

UNITED STATES PATENT OFFICE

2,085,302

METAL FOUNDED

Marvin W. Dundore, Beloit, Wis., assignor to
Beloit Iron Works, Beloit, Wis., a corporation
of Wisconsin

No Drawing. Application January 28, 1929,
Serial No. 335,750

6 Claims. (Cl. 22—188)

This invention relates to metal founding and has more particular reference to the manufacture of sand cores and molds.

The present day commercial practice of casting ferrous and non-ferrous metals using sand molds and cores, is, and has been, handicapped by the varied and costly processes and operations required in freeing the castings of their cores and these difficulties are increased by reason of the many sizes and intricate shapes of the designs as well as by the varying requirements of workmanship in the finished casting. It is desirable to obtain cleaner and more accurate cast surfaces and shapes and to reduce the cleaning labor as much as possible. However, the attainment of these objects with cores of the prior art is beset with difficulties resulting from broken cores in handling after baking, cracked castings due to baked cores not contracting sufficiently as the metal contracts when cooling, core blows due to low permeability of the cores, crushed cores due to over-baking, dirty castings due to the surface skin of the core being washed to the surface of the casting, and distorted and strained castings due to the cores yielding slightly and temporary arresting shrinkage. The faults of core binders now commonly used require close supervision on the part of the management and the laboratory, in order to minimize their effects upon the resultant product, the casting. There are, however, many other facts incidental to sand cores as now used and to their physical characteristics which are objectionable. For example, it is not infrequent that a casting, due to high shrinkage, cannot be prevented from cracking unless the cores are broken up as soon as the metal shows evidence of solidification. The uncovering of castings in order to partially or wholly remove the cores while the castings are still too hot to be handled is the cause of great discomfort as well as being attended with some little danger to the workmen who are subjected to flying hot sand and contact burns. Such premature removal of cores is also apt to be injurious to the castings be-

cause of accelerated cooling and consequent shrinkage cracks.

Another objection is that fusion of core sand takes place on the interior metal surfaces, which cannot be altogether removed by ordinary cleaning methods nor avoided by cautionary steps such as treating the surface of the cores with silica wash, graphite, or plumbago.

Consequently, fusion of sand to interior surfaces is apt to be harmful and apt to cause inextensible damage in cases where castings are used as conduits for steam and other liquids in machinery and systems of various cases.

Fusion of the molding sand also takes place at the interface between the mold and the metal and results in a rough outer surface and burned in portions of fused sand, which present an unsightly appearance and often materially interfere with the use of the casting unless removed. Considerable time and labor is involved in the cleaning of the outer surfaces.

My improvements in metal founding contemplate means for obviating these many difficulties in a simple and convenient manner whereby almost perfect castings of any size or shape may be obtained without resorting to the many cumbersome proceedings of the prior art.

I have also aimed to provide a new and improved sand core having the desired refractory properties whereby fusion of the core sand and "burning in" is effectively prevented.

A still further object of the invention is the provision of a method of preparing sand cores whereby considerable time is saved in the making thereof.

Another object is the provision of easy and effective means for treating sand molds whereby fusion of the mold sand with the surface of the casting is obviated and the use of plumbago or graphite is obviated.

The invention also contemplates the provision of a sand core which will permit the metal to freely contract on solidification offering no appreciable resistance thereto thereby avoiding internal strains and stresses in the casting and

deformation thereof either during solidification or after the casting has been put into use.

Another object is to provide a new and improved binding material for sand cores composed of a heat-plastic rubber isomer and suitable solvents.

One phase of my invention includes broadly the thorough mixing of dry core sand with a solution of a thermo-plastic rubber isomer, such, for example as the so-called Vulcalock cement, the forming of cores therefrom according to standard foundry practice, and the heat treatment thereof to convert the soft thermo-plastic materials into hard, high melting products and produce a hard, tough, refractory core.

