DIE-CASTING MACHINE

BY

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T H E S I S

D I E - C A S T I N G   M A C H I N E

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C O N T E N T S

I
I N T R O D U C T I O N

In overhauling automobile, truck, and tractor, engines, to make them perform as well as new engines, the bearings on the crankshafts are always re-turned and ground to make them perfect again, as far as being round is concerned. This process of re-turning and re-grinding the bearings necessarily reduces the size of the bearings and as babbitt bearings to fit the crankshaft are not obtainable from the factory, these must be made special; and as the same amount of metal is not taken from all crankshafts each overhauling job requires special bearings. Thus it would be impossible to have bearings die-cast from one mould to meet all requirements. This being the case the bearings are turned out on a machine lathe from a cored babbitt bar made either by casting in sand or by a die-casting machine with a mould for this purpose.

It is the purpose of this treatis to give a general outline of the die-casting process, showing its possibilities, and also to give a description of the die-casting machine and its operation, of the principle involved, and the method used in the die making, (based on results obtained from actual experience along with the blue print of the finished machine and die mould as used).

II
Making Cored Babbitt Bars.

Cored babbitt bars are nothing more than cylindrical bars with a definite outside diameter the full length, and also a hole with a definite diameter running centrally the full length of the bar. A cored bar would be something on the order of a pipe or tube with very heavy walls.

a. Moulding in Sand.

In casting cored bars in sand a pattern must be made the size the cored bar is to be, and in moulding and casting the mould may be made either horizontally or vertically.

In pouring the babbitt into a sand mould there will always be particles of loose sand which will be taken up by the moulten babbitt and these particles will float. If the mould is made horizontally these particles of sand will be all along one side of the cored bar. If cast vertically the sand particles will be in one end of the cored bar. In either case when it comes to turning these bars in the lathe , the tool will be ground off to some extent when these sand particles come in contact with the turning tool; and in the finished bearing sand particles in the babbitt bearings will cause undue wear on the crankshaft, and this being the case the work of overhauling must be done over again.

In casting cored bars in sand it is also difficult to get a perfectly round casting on the outside and to get the hole in the casting concentric the full length. This will cause a waste of material and time in turning down to the required size and necessarily means that the outside diameter of the cored bar must be cast larger, and that the inside diameter must be smaller than the finished product is to be, and often the whole cored bar must be discarded, due to the inside and outside diameters not being near enough concentric; too much sand in the bar, or bad casting caused by the sand being too wet.

b. Die-casting.

In casting cored bars in a die, the die is made so that the core is always concentric with the outside diameter of the bar. The core and the outside of the die being made of steel there is no danger of getting sand into the finished bar nor danger of the mould blowing up from the sand being too wet. Then in turning the cored bar in the lathe there is no sand in the bar to grind off the point of the tool, and in the finished bearing there is no sand to cause undue wear on the crankshaft.

Die-casting, a comparatively recent method for producing finished castings, is rapidly proving itself an important factor in the economical manufacture of interchangeable parts for adding machines, typewriters, telephones, automobiles, and numerous other products, where it is essential that the parts be nicely finished and accurate in dimensions. The term "die-casting" is self explanatory; meaning, "to cast by means of dies". Described briefly; the process consists of forcing molten metal into steel dies, allowing it to cool in them, then opening the dies and removing the finished casting.

III
Designing Die-Casting Machine

The designing of the die-casting machine must be considered from the view point of having the smallest number of working parts consistent with obtaining good results. The machines, metals, and methods, employed in the manufacture of die-castings are as yet very little known. This is due no doubt to the fact that the apparatus and methods employed have been jealously guarded as secrets by those engaged in the manufacture. It may be surprising to many to learn that the commercially successful manufacture of castings from alloys in metal die moulds has not yet been accomplished through any recent inventions, nor been the result of any one individual's efforts. Like most industries, it has been of gradual growth through a period covering more than sixty years. The machines have been slowly perfected and the alloys for the castings have been continually improved. Thus it is now possible to make dense, sound die-castings from alloy nearly as strong as brass, and a process by which a very strong bronze can be cast in die mould is being developed.

a. Mould

The cast cored bar which we are considering is 12 inches long, 3 inches outside diameter and 1 1/2 inches inside diameter. After considering all possible ways of making the mould it was decided to make it in four parts, that is, the core, the shell, the lower end, and the upper end. By referring to the blue print the construction can be easily seen.

