

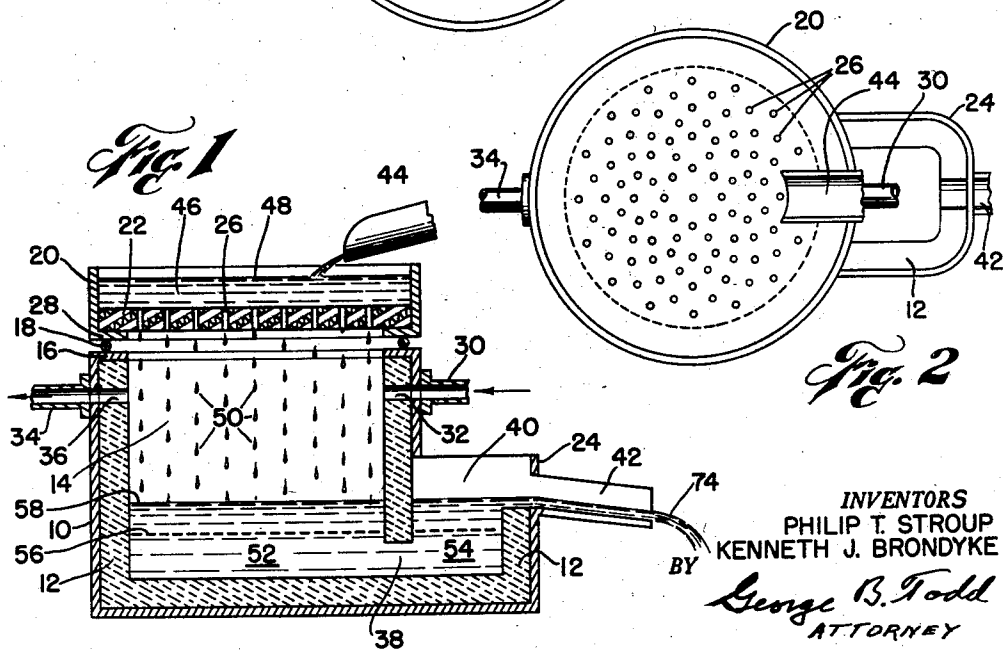
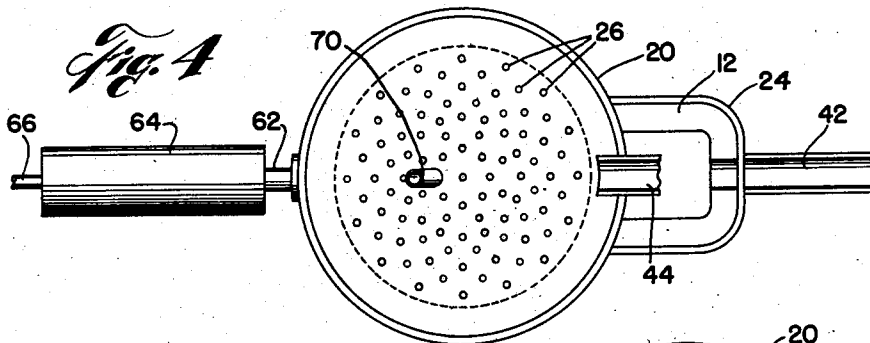
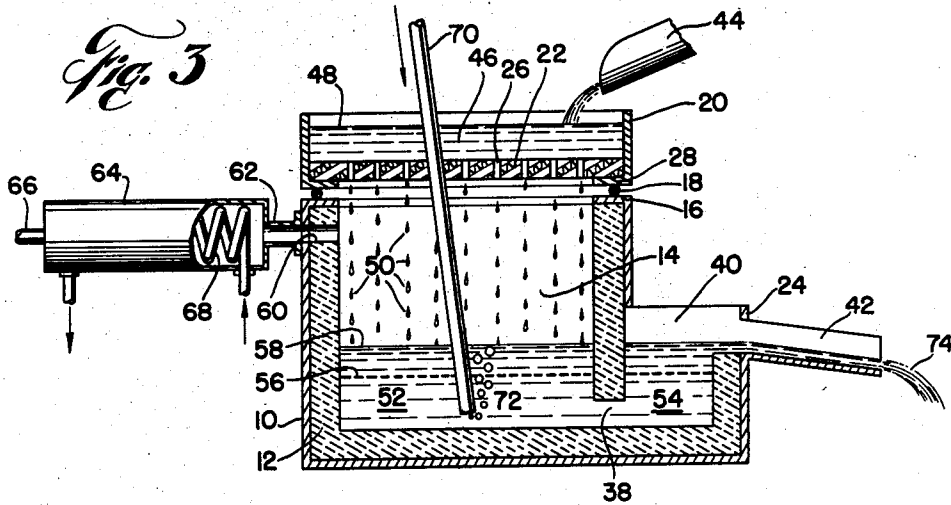
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DEGASSING AND PURIFYING MOLTEN ALUMINOUS METAL