I have discovered that when the so-called thermo-plastic rubber isomers or rubber derivatives are used as binders for the sand in making cores and treating the surface of molds and subjected to various treatments remarkably improved castings may be obtained therefrom. While little is generally known as to the chemical characteristics or the properties of this class of materials, they are formed by the treatment of undissolved rubber with agents having the general formula $R-SO_2-X$ wherein R represents an organic radical or a hydroxy group and X represents a hydroxy group or chlorine, such reagents including sulfonic acid, organic sulfonic acids and organic sulfonyl chlorides or mixtures thereof. A mass of undissolved rubber is thoroughly masticated, for example, on an ordinary roller mill and the reagent is added directly to the rubber during working in the mill. When the reagent has been thoroughly dispersed throughout the rubber, the mixture is removed from the mill and heated. The product is then cooled and after removal from the oven is masticated on a warm mill to homogenize it and it may be washed free of remaining acid and other water soluble impurities during that process. Various other methods of reworking are also employed for homogenizing the product. Materials of various characteristics are obtained by varying the particular agent and the conditions of the process such as temperature, etc. Their preparation is described in some detail in U. S. Letters Patent Nos. 1,605,180 to Harry L. Fisher and 1,617,588 to William C. Geer, in the latter of which the materials are defined as "heat-plastic rubber isomers, a designation not wholly inapt for the reason that their main constituent has the same empirical formula as rubber and they possess a much higher degree of plasticity at moderately high temperatures than does rubber". The discoverers have given this class of materials the general name "thermoprene" using appropriate suffixes to indicate the various types. The only commercially obtainable material of this character so far as I am aware is the so-called "Vulcalock cement", having a base of the so called G. P. or gutta percha type, so called because of its resemblance to gutta percha. This material is formed through the use of pi-phenolsulfonic acid as a reagent.

In the preferred manner of practicing my invention I take a cement such as "Vulcalock" containing in the region of 18% of these heat-plastic rubber isomers and add thereto about an equal part by volume of gasoline or other cheap solvent with which the cement is miscible. I have found this proportion to be best suited for the purpose for practical reasons. More cement tends to make the resultant sand mixture too tacky and sticky while a lesser proportion produces a some-

what weaker core. I add this diluted cement in the ratio of about fifteen to one by volume to dry core sand of the kind ordinarily used in foundry operations. No particular care need be exercised in selecting the sand, one having the following analysis having been used with excellent results:

Chemical analysis of sand used.		Fineness	
SiO ₂	89.40	Mesh 20.....	0.2
Al ₂ O ₃	2.05	35.....	2.0
Fe ₂ O ₃	5.24	65.....	79.4
CaO.....	1.64	100.....	16.2
MgO.....	.28	150.....	1.2
K ₂ O.....	.59	200.....	.2
Na ₂ O.....	.46	270.....	.2
		Pan.....	Trace
Loss ignition.....			0.32
Moisture.....			Trace
Clay.....			None

While any suitable means may be employed in mixing the cement into the sand, I have found it convenient to place the dry sand in a mixer having rotating blades and gradually add the requisite amount of the cement solution, running the mixer until the liquid cement has been thoroughly and uniformly incorporated into the sand. Each grain of sand should, by this time, be completely coated with a thin film of the adhesive cement. When properly mixed the mass has a certain sticky quality but will rub off the hands readily and will not adhere to the core box unless the same is waxed, for the diluted cement has a tendency to stick to a waxed box unless it has been thoroughly covered with some other coating.

The core is rammed the same as any other core although in "slicking" and "striking off" the sand has a tendency to crawl. This may be prevented by keeping the tools moistened with a solvent such a gasoline.

The rammed core is placed upon a thin steel plate of sufficient strength and is then placed in a core oven and heated. It is not essential that a steel plate be used but I have found that the plate should be a ready conductor of heat in order to insure proper heat treatment of the bottom of the core. Cast iron plates, for example, were used in early experiments and found to be unsatisfactory because, perhaps, of their greater thickness and lower conductivity, the greater mass heating slowly as compared to thin steel sheets. The time of heating is dependent upon the temperature in the oven, the volume of sand in the core and the rate of evaporation of the solvent. While I have not determined with any degree of accuracy the exact range of temperature which will produce the desired result I have found that if the core is heated to 425 to 600 degrees Fahr., excellent results are obtained in all cases. The temperature may be carried considerably higher if desired without detrimental effect. The temperature acts to vaporize the solvent and convert the base of the cement into a rather hard brittle resin-like product which is highly resistant to heat and binds the particles of sand firmly together. The interior of the core is affected to a lesser degree than the outer portions and seems to retain to a great degree its plasticity and doubtless a portion of its solvent. The thickness of the outer hard film may be increased by increasing the time of heat treatment. It will be seen that as the core increases in size the thickness of the outer film required to produce a core of sufficient strength for satisfactory use in-

creases and the time required for heat treatment also increases, the time varying between a few minutes for relatively small cores and three to four hours for the largest cores. Large oil sand cores having a volume of 350 cubic inches of sand and requiring all night baking in a core oven, 425 degrees F., are prepared by my process in two hours, using the same oven and temperature.

