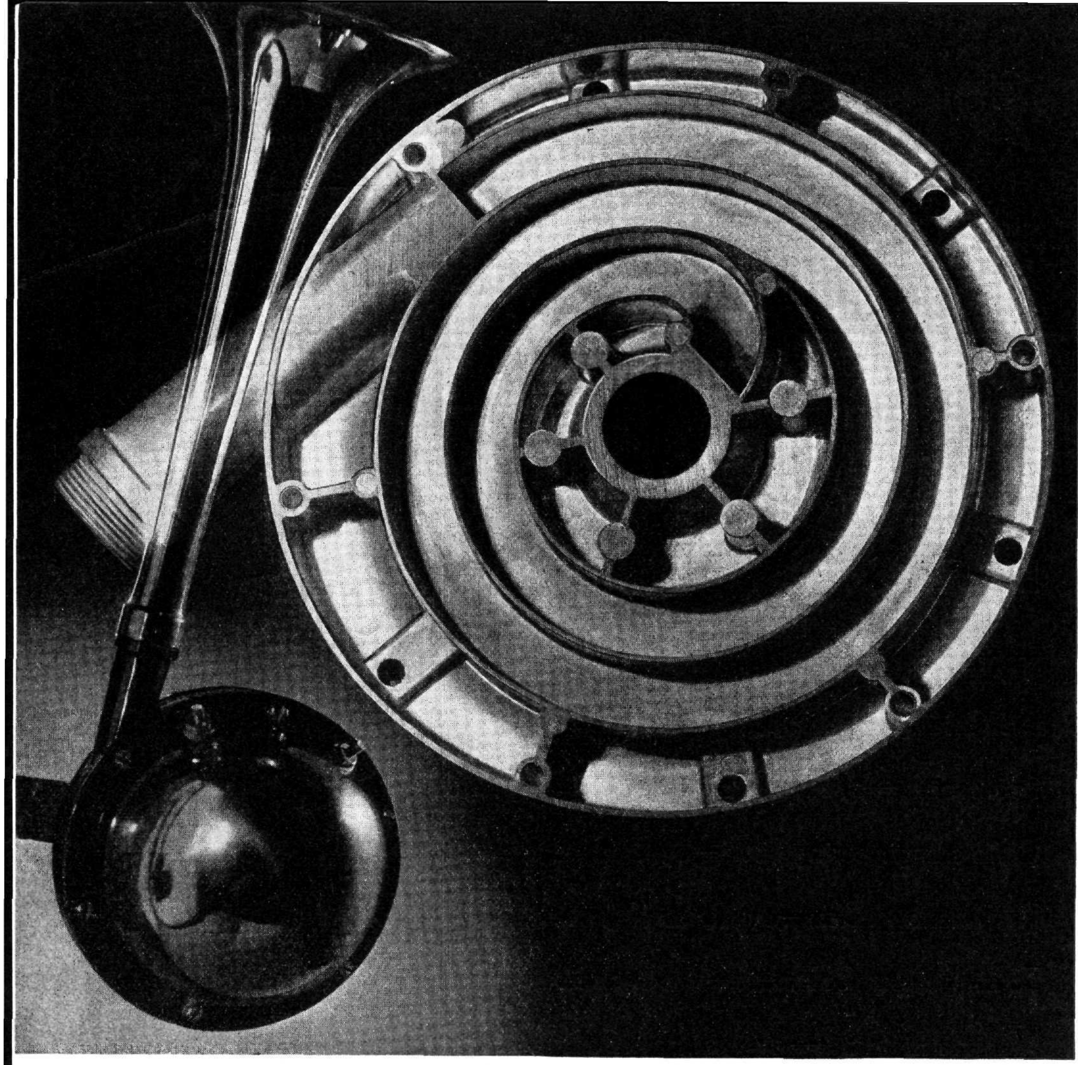


(All Cuts Courtesy of The New Jersey Zinc Co.)

AUTOMOBILE AIR HORN . . . DIE CAST

Automobiles—Machine Parts—Small Tools—Office and Store Equipment—Household Appliances—Clocks and Novelties—Locks and Hardware—Toys—All Make Use of Zinc Alloy Die Castings.

