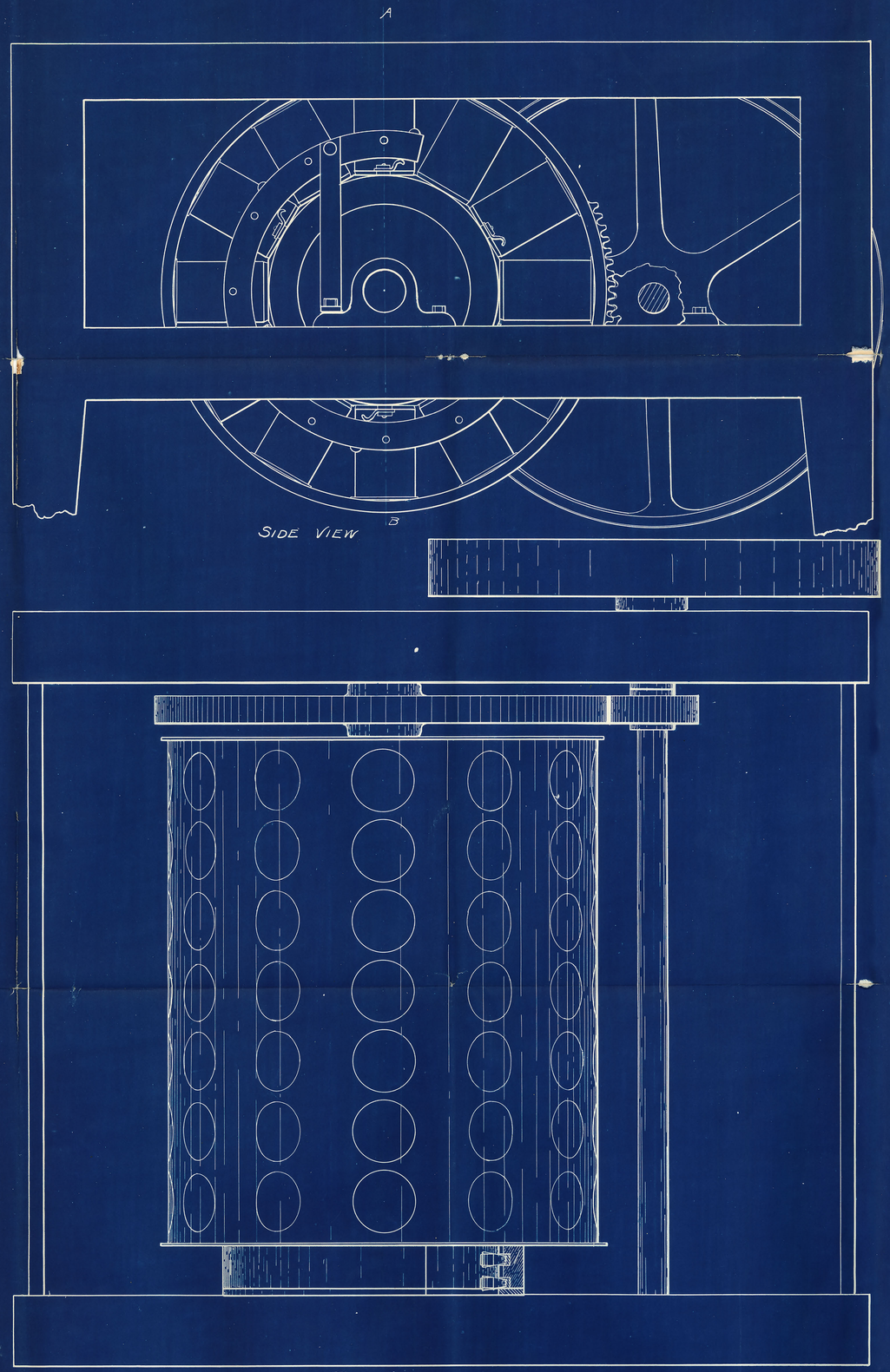
The next thing to consider was the proper gearing for rotating the drum and shaking the pan. It was found that if the drum rotated too rapidly the centrifugal force would throw off particles of iron

with the brass. If rotation was too slow the capacity of the machine would be decreased. From tests made on rotating bodies, 20 R.P.M. was found to be about the proper speed for this size of drum. Details of the gear wheels are shown in Plate VIII.

The shaker attachments are drawn in Plate VII. It gets its motion from the shaft which rotates the more rapidly so that the motion is enough to be effective. The shaker pan and hopper with the supports are drawn on Plate VI. The pan may have its inclination varied thus varying the flow of filings. In this drawing the shaker attachments are not shown but by reference to Plate VII it will be seen that the back portion of the pan is supported by the shaker rod which reaches across the frame. The pan is placed above the frame so that its mouth is slightly in front of a perpendicular plane passing through the center of the drum. Thus the filings fall upon the drum with no chance of falling or bouncing upon the demagnitized portion and into the iron bin without separation.

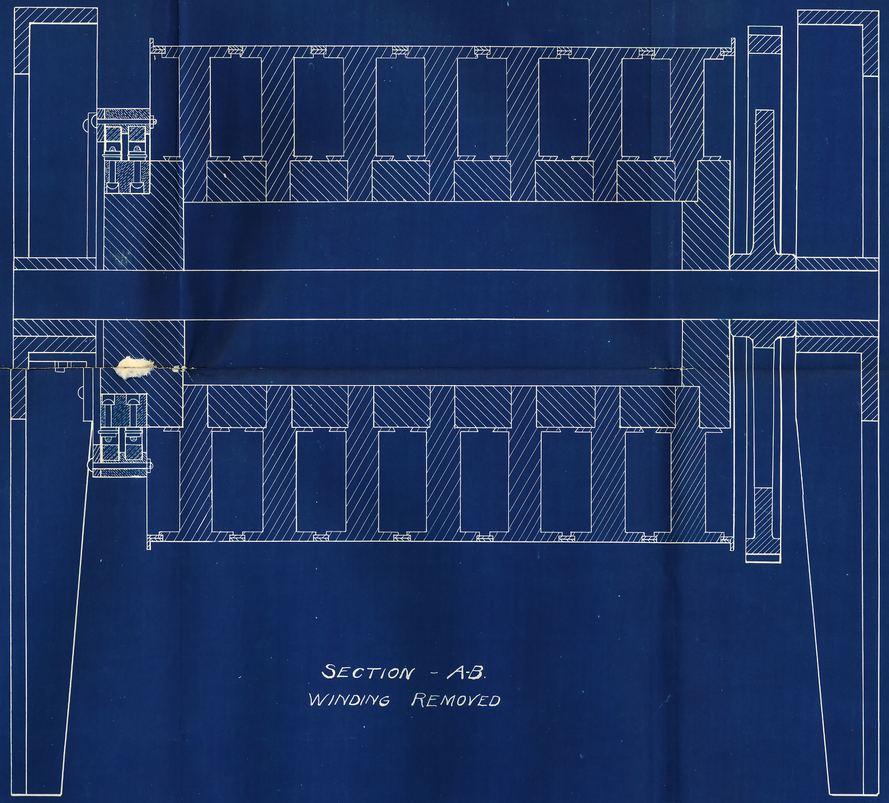
The frame is made of cast iron, each side being one casting, details of which are shown in Plate V. The sides are held together by end bars also shown in same plate.

In designing this machine the following points were kept in view, - economy, simplicity, durability and proportion.



