Dec. 1, 1942. O. C. NUTTER 2,303,655

METHOD OF DETERMINING GAS-CONTENT OF MOLTEN BRASS

Filed Aug. 18, 1941

Fig. 1a

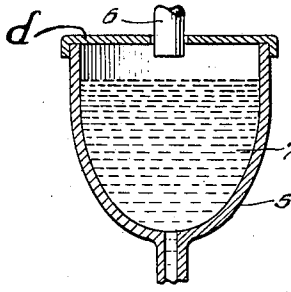


Fig. 1

Fig. 2

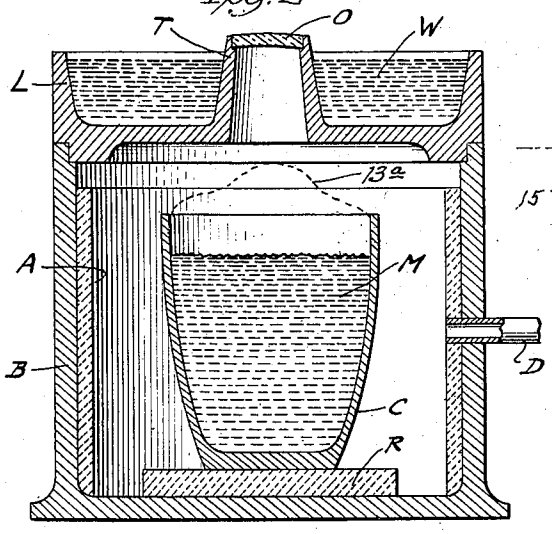


Fig. 3

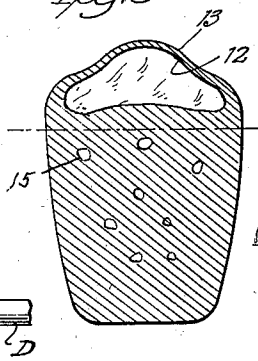


Fig. 4

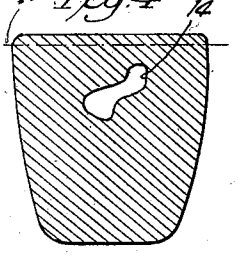
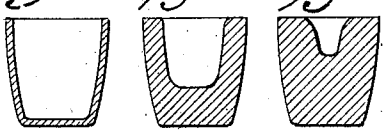


Fig. 5 Fig. 6 Fig. 7



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METHOD OF DETERMINING GAS CONTENT OF MOLTEN BRASSES

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8 Claims. (Cl. 73—51)

My invention relates to a method and means for making a test ingot from a melt of an alloy such as a rich brass, nickel brass or nickel silver, from which test ingot a foundryman who knows the zinc content of the alloy can readily estimate the degasification required by that melt to prevent the occurrence of cavities which make castings unsuitable for many purposes.

In castings of such alloys having not over 17 per cent zinc content, such cavities are usually due to the absorption by the molten copper (or nickel) in the melt of reducing gases to which the top of the melt is exposed in usual brass foundry practice, which absorbed gases then are dissolved into the melt. In a pouring made into a mold, the solubility of gases decreases as the metal cools, and during the mushy state preceding solidification, such gases are released to form gas bubbles which produce pin holes and larger cavities in castings. Consequently, cavity-free castings cannot be made from a melt of such an alloy until after the gas in the melt has been eliminated, as for example by the addition of an oxidizing agent in a quantity proportioned to the gas content of the melt.

This gas content cannot be judged from a test ingot made by scooping a melt sample into a crucible, because solidification will start around the riser side and at the bottom of the melt sample to form a gradually thickening cup-shaped crust, before a crust forms on the top of the melt sample, and most of the gas released within the melt will in the meantime have escaped. Moreover, the cooling of the resulting ingot is apt to require so much time as to allow the main melt to cool below the temperature needed for having pourings from it completely fill the molds. Consequently, foundrymen have had to be satisfied with mere guesses as to the proportion of a gas-eliminating agent needed for any freshly made melt, of copper and zinc alloys, which guesses frequently resulted in the scrapping of considerable quantities of castings.

My present invention aims to overcome the above recited uncertainties and profit losses by providing a test-ingot manufacturing method which will avoid the escape from the melt sample of any material portion of the gases released within it during its cooling, and by which method gas bubbles within the melt will be so greatly enlarged as to effect both an increase in the height of the test ingot and an upward bulging of the top of the ingot, so that the foundryman can readily estimate the proportionate gas content of the melt visually from this ingot without even waiting for it to solidify completely. It also provides for enabling a foundryman to vary this method according to the known percentage of zinc in each melt of such an alloy which he tests for its gas content.

