In connection with the production of metal castings, it is known that gases dissolved in the liquid metal greatly influence the quality of the castings. Generally, the gases are considered to be objectionable owing to the occurrence of cavities in the castings which are filled with the gas released from the liquid metal during its cooling and solidification. However, it has been found recently that there are instances where gas has to be introduced intentionally into the liquid metal in order to make the industrial production of useable castings possible without excessive and uneconomical elaboration of the foundry technique. The reason for this is that it is not always possible, without resorting to complicated precautions, to attain in the solidifying casting a temperature distribution that will ensure perfect feeding of all parts of the casting during solidification of the cast metal. The parts that cannot be completely fed with liquid metal will produce shrinkage cavities, and these shrinkage cavities in certain types of alloys appear in the form of depressions in the surface of the casting, or may even lead to the formation of inter-crystalline cracks.

If the liquid metal contains a sufficient amount of dissolved gas which is released during solidification of the cast metal, the distributed gas cavities produced during such solidification will counteract the formation of shrinkage cavities. Generally, if such gas cavities are suitable, and will therefore prevent the formation of pronounced local depressions or inter-crystalline cracks. Accordingly, it has become the practice in industrial foundries, especially aluminium foundries, to incorporate gas in the liquid metal in those cases where defects of shrinkage and inter-crystalline cracks cannot be eliminated economically by feeding arrangements. Obviously, it is desirable to limit the gas content of the liquid metal to the amount absolutely necessary to achieve the elimination of the shrinkage defects, as too high a gas content would unnecessarily weaken the casting by the production of an excessive number of gas cavities.

The problem of controlling the gas content of the liquid metal in the foundry is not simple, because there is no simple means of measuring the dissolved gas in a convenient way for practical purposes. Further, the gas content once established does not remain consistent for any duration of time because the gas dissolved is lost through the surface of the melt into the atmosphere.

In the case of aluminium alloys and magnesium alloys, the only gas capable of producing the desired effects is hydrogen; copper alloys can be gassed by hydrogen or sulphur dioxide or steam; steel can be gassed by carbon monoxide. In order to keep a certain amount of gas in the liquid metal without loss, it would be necessary to maintain an appropriate and uniform concentration of the gas above the melt. This is not generally possible in practice as it would mean enclosing the top of the melt by a lid. For the production of smaller castings, the top of the melt must be accessible in order to take out metal. If this is done, air will enter and upset the concentration of the gas in contact with the metal, with the result that gas escapes from the liquid metal into the atmosphere.

For practical means of introducing the required gas so far in use is the plunging into the melt of chemical substances that release the gas when in contact with the molten metal either by heat or by chemical reaction. For example, in the case of molten aluminium, a mixture of magnesium and calcium, water is bubbled through the melt by plunging into the melt green wood or asbestos wool soaked in water; or a water containing salt is used, or hydrogen containing substances such as certain oils or ammonium chloride, the hydrogen content being released either by decomposition at the temperature of the melt, or by the chemical action of the aluminium. These procedures allow a certain amount of control of the hydrogen content of the melt immediately after the end of the reaction by using predetermined quantities of the reagent, but this control is obviously very rough, as the hydrogen is not all absorbed, but part of it simply bubbles through the melt and the quantity of hydrogen retained is to a large extent dependent on the method of plunging and the tools used for plunging, and also the shape of the bodies. If the hydrogen content required for good casting is considerably less than the quantity of hydrogen introduced originally. This lack of proper control causes, first excessive porosity immediately after introducing the hydrogen in excessive quantities, and second, scrap castings owing to the impossibility of conveniently measuring the hydrogen content when it drops during the casting period.

The present invention provides a method and means of keeping the gas content of the melt continuously constant without interfering with the casting operations. In accordance with the invention there is maintained in the liquid melt a stream of the required gas, this gas current being controlled at a constant rate of flow through the melt and is maintained into the melt through a suitable distributor or diffuser, thereby establishing a stationary gas content in the melt. This stationary gas content represents the equilibrium between the amount of gas introduced into the liquid metal from the bubbles rising from the distributor to the surface of the metal and the rate of loss of the gas from the top surface of the melt into the atmosphere. By altering the flow or the concentration of the gas, any required gas content in the melt can be maintained for any required period.

The apparatus for introducing the gas is very simple and convenient to handle, and does not interfere with the casting operations, especially in the case of a basic furnace. In the case of a tilting pot, the diffuser can be inserted in the pot some time before the actual casting starts, and if necessary removed from the pot immediately before casting, without alteration in the normal foundry operations.

The rate of flow of the gas stream cannot be fixed beforehand without calibration, as it is dependent not only on the nature of the gas and the diffuser, but also on the depth of the liquid bath, the nature of the alloy being cast, the temperature of the gases, and on the condition of the top surface of the melt. If the depth of the bath increases, the amount of gas absorbed by the liquid metal from a given stream of gas through a given diffuser becomes higher. Further, if the top surface of the melt is kept clean from dross and flux, the rate of loss of gas into the atmosphere is lower than if the top of the melt is left covered with dross or flux, provided the dross or flux does not react with the gas. It is a matter of a short period of trial to establish with a given furnace, alloy, tem-
perature and diffuser, the right rate of flow required to provide sound castings from a particular mould. The rate of flow is established in this way it is necessary to keep the height of the metal bath and the condition of the metal surface in the pot consistent in order to maintain the gas content at this level for an unlimited time.