SIDE VIEW

TOP VIEW



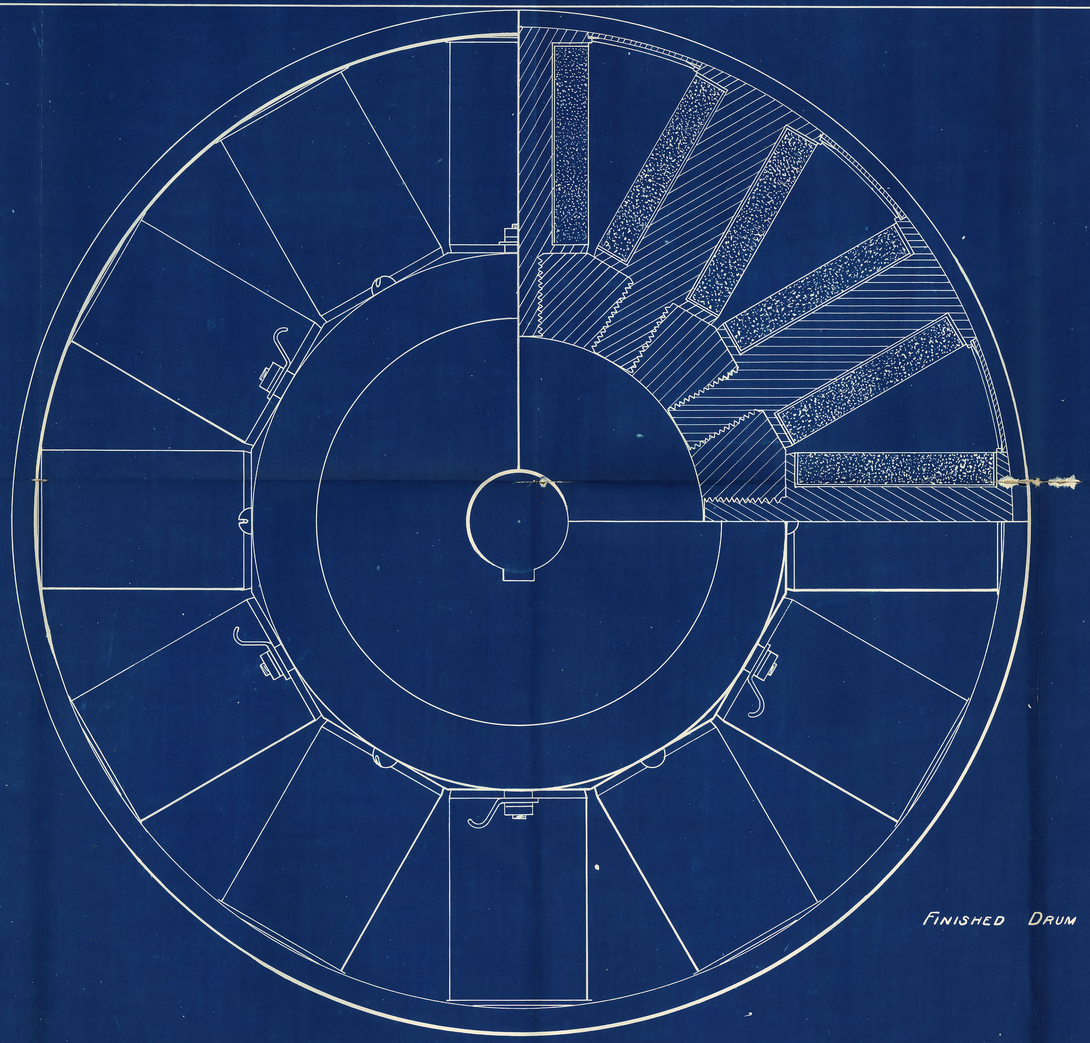
SECTION - A-B.
WINDING REMOVED

GENERAL PLAN of a
MAGNETIC SEPARATOR
SCALE - ½" = 1"
(HOPPER and SHAKER REMOVED)

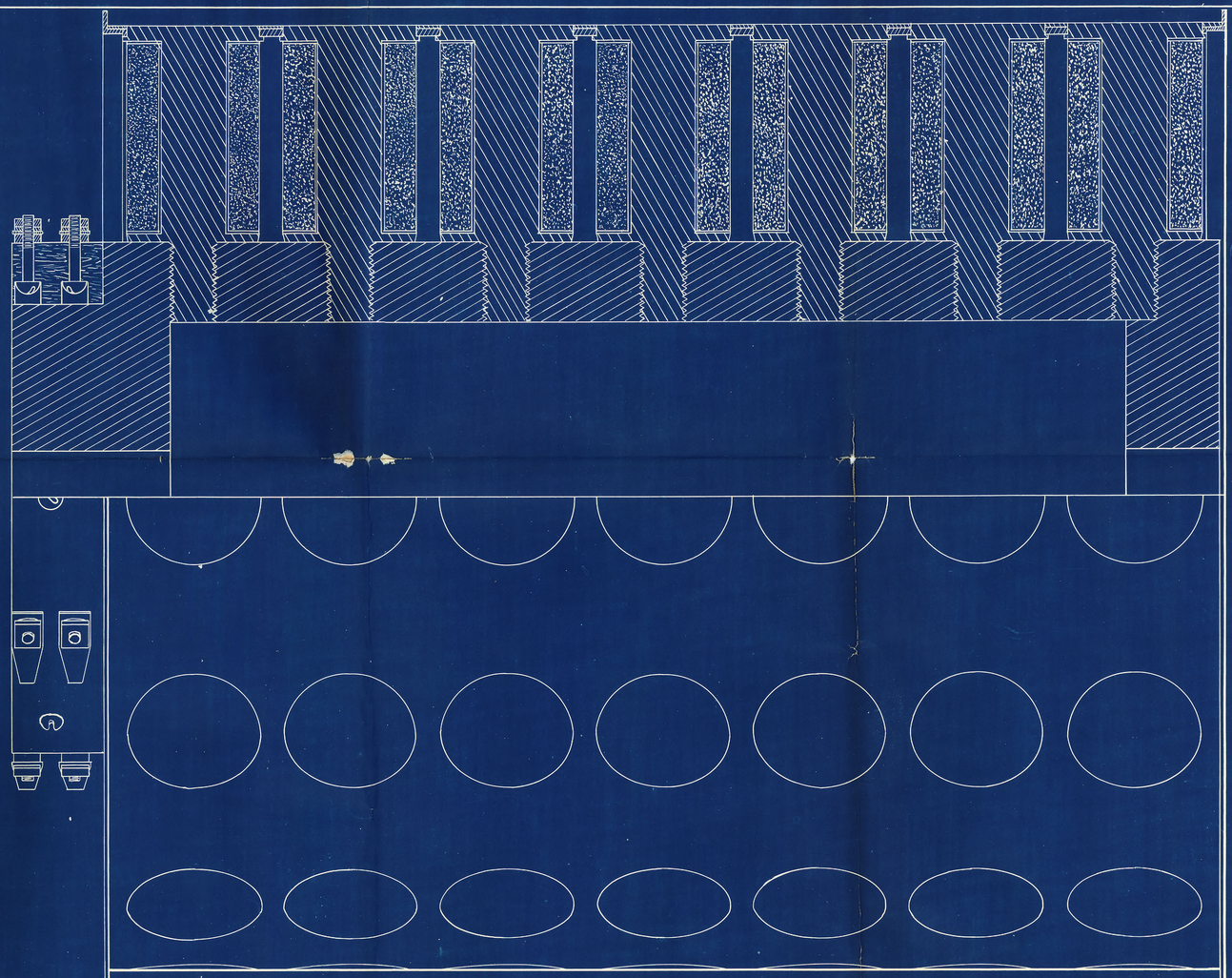
(1)