In addition, my invention includes the providing of an easily manipulated apparatus of modest cost by means of which any competent foundryman can readily employ my said method for producing each such test ingot so speedily that both the making of this ingot and the corresponding degasifying of the main melt can readily be made before the pourability of the main melt has been materially reduced.

Fundamentally, my here presented method is based on a study of both published and unpublished data relating to effects of temperature, atmospheric pressure, and the solubility of gases in melts or brasses of various compositions; on my also studying the previously ignored effect of the general vapor pressure which zinc imparts to such alloys and calculating the variation of that general vapor pressure with different percentages of the zinc content of a copper and zinc alloy, and studying the general interrelated effect of all of the above listed factors; on my then calculating the conditions needed for speedily producing a dependable gas-content indicating test ingot, and on my demonstrating the adequacy of these calculations in actual brass foundry practice with an apparatus specially devised for that purpose. Briefly summarized, I found the following:

Copper melts at about 1980 degrees Fahrenheit, is not readily vaporizable and even in a melt raised to 2400 degrees (considerably higher than the usual pouring temperatures of all melts of brasses) has no vapor pressure to resist the ready absorption of reducing gases by the copper content of the melt, which gases then are dissolved to form part of the liquid melt. However, zinc (which melts at about 787 degrees and vaporizes readily when raised to beyond its boiling point of 1665 degrees) has a vapor pressure which rises with further increases in temperature, and the vapor pressure of the zinc gives every copper-zinc melt a general vapor pressure, tending to resist the absorption of reducing gases by the copper (or nickel) of the melt.

This general vapor pressure of the melt varies with the liquidus of the alloy, meaning the temperature at which the melt begins to solidify during its cooling, and with the term "general vapor pressure" used in its absolute sense, my calculations have shown it in melts of rich brasses

to be .92 per cent for a 5 per cent zinc content, 1.92 per cent for 10 per cent zinc, 2.92 for 15 per cent, and 3.17 for 17 per cent. Measured with a vacuum gauge, each such absolute vapor pressure (at the liquidus of the melt) will show as the difference between that pressure and the normal 29.92 inch atmospheric pressure. Hence the usual gauge readings will be 29 inch for a 5 per cent zinc content, 28 for 10 per cent, 27 for 15 per cent, and 26.75 for 17 per cent.

With zinc, contents greater than 17 per cent, the general vapor pressure of a copper-zinc melt becomes still higher and then effectively resists the absorption of reducing gases by the melt, thus accounting for the absence of detrimental cavities in castings made from melts containing more than 17 per cent of zinc or the like, and having copper or nickel (or these jointly) as their remaining constituent. However, with zinc contents of not over approximately 17 per cent, the general vapor pressures are inadequate for preventing this gas absorption, so that melts of brasses rich in copper, as also nickel silver and the like invariably contain absorbed and liquified reducing gases. Moreover, the different general vapor pressures which melts of the just recited class have according to their zinc content show correspondingly different effects, for which I have found appropriate allowances to be needed while making tests ingot in which the absorbed gases are enlarged by means of a vacuum or near-vacuum, in order that these ingots will definitely indicate the approximate gas content of the melts from which they were made.

For obtaining adequately comparable test ingots from different melts of the same known zinc percentage, these ingots must also be made under substantially the same temperature and pressure conditions. In view of this and of my previously recited findings, I desirably employ a speedily sealable container having its interior connected both to a quick-acting vacuum pump and to an adequately accurate vacuum gauge, which container has its (desirably metallic) cover chilled by cold water or ice so as to exert a cooling influence on the top of a melt sample in a crucible set down into the container and freely spaced from both the riser wall and the top of the container. To prevent this cooling effect from also being conducted through parts of the can-like body of the container to the bottom of the crucible and through air in the container to the riser wall of the crucible, I dispose a layer of refractive material on the container bottom and interiorly line the riser wall of the container with asbestos or the like. These provisions cause the cooling effect of the cover to be concentrated on the top of the melt sample so that a top crust forms on that sample before any crust forms in the bore of the crucible and before any appreciable quantity of gas has escaped. When the container has been closed after setting the crucible into it, I desirably immediately start the vacuum pump, but operate it only long enough to reduce the air pressure within the container a few inches below atmospheric pressure, so as merely to offset the increase in air pressure which otherwise is caused by heat radiated from the crucible and the melt.