In the case of aluminium the gases used are preferably of the oxygen-free type in order to prevent the formation of aluminium oxide which, for example, forms if water vapour is used to introduce hydrogen. Compounds useful for the introduction of hydrogen are for example hydrocarbons such as methane, butane, the mixture of low hydrocarbons sold as butagas, town gas, producer gas. Also partly chlorinated hydrocarbons, that is trichloroethylene vapour, methyl chloride and so on can theoretically be used, but have various practical disadvantages. In the case of vapsours, it is advantageous to use an inert carrier gas to introduce these into the liquid metal. The use of pure dry hydrogen as supplied in steel containers for welding and similar purposes has been found particularly efficient. As it is essential that the gas be introduced under a pressure sufficient to overcome the hydrostatic pressure of the liquid metal at the bottom of the ladle or crucible, the use of town gas and producer gas from the normal gas mains is excluded for most practical cases. These two substances have also the disadvantage of being saturated with water vapour, which produces a certain amount of dross by reaction with aluminium.

The distributor or diffuser employed in carrying out the invention may consist of a straight or curved piece of suitably protected steel pipe or refractory pipe which is equipped with a number of fine holes and is placed near the bottom of the metal bath.

Two suitable forms of distributor or diffuser are illustrated by way of example on the accompanying drawing.

Fig. 1 is an elevation of one form.

Fig. 2 is a section on the plane II—II of Fig. 1.

Fig. 3 is an elevation of the second form.

The diffuser illustrated by Figs. 1 and 2 comprises a steel tube 1 bent as shown and protected by asbestos tape wrapping surrounded by refractory cement 2. The head of the diffuser has a number of small holes 3 for the outlet of the gas.

In use the upper end of the diffuser is connected with a supply of the required gas and, with the gas streaming through the diffuser, it is lowered into the metal bath. The rate of flow of the gas can be ascertained by any suitable flow meter, for example of the Venturi type, or if no great accuracy is required it may be possible to control the rate of flow simply by keeping constant the pressure under which the gas escapes from the diffuser and the head of liquid metal above the diffuser.

The form of diffuser illustrated by Fig. 3 consists simply of a thin vertical steel pipe 1 protected as already described or by refractory material. Gas escapes from the lower end of the tube 1 and bubbles through the liquid metal in the crucible A. The pipe 1 is surrounded by a wider vertical tube 2a having ample openings near the bottom and immediately below the top of the metal bath B. This diffuser has a gentle stirring effect in that the rising bubbles draw a stream of liquid metal through the wider tube 2a.

In certain cases the described means may be supplemented by keeping the largest part of the metal surface under a lid retaining the hydrogen concentration at an appropriate level and taking metal out by an open well of comparatively small surface area.

As an example of the rate of flow necessary for practical purposes, the following case is mentioned: A casting weighing about 8 oz. with a wall thickness of about 1/4" and ribs on both sides of the main panel was to be cast in aluminium alloy of the composition Cu 3%, Si 5% Mn 0.5%, remainder Al with normal impurities. The metal for casting was contained in an oil heated plumago pot of 250 lbs. capacity, the depth of the bath being about 15". In order to obtain sound castings it was necessary prior to the present invention to treat the metal with a gassing compound, say ammonium chloride, once in every 5 minutes. Immediately after treatment the gas content was far in excess of what was necessary, whilst after 5 minutes it had fallen to an extent so as to raise the scrap percentage to more than 30% of the castings produced. However, by inserting a diffuser as herein described and passing through the melt a constant stream of dry pure hydrogen from a steel container at a rate of 0.5 to 1 litre per minute, the gas content was kept permanently just above the minimum limit for the production of sound castings, whereas in order to produce the same gas content immediately after treatment with gassing compound a hydrogen stream of about 3 litres per minute was required.

I claim:

1. In the production of metal castings wherein shrinkage defects are reduced by having dissolved in the molten metal at the time of casting a definite content of hydrogen within the limits required to produce a sound casting, a method of establishing said content of dissolved hydrogen comprising bubbling through the metal in a molten state and in a vessel open to the atmosphere a stream of said gas at a predetermined and constant rate to the point of equilibrium between the gas introduced into the metal and that escaping into the atmosphere from the metal, and thereafter maintaining said equilibrium by continuing said bubbling at said predetermined and constant rate independently of time up to the point of casting.

2. In the production of metal castings of aluminium and its alloys wherein shrinkage defects are reduced by having dissolved in the molten metal at the time of casting a definite content of hydrogen within the limits required to produce a sound casting, a method of establishing said content of dissolved hydrogen comprising bubbling through the metal in a molten state and in a vessel open to the atmosphere a stream of hydrogen at a predetermined and constant rate to the point of equilibrium between the hydrogen introduced into the metal and that escaping into the atmosphere from the metal, and thereafter maintaining said equilibrium by continuing said bubbling at said predetermined and constant rate independently of time up to the point of casting.

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