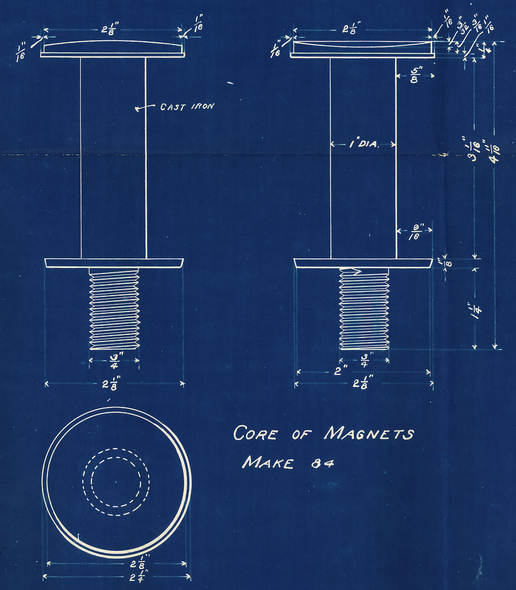
DEPARTMENT of
ELECTRICAL ENGINEERING
K-S-A-C
MANHATTAN KANSAS

C.E.D.

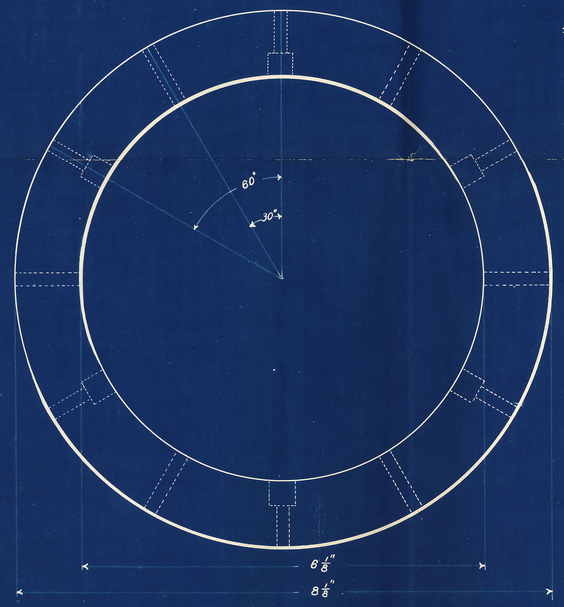


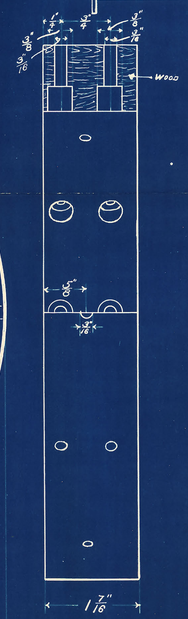
FINISHED DRUM

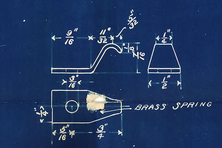




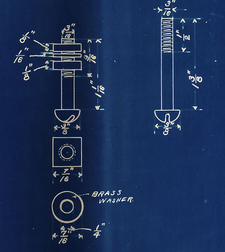
CORE OF MAGNETS
MAKE 84



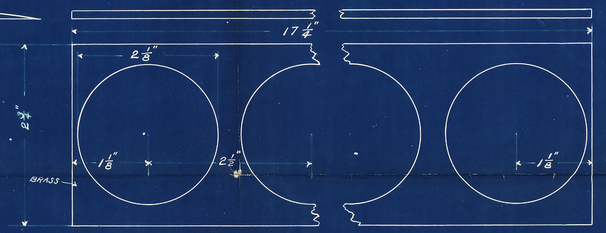




BRUSHES - MAKE 12



CAP FOR MAGNETS
MAKE 12



DETAILS OF A

MAGNETIC SEPARATOR

SCALE: FULL SIZE

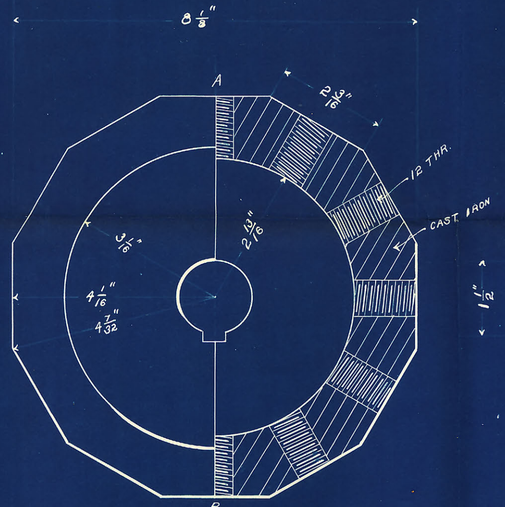
$ MEANS FINISH

(2)