The core is 1 1/2 inches in diameter at the lower end and tapers to 1 1/2 inches minus .012 of an inch at the upper end so it can be easily forced out of the casting. The lower end has a 3/8 inch hole drilled centrally 3/4 inch deep, then 4 1/4 inch holes radially to allow passage of metal. The shell is 3 inches in diameter at the upper end and tapering to 3 inches plus .012 of an inch at the lower end, this gives a taper of .001 of an inch per inch of length.

The lower and upper ends of the mould are both cone shape. The lower end has a 3/8 hole through the center to allow the molten metal to pass through and the lower side is recessed to fit over the nozzle. The upper end of mould is drilled through with several 1/64 inch holes to allow for the passage of air out of the mould as the metal rushes into the mould. The upper side is counter sunk in the center to receive the point of the hold down screw which holds the mould together and in place.

b. Machine.

The machine must necessarily consist of a melting pot, a reservoir, a cylinder, a piston, and some passage for the molten metal to pass from the reservoir to the die mould.

These are to be constructed circular in **form** and concentric with each other. The melting pot is the frustum of a cone. The cylinder is an elogation of the reservoir and they are both concentric with the melting pot. A hole drilled through the piston serves as a passage way for the molten metal from the reservoir to the mould. The piston then serves three purposes, as the piston proper; a passage way for the molten metal; and to carry the die-mould itself.

IV
Calculations

a. Mould.

The capacity of the mould then is

$$\frac{3^2 \times 3.1416 \times 12}{4} - \frac{1\ 1/2^2 \times 3.1416 \times 12}{4} = \text{capacity in}$$

cubic inches. 84.8232 - 21.2052 = 63.618 cubic inch capacity of the Die Mould.

b. Reservoir.

The capacity of the Reservoir displaced by piston, below port opening in cylinder

$$\frac{3^2 \times 3.1416 \times 9\ 1/2}{4} - \frac{3/8^2 \times 3.1416 \times 20\ 1/2}{4} = \text{displacement.}$$

7.0686 x 9 1/2 - .11014 x 20 1/2 = displacement.

67.1517 - 2.2578 = 64.8939 cubic inch displacement of piston below port opening in cylinder.

64.8939 - 63.618 = 1.2759 cubic inch greater displacement of piston over capacity of mould.

c. Melting Pot.

The capacity of melting pot by the prismoidal formula.

$$V = \frac{h}{3}\left(A_1 + A_2 + \sqrt{A_1 \times A_2}\right) = .2618 \times h\ (D^2 + d^2 + D \times d)$$

Capacity of melting pot above bottom of part hold then is

$$V = .2618 \times 5\ 1/4\ (8^2 + 7^2 \times 8) - \frac{3\ 3/4^2 \times 3.1416}{4} \times 5\ 1/4$$

volume of cylinder above port.

V = 1.3744 (64 + 49 - 56) - 110.747

V = 232.2736 - 110.747 = 121.5266 Cubic inches as capacity of melting pot.

Dividing 121.5266 by 63.618 gives 1.91, the capacity of the melting pot over the capacity of the Die-Mould.

d. Pressure Obtained.

The pressure per square inch on the molten metal then will be calculated from the second case of the lever, which is the power on one end of the lever, the fulcrum on the other, and the weight between. Considering the lever 48 inches long and the power 100 pounds, the short end of the lever 12 inches and the weight is X.

48 x 100 = 12 x X = 400 lbs. for the weight.

Dividing 400 by the area of the piston 7.0686 square inches gives 56.588 pounds per square inch, the pressure exerted on the molten metal when 100 pounds pressure is exerted on the end of the lever.

V
Building the Die-Casting Machine

a. **Making Patterns.**

In making the patterns there were only four patterns that were used. The pattern for the melting pot being the main one. This was easily made as it was turned out complete on a lather and did not require any extra hand work.

The pattern for the cylinder and reservoir was the next one to be made and this, also, was nothing but turning; the core box was made so that the core was large enought for the reservoir, therefore, this part of the casting required no machining for the piston to pass through; then the part of the casting that constituted the cylinder was left small enough to allow for machining.

The pattern for the piston was a straight round pattern without core, except where the pins for the operating levers are located. Here two bosses were put on opposite sides. The patterns for the top and the bottom of the die-mould are the same and require but the one pattern for the two pieces.

The actual measurements for all these patterns are, of course, taken from the drawings where the designing was done.

b. Machining Castings.