DIE CASTING

By ROBERT J. GILCHRIST, '38

History

THE die casting industry has grown up through an evolutionary process. The casting of metals began with sand molds, then the adoption of permanent metal molds, and finally, the application of pressure to the metal as it flowed into the mold gave rise to the die casting industry.

The first machine to use the die casting principle was invented in 1838. This machine was used in casting type. The first patent on a die casting machine was granted in 1849. However, it was not until 1910 that the first commercial machine was offered on the open market and used in the production of a number of articles.

And so it can be seen that the die casting industry is still in its infancy, the commercial process being in use less than 30 years.

Alloys

Many and varied alloys have been used in die castings. At first, low melting metals such as tin and lead were used. Today, alloys consisting of zinc, tin, lead, magnesium, aluminum, copper, and even iron as a base, are being cast.

Several important points have to be kept in mind in choosing a metal for die casting. The metal should have a low melting point to lengthen the life of the dies, its shrinkage should be low to take the details of the die accurately, and its viscosity at casting temperature is important.

Today, the most widely used metals in die casting are the zinc alloys. Three-fourths of the castings produced are made from them. The advantages of the zinc alloys over the others are numerous. Its low melting point of 718 deg. F. gives a long life to unhardened steel dies. The physical properties of these alloys make them suitable for most applications. The castings have fair corrosion resisting qualities and may be treated easily and economically to give much higher qualities along this line. The cost of the metals that are used to make up the alloys are low enough to allow them to compete successfully against other methods of producing the same article. With a comparatively low and uniform shrinkage, castings can be made with close dimensional limits and sharp detail of relief. The standard limits used in practice are ± 0.001 of an inch per inch of length or fraction thereof and ± 0.003 of an inch across the parting line of the casting.

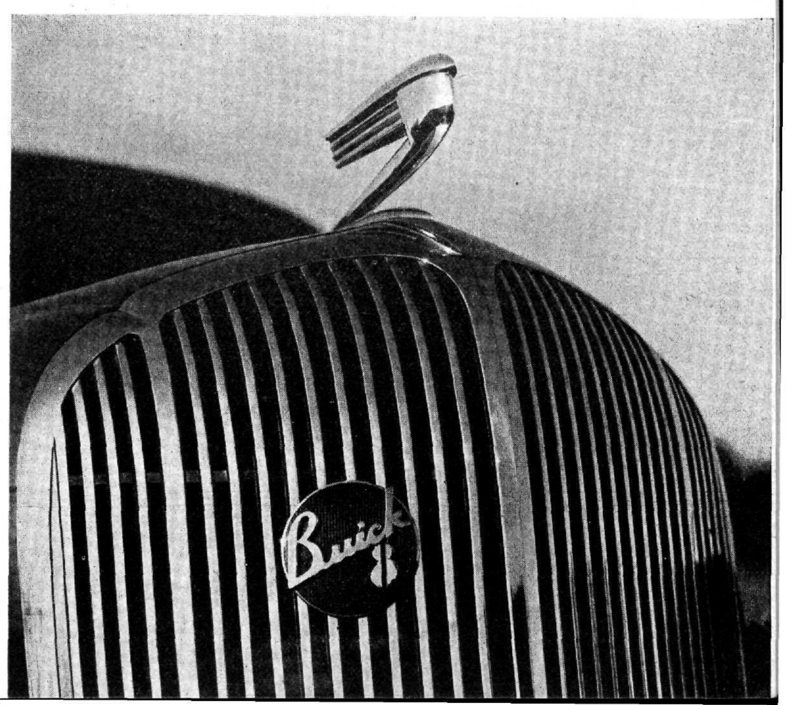
Perhaps the one company to do the most toward the development of a suitable zinc alloy is The New Jersey Zinc Company. This company has placed three alloys upon the market that are in general use today. They appear under the registered trade name of "Zamak." The chemical composition and "as cast" properties of these alloys are:[1]