As soon as an observation through a window in the top of the container, made while the container is lightly tapped or agitated, shows no movement in the top of the melt sample and thereby indicates that a top crust is forming, I again operate the vacuum pump for speedily reducing the residual air pressure a few times the (absolute) general vapor pressure which the melt sample has at is liquidus, thereby preventing this general vapor pressure from rupturing the crust while the latter is still quite thin. Theoretically, only a slight increase above the said general vapor pressure may suffice, but I preferably double it to allow for variations of different operators, as for example in the promptness of judging when the top crust has formed. For the previously listed zinc percentages, this doubling would mean vacuum gauge readings of 29.3 inches for 1.5 per cent, 28.1 for 5 per cent, 26.1 for 10 per cent, 24.34 for 15 per cent, and 23.6 inches for 17 per cent.

With the top crust formation thus speeded by the chilling of the top of the melt and the considerable vacuum then produced in the container, the quickly expanding and accumulating gases exert their crust-flexing and top-raising action while this crust is still rather thin and adequately flexible, so that only a few minutes suffice for shaping the upper part of a gas-containing test ingot, as shown for example by the section of Fig. 3. Since the resulting change, indicated also by the corresponding dash-dotted line in Fig. 2, can easily be observed through the window in the cover, the gas content of the melt can readily be estimated from it long before the test ingot solidifies entirely. Moreover, an additional test ingot can also be made, after the addition of a definite quantity of an oxidizing agent to the main melt, before that melt cools unduly. Consequently, any competent foundryman can soon learn how to estimate the gas elimination needed for a given volume of a melt of any brass alloy rich in copper, when he knows the percentage of zinc content of this melt.

To obviate the need of a high priced vacuum pump of the scientific laboratory type, I have also devised a simple and unitary apparatus including both a cheaper blower-type pump and means for controlling the vacuum in the container both speedily and with adequate accuracy. Illustrative of such an apparatus and of test ingots respectively made both with and without my apparatus and method,

Figure 1 is a somewhat diagrammatic elevation of a suitable apparatus for employing my method;

Figure 1[a] is an enlargement of an upper part of Figure 1, including a dust excluding cover on the oil receptacle;

Figure 2 is an enlarged and fragmentary central and vertical section through the container and a melt-containing crucible disposed in it;

Figure 3 shows the appearance of the cut face of a longitudinal half section of a test ingot made by the method of my invention and by means of the apparatus of Figure 1 from a melt sample containing a large quantity of gases, including a dash-dotted line showing height of the original top of the melt sample in the crucible;

Figure 4 is a section, allied to Figure 3, of a test ingot made from a melt sample which contained practically no absorbed gases, showing merely the cavity due to the shrinkage of the metal; and Figure 5, Figure 6, and Figure 7 comprise three vertical and diametric sections drawn on a relatively smaller scale to show the consecutive thickening of the cup-shaped crust which ordinarily would form on a crucible-housed melt before any top crust is formed, and while most, if not all, absorbed gases are emitted, showing what would occur if the crucible containing the test sample was left in the open air and did not have the melt top chilled.

In the drawing, Fig. 2 shows the melt sample M as it initially appears in a crucible C seated on a refractory plate R fastened to the bottom of the can-like body B of a container which freely houses the crucible and is sealed by a cover or lid L made of a metal of high conductivity. This cover is formed to provide an annular and upwardly open trough surrounding an upwardly tapering axial tube T, into the upper end of which tube an observation window O is sealed, and a filling W of cold water is disposed in the said trough to exert a cooling influence on the upper portion of the melt sample in the crucible. Moreover, the riser wall of a container body has an interior lining A of asbestos or other heat-insulating material which preferably extends for a greater height than that of the crucible. This lining deters heat transfer from the riser wall of the crucible through air in the container and the riser wall of the latter to the outer air, thereby cooperating with the refractory plate under the crucible for enabling the cooling influence of the water-cooled cover L to expedite the formation of a crust on the top of the melt sample M in the crucible.

Mounted on the same base 8 with the container body is a vacuum pump P which has as its inlet the lower end of a riser pipe 4 leading to a cup 5 partly filled with lubricating oil, the flow of oil from that cup to the pump being controlled by a valve 3. This riser pipe is connected by a horizontal cross-pipe d^2 to the upright end portion d' of a duct which leads from the interior of the container to a vacuum gauge G and which duct also has a part D coiled upwardly to prevent a vacuum in the container from drawing oil out of the pump (in case of leakage in the check valve 14) and into the container when the pump is halted. The vacuum duct system also includes a valve 2, desirably near the container body, for admitting air to relieve a vacuum in the container so that the container lid L can readily be lifted off, and a swing valve 14 in the cross-pipe d^2 for automatically preventing a flow through that pipe in a direction away from the pump.