DEPARTMENT OF
ELECTRICAL ENGINEERING
-K-S-A-C-
MANHATTAN KANSAS

RRW 5-25-06

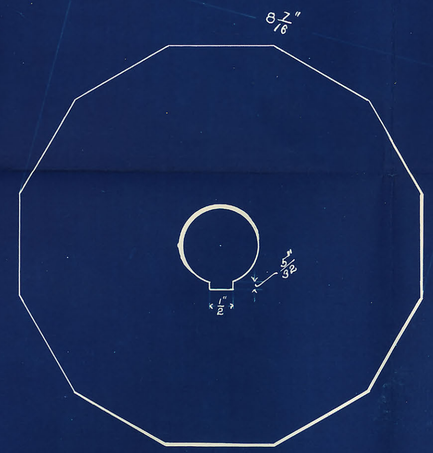
FINISHED HUB



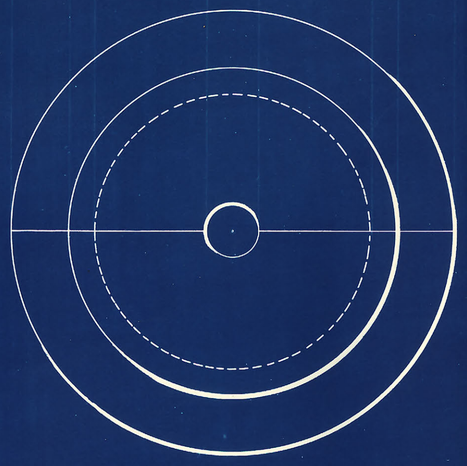
END VIEW

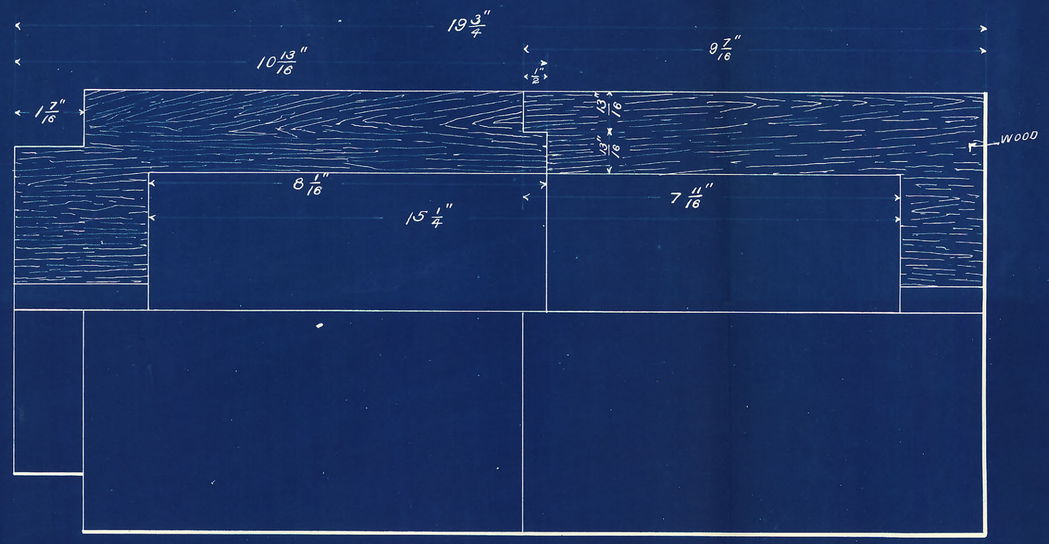
SECTION AT CD

SECTION AT AB



VIEW OF END EF





PATTERN FOR HUB WITH EXACT DIMENTIONS

DETAILS OF A

MAGNETIC SEPARATOR

SCALE: 1/2 FULL SIZE

FINISH OUTSIDE SURFACE

(3)