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DEGASSING AND PURIFYING MOLTEN ALUMINOUS METAL

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This invention relates to removing dissolved or sorbed gas and other impurities from molten aluminum and aluminum base alloys and is concerned with both the process and apparatus for accomplishing this purpose. For the sake of convenience both aluminum and aluminum base alloys will be referred to as aluminous metal.

It is well known that aluminous metal absorbs various gases either directly from the air or from the solids placed in contact with the liquid metal or by the reaction of certain chemical compounds with aluminum. Hydrogen appears to compose the major portion of the gas occurring in aluminous metal and is regarded as being chiefly responsible for the defects associated with gas in the metal. It is further well recognized that the amount of gas which can be held by molten metal varies with the temperature, the capacity to hold gas diminishing with the temperature and hence some gas is released as the liquid metal cools. Of greater importance is the fact that as the molten metal solidifies a relatively large proportion of the gas held by the metal is expelled with the resultant formation of bubbles or other voids in the cast product. Such discontinuities are objectionable both from the standpoint of reducing the strength of the metal and the surface appearance, if the voids are at the surface. For these and other reasons an effort is usually made to minimize the absorption of gas by careful melting and metal transfer practices.

To remove gas which has been absorbed in the course of melting, various treatments have been proposed and used. One of the most obvious methods proposed has been that of creating a vacuum above the molten metal bath and extracting any gas which diffuses through the metal. This kind of treatment is difficult and expensive to operate on a commercial scale and requires a long exposure to remove substantially all of the gas. In addition, such treatment does not remove any solid impurities dispersed throughout the metal bath.

Another method which has been used from time to time has consisted of introducing into the melt small amounts of certain solid halides which either react with aluminum to form an aluminum halide vapor or which merely vaporize without reaction. Zinc chloride is an example of the first type and aluminum chloride is representative of the second kind of substance. Such treatments are usually carried out in a furnace or in an open ladle, and do not remove much of the gas unless large quantities of the halides are employed. The large volume of fumes resulting from the treatment create a difficult disposal problem.

An alternative practice which has been widely used in the melting and purification of aluminous metal is that of bubbling gaseous chlorine through the metal shortly before the metal is cast. This treatment is also carried out in a furnace or in a ladle with the generation of a large amount of fume. To reduce the gas content of the metal to a low value it is usually necessary to introduce a large quantity of chlorine over an extended period of time. This means that one unit of metal holding equip-

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ment is tied up for a long time and hence a large number of units are required to process the output of but a few melting furnaces. As an illustration of the quantity of chlorine that is consumed, it is not uncommon to introduce 30 pounds of chlorine in a 5000 pound melt over a period of 20 minutes to bring about a reduction in gas content of the melt. The chlorine fluxing treatment is therefore a costly operation.

One of the objects of this invention is to provide a method for rapidly removing substantially all of the gas held by an aluminous metal melt. Another object is to reduce the sodium impurity content of a melt as it is being degassed. A further object is to provide a method for effectively degassing a stream of aluminous metal delivered from a melting furnace to a mold or other receptacle. Still another object is to provide a method for adding certain alloying elements simultaneously with the degassing treatment. Another object is to provide a degassing unit which is adapted to handle a relatively large volume of molten metal in a short time.

These and other objects and advantages are achieved by the invention described hereinbelow, the examples given to illustrate the principles of the invention and not as limitations thereof.

