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METHOD OF DIE CASTING

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2 Sheets-Sheet 1

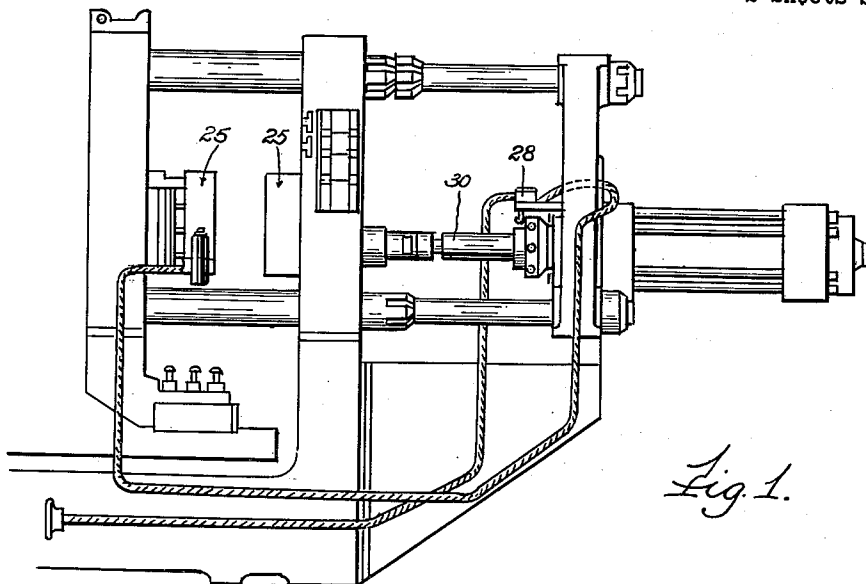


Fig. 1.

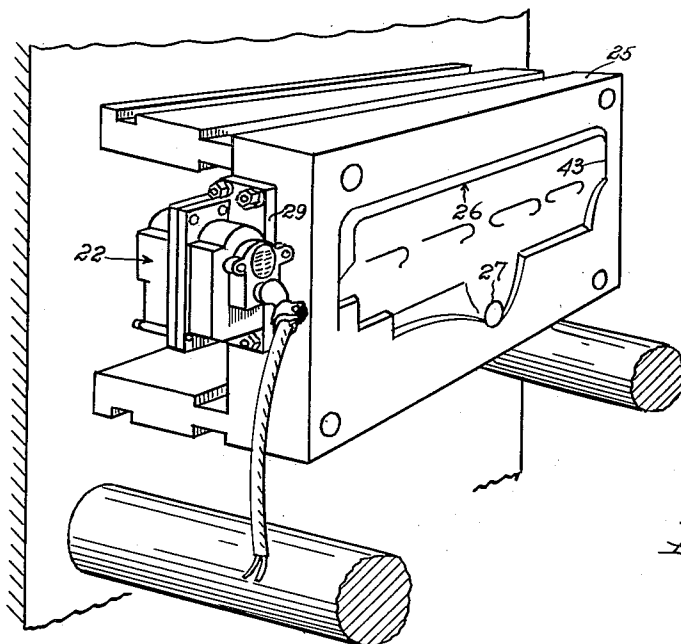


Fig. 2.