The machining of the castings after they came from the foundry was not a large task. The lower end of the melting pot was faced in a lathe and the opening threaded for a 4 inch female pipe thread.

The cylinder was then chucked and the upper side of the flange faced and a 4 inch male pipe thread cut above the flange to fit the melting pot. The cylinder was then roughed out a little less than 3 inches leaving enough metal for grinding. The melting pot was then screwed on to the cylinder and upper end of the melting pot faced. The lower end of the cylinder and reservoir casting was then threaded with a 2 inch male pipe thread to receive a coupling when assembling. The cylinder and melting pot were then bolted to the angle plate of a cylinder grinder and the cylinder ground out to 3 inches, exactly to the thousandth part of an inch.

The piston was then chucked in a lathe and the passage for the molten metal drilled, and the upper end drilled and threaded for the nozzle. The outside was turned to nearly 3 inches, leaving enough metal for grinding. The holes for the lever pins in the bosses were drilled and reamed and the upper end of the piston was also faced to give a smooth face for the surface plate. The piston was next transferred to a surface grinding machine and ground to 2.997 inches, this giving a clearance of .003 of an inch between piston and cylinder, or.001 per inch of diameter of cylinder.

The inside of the die-mould shell and the core of the die mould are also ground to give a smooth surface for removing the cored bar from the mould.

C. Assembling Parts.

The rest of the machine is made and assembled according to the blue print, which gives a list of material and all necessary measurements to be followed in the building of the die-casting machine.

VI
Operating Die-Casting Machine

a. Melting the Metal.

After the machine is all assembled, according to the blue print and the mould is all in place, the babbitt is put into the melting pot and the burners lighted to bring the babbitt to the melting point. More babbit must be added, as it melts down until the pot is nearly full. As soon as there is enough molten babbitt in the pot; just hot enought to be in the molten state, (this is very important in order to get good results, also the mould must not be hot, it can be warm but not hot) then we are ready to operate.

b. Operating the Machine.

Now the operating lever is raised until the bottom of the piston is above the port holes in the cylinder, which are drilled through the cylinder walls, the lever is held in this position until the reservoir is full of molten metal, the lever is then brought down quickly and as soon as the lower end of the piston passes the port holes we have a pressure on the molten metal which will force the metal up through the passage in the piston into the mould: the air in the mould will rush out through the 1/64 inch holes in the top of the mould and as soon as the metal comes through these holes it cools and we have a pressure of 56 pounds per square inch on the metal. Holding the lever down a short time it soon cools in the mould. Then the operating lever can be released. The hold down screw of the mould is then unscrewed and the mould head plate swung out of the way and the mould lifted out by using tongs.

c. Removing Casting from Mould.

The mould and casting can now be cooled in water or left to cool in the air, if no more castings are required at once. After these are cold enough to handle they are taken to a press where first the core is pressed out of the casting and then the casting is pressed out of the shell, always being sure to press on the small end of the core and cored bar. Then there will be no trouble in getting the mould and cored bar separated.

Care must always be exercise not to dent or mar the ground surfaces of the mould as much of the success of separating the mould and the cored bar depends on these ground surfaces.

The babbit must always be melted out of the nozzle beofre assembling the mould on the piston, preparatory to making the next cored bar.

VII
Die Casting Metals

The metal used for making these cored bars was what is known as XXXX nickel and another one was Atkins nickel. These were the best grade of babbitt that was obtainable, neither one of them contained any lead or zinc whatever and yet were not so hard as to cause undue wear on the crankshaft when in use, and the bearings themselves stood up well.

It is hard to find any two or more authors that agree exactly on the composition of bearing metal. The following are a few that will give complete satisfaction:

	Tin	Copper	Anti-mony	Zinc	Lead	Bismuth
High Speed Dynamos	88	3.5	8			0.5
Genuine hard Babbitt	80	10	10			
Genuine Babbitt (No. 2)	83	8	9			

Before pouring babbitt should be stirred thoroughly to insure a uniform composition. Whenever practicable the bearing should be in a vertical position when pouring.

For the best class of die castings tin base metals are employed. They are made from 60% to 90% tin and from 2% to 10% copper, the remainder being zinc with a slight amount of antimony. The melting point of a mixture of this composition is about 675 degrees F. It is essential that tin base metals are used for carburetor parts and other parts coming in contact with gasoline as well as for parts which come in contact with food products as the lead and zinc alloys have a contaminating effect.