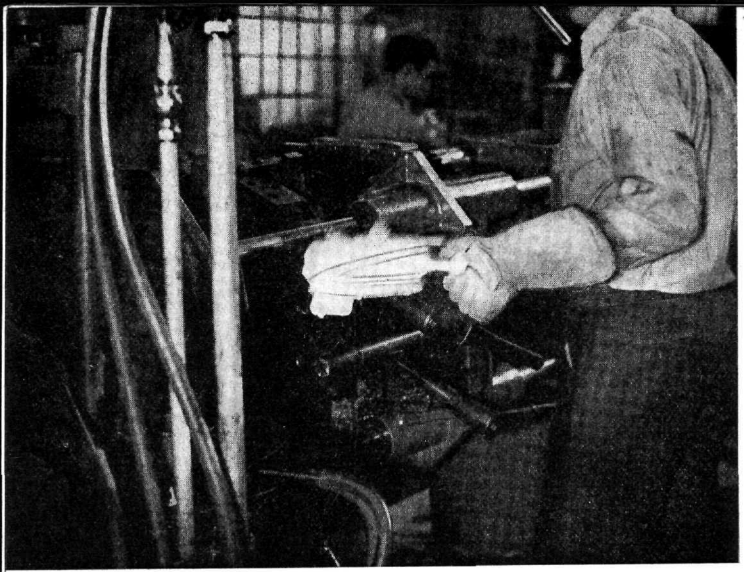
		#2	#3	#5
Aluminum	%	3.9 to 4.3	3.9 to 4.3	3.9 to 4.3
Copper	%	2.5 to 2.9	0.03 max	0.75 to 1.25
Magnesium	%	0.02 to 0.05	0.03 to 0.06	0.02 to 0.05
Iron	%	0.075 max	0.075 max	0.075 max
Lead	%	0.003 max	0.003 max	0.003 max
Cadmium	%	0.003 max	0.003 max	0.003 max
Tin	%	0.001 max	0.001 max	0.001 max
Zinc	%	remainder	remainder	remainder
Tensile strength— #/sq. in.		45,700-52,800	36,600-44,600	43,100-47,900
Modulus of rupture— #/sq. in.		116,000	94,700	105,200
Compressive strength — #/sq. in.		93,100	60,500	87,300
Shearing strength— #/sq. in.		45,800	30,900	38,400
Brinell hardness		75-96	59-89	68-86
Charpy impact strength— ft.-lbs. on ¼ in.		16-23	14-35	15-20

While all of the three alloys have the same general characteristics, each has been formulated to emphasize one particular property or combination of properties. Number two alloy excels in hardness and tensile strength. Number three is outstanding for its retention of impact strength and dimensions. Zamak 2 and 5 give excellent resistance to corrosion. Zamak 5 is a combination of 2 and 3 with regards to strength and retention of dimensions.

[1] *Zamak Alloys for Zinc Alloy Die Casting*, The New Jersey Zinc Company, September, 1935, pp. 7-10 .

RADIATOR GRILL AND ORNAMENT





CASTING

Casting Machines

The essential functions of a casting machine are to close the die, force the molten metal into the die cavity, and then open the die so that the solid casting can be removed.

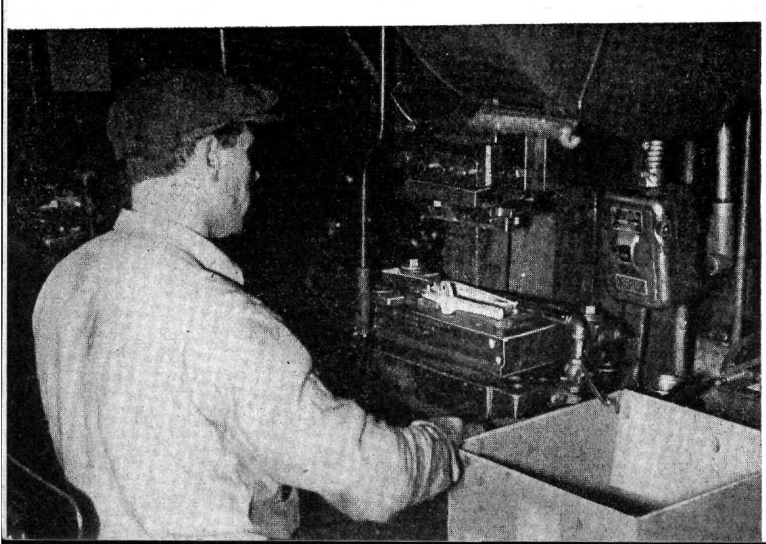
Die casting machines may be divided into two groups: the air and the plunger types, depending upon the manner in which the metal is forced into the die.