It has been discovered that molten aluminous metal can be degassed quickly, effectively and economically by passing metal in a finely divided form through an inactive atmosphere containing aluminum chloride in vapor form as the essential active component of the atmosphere. By means of the same treatment the sodium impurity content of the melt can also be reduced. To bring about the rapid degassing and purification of the melt it is necessary to provide an extremely large surface area with respect to the volume in order to expose the maximum area of the metal to the aluminum chloride vapor. In referring to an inactive atmosphere it is to be understood that this means an atmosphere which does not increase the gas content of the molten metal when in contact therewith. Such an atmosphere may contain nitrogen, helium or similar gases, or dry air or even air with a slight moisture content but in no case does it contain hydrogen or compounds yielding hydrogen in an amount sufficient to introduce that element into the melt whereby the gas content is increased.

As mentioned above the treatment not only reduces the gas content of the molten metal but it serves to remove some solid impurities. For example, the sodium and calcium impurity content of a melt is lowered by exposure to the aluminum chloride atmosphere. In addition it serves to disengage suspended oxide particles dispersed in the molten metal. Such non-volatile impurities collect on the surface of the melt in the degassing unit.

The degassing and purification can be accomplished by subdividing the metal into droplets or very thin streams which pass through a chamber filled with the aluminum chloride-containing atmosphere. Also, to obtain the desired rapid action it is imperative that a current of aluminum chloride vapor pass through the space wherein the treatment is effected. The constant movement of aluminum chloride through the chamber sweeps away the gas released from the molten metal and transports it from the treating chamber while at the same time reabsorption of gas is prevented. Lastly, according to this invention the degassed and purified metal is immediately discharged from the treating chamber and transferred to suitable molds or other receptacles before any substantial re-gassing occurs.

The apparatus for carrying out the process is simple, compact and does not include any moving parts. It is therefore easy to maintain and to replace any worn out parts. The apparatus can be conveniently constructed in the form of a small unit which is adapted to handle a

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single charge of metal, as from a holding ladle, or to be placed in the metal transfer line between a melting furnace and ingot casting means. By providing a condenser on the unit practically all aluminum chloride fumes are condensed and there is no pollution of the adjacent atmosphere. The whole apparatus operates at atmospheric pressure and thus avoids expensive pumping equipment to evacuate the treating chamber.

A better understanding of the invention will be gained by referring to the accompanying drawings wherein:

Fig. 1 is an elevation in section of a simple degassing unit;

Fig. 2 is a top plan view of the unit shown in Fig. 1;

Fig. 3 is an elevation, partially in section, of a modified form of apparatus; and

Fig. 4 is a top plan view of the unit shown in Fig. 3.

Referring to Fig. 1, steel shell 10 lined with refractory 12 forms the base and side walls of chamber 14 wherein the degassing and purification treatment is conducted. The top of the chamber is enclosed by the perforated plate 22 which forms the bottom of distributing basin 20 which in turn is supported on the bottom flange 28. In operation the basin is filled with molten metal thus preventing access of air to the treating chamber. The basin 20 rests on top flange 16 of the vertical wall of the chamber and a seal 18, such as asbestos rope, is provided between that flange and the bottom flange 28 of the basin to maintain a gas tight joint.

Immediately adjoining the treating chamber 14 is discharge well 40 which is in communication with the chamber through opening 38. The shell 24 of the well is also lined with refractory 12. Discharge from the well is effected by means of spout 42 mounted in the outer wall thereof.

The aluminum chloride vapor to provide the desired atmosphere is supplied to the chamber from an external source through inlet pipe 30 and complementary opening 32 in the refractory lining and the outgoing aluminum chloride vapor is discharged through aperture 36 and pipe 34 to a condenser or other suitable means for receiving the halide vapor.

The molten metal to be degassed is brought to the apparatus by trough 44. The basin 20 filled to a level of 48 distributes the molten charge to the treating chamber. The base plate 22 provided with holes 26 serves to subdivide the melt into the form of droplets 50 which descend through the chamber to the pool of metal 52. When the metal level in the chamber and discharge well rises above the bottom of spout 42 a discharge of degassed metal occurs.

The modification of Fig. 1 appearing in Fig. 3 relates to another method of supplying aluminum chloride vapor to the treating chamber. Here gaseous chlorine is introduced below the surface of the metal pool 52 by means of the long downwardly extending tube 70. By this arrangement a gas tight seal is provided where the tube passes through plate 22. Other means of introducing chlorine, such as a horizontal perforated pipe near the floor of the degassing chamber can be used. Upon contact between the chlorine and the aluminum, aluminum chloride vapor is formed which together with any unreacted chlorine rise through the metal in the form of bubbles 72. The aluminum chloride leaves the chamber through aperture 60 and pipe 62 and passes into condenser 64 cooled with water coils 68. Any uncondensed aluminum chloride and gases associated therewith can escape through vent 66. It will be appreciated that the systems shown in both Figs. 1 and 3 operate at substantially atmospheric pressure, it being necessary to provide only sufficient pressure to drive the aluminum chloride through the degassing chamber.