Thus, by this method cores of all sizes, shapes, and forms may be produced in a relatively short period of time having a hardness equal to or greater than baked oil or cereal bonded cores in all respects and useable in either green or dry sand molds.

The heat treated cores will withstand hard handling and abuse to a greater extent than oil sand cores and may be dropped without affecting the structure or shape to any appreciable degree. They do not shatter as do heat treated cores and will not pulverize from handling in the core room.

Of great importance is the fact that the sand on the surface of the core does not fuse and "burn in" as is common in oil or cereal bonded cores. The molten metal does not seem to affect the surface of these cores in the same manner as oil or cereal bonded cores, and, while I do not know the reason for this difference, I am led to believe that it is due to the great difference in permeability of the two classes of cores as shown by the results of Standard A. F. A. tests, the excessive heat being conducted rapidly away from the core surface. Tests were run upon two simple oil sand cores which had been baked at 500° F., for one hour. The permeabilities were 17 and 20. Tests were also made upon four cores prepared according to my invention and heat treated at 475° F., for twenty minutes. The permeabilities were 102, 120, 99 and 128, running from five to six times greater than corresponding baked oil sand cores.

The fact that such "burning in" does not take place permits the casting of smooth internal surfaces which in most cases will require no further treatment.

Again little care is required in heat treating my processed cores since fairly wide variations in temperature do not materially affect the result. However, with oil or cereal bonded cores great care and considerable skill must be exercised in baking the cores to avoid overbaking and excessive temperatures and to produce a core of maximum strength.

The cores will not "wash" under the impact of entering metal or the flow thereof over its surface due to the refractory and tough layer upon the surface of the heat treated core. Here again it is probable that due to the high permeability the heat is conducted rapidly away from the surface of the core preventing excessive local overheating. I have also found that the binding material of the heat treated cores is capable of withstanding considerably higher temperatures than the oil or cereal bonded cores without disintegration, which render them less susceptible to "washing" with the metal.

Perhaps most important of all the thermo-plastic core does not obstruct the free contraction of the metal and is easily removed from the casting, for as the metal contracts the core is gradually pushed from the casting as loose free flowing sand. While I do not know what occurs in the mold, other than that the sand is progressively released from bondage, I have formed a theory as to the manner and reason of this occurrence which may or may not be true and I do not wish to restrict myself to the validity of the theory. I have found, however, that the core passes through a series of progressive changes. A core prepared as indicated above having a volume of 91 cubic inches was placed in a gas heated furnace heated to an initial temperature of 450° F., and the temperature therein progressively raised. The following table will show the consecutive changes through which the core passed:

Core condition	Time in minutes	Temperature, °F.
Core placed in oven	0	525
Core volatile ignited	3	610
Noticeable surface bond	4	550
Heavier encrustation, combustion gradually decreasing	10	
Decided crust $\frac{1}{8}$ " deep, combustion faded, interior core plastic or soft	13	550
Crust $\frac{3}{8}$ " deep	20	550
Started to raise temperature in order to quickly increase depth of crust	23½	575
Crust $\frac{1}{2}$ " deep	25	610
Core set very hard. Good for all practical purposes	35½	1025
Combustion of volatile resumed from interior core	36½	1080
Interior core soft	38½	1100
Spasmodic combustion volatile	41	1160
Core soft interior	42½	1180
Core still retaining full shape	45	1200
Very slight combustion	45½	
Depth of exterior sand dry $\frac{1}{4}$ "	46½	1220
Depth of exterior sand dry $\frac{3}{8}$ "	49	1260
Interior core still soft	50	
Core still retaining full shape	51	1280
Core still soft on interior	53½	
Depth of exterior sand dry $\frac{1}{2}$ "	57	1380
Depth of exterior sand dry $\frac{3}{4}$ "	59	1420
No fracture in core surface. A gently receding reversion to dry sand	69½	
Core readily disintegrated when disturbed. Certain resistance to disintegration still noticeable	70½	1600
Core still erect	78	1620
Certain resistance to complete disintegration	84½	1680
Reversion to full free flowing sand	87½	1700
	93	1720