The air or low pressure type has its supply of molten metal in an airtight container. When the "shot" is made, compressed air is forced in on top of the metal and forces it into the die. The maximum metal pressure in this type of machine is the same as the air pressure. When the "shot" is completed, the air is released and the excess molten metal runs back into the melting pot by gravity. It is necessary to use the air type machine on certain alloys where the heat or chemical action prohibits the use of a plunger type.

The plunger or high pressure type machine takes its charge of metal into a cylinder and when the "shot" is made, a plunger in the cylinder forces the metal into the die; and on its return stroke pulls the excess molten metal back into the cylinder. This type of machine is capable of producing high metal pressures because a comparatively small force on the plunger operating in a small cylinder will build up considerable pressure. Metal pressures ranging up to 1500 lb. per sq. in. are in use today.

The methods of actuating the plunger in that type machines varies greatly. Some very small machines have a padded knob on the end of the plunger which the operator strikes with his hand to exert the necessary force to make the "shot." Other slightly larger machines have compressed springs or weights which are released to make the "shot." Still others use oil pressure on a piston that is directly connected to the plunger. The most successful method, however, seems to be the use of a large air cylinder whose piston is directly connected to the metal plunger. This type can use comparatively low pressure air and still obtain high metal pressure by having the diameter of the air cylinder many times larger than the metal cylinder. The use of air gives a certain amount of flexibility to the "shot" which the operator can vary to suit the type of casting. Usually, it is best to flow the metal into the die slowly at low pressure until the cavity is practically full, then release the maximum pressure to "pack" the metal.

TRIMMING



Dies

The dies or molds used in die casting work are made in essentially two parts, the stationary or cover half and the movable or ejector half.

The cover half of the die is mounted solidly on the machine and receives the metal from the injection mechanism. The ejector half is mounted on the movable portion of the machine and contains the casting when the machine is opened. This half also contains the ejector mechanism for removing the casting from the die.

The parting line or line of joining of the two halves of the die should be made to contain the largest periphery of the casting cavity or impression. The impression should become progressively smaller as its depth increases either way from the parting line so that the solid casting can be removed from both halves of the die. At times, it is impossible to design a die that will meet these requirements, in which case overhanging portions of the die are produced. Such conditions are known as undercuts.

All undercuts must be removed from the die before the casting can be removed. This can be accomplished by making the overhanging section of the die movable, in the form of a slide, so that it may be pulled back to cleat the casting before the ejection is made.

Any holes in the casting parallel to the axis of motion of the die can be produced by suitable cores set solidly in one half of the die. To produce holes at any other angle, the cores must be made movable so that they can be pulled into the clear before the casting is ejected.

At times it is necessary to use loose pieces in a die to produce the desired cavities in the casting. These pieces are parts of the die that are ejected with the casting to be removed in a subsequent operation and used over again in the die. This method will accomplish the purpose, but it slows down production and limits the accuracy of that section of the casting.

When the impression of the die is designed, allowance for shrinkage of the cast metal must be made. The normal shrinkage on zinc alloy die castings is about 0.5 per cent. Draft or taper must also be allowed on all walls and cores so that the casting can be ejected freely. To aid this, all portions of the die should be finished, if possible, by filing and polishing with strokes parallel to the axis of motion of the die.

The impression should be polished as smoothly as possible because the casting cannot have a better finish than the die that produces it; also, the casting metal must not have any minute crevices to hang to and build up in the form of solder as the die is run.

The control of the flow of the metal from the time it enters the die until it fills the cavity is known as gating. Gating is a science in itself and is best learned from practical experience. Most dies are built so that the metal enters through the cover half of the die. A water-cooled post, in the ejector half, known as a sprue post, extends well up into the opening in the cover half to split the flow of metal and direct it parallel to the parting line. The sprue post also helps to control the boundary between the metal that solidifies and that which is drawn back into the cylinder. The metal then flows through channels, usually cut in the ejector half, to the impression itself. Where the metal enters the impression, the gate is made very thin to facilitate the breaking of the casting from the solid gate metal and also reduce to a minimum the operation of removing any marks on the casting left by the gate.

It is necessary to provide some means of removing the air from the impression as the metal is forced into the die. This is accomplished by the use of vents and overflows. Vents are any seams or openings in the die that will let air but not the metal escape. The term "vent" is usually applied to very thin channels ground in the face of the die leading from the impression directly to the die's edge. Overflows are small pockets milled in the die's surface just beyond the impression and connected with it by a thin channel. The overflows act like a dashpot for the air and metal.