Before starting operation of the degassing unit the apparatus should be preheated to insure absolute dryness as well as to bring it up to a temperature such that the molten metal will not freeze therein. Once the flow of

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metal has started through the unit it has been found that it is unnecessary to supplement the heat derived from the molten metal to maintain the desired temperature. Prior to introducing the aluminum chloride atmosphere or gaseous chlorine the chamber should be filled with molten metal to a depth indicated at 56 to seal the chamber from the discharge well and thus prevent access of the outside atmosphere or other gases to the chamber during the period of degassing and purification. When the molten metal seal has been thus effected the aluminum chloride or gaseous chlorine may be introduced and the metal level permitted to rise to level 58 just above the bottom of spout 42 in the discharge well. To maintain a uniform flow of metal through the unit it is desirable to keep the metal level in the distributing basin 20 at a substantially constant depth. The flow can be varied, of course, by changing the depth of the pool of metal in basin 20. Also, it is sometimes desirable to block off a portion of the perforations 26 where a marked reduction in metal flow is demanded.

Several factors are important to the successful operation of the process and construction of the apparatus. First, the degassing and purification treatment must be conducted in a confined space out of contact with the air in the melting room. The atmosphere in the confined space must contain aluminum chloride as the essential component for it is this compound which appears to create the condition prerequisite to escape of gas from and reaction with impurities in the subdivided molten metal. If desired, the aluminum chloride may be diluted with such bases as dry air, nitrogen or helium but in any case the aluminum chloride should not be less than the quantity necessary to effect degassing and purification. Where the aluminum chloride is generated by a reaction between chlorine and aluminum no evidence has been observed of chlorine escaping from the treating chamber. It is possible that some chlorine may escape from the pool of metal but if this occurs, the chlorine probably reacts with the metal droplets.

If chlorine is used, only a relatively small amount is required for producing the amount of aluminum chloride essential to the degassing and purification operation. As a result the amount of metal consumed to from the chloride is so small as to be insignificant. Also, the quantity of chlorine consumed to achieve substantial degassing is extremely small as compared to the prior conventional practice of bubbling chlorine through a molten charge in a furnace or in a ladle. Furthermore, it is possible to dilute the chlorine with a gas such as dry air, nitrogen or helium but obviously enough chlorine must be supplied to generate an adequate amount of aluminum chloride.

Another factor to be taken into account in the successful degassing and purification treatment is that of maintaining a flow of aluminum chloride through the treating chamber. In the absence of a flow of the chloride any degassing action shortly comes to a halt as the ability of the chloride vapor to carry away the gas is quickly lost. Moreover, a static atmosphere does not provide the proper condition for the continuous treatment of a large volume of metal. Although the rate of flow of aluminum chloride is not highly critical, nevertheless for most degassing treatments it is preferable to maintain a flow of 1 to 20 pounds per hour. In any given case it will be necessary for those skilled in the art to make minor adjustments in order to use the least amount of chlorine without sacrificing the benefits of the invention.

Instead of providing aluminum chloride from an external source, the solid halide may be placed in the confined space either in contact with the molten metal or in close proximity thereto. In both cases the heat from the molten metal serves to vaporize the halide. To obtain a continuous flow of aluminum chloride through the space, it is necessary to introduce the solid chloride

either continuously or from time to time. This may involve some operating difficulties which are not present only when a gas vapor is introduced into the chamber.

The aluminum chloride may be provided in other ways than those mentioned above. For example, decomposable metal halides may be introduced into the treating chamber in solid or vapor form which react with the molten aluminum. Such halides as the chlorides of zinc, boron or titanium may be used. In addition, organic chlorides may be employed.