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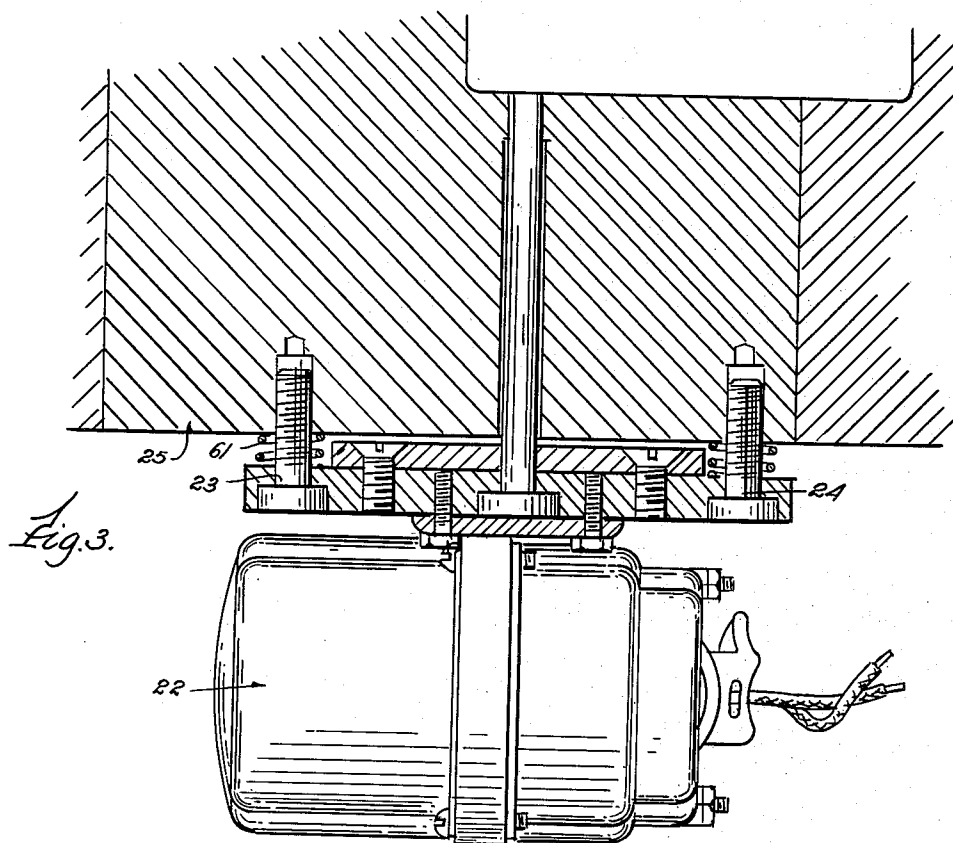
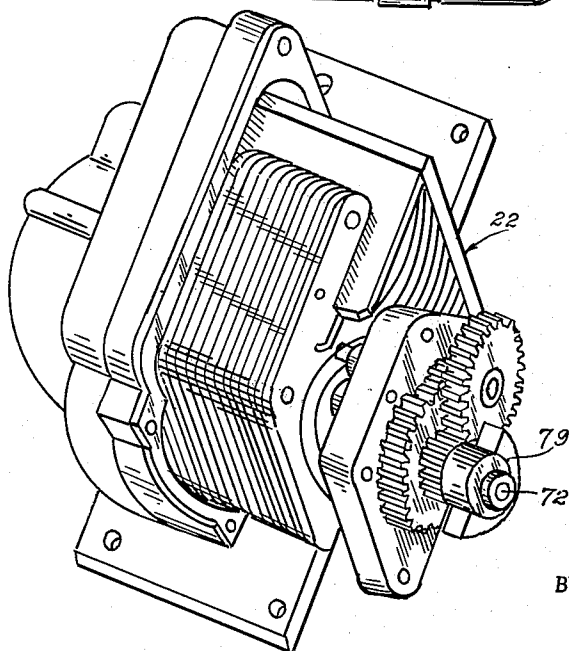
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2 Sheets-Sheet 2



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METHODS OF DIE CASTING

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1 Claim. (Cl. 22-216)

The present invention relates to methods of die casting, and is particularly concerned with die casting processes for non-ferrous alloys in which the metal in the die casting mold is subjected to mechanical vibration of a sonic frequency during the time the molten die cast metal is being injected into a closed die under pressure and while the casting is solidifying.

The apparatus for carrying out the present method is the subject of one or more separate applications; but as the elements of the apparatus may include conventional machine elements, the present application relates solely to the method.

One of the objects of the invention is the provision of an improved method of making die castings which results in improved physical characteristics of the die castings, such as a marked increase in tensile strength and in the yield strength of the castings.

Another object of the invention is the provision of improved methods which result in the substantial elimination of gas porosity in the metal castings and in an increase of ductility.

Another object of the invention is the provision of improved methods which bring about a substantial reduction of the grain size and a reduction in the size of dendrites in the castings, which also gives the metal better polishing characteristics.

Another object of the invention is to effect a substantial elimination of micro-shrinkage and an increase in density of from 6% to 8% in the metal of the castings.

Another object is the beneficial alteration in the formation of dendritic openings in the solid solution matrix.

Another object of the invention is to effect a reduction in the number of reject castings and to effect a saving in time and labor by speeding the cycling time of the die cast machine.

Another object of the invention is the simplification of the methods of making die castings by reduction to a minimum the complexity of such processes and the accomplishment of the foregoing results with the most simple and economical and effective apparatus.

Other objects and advantages of the invention will be apparent from the following description and the accompanying drawings, in which similar characters of reference indicate similar parts, throughout the several views.