Ejection of the solid casting is usually accomplished by the use of ejector pins whose ends are normally flush with the surface of the impression. After the casting has solidified and the die is open, these pins advance, pushing the casting ahead of them.

Most dies require cooling to speed up production. Cooling is usually accomplished by passing water lines through the die blocks themselves. The proper placing and use of water lines can make or break the production of a die or the quality of the casting it produces.

The Casting Cycle

The molten metal is supplied to the machine's furnace which contains enough metal for about one hour of continuous operation, although the supply is replenished much more often than that. The temperature of the metal in the machine's furnace is held very accurately at the temperature best suited for the particular job at hand. The machine operator closes the die, makes sure that all cores, slides, and safety devices are in place, and then makes the "shot." The metal plunger is forced down upon the charge of metal in the cylinder. The metal is forced into the sprue hole, past the sprue post, through the gate and

DRILLING

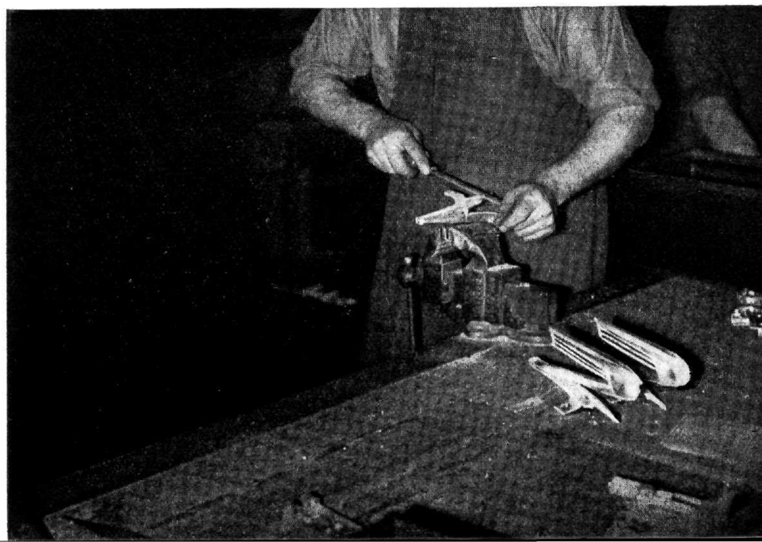
into the impression, forcing the air out ahead of it. The plunger then returns to its original position, pulling the surplus molten metal back into the cylinder. At the top of its stroke, the plunger uncovers a port which allows metal from the metal pot in the machine's furnace to refill the cylinder. After sufficient time has passed for the casting to set, the operator pulls any core or slides in the cover die, opens the die, manually pulls any cores or slides that are not automatically operated in the ejector die and then ejects the casting which is still attached to the solid gate metal and surrounded by flash. Flash is the thin sections of metal that forces its way into any and every jount or seam in the impression. The gate metal and flash must be removed in subsequent operations.

The actual casting cycle is much faster than the above description would lead one to believe. The speed is entirely dependent upon the type and size of casting being produced. Some small castings that require little work on the part of the operator and cool quickly will run as high as five hundred cycles per hour normally. Other large jobs containing heavy sections of metal, requiring inserts, and many manual pulls may run only thirty-five cycles per hour.

Casting Design

It can be seen from the discussion on dies that undercuts are not desirable. Although it is possible to cast them, they make necessary the use of slides and slide actu-

FILING



ating mechanisms which not only boost the die price, but also increase the labor cost necessary to remove the additional flash left on the casting by the slides.

Although it is possible to produce die castings of extreme accuracy, it is well, in the interests of economy, to make the limits on the finished casting as wide as possible. Generally, the die cost and casting price is approximately proportional to the accuracy required. The die cost is greatly reduced, also, if all lettering and engraving on the casting is raised.

If the wall stock or sections of the casting are kept as uniform as possible, small fillets placed in all corners, and large, heavy sections avoided entirely, much better castings can be produced.

(Much thanks and credit are given to Chas. A. Schultz of The Schultz Die Casting Co., Toledo, Ohio, for his aid in obtaining information used in the above discussion.)