A third factor in the successful degassing and purification of aluminous metal is that of subdividing the molten metal into sufficiently small droplets or streams which will permit almost instantaneous escape of any dissolved or sorbed gas and reaction with any sodium or calcium impurity. One very effective means of accomplishing this result is to pass metal through a perforated plate as illustrated in the accompanying figures. Instead of forming droplets, the liquid metal can be subdivided into very thin streams depending upon the size of the hole and pressure exerted on the metal in contact with the plate. Care must be taken to avoid making the perforations in the plate so small that they can easily become clogged. It is also desirable to space the holes far enough apart to maintain the individual lines of drops or streams of metal. The simplest way of passing the subdivided metal through the chamber is that of allowing the droplets or streams to descend under the influence of gravity. However, it is also possible to project the metal into the chamber in the form of a spray and accomplish the same result. In view of the simplicity of the foregoing gravity flow method this is generally preferred in large scale operations.

Another factor is that of providing a sufficient distance for the subdivided metal to travel through the aluminum chloride containing atmosphere. If the metal droplets or streams move at a high velocity, the distance through the atmosphere should be greater than where the velocity is low. A distance sufficient to accommodate gravitational velocity is ordinarily satisfactory. While in theory a greater distance and longer exposure of the metal to the aluminum chloride might be more effective in degassing the metal, this has not proved to be necessary in practical operation. Where the metal drops from a perforated plate a distance of 5 to 8 inches from the plate to the surface of the metal pool is adequate. It is to be understood, of course, that it is not harmful to employ a greater fall in this or similar forms of degassing units but this is not imperative from the standpoint of effective degassing. In units providing for a fall of 5 to 8 inches it has been possible to effectively treat as much as 30,000 pounds of metal per hour. An even higher flow rate can be used if enough fresh aluminum chloride is provided.

The size of the droplets or streams of metal are also important. For rapid and effective treatment there must be a large surface area per unit volume of metal. Generally speaking in a gravity system such as that shown in Figs. 1 and 3 the holes in the perforated plate should be of sufficient size to permit a free flow of the metal without becoming clogged, and yet not so large as to prevent adequate exposure of the metal to the atmosphere. It has been found that holes of a diameter between 0.113 and 0.116 inch produce adequate subdivision of the metal. In addition, the number of holes must be taken into account in treating a predetermined volume of metal within a specified period of time. It has been found, for example, that a plate 10 inches in diameter containing 100 holes 0.166 inch in diameter will conveniently pass 7000 pounds of metal per hour.

The temperature of the metal being treated is not critical except that it should be high enough to prevent freezing in the degassing unit. The metal temperature can be that normally used in melting and pouring practices,

for example, within the range of 1250° to 1400° F., or it may be higher.

The process and apparatus herein described is effective in degassing and purifying both aluminum and aluminum base alloys. Neither the aluminum chloride nor the chlorine have any appreciable effect upon the amount of most of the common alloying elements present in the alloys. If there is a reaction the reduction in quantity is too small to be significant. If magnesium is present, however, it will react with both the chloride and chlorine to form magnesium chloride. In spite of the reaction the flow of metal through the unit is rapid enough that only a very small portion is affected, and generally, this is negligible in respect to the limits specified for the element in the alloy and hence none need be added to compensate for the loss.

The presence of the magnesium chloride in the treating chamber has been found to be distinctly beneficial in the degassing operation even though at first it might be regarded as an undesirable by-product. It appears to supplement the action of the aluminum chloride as the droplets or thin streams of metal pass through it on their way to the pool of metal in the bottom of the chamber. The liquid magnesium chloride, of course, floats on top of the molten metal because of its much lower density. Also, for the same reason it does not become entrapped with the metal discharged from the chamber. After continued operation of the unit too much magnesium chloride may accumulate with the result that the operation must be stopped and the chloride be removed.

As mentioned hereinabove, the treatment of molten aluminous metal with an aluminum chloride atmosphere not only serves to degas the metal but it reduces any sodium or calcium impurity content of the molten metal. For the purpose of this invention these elements are considered as constituting a group of metallic impurities which are removed by the treatment. These impurities are deleterious in certain aluminum base alloys, especially the aluminum-magnesium type, and hence their removal is highly beneficial. It has been found, for example, that a sodium content of 0.002% can be reduced to 0.001% in an aluminum base alloy containing 2.5% magnesium and 0.25% chromium.

