Graduation Thesis

of

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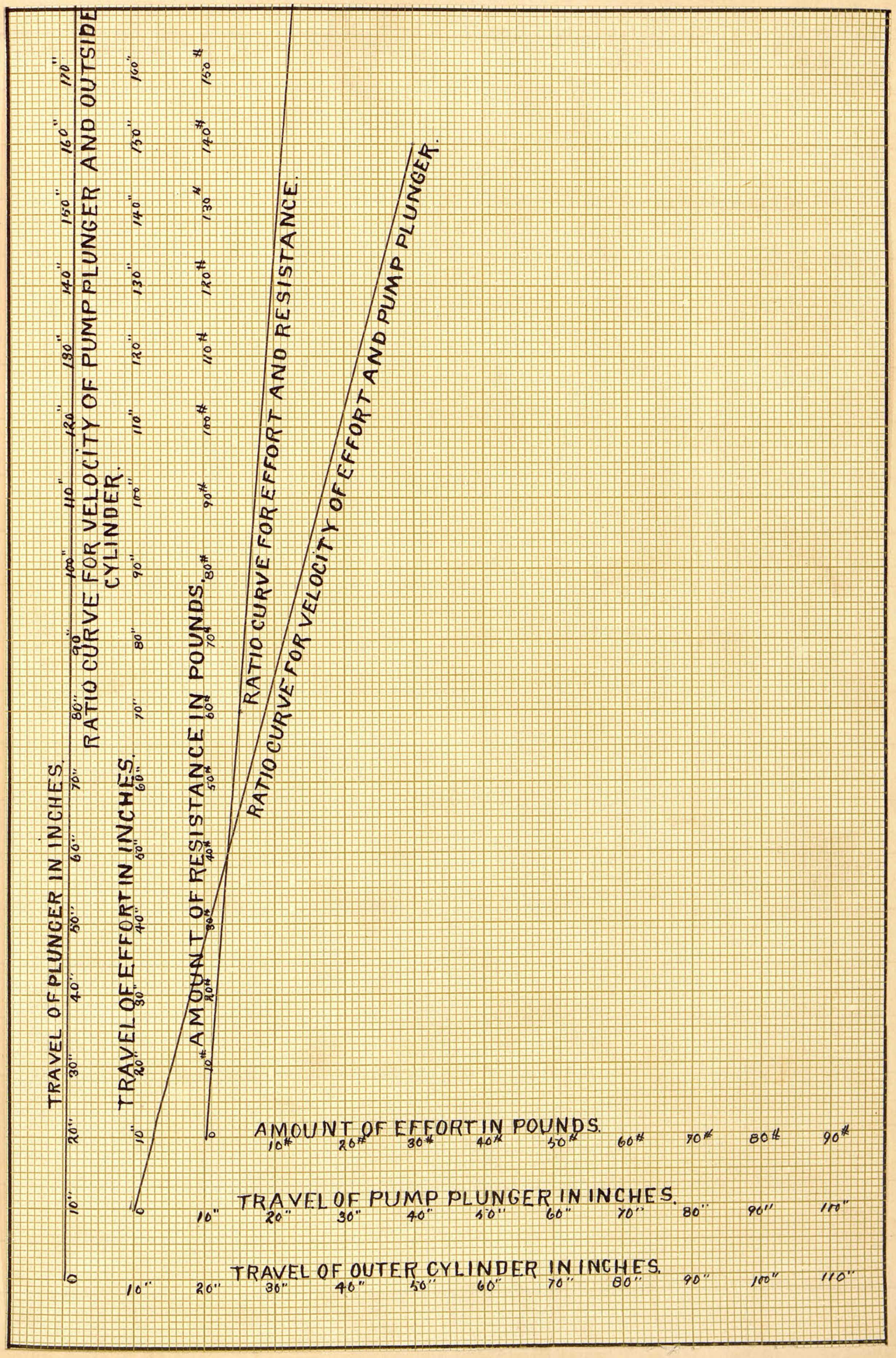
DESIGN
FOR A
HYDRAULIC ARBOR
PRESS

7 TONS PRESSURE

UNIFORM STRENGTH


RATIO CURVE FOR VELOCITY OF PUMP PLUNGER AND OUTSIDE CYLINDER.
RATIO CURVE FOR EFFORT AND RESISTANCE.
RATIO CURVE FOR VELOCITY OF EFFORT AND PUMP PLUNGER.
TRAVEL OF PLUNGER IN INCHES.
TRAVEL OF EFFORT IN INCHES.
AMOUNT OF RESISTANCE IN POUNDS.
AMOUNT OF EFFORT IN POUNDS.
TRAVEL OF PUMP PLUNGER IN INCHES.
TRAVEL OF OUTER CYLINDER IN INCHES.