Associated with the elevated oil cup 5 is a riser pipe 6 leading upwardly from the pump, which pipe has its upper end portion recurved and presenting its outlet above the oil in the said cup, so that oil forced upwardly out of the pump through that pipe by the mechanism of the pump can cause oil to issue in drops from the outlet end of this pipe. Each such drop then carries a little air with it, so that by adjusting the valve 3 the user can readily reduce the vacuum by minute degrees, thereby enabling this vacuum to be accurately adjusted and maintained when the pump is of a simple blower type of much lower cost than the usual laboratory types.

With this simple apparatus, the mere setting down of the properly fitting cover d on the container body will effect an ample seal, particularly if a little plumber's grease has been smeared on the mouth edge of the container body, and the conveniently disposed valves enable the user to employ my previously outlined method easily and speedily.

By thus employing my here presented method for estimating the gas content of melt samples of a given shape and size, such as the sample M in Figure 2, a foundryman can readily obtain these results: If the melt was entirely free of cavity-producing gases, no gas bubbles would be released in the melt during its solidification, so that none would be enlarged in it by the near-vacuum to increase the height of the resulting test ingot or to bulge the top of the ingot. Consequently, this test ingot, while having a small interior cavity due to shrinkage, will be flat-topped and of approximately the same height as the melt sample.

If the melt sample was approximately free of gas content, little or no gas bubbles will be produced in the melt sample and enlarged by the vacuum to raise and bulge the top of the resulting test ingot. This top then will remain substantially flat, but may be raised slightly as in Figure 4 and a section through the ingot will then show both a cavity 14 (due to shrinkage of the metal) and a metal portion above the melt top line 11 corresponding in volume to that of the gas in the melt sample.

When the melt sample has a detrimental gas content, a large portion of the released gases will speedily be collected under the initially thin top crust and expanded there for upwardly bulging and raising this crust while the latter is still flexible, thereby producing correspondingly large cavity 12 under the crust 13 and above the initial elevation plane 11 of the melt (as shown for example in Figure 3) and also causing much smaller gas bubbles 15 to form cavities distributed in lower portions of the resulting ingot, the volume of metal above the said plane being approximately equal to the total volume of the cavities.

The thus produced change in the height and shape of the top crust by the time it becomes stable, as indicated in Figure 2 by the dotted line 13^a, can readily be seen by the foundryman looking through the window in the top of the container. Consequently, he ordinarily will not need to wait for a tooling and cutting of the test ingot, but can soon learn to judge the approximate gas content from such a speedily made visual observation.

However, while I have heretofore described the utilizing of my invention for making test ingots of brasses containing only zinc and a far greater percentage of copper, my here disclosed method and apparatus are also equally suitable for determining the approximate gas content of brasses or the like in which nickel, almuminum, or tin is substituted for part or all of the preponderant copper, and in which other low-melting and highly vaporizable metals (such as cadmium) are substituted for part or all of the zinc.

In view of this it should be understood that I am referring to any metal (or plurality of metals), a melt of which has no material vapor pressure at its pouring temperature but readily absorbs gases, and to rich brasses including also zinc, which can be cast without involving decided profit losses and also without requiring tensile or hydraulic tests to determine the fitness of the castings for particular purposes.

I claim as my invention:

1. For use by foundries making castings from a melt of an alloy which has a general vapor pressure inadequate for preventing the absorption of reducing gases during the making of the melt, a method of converting a crucible-housed sample, taken from the melt at its pouring temperature, into a test ingot having its height and the upward bulging of its top indicative of the proportionate gas content of the melt, which method comprises: subjecting the crucible and the top of the melt sample to temperature-affecting influences causing a thin and flat crust to form on the top of the melt sample while this top is under approximately atmospheric pressure and before crust forms on other portions of this

melt sample; and then, while the said crust is still thin and flexible, speedily reducing the air pressure on the top of the melt sample to a pressure adequate for effecting an enlargement of gas bubbles released from other portions of the sample melt, which reduced pressure is not less than approximately twice the absolute general vapor pressure which the molten alloy has at its liquidus.

2. A test ingot manufacturing method as per claim 1, including the subsequent step of expediting the general solidification of the melt sample by subjecting the top of the said crust to atmospheric air pressure when the said top crust no longer continues to raise or bulge upwardly.