DEPARTMENT OF

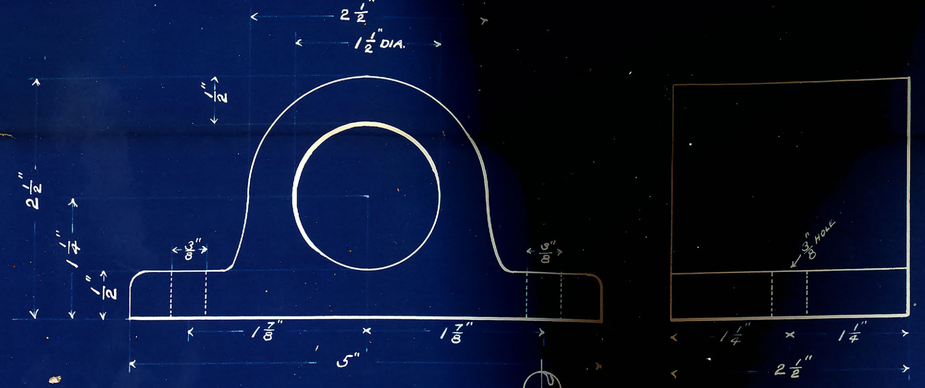
ELECTRICAL ENGINEERING

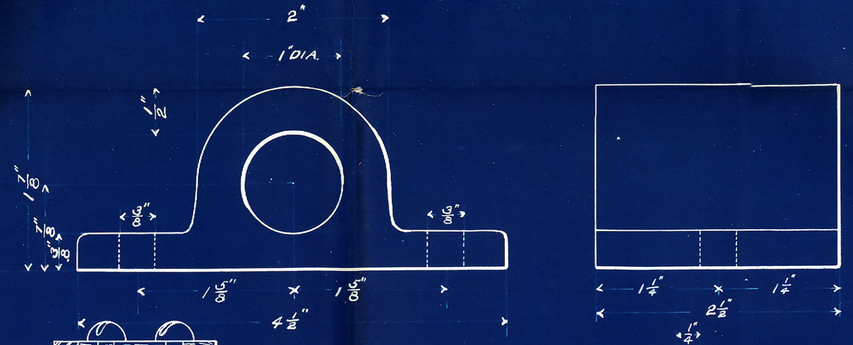
-K-S-A-C-

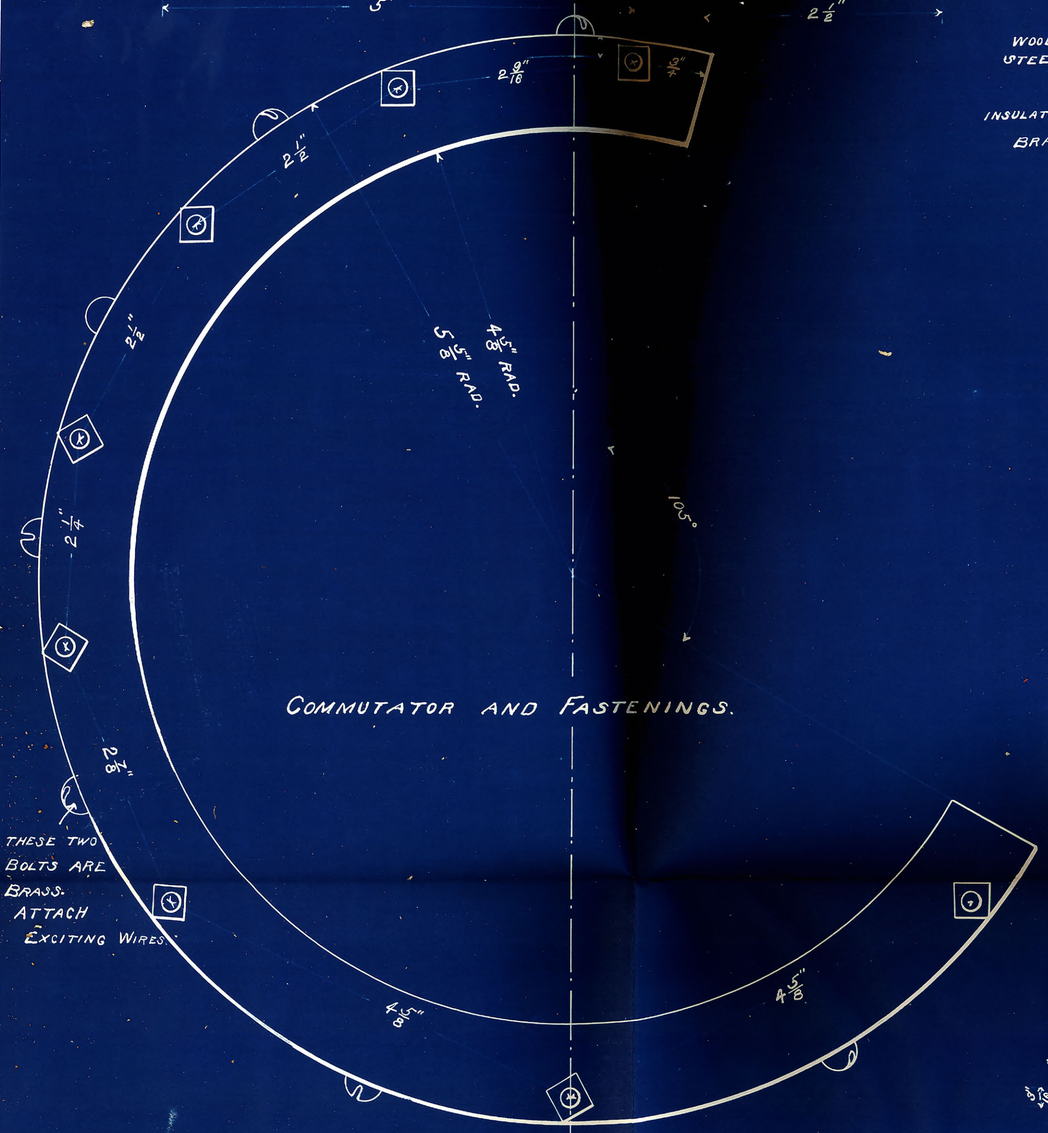
MANHATTAN KANSAS

RRW 4-13-06

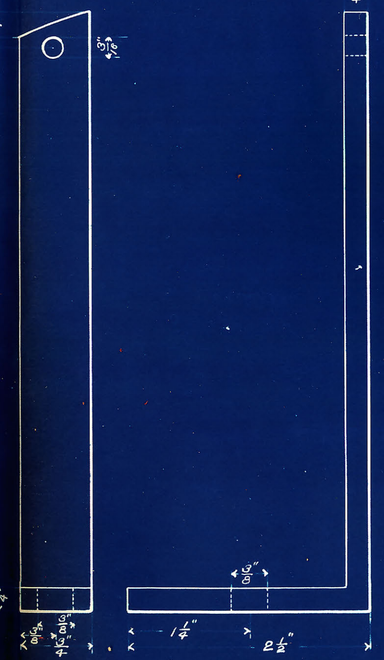
Boxings For Main Shafts.
Make Two of Each Size.

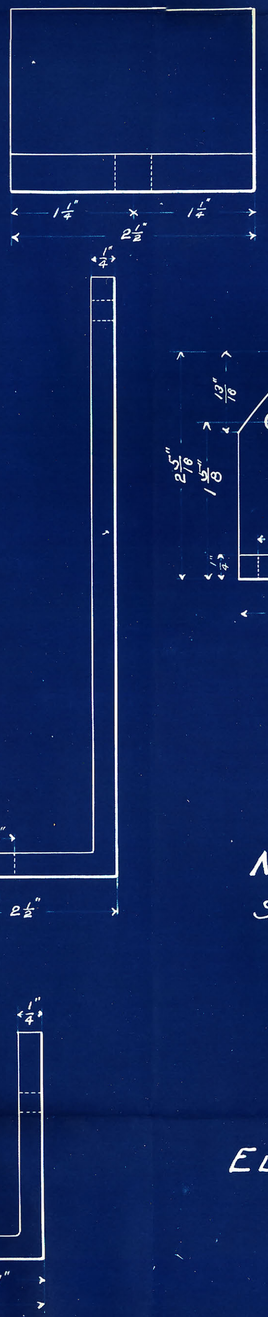


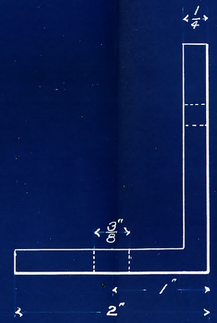




Commutator and Fastenings.







Details of a

Magnetic Separator

Scale: Full Size

X means finish

(4)