Outline

Object

Computations for

1. Outer cylinder.
2. Inner cylinder.
3. Supporting rods.
4. Cap.
5. Base.
6. Pump lever.
7. Pump attachments.

Specifications for.

1. Outer cylinder,
2. Inner cylinder.
3. Supporting rods.
4. Cap.
5. Base.
6. Pump attachments
7. Pump.
8. Minor details.

The following is a design for a tool to be of convenience for general machine shop use; such as pressing in bushings, shafts, mandrills, or tight fitting pins of any kind. It has a maximum power of seven tons and a sixteen inch throw. The cylinders are strong enough for pumping up to one thousand pounds pressure per square inch. It is to be operated by the hand, the effort being exerted thru a medium of oil instead of water.

Computations

If 7 tons is the desired working pressure, then 7 x 2000# = 14000# the desired maximum pressure in pounds in the cylinder.

The desired effort (45#) is to be exerted on a plunger thru a lever, in which the resistance bears a ratio to the effort of 1:3. If 45# is the maximum effort to be exerted on the lever, then 3 x 45# = 135#, the resulting force exerted on the pump plunger.

The desired area of pump plunger is 1/4 square inch. Hence, a force of 135 pounds acting on a plunger 1/4 square inch in area, will give a maximum working pressure of 540 pounds per square inch in the cylinder.

Since the maximum pressure to be exerted is 14000 pounds, then $\frac{14000^{\#}}{540^{\#}} = 25.9$ square inches, the sectional area of a cylinder necessary to give the desired result.

The area of a piston with a diameter of 6 inches is 28.2743 sq. inches. Therefore, a cylinder with a 6 inch bore will be used.

From Kent. W. G. Armstrong's table for cast iron cylinders. for an interior pressure of 1000 pounds per square inch, a cylinder with a diameter of 6 inches must be 1.552 inches thick. This corresponds to the formulae $t = .175d + .48$

Cylinder volume necessary for a 16 inch stroke

Area of a piston with a diameter of 6 inches is 28.2743 square inches. Length of stroke 16 inches; therefore, 16 X 28.2 square inches = 452.32 cubic inches, volume of the outside cylinder at the end of a 16 inch stroke. Also the volume of oil to be contained in the inner cylinder, necessary to produce the maximum stroke.

Taking a 16 inch stroke and allowing 12 inches for lap and $4\frac{1}{2}$ inches for the bottom of the cylinder, the following result is obtained. $16'' + 12'' + 4\frac{1}{2}'' = 32\frac{1}{2}''$ inches the extreme length of the outer cylinder.

Inner cylinder.

The ultimate compressive strength of cast iron is 90000 pounds per square inch. For varying stresses a factor of safety 15 should be used. Therefore, $\frac{90000}{15} = 6000$ pounds per square inch, allowable unit working stress.

Area of piston 6 inches in diameter, 28.2743 square inches.

Area of piston 5 inches in diameter, 19.635 square inches.

Therefore $28.27\square'' - 19.63\square'' = 8.64\square''$ of cast iron in a cylinder with an assumed thickness of 1/2 inch.

Now $8.64\square''$ of cast iron is to sustain a maximum pressure of 14000 pounds. from this it follows that $\frac{14000\#}{8.64\square''} = 1664$ pounds will be the unit working stress per square inch. The inner cylinder will be made 1/2 inch thick allowing for attatchments and a larger factor of safety.

Since 452.32 cubic inches is the volume of the outer cylinder at the end of a sixteen inch stroke. $\frac{452.32}{19.63} = 23$ inches, length of a cylinder of a 5 inch bore necessary to contain 452.32 cubic inches of oil, the amount required to give the outer cylinder a 16 inch stroke.

Supporting rods.

To be made of wrought iron.