3. In a method of making a test ingot of gas-content-indicating shape from a sample of a molten alloy at its pouring temperature in a crucible housed by a sealed container, by which method a considerable vacuum is produced in the container for greatly enlarging bubbles of gas released from the melt sample under an initially flat top crust on this melt sample, the step of speedily causing such top crust to form on the top of the melt sample before a crust forms on the bottom and periphery of that sample, which step consists in subjecting the top of the melt sample to a chilling influence while deterring the said chilling influence from reaching the side and bottom of the crucible while maintaining the air pressure in the container near but not higher than normal atmospheric pressure to prevent the emitting of an appreciable amount of gases from the melt while the top crust is forming.

4. The step of first producing only a top crust on a sample melt of an alloy during the making of a gas-content-indicating test ingot, as per claim 3, in which the air pressure within the container during the recited step is about two mercury inches lower than normal atmospheric pressure, so as to compensate for the raising of this air pressure by heat radiated from the crucible.

5. In a method of making a gas-content-indicating test ingot from a sample of a melt of an alloy which has a general vapor pressure inadequate for preventing the absorption of gases during the making of the melt, according to which method the melt sample is disposed in a crucible housed by a sealed container, and a considerable vacuum is produced in the said container after a thin and initially flat crust on the top of the melt sample before the said vacuum is produced, the step of speedily causing such a crust to form on the top of the melt sample before crust forms on the bottom and the periphery of the melt sample, which step consists in chilling the top of the container while shielding both the inward faces of both the bottom and the riser wall of the container to prevent a material heat transfer from the crucible to the said container bottom and riser wall.

6. In the making of a gas-content indicating test ingot from a melt of an alloy composed mainly of a metal which when molten absorbs reducing gases, and also including metal of lower melting point, a melt of which latter metal imparts a vapor pressure to the melt of the alloy, during which ingot making a sample of that melt is disposed in a crucible and first while under approximately normal atmospheric pressure is subjected to temperature influences causing a thin, flat and flexible crust to form on the top of the melt sample before crust forms on other parts of the said sample, the step of thereafter effecting an approximately maximum enlargement of gases released below the said crust from the melt, without having part of these gases forced through the crust by the general vapor pressure of the said alloy; which step consists in subjecting the top of the said crust, beginning while the crust is still thin and flexible, and continuing at least as long as the crust is being raised and bulged upwardly by gases under it, to a near-vacuum, leaving a residual air pressure approximately twice the absolute general vapor pressure which the said alloy has at its liquidus.

7. The method of converting equal sized samples of melts of alloys rich in copper and each including the same percentage of zinc, into test ingots, each of which will have its increased height and the upward bulging of its top crust indicative of the relative gas content of the melt sample from which that test ingot was made, which method consists in disposing each such sample in a crucible of a given size and shape, then subjecting each crucible and its contents to identical temperature and air pressure conditions for first causing a thin and flexible crust to begin to form on the top of the melt sample, and thereafter throughout the upward bulging and raising of that crust subjecting the top of this crust to a near-vacuum leaving a residual air pressure sufficiently high to overbalance the absolute general vapor pressure which the melt of that alloy has at its liquidus according to its percentage of zinc content.

8. The method of producing a test ingot from a melt of a molten alloy of copper or the like containing not more than about 17 per cent of zinc, the height and top shape of which ingot when compared with the configuration of the crucible-housed melt sample, from which the test ingot was produced, will visually indicate the entire proportionate gas content of the melt, which method comprises the steps of pouring the melt sample into the crucible at the usual pouring temperature of that alloy; disposing the crucible in a speedily sealed container having a chilling medium associated with its top and having means deterring heat exchange from the melt sample to the bottom and riser wall of the container; initially, and until a tapping or shaking of the container no longer produces an agitation of the top of the melt sample, maintaining within the container an air pressure approximating normal atmospheric pressure; then reducing the said air pressure with sufficient speed so that no material proportion of the gas in the melt sample is emitted from it before a substantially flat top crust forms on the top of the melt sample, to a near-vacuum for enlarging gases in the melt and trapping the enlarged gases under the said crust, while the latter is still sufficiently thin and flexible to be elevated and bulged upwardly by the pressure of the gases; the said near-vacuum being such as to leave the top of the said crust exposed to an air pressure corresponding to only a few times the absolute general vapor pressure of the alloy, as long as the said top crust continues to be raised or bulged upwards.

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