While chlorine has been referred to as the gas for reacting with aluminum to generate aluminum chloride it is possible to employ it in combination with decomposable halides of elements which are to be alloyed with aluminum. The halides are preferably vaporized and admixed with the chlorine. It has been found that a small amount of boron or titanium can be conveniently added to an aluminous metal by using a mixture of chlorine and vaporous boron chloride or titanium chloride. The introduction of these alloying elements shortly before the metal is cast appears to have a greater beneficial effect in refining the grain size of the resultant castings, than where the elements are added at an early stage of melting.

The process and apparatus which have been described can be used in single or multiple stages to effect removal of gas and sodium and/or calcium from molten aluminous metal. The single stage operation which has been referred to hereinabove is ordinarily effective in degassing aluminous metal melts. However, where the gas content must be brought to a very low value or it is particularly difficult to extract gas from the alloy, it may be desirable to use two units in tandem. The same considerations apply to the removal of sodium and calcium impurities. In the tandem arrangement the discharge from one unit flows through the second unit. If desired, still another degassing unit could be added. Such a multiple arrangement may also be advantageous where a large amount of gas is held by the melt and the period of flow through a single unit is insufficient to remove all of the gas.

Another advantage gained from the treatment described hereinabove is that of causing separation of any

entrapped oxide particles. It has been noted that a cleaner metal is produced by this method with far less aluminum chloride and chlorine than has been used in prior fluxing practices.

In the construction of the apparatus, the treating chamber is lined with any suitable refractory such as alumina, graphite or silicon carbide which does not react with molten aluminum or aluminum chloride. It is desirable that the refractory not only resist attack by the molten metal but that it be resistant to spalling during heating and cooling. The perforated plate, if one is used, may be made of a strong asbestos board, silicon carbide, graphite or even cast iron. It is often necessary to discard the plate after a period of use because the holes become worn and hence a relatively cheap plate material should be used.

As to the design of the apparatus, the aluminum chloride may be introduced to the chamber through an opening in the vertical wall or through a tube passing through the perforated plate or other cover of the chamber. Likewise, the aluminum chloride vapor may be withdrawn through suitable openings in the walls or cover of the chamber. Also, it is to be understood that the metal may be withdrawn through a tap hole in the bottom of the chamber instead of through the discharge well shown in the figures. The means for supplying metal to the basin and of receiving it from the unit are conventional.

As examples of the effectiveness of our method and apparatus the following examples may be cited.

In one series of tests involving the simultaneous casting of four ingots of an aluminum-2.5% magnesium-0.25% chromium alloy in continuous ingot casting units the molten metal was supplied from a melting furnace at a rate of 22,500 pounds per hour. A degassing unit of the type illustrated in Figs. 3 and 4 was placed in the transfer line to treat all of the metal coming from the furnace. Gaseous chlorine was introduced into the molten metal at the rate of 20 pounds per hour with the resultant production of both aluminum and magnesium chlorides. A small amount of the latter was removed from the unit after each casting operation. Samples of the metal were taken before it entered the degassing unit and after it has passed through the unit for the purpose of determining the density of the metal which in turn indicates the gas content. The density determinations were made by the modified Pfeiffer vacuum method described in the publication, Fosco Foundry Practice, No. 102, November 1950, pages 481 and 482 under a pressure of 2 to 3 mm. The densities of different runs of the alloy are given below in Table I.

Table I.—Densities of Al-2.5% Mg-0.25% Cr alloy

Run No.	Density (g./cc.)	
	Before Degassing	After Degassing
1	2.4	2.6
2	2.3	2.6
3	2.3	2.6
4	2.4	2.65
5	2.4	2.6
6	2.4	2.65

The same alloy when frozen in air and showing no evidence of any gas has a density of 2.6 to 2.65. It is apparent from the results obtained above that the gas in the metal was completely removed for all practical purposes thus indicating the effectiveness of the degassing process.

In a second test involving casting the same type of ingot but using an alloy having a nominal composition of aluminum-5.6% zinc, 2.5% magnesium, 1.3% copper, 0.3% chromium, the following results were obtained

where the alloy was treated at a rate of 27,000 pounds per hour with 10 pounds of chlorine per hour. Both aluminum and magnesium chlorides were produced with beneficial effect upon removal of gas. The density values given in Table II were obtained with the same vacuum test method described above but the pressure was 50 mm. instead of 2 to 3 mm.

Table II.—Density of Al-5.6% Zn-2.5% Mg-1.3% Cu-0.3% Cr alloy

Run No.	Density (g./cc.)	
	Before Degassing	After Degassing
1	2.4	