Tin base metals shrink very little. The zinc base metals shrink more, and those with a large percentage of aluminum have a very high shrinkage. The most frequently used die castings are the zinc base metals, which have a melting point of about 850 degrees F. These are not the best die casting metals but they contain only a small amount of tin and are comparatively cheap. The zinc base metals are often affected by heat and cold and sometimes deteriorate with age. The lead base metals melt at approximately 550 degrees F. and are generally used for castings subject to little wear and where no great strength is required. Alloys containing aluminum in high percentage deteriorate the surface of the moulds and the steel in the die seems to flake off. They are used but to a limited extent. Alloys of zinc and aluminum in certain percentages make fair die castings, but the percentage of aluminum must not be very high as it causes the alloy to disintegrate into a granular mass inside of a year. Zinc and tin mixtures also show an inclination to disintegrate and some other metal is, therefore, alloyed with them to act as a binder. Zinc and tin alloys containing a small percentage of copper have good wearing qualities and can be easily plated and japaned. Tin alloys with lead and zinc cast freely and can be made to fill small details of the mould.

Aluminum, in small percentages, is used in many of the die castings. It acts as a purifier of the alloy and causes it to flow more freely in the mould. To cast pure aluminum in die moulds or aluminum alloys with small percentage of zinc, or copper, or both, is very difficult. These allovs cannot be cast at all in very thin section or with very fine detail in figured work, such as is produced in art castings. The lighter aluminum magnesium alloys have also been experimented with but these experiments have not met with much success as yet.

Much time and money has been spent by the different die casting firms to die cast manganese bronze but this has been a failure owing to the zinc oxide which forms on the surface when the alloy strikes the cold metal from which the die mould is made. It is very doubtful if this feature can be overcome. One of the great difficulties encountered in casting metals of these comparatively high melting temperatures is the oxidation that the casting surface of the steel mould undergoes when the temperature is raised by the molten metal coming in contact therewith. This causes the mould to alter in size and shape and thus destroys the accuracy of the casting. As this is an expensive way to produce castings, it is only by making them accurate as regards size and shape, and thus saving all machine work, that this can be made a commercial success. When this is done, however, the saving effected is so great that the die-casting machine and its products have become a necessity in the manufacture of many parts of machines, instruments, etc., in the modern shop.

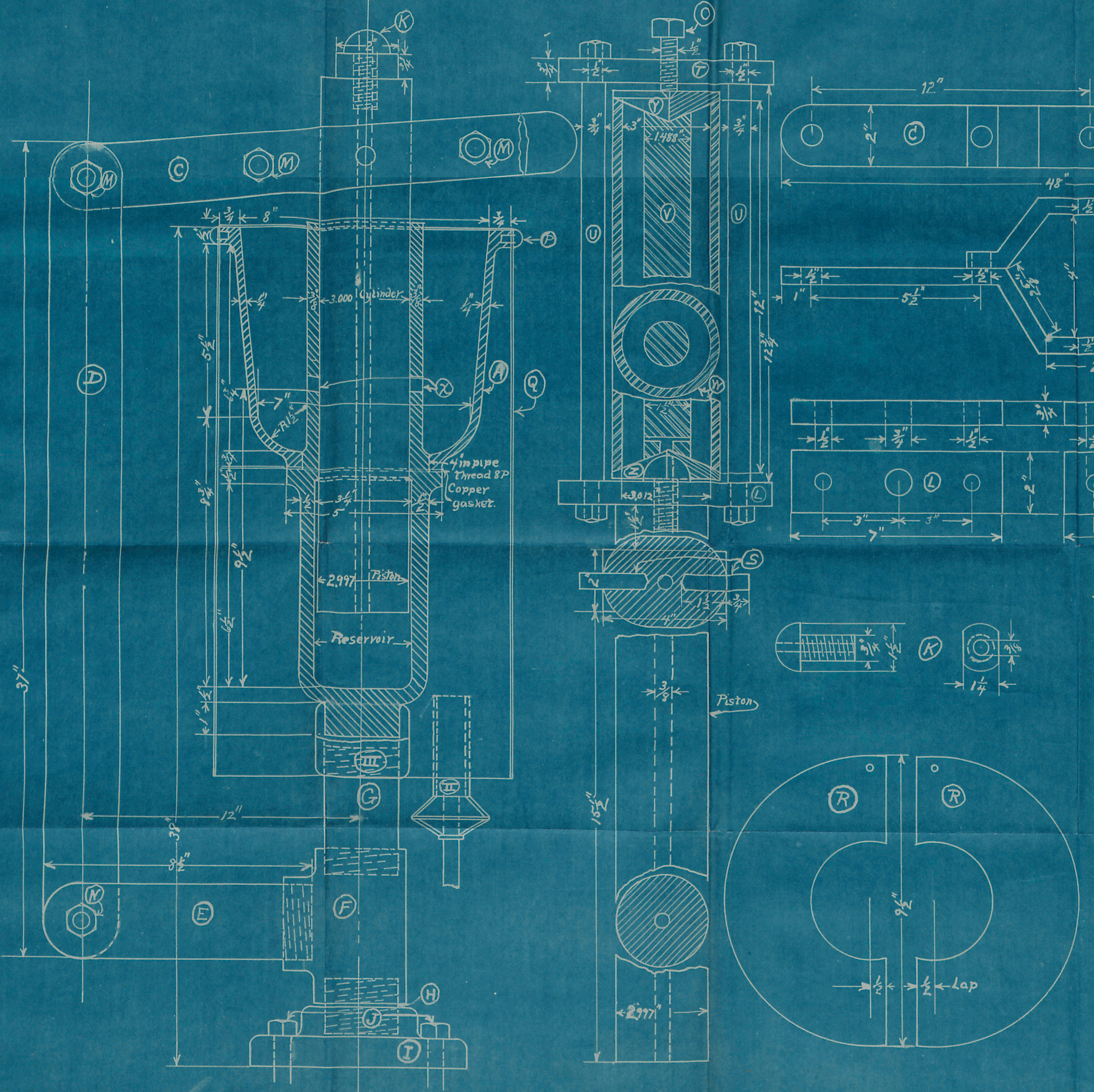
VIII
Machine Adapted to Different Moulds.