Ultimate tensile strength of wrought iron 55000 pounds per square inch. For varying stresses, a factor of safety of 10 should be used. $\frac{55000}{10} = 5500$ the unit working stress of wrought iron.

Since the maximum tensile force to be exerted is 14000 pounds, then $\frac{14000\#}{5500\#} = 2.54$ square inches necessary to sustain the given tensile force. Since there is to be two supports, $\frac{2.54\square''}{2} = 1.27$ square inches required area of the cross section of each support. This gives a rod $1\frac{5}{16}$ inches in diameter. However, the supports will be made two inches in diameter to give rigidity to the tool, and will also make allowance for the cutting of a shoulder for the jam nut to rest upon at the same time doing away with the upsetting of such a large bar. An eight of an inch shoulder will be allowed.

Nuts.

From Lowe and Bevis, the short diameter $= 1\frac{1}{2}D + \frac{1}{8}$ when D is the diameter of the bolt. This makes the short diameter of a hexagon nut $2\frac{3}{4}$ inches. Thickness of nut $= D$ or $1\frac{3}{4}$ inches. Long diameter $= 3\frac{3}{16}$ inches.

Cap.

To be made of cast iron, and formed like an I beam.

Spacing 2 feet.

Load 14000 pounds. Formulae for a simple beam with concentrated load $M = \frac{wl^2}{8}$.

$M = \frac{wl^2}{8} = \frac{14000 \times 4 \times 12^{6}}{8_{2}} = 84000$ pound inches.

Ultimate tensile strength of cast iron 20000 pounds per square inch. For shocks, a factor of safety 20 will be used.

Hence $\frac{20000}{20} = 1000$ pounds per square inch, unit working strength for cast iron. Since $M = \frac{SI}{c}$ in which M = the bending moment and $\frac{SI}{c}$ = the resisting moment. From $M = \frac{SI}{c}$ the formulae $\frac{I}{c} = \frac{M}{S}$ is obtained. Since $M = 84000$ pound inches and $S = 1000$ pounds, then $\frac{I}{c} = \frac{84000}{1000} = 84$.

From Merriman, according to Hodgkinson's investigations, the following are dimensions for cast iron beams of equal ultimate strength.

Thickness of web	$= t$
Depth of beam	$= 13.5t$
Width of tensile flange	$= 12t$
Thickness of tensile flange	$= 2t$
Width of compressive flange	$= 5t$
Thickness of compressive flange	$= 1\frac{1}{3}t$
Value of c	$= 9t$
Value of I	$= 923t^4$.

From this, $\frac{I}{c} = \frac{923t^4}{9t} = 102.5t^3$

and $102.5t^3 = 84$.

$t^3 = \frac{84}{102.5} = .82$

$t = \sqrt[3]{.82}$

$t = .93+$

For convenience, taking the value of t as one inch the following results are obtained

Thickness of web	$= 1''$
Depth of beam	$= 13.5''$
Width of tensile flange	$= 12''$
Thickness of tensile flange	$= 2''$
Width of compressive flange	$= 5''$
Thickness of compressive flange	$= 1\frac{1}{4}''$

As the beam is to be 2 feet between supports, and as there is $3\frac{1}{2}$ inches for support holes and it is to project 2 inches beyond the supports on either side it will have a total length of $31\frac{1}{2}''$ inches.

Base.

The base will be made $31\frac{1}{2}$, 18 inches wide, and $5\frac{3}{4}$ inches high. This is extra heavy.

Pump Lever.

To be made of steel.

The ultimate tensile strength of steel is 100000 pounds per square inch. For shocks a factor of safety 15 should be used. Hence, $\frac{100000\#}{15} = 6666$ pounds per square inch, unit working strength for steel.

For a cantilever beam, loaded at the end, $M = Wl$, in which M = bending moment, W = weight, and l = length. In this case $W = 45$ pounds, and $l = 18$ inches. Hence, $W = 45 \times 18 = 830$ inch pounds.

From the above, $\frac{830}{6000} = .13$ square inches, area of cross section of lever necessary to sustain the effort of 45 pounds. However, the lever will be made with the area of its cross section equal to $\frac{1}{2}$ a square inch, or it will be $1'' \times \frac{1}{2}''$

For pump attachments see drawings.