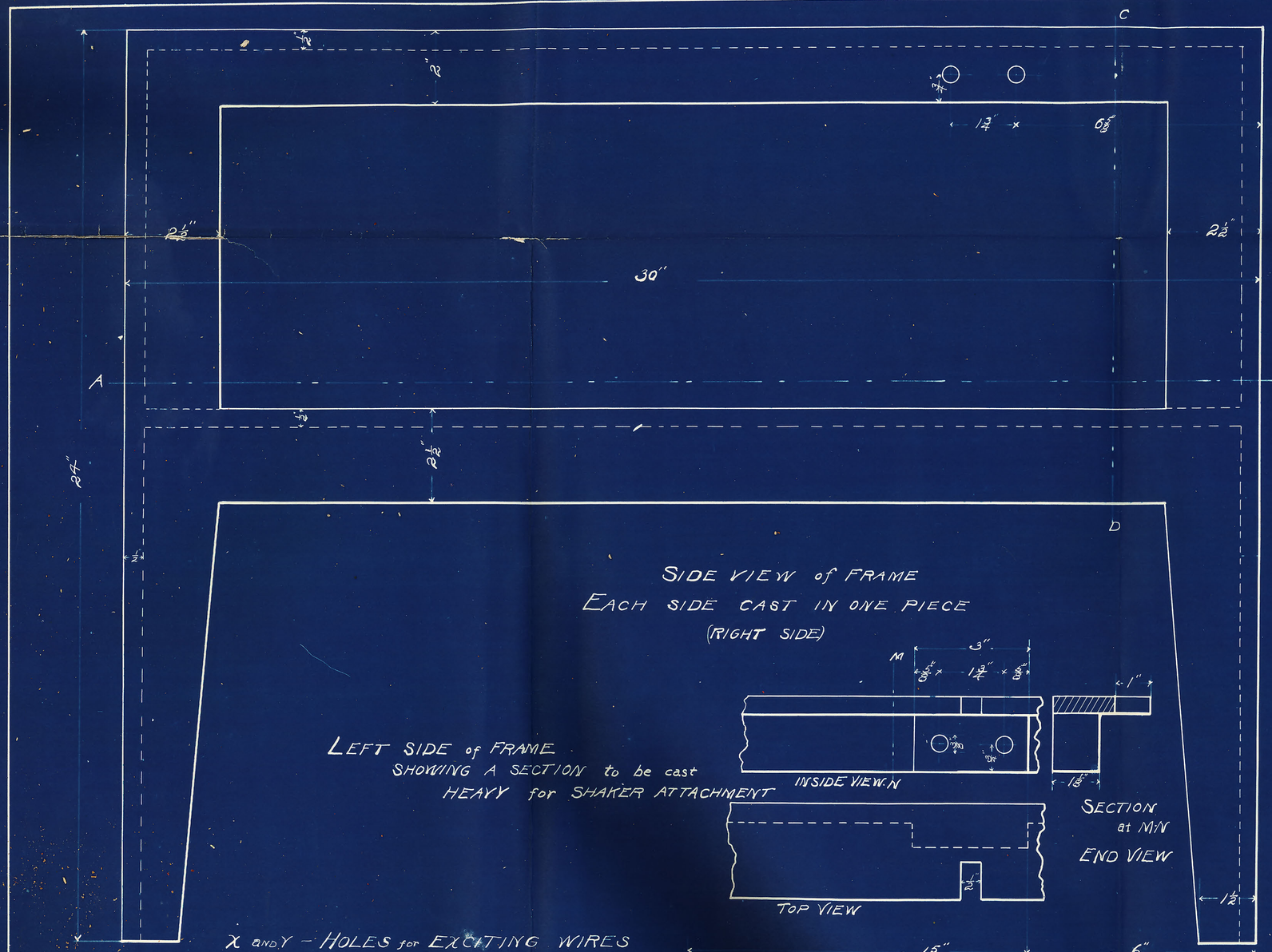
Department of

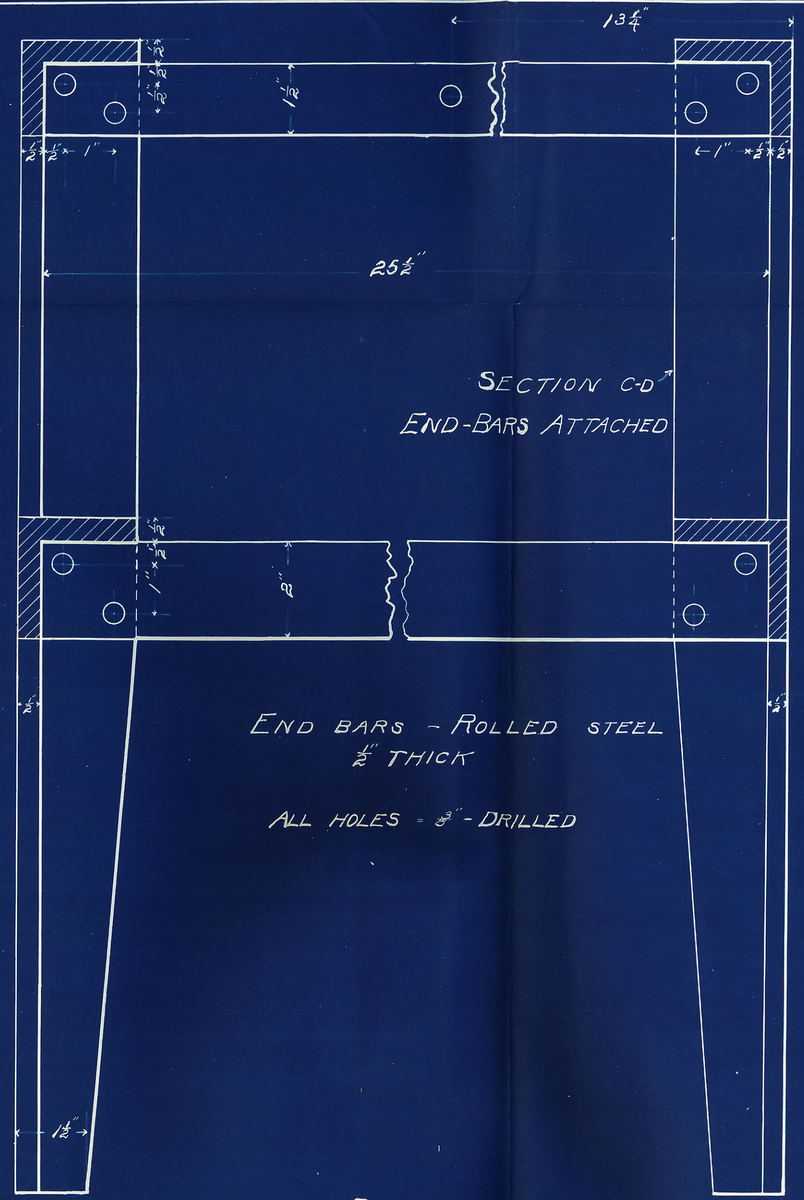
Electrical Engineering

-K-S-A-C-

Manhattan Kansas.

R.R.W. 5-22-'08





DETAILS of a

MAGNETIC SEPARATOR

SCALE:- ½" = 1"

(5)

DEPARTMENT of

ELECTRICAL ENGINEERING

K-S-A-C

MANHATTAN KANSAS

C.E.D.

12"

CROSS BAR at M — HOLES DRILLED to CORRESPOND with those of END-PLATE —

STEEL

N. = ⅜"×1"×15" — (RINGS EXCLUDED) — a BAR across SHAKER PAN — RINGS FORMED on ENDS — HOLES DRILLED to CORRESPOND with those on PAN

⅜" BOLTS USED for BRACES

GENERAL VIEW of SHAKER-PAN and HOPPER

¼"×1½"×12" — STEEL HOLES DRILLED to CORRESPOND with those of END PLATE

ONE BRACE MID-WAY BETWEEN SIDES

STEEL

CHAIN

END BAR of FRAME

1" BACK BRACE

2½"

1"×1½"×2"×2"×2"×2"×⅞"×¾"×1½"×⅞"

ONE SIDE of SHAKER-PAN ⅛" SHEET IRON

FLOOR of SHAKER-PAN ⅛"-SHEET IRON

THIS HOLE in BACK PLATE

1½"×1½"×2"×2"×2"×1½"×1½"

END PLATE of HOPPER ⅛" SHEET-IRON

ONE SIDE of HOPPER ⅛" SHEET-IRON

DETAILS of a

MAGNETIC SEPARATOR

SCALE:— ½" = 1"

f MEANS FINISH

(6)