Referring to the drawings, of which there are two sheets, FIG. 1 is a fragmentary side elevational view of a die casting machine, embodying the invention;

FIG. 2 is a fragmentary view in perspective, showing the ejector half of the die with the cover removed;

FIG. 3 is a fragmentary sectional view showing the ejector half of the die with its cavity, and the mode of attachment of the vibrator, taken on a horizontal plane above the vibrator attaching bolts;

FIG. 4 is a perspective view of the vibrator mechanism. The methods of the present invention contemplate the

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use of conventional die casting machines, which includes the use of cold chamber machines and hot chamber or "gooseneck" machines.

Various types of vibrators for inducing sonic vibrations in the die cast metal inside the die cast mold during the injection and solidification cycle may be employed, such as electrical vibrators, pneumatically driven vibrators, hydraulically driven vibrators or mechanical vibrators, which are preferably driven by means of an electric motor.

Such mechanical vibrators of the electric motor type are provided with a drive shaft preferably having reducing gearing transmitting rotation from the motor shaft to a driven shaft which carries an off center or eccentric metal mass, which is driven at such a speed that the range of vibrations is in the sonic range, that is, within the audible range of 11 to 20 kilocycles per second.

The electrically induced mechanical vibrations may be transmitted to the die cast mold 25, which is preferably of the metal permanent mold type, by having the vibrator 22 fixedly attached to the mold; but the vibrator is preferably slidably mounted on guides 23, 24, such as bolts, which are fixedly secured to the mold 25; and the vibrator is preferably spring pressed to a position spaced from the mold by springs 61 on said bolts, so that the vibrator assembly impacts against the mold at the sonic frequency, thereby employing the entire mass of the vibrator assembly for inducing vibrations in the mold and the metal.

By impacting the vibrator assembly against the mold once for each rotation of the eccentric weight 79 and shaft 72, the same frequency is attained in the vibration as the rate of rotation of the off center shaft; and the vibrator 22 is moved in one direction by the spring and in the opposite direction by the eccentric weight on the shaft, which also tends to move the vibrator in the other direction with the spring.

The vibrator and the vibrations are preferably applied to the die cast mold and to the metal therein at a point adjacent the initial freeze point 26 of the metal in the mold; and this is usually opposite the point 27 at which the metal is injected into the mold, since the cooling of the metal starts by its engagement with the cooler wall of the mold; and the metal is reflected from that point into the other parts of the mold, where it spreads and fills the mold, while simultaneously the growth of a dendrite structure takes place in the casting.

Dendrites are the tree-like crystalline growths which occur in the casting and which are initiated as the metal engages the chill wall of the mold cavity 43. The dendrites grow and interlace into minute pockets containing high solute or unaltered liquid metal; and as the chilling progresses, the high solute and unaltered liquid metal freezes and shrinks.

The sonic vibration of the mold and metal at this time increases the formation of the interlocking dendrites and reduces the size of the dendritic structure, causing formation of dendritic structure throughout the entire mold, thereby reducing the sub-microscopic voids and gas inclusions, and reducing the place where hot tears may occur between the dendrite arms.

By using the present method a better die fill is accomplished and a quicker freezing rate it promoted, resulting in a faster operating cycle and a fine porous-free casting

with an exceptional surface condition. The dendrite structure is refined and the grain structure improved; and the density is increased in the metal by elimination of gas porosity.

The vibration according to the present method results in the expulsion of bubbles which tend to form at the inner surface of the mold, where the waves have their nodes; and the gas expelled has a high percentage of air.

The degassifying action is increased at lower frequencies; and my method includes the provision of vents for permitting the escape of the entrapped gas at the node points; and therefore the mold preferably has bleeders extending from the node points to the perimeter of the die, such as, for example, vents in the form of grooves $\frac{1}{4}$ " wide by .003" deep.

In order to ascertain where the bleeders should be located, the location of the nodes may be determined after a trial casting; and this may be ascertained by using X-ray or by sectioning the casting and observing the bubble lines.

The vibration is applied during the injection and solidification cycle; and when an electrically driven vibrator 22 is employed, the vibration may be turned on by a limit switch 28 located on the plunger 30 in a cold chamber machine or a limit switch connected in the same circuit as the shot switch for a hot chamber machine when that is employed.

Another limit switch in each case may be employed for turning off the vibration on the return stroke of the piston of the die cast machine. A timing device may also be employed and connected into the wiring of the shot system of the die cast machine for turning on the vibration at the same time the injection takes place and for turning it off after solidification has occurred.

The vibrations employed must be of a definite sonic frequency, within the limits specified; and the frequency is set forth herein in cycles per second, specified in column 2 as "c.p.s." and the vibrations should be of a type to induce a pure wave in the mold and metal; that is, a wave which, when seen on the oscilloscope, presents a smooth, symmetrical curve in both directions, without ragged variations.