It will be seen that decomposition of the binder does not begin until a temperature of approximately 1000° F., is reached. As the temperature increases the core progressively reverts to soft free flowing sand. I have assumed, therefore, that the action of the core under the heat of the molten metal in casting is somewhat similar, the core, because of the refractory properties of the binder, retaining its shape until the surface layer of metal has taken its initial set and then, as the excessive heat of the metal permeates the core, progressively breaking down, the surface of the core breaking down first, and liberating the sand to permit the contraction of the metal. Cores containing 114 cubic inches of my thermo-plastic bonded sand were immersed in a ladle of molten semi-steel as tapped from a cupola. Under this intense heat it required eight and one half minutes to make the transition from a thoroughly hardened core to entire loss of firm bond. It required twenty minutes for the core to revert to free flowing sand. Equivalent baked oil sand cores immersed in the ladle for twenty minutes revealed no sign of loss of bond and shape although heated half way through to a cherry red color. This clearly indicates the difference in the action of the two types of cores. The first retains its shape sufficiently long for casting purposes and then breaks down to permit the casting to contract, while the latter retains its shape and strength with persistency preventing the casting from contracting even though heated to a cherry red color.

Thus one result of my invention is a casting having no core strains from which the core is removed with ease and which has not been subjected to uneven cooling through the necessity of uncovering the hot casting to remove the core.

Another important characteristic of cores prepared according to my process is that they do not require venting as do other cores. There is very little smoke and no violent explosions such as accompany the use of oil and cereal bound cores. It is probable that this is due to the high permeability of the mass, and the fact that the decomposition of the ingredients does not take place until the core is sufficiently plastic to permit the escape of gases if formed. This completely eliminates the loss due to blow holes.

The cores because of their strength and refractoriness permit smaller cross-sections to be cast than is possible with other types of cores since there is no danger of fusion and the core is easily and cleanly removed. Nor do the heat treated cores require a "silica wash", "blacking", or any other surface wash in order to affect a smooth surface on the exterior of the core or increase its refractoriness. In this they are unlike all other cores as the surface of the core presents a smooth film having a high heat resistance.

It will have become evident that the cores after ramming can be made available for foundry use a great deal quicker than baked oil or cereal bonded cores of like weight and volume. By this process I produce a core fit for molding or casting purposes in 50 to 80% less time than is possible with a baked oil or cereal bonded core.

The cored surfaces do not have to be cleared of cores by or through the agency of core busting, sand blasting, hydraulic washing, pickling, chipping, tumbling, wire brushing, grinding, drilling, drifting or any other means for clearing the cores or removing burned-in or adhering sand since the cores do not fuse and thoroughly disintegrate under the casting heat.

Commercial castings have been made in brass, aluminum, bronze, gray iron, semi-steel and malleable iron using my improved cores. These castings have weighed up to and including twenty five hundred pounds and have been of plain and intricate design, utilizing plain slab cores, cylindrical shapes and pastered cores of intricate design and workmanship. All of these resulted in perfect commercial water and steam tested castings.

I have also found during the course of my investigation that when cores of small size are required the heat treatment may be dispensed with. In that case care must be taken in the selection of sand that it conform fairly closely with the analysis already given. In preparing cores of this kind the process is the same as previously outlined to the point where the core is heat treated except that the proportion of sand to diluted cement should be reduced to twelve to one or less in order to result in sufficient core strength. Instead of placing the cores in an oven they may be merely exposed to the air to permit the evaporation of the solvent from the outer portions thereof. They may be permitted to stand until they have attained sufficient hardness for use. Care must be taken to permit or cause sufficient movement of air over the cores to increase the rate of evaporation and prevent the accumulation of dangerous or explosive mixtures of solvent and air. Where, for example, only very small cores are used, or for some other reason heat treatment is not desired the small cores may

be prepared by simply drying them. This phase of the invention is limited, however, to small cores since in the larger ones the drying time becomes too great and sufficient core strength is not developed. When the larger sized cores are so prepared they are too flexible to be readily handled and the hard outer wall thereof is too soft to support the molten metal during casting.

Another factor which limits the size of the dried cores is the fact that vibrations and jars over the long drying period tends to shake the plastic mass down and develop cracks in the thinly formed crust thus distorting them, altering the shape and preventing their use with intricate designs. This may be partially overcome by careful rodding but in larger sizes the amount required becomes excessive.