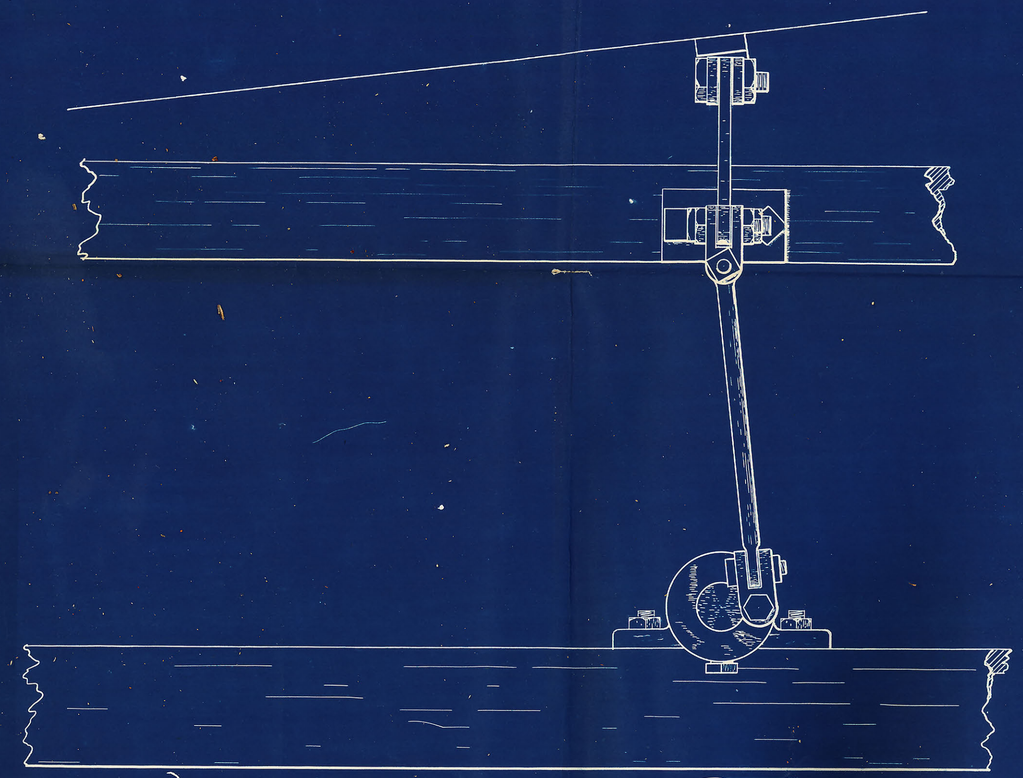
DEPARTMENT of

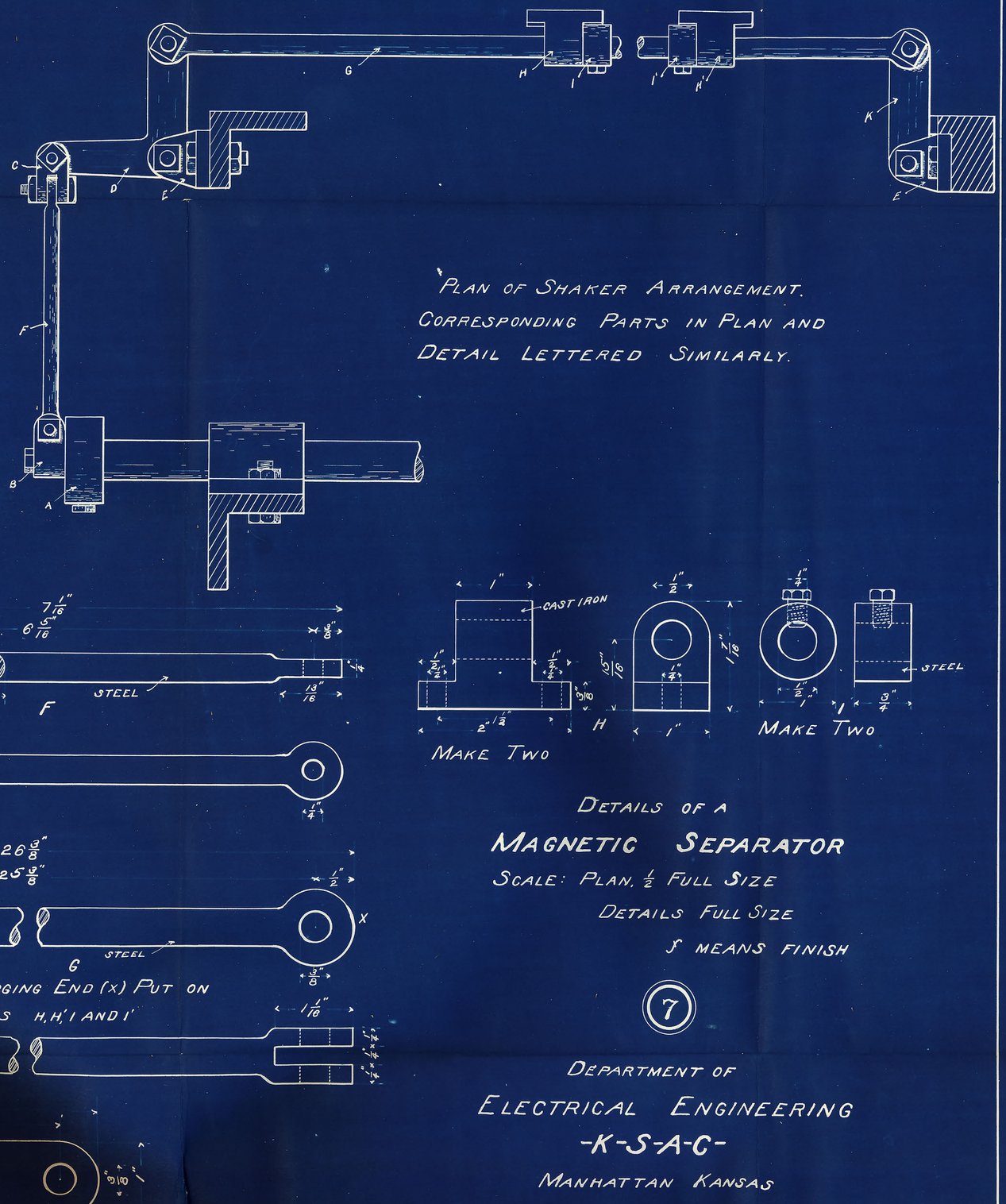
ELECTRICAL ENGINEERING

K-S-A-C

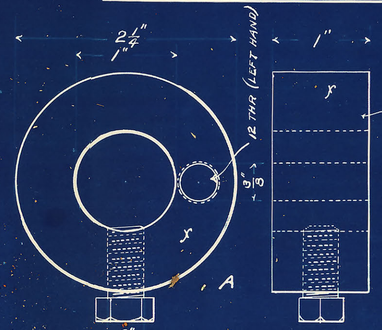
MANHATTAN KANSAS —

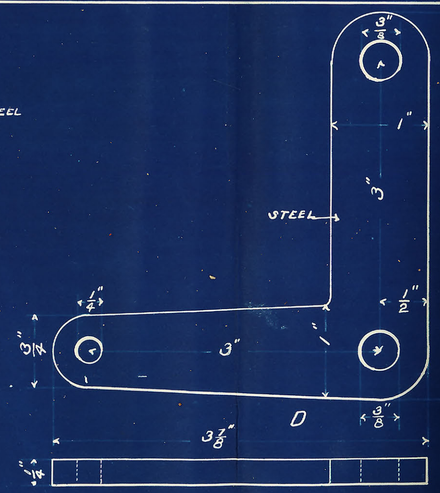
CED



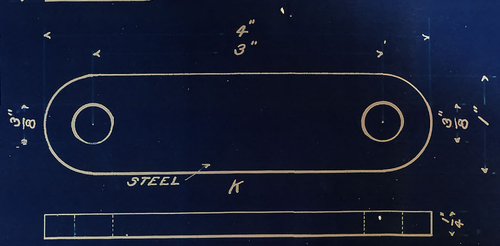


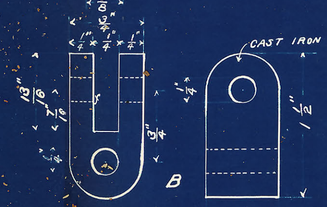
PLAN OF SHAKER ARRANGEMENT.
CORRESPONDING PARTS IN PLAN AND
DETAIL LETTERED SIMILARLY.

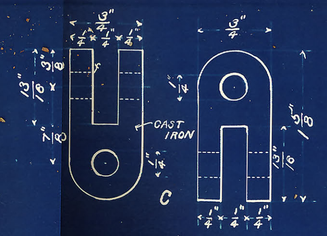


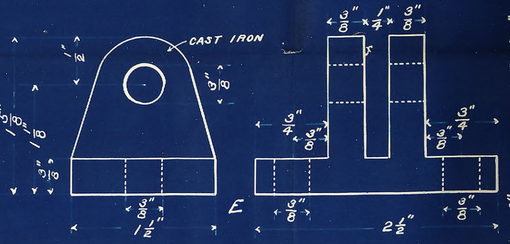


BEFORE FORGING END (X) PUT ON
PARTS H, H', I AND I'