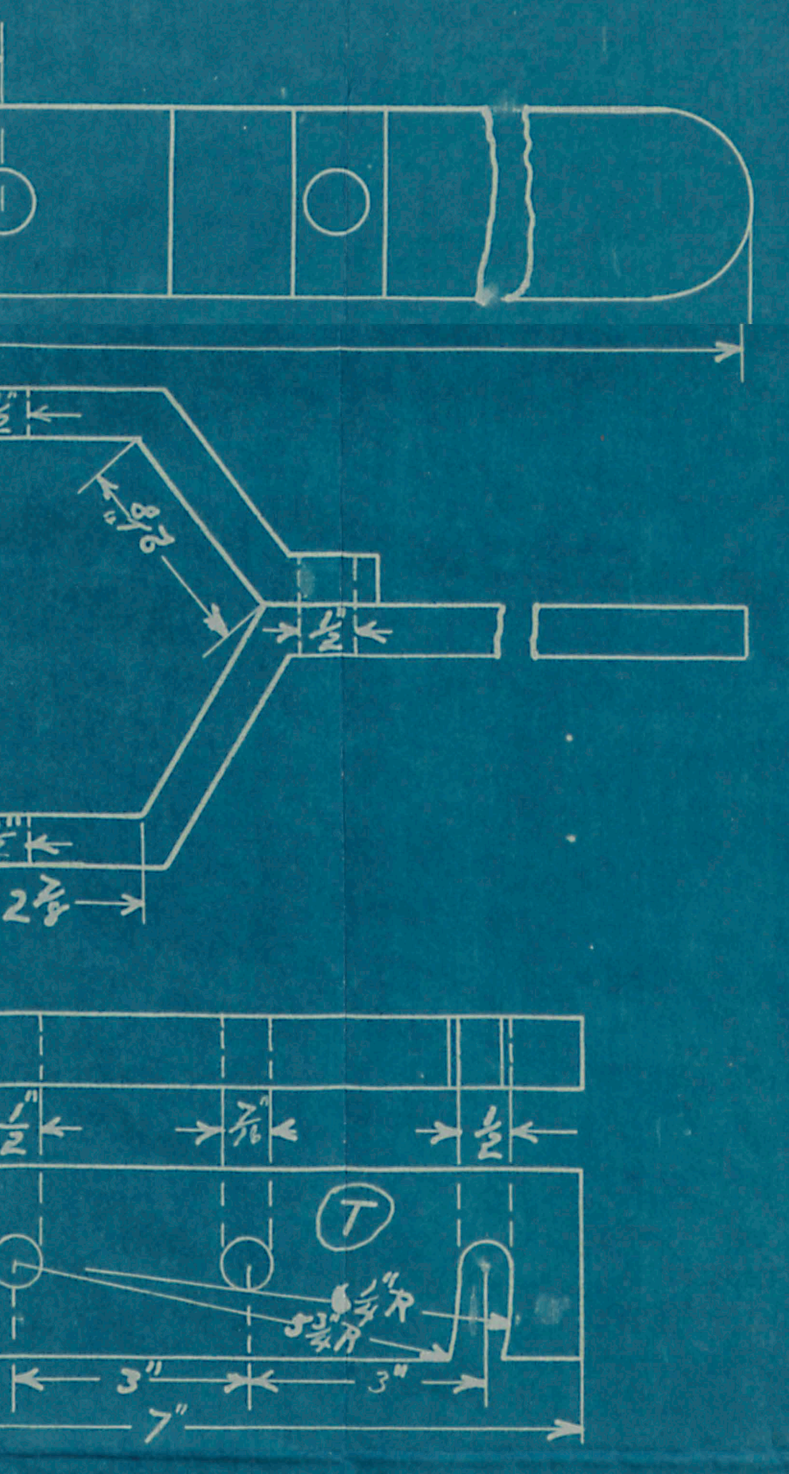
While this die-casting machine was built primarily for the purpose of making cored babbitt bars, still the machine and the moulds are really two separate parts. Other moulds can easily be substituted for the one that was used. At the present stage of manufacturing a great many things are made by die casting, in fact nearly every machine made has one or more parts made by die-casting. On the automobile, truck, and tractor, such things as bearings, water pump parts, magneto bases and parts, carburetor parts, steering and control parts, vacuum feed parts, and others are made by this method. Parts for graphophone, telephone, telegraph, radio, and other things too numerous to mention are made by die-casting.