The rod will be made $\frac{9}{16}$ inch in diameter at the plunger end, and to give rigidity $\frac{3}{4}$ of an inch in diameter above that.

Specifications

Outer cylinder, or ram.

The outer cylinder is to be made of cast iron, 1½ inches thick. The bore is to be 6 inches in diameter, and 28 inches long. The bottom will be 4½ inches thick, below 1½ inches it will be turned down to a 5 inch diameter. On the part with a 5 inch diameter, 2½ inches of threads will be turned, but at the bottom ½ of an inch of the threads will be removed. This will allow for the attachment of a chuck for holding various tools, and it may still be used without the attachment for press work. At the upper end of the cylinder there will be a coller left, ½ of an inch wide and 1½ inches deep. This will allow the attachments of weights, to be used in raising the cylinder back to its initial position after the stroke has been completed.

At the bottom of the bore, a hole will be drilled, thru which connection may be made with a pressure guage on the outside

Inner cylinder.

The inner cylinder will be made of cast iron. It is to be ½ of an inch thick. The outside diameter is 6 inches and the inside diameter is 5 inches. The length of the bore is 28½ inches, thickness of bottom 1½ inches, making a length over all of 30 inches.

In the bottom, two 1/4 inch bolt holes for counter sunk heads will be bored, 3 inches apart from centre to centre. There will also be a 1/2 inch hole, for the attachment of a release cock, and a 3/8 inch hole for communication between the inner and outer cylinder. On the outside of the bottom of the cylinder, a shoulder will be turned off, for a ring of 1/2 inch U packing. The packing will be held in place by a 1/8 inch plate fastened at the middle by a screw. At the upper end of the of the cylinder, a flange will be left, 1 1/2 inches wide and 1/2 of an inch deep. Thru this then will be two 1/2 inch holes drilled to provide for attaching the cylinder to the cap.

The Supporting Rods.

The supporting rods will be made of wrought iron, 2 inches in diameter and 64 inches long. A shoulder of 1/8 of an inch will be left at the ends for the jam nut to rest upon, this leaves a diameter of the thread part of the support of 1 3/4 inches. For the length of threaded part see drawings

The Cap.

The cap is to be made of cast iron, and will take the form of an I beam; for dimensions, see computations and drawings. A hole 3/4 of an inch in diameter will be cast in the exact centre. The holes for the supporting rods will also be cast in as shown by the drawings. Allowence must also be made for the attachment of release valve and pump mechanism as shown.

The Base.

The base is to have the dimensions shown by the drawings. The bottom will be cast corrugated, and a hole 4 inches in diameter will be cast in the center.

Pump attachments.

The lever will be made so that the plunger rod is attached 18 inches from the effort end of the lever arm and 6 inches from the fulcrum end; it must be made to given dimensions. The linkage is to be made of wrought iron to fulfill the graphical dimensions. The plunger rod is to be 41½ inches long, for 37 inches of its length it will be ¾ of an inch in diameter; but 4½ inches from the end it will be turned to a diameter of 9/16 of an inch. The end will be covered by a piece of cupped leather packing fastened down by a plate and screw. The plunger rod guide will consist of a brass stuffing box, to be made according to the given dimensions.

The Pump.

The pump is to be made of cast iron and is to be fastened to the bottom of the inner cylinder by two 1/4 inch bolts with countersunk heads. The dimensions given in the drawings must be followed. The bore is to be 9/16 of an inch in diameter and 4 1/2 inches long, at the bottom, it is to be intersected by the valve bore. The valves to be used are as follows. For admittance a Lunkenheimer horizontal flap valve, and for the connecting valve, a Lunkenheimer angle check will be used. The connections with the cylinders will be made by joints of gas pipe.

A high pressure gage will be attached to the outer cylinder, so the working pressure can be noted while the tool is in action.

The release valve will be of the plug form, and will be operated by a lever attached to the compression flange of the cap.

The weights to be used in raising the ram after its stroke and as soon as the release valve is turned, may be suspended by wires passing over pullies fastened to the struts in the roof truss, and down; are to be fastened in the collar left on the upper end of the outer cylinder.

In building the tool all work must be done from the drawings, which if followed precisely, it is to be trusted will make a successful machine for the use of workmen in ordinary shops, or more especially in the shop of the Kansas State Agricultural and Mechanical College.