The vibrator should be tuned within its component parts and in its connection to the mold, so that other vibrations than the pure sonic vibrations are not created or transmitted.

The frequency of the vibrations applied varies with the specific gravity or density of the metal; and the higher the specific gravity the higher the frequency, and the lower the specific gravity the lower the frequency which should be applied.

For example, the frequency preferably employed for various non-ferrous metals and for certain alloys is as follows:

Metal	Frequencies	Specific Gravity	Weight in Lbs. per Cubic Inch
Aluminum 380-----	100-160 c.p.s. +10 c.p.s.---	2.76	.099
Aluminum 43-----	110-166 c.p.s. +10 c.p.s.---	2.69	.097
Aluminum 13-----	130-178 c.p.s. +10 c.p.s.---	2.66	.096
Zinc #3 (zamak)-----	200-450 c.p.s. +10 c.p.s.---	6.6	.24
Zinc #5-----	200-460 c.p.s. +10 c.p.s.---	6.7	.25
Copper (85-5-5)-----	250-500 c.p.s.-----	8.7	.314
Magnesium (AM11)-----	80-100 c.p.s.-----	1.705	.062

The present method results in a lesser number of reject castings. For example, on one case the number of rejects in which the present method was used amounted to only 2%, while the same zinc part with a number of iron inserts die cast in the conventional manner resulted in 85% rejects.

The present method results in a definite increase in the

number of shots per hour due to the accelerated set-up or freezing time of the metal.

Closer dimensional tolerance can be held and surface hardness and resistance to elongation is increased by the present method. The dwell time may be decreased from 20% to 25%; and the pressures employed may be lowered to a point where the metal enters the die as a stream rather than a spray. The life of the dies may be increased greatly.

The tensile strength of the metal in the resulting castings may be increased greatly, such as, for example, in aluminum alloy No. 380 the tensile strength is increased from 43,000 p.s.i. to 68,000-72,000 p.s.i.

In the same alloy the yield strength was increased from 23,000 p.s.i. to 48,000-51,000 p.s.i. The elongation was decreased from 1.0% to .05%. Density was increased by approximately 4.5%.

The present method of die casting results in marked improvement in the castings and a saving of time and labor; and the results accomplished may be summarized as follows:

- (1) Degassification of metal while metal changes from liquid to solid state;
- (2) Elimination of micro shrinkage;
- (3) Reduction of grain size;
- (4) Altering the formation of dendrite openings in the solid solution matrix;
- (5) Reduction of size of dendrites;
- (6) Increase in density by 6% to 8%;
- (7) Decreased cycle time.

These results produce the following changes in physical characteristics of the castings and operations involved:

- (I) Marked increase in tensile strength;
- (II) Elimination of gas porosity in metal;
- (III) Increase in ductility;
- (IV) Speeds the cycling time of die cast machine;
- (V) Give metal better polishing characteristics;
- (VI) Reduces rejects.

While I have described a preferred embodiment of my invention, many modifications may be made without departing from the spirit of the invention, and I do not wish to be limited to the precise details set forth, but desire to avail myself of all changes within the scope of the appended claim.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent of the United States, is:

The method of die casting metal parts of nonferrous metal in a closed metal die body, provided with an injection plunger arranged to direct molten metal into the mold cavity of a metal die through the gate, the die body movably supporting an electric motor body having a shaft provided with an eccentric weight, said motor body being spaced from the die body by a spring, comprising, energizing the motor to rotate the shaft and eccentric weight, the eccentric weight causing the motor body to vibrate toward and away from the mold body, impacting the mold body, and driving the motor at a predetermined speed to cause the vibrations within the audible sonic range, the frequency of the vibrations being selected in accordance with the particular metal being cast, as determined by the table of metals set forth in column 3 of the specification, setting forth the metals, and the corresponding frequency for each metal in cycles per second, and the corresponding specific gravity of each metal and the weight in pounds per cubic inch of each metal, injecting the molten metal under pressure through the gate while the mold is vibrating, under impact of the motor body, inducing vibration in the metal inside the mold under pressure, projecting the metal against the cool wall of the metal mold cavity to initiate freezing action while reflecting the molten metal from the initial freeze point in the cavity into other parts of the mold cavity, which is then filled, transmitting the vibration

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impacts directly to the metal inside the mold cavity, the vibration expediting the growth of dendrite structure, forming interlocking dendrites, reducing grain size, reducing voids and gas inclusions and increasing density and tensile strength, increasing ductility and surface finish, reducing the number of rejects, continuing the vibration through the injection and solidification of the metal in the cavity, stopping the vibration after solidification, opening the mold, and removing the casting.

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