Care must also be taken in choosing cores to be dried that the area thereof in contact with the supporting plate is small since these areas are very slow drying. The core, therefore, requires turning in order to permit the bottom to dry. If the core is too large or the bottom area too great a great deal of time is required before the crust becomes strong enough to support the core while it is being turned. The center and bottom thereof remains soft and when handled the fingers break through the crust or the core buckles and the soft center breaks out. For the same reason the cores cannot be placed in core driers to aid in retaining the form thereof when intricate shapes are desired, since covered areas will not dry with commercial speed. It is, therefore, necessary to heat treat such shapes.

Perhaps the most serious factor in limiting the size of the dried cores is that the larger cores will not withstand the molten metal since the skin is comparatively thin and there is a very large proportion of soft plastic sand beneath. The dried surface is plasticized at a low temperature and so becomes plastic with the first rush of metal, it, as well as the plastic sand beneath, being washed away by the impact of the incoming molten metal. The hydrostatic pressure of large volumes of metal also tends to deform the softened cores.

My invention further contemplates the use of the diluted thermo-plastic rubber isomers as a facing for sand molds. By the use of this liquid as a facing material the use of dry sand molds may generally be eliminated. Green sand molds, made from fresh, untreated sand, are cheap, but because of the moisture in the sand, fuse to and into the surface of the castings. In general practice this is avoided by preparing dry sand molds which involves heating the rammed molds to a temperature of 225 to 350° F., for about twelve hours. However, I have provided two ways in which all of the advantages of a dry sand mold and none of the disadvantages may be obtained from a treated green sand mold.

The green sand mold is prepared in the usual manner, after which the surface thereof is sprayed or otherwise treated with the diluted cement already described. Sufficient liquid should be applied to penetrate into the face to a depth of one fourth inch or less depending upon the weight of metal to be poured into the mold. The metal may be poured immediately after treating the mold if desired, and the resulting casting will have a smooth clean surface and will require no tumbling to remove the mold.

However, if desired, the procedure may be altered. In making the mold the patterns may first be covered with a layer of molding sand

which has been thoroughly mixed in the ratio of about fifteen to one with the diluted cement. The remainder of the mold may then be made from ordinary green sand and rammed up as is usual. The metal may be poured into the mold immediately if desired.

It will be evident that this phase of my invention is of considerable importance. All of the advantages of dry sand molds are obtained from green sand molds yet the time required to produce them is 75% less. No baking is required and the mold is ready for use immediately after ramming. The costs of ovens, tracks, trucks, hoists, fuel, building space, and operators for handling the same are eliminated.

While I have thus set out my invention in considerable detail it will be understood to be for purposes of illustration. I realize that numerous alterations and changes may be made without materially departing from the spirit of the invention or the scope of the appended claims, in which—

I claim:

1. The method of making a core for metal casting consisting in mixing a quantity of sand with a binder including a heat-plastic rubber isomer, forming a core of such mixture, and heating the same to a temperature sufficient to convert the isomer to a product melting at a higher temperature.

2. The method of making a core for metal casting consisting in mixing sand with a binder

including a heat-plastic rubber isomer, forming a core of such mixture, and heating the core to a temperature sufficient to convert at least a portion of the isomer to a product melting at a higher temperature.

3. The method of making a core for metal casting consisting in mixing a quantity of sand with a binder including a thermoprene of the G. P. type, forming a core of such mixture, and heat treating the same at a temperature sufficient to convert the thermoprene to a product melting at a higher temperature.

4. The method of making a core for metal casting consisting in mixing a quantity of sand with a binder including a thermoprene of the G. P. type, forming a core of such mixture, and heat treating the same at an elevated temperature between about 425 and 600° F.

5. The method of forming a core for metal casting consisting in mixing a quantity of sand with a binder including a thermoprene, forming a core of such mixture, and heat treating the same between about 425 and 600° F. for a period of time dependent upon the size of the core.

6. The method of making a core for metal casting consisting in mixing about fifteen parts of sand with about one part of a binder including a solvent and a thermoprene, forming a core of such mixture, and heating the core to a temperature sufficient to convert the thermoplastic residue to a product melting at a higher temperature.

MARVIN W. DUNDORE.