MAKE TWO

MAKE TWO

MAKE TWO

DETAILS OF A

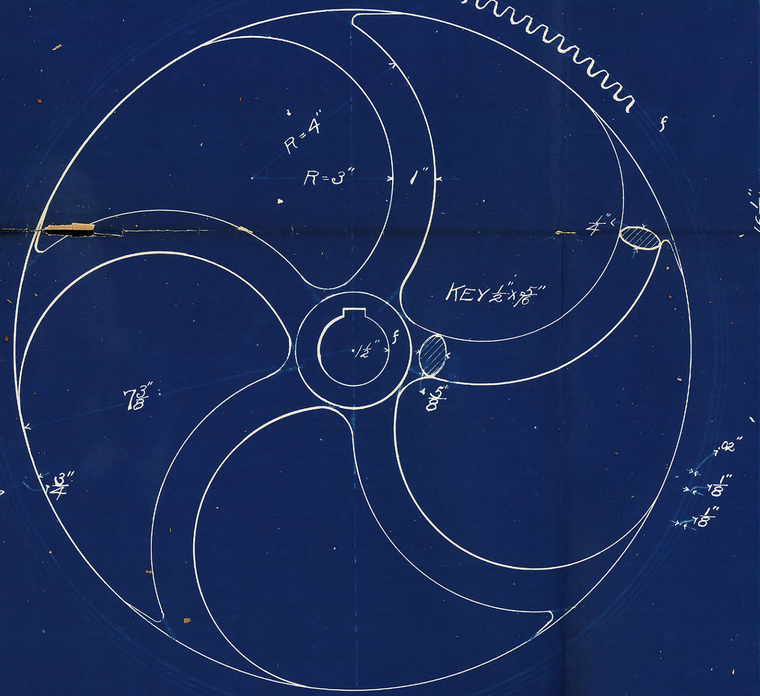
MAGNETIC SEPARATOR

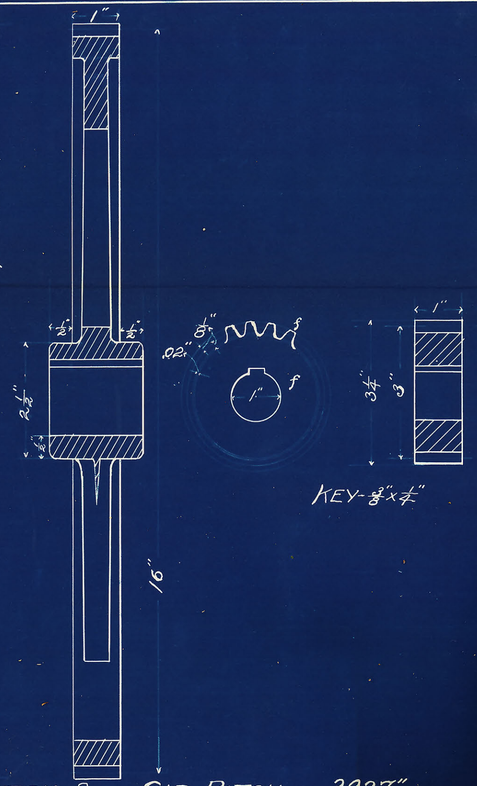
SCALE: PLAN, ½ FULL SIZE
DETAILS FULL SIZE
X MEANS FINISH

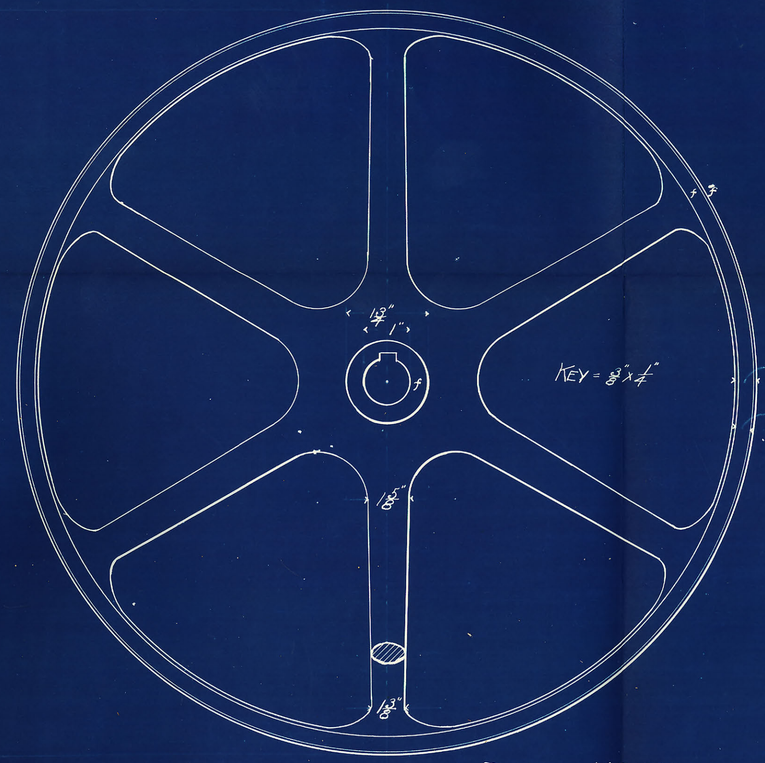
7

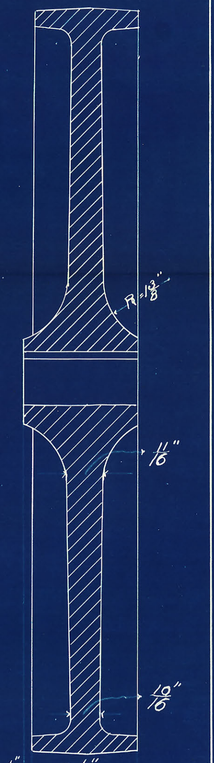
DEPARTMENT OF
ELECTRICAL ENGINEERING
-K-S-A-C-
MANHATTAN KANSAS

R.R.W. 5-17-06







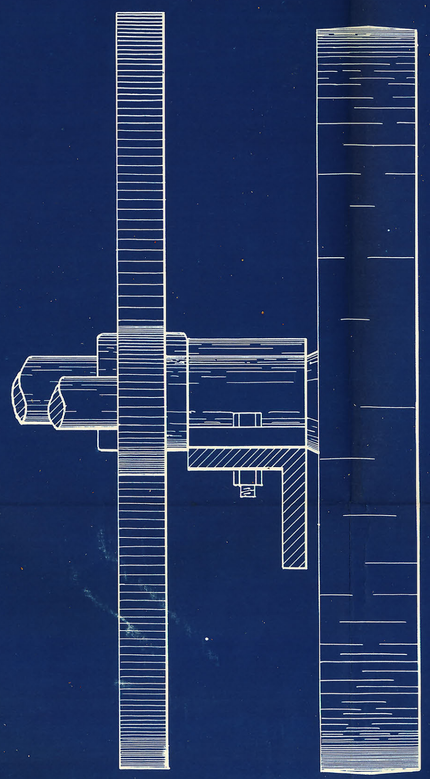


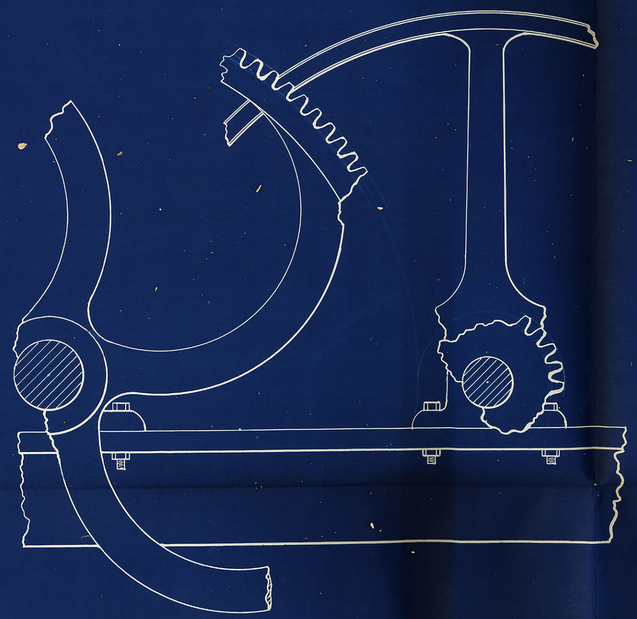
No. Teeth — Large Gear – 128
Small Gear – 24

Pitch-8 Cir. Pitch – .3927"

All Wheels – Cast Iron

Belt Wheel





End and Side Views
Showing Arrangement

Details of a

Magnetic Separator

Scale:- ½" = 1"

f means finish

8

Department of

Electrical Engineering

-K-S-A-C-

Manhattan Kansas

C.E.D.