There are numerous advantages in the use of die-castings, many of which are not fully appreciated until the castings are used for a given period and comparative data are available. In many cases they present manufacturing advantages peculiar to the job in hand, which is not possible to point out in a general summary.

The elimination of error by avoiding the "human variable" is accomplished in die-casting to a greater extent than in any other process. The die is virtually a gauge and the size of the casting is in no way dependent upon the will or discretion of the operator. Consequently die-castings are interchangeable, which offers well understood advantages in manufacture and assembly and in making replacements for worn and broken parts. A die-casting, unlike a sand casting, has a perfect finish over its entire surface which is smooth and clean cut. Almost any shape may be cast, frequently permitting a certain beauty or grace in outline which would be impractical or prohibitive if cast by other manufacturing methods. Many devices are now designed so that they may be made of die-castings, in whole or in part, and could not be commercially produced by any other method.

Die-castings as a general rule cannot be made faster than plain punchings or simple screw-machine parts, but they are less subject to delays in production caused by lack of sheet metal of suitable kind or the needed sizes or shapes of rods or bars used on the screw machines. But die-castings can always be produced much faster than similar parts can be sand cast and machined. As a rule less labor is required to produce a die-casting than any other process would require for the same part. Consequently production is quicker and surer because the die is virtually a positive automatic machine not subject to the errors of machine work.





Die-Casting Machine.

by E.J. Mayer

List of material.

Sym.	Name of parts,	material,	no. of pieces
II	Burner		3
III	2" pipe coupling	WI	1
A	Round metal melting pot	Cast iron	1
B	Cylinder & Reservoir	C I	1
C	Operating lever	WI	1
D	2" Pipe connecting link	WI	1
E	2" Pipe	WI	1
F	2" Tee	WI	1
G	2" Pipe	WI	1
H	2" Close Nipple	WI	1
I	2" Floor flange	CI	1
J	½" Lag screws 2½" long	WI	4
K	Piston nozzle	CRS	1
L	Surface plate	CRS	1
M	½ x 1½ Bolts	CRS	3
N	½ x 3 Bolt	CRS	1
O	½ x 2½ Hold down cap screw	CRS	1
P	10-32 x ½" Screws	CRS	12
Q	Sheet iron inclosure	WI	1
R	Sheet iron cover	WI	2
S	½ x 2¼" Pins	Drill rod	2
T	Mould Head plate	CRS	1
U	Mould frame spacing rods	CRS	2
V	Mould core	CRS	1
W	Mould shell	CRS	1
X	½" Drilled port holes		2
Y	Mould top end	CI	1
Z	Mould bottom, to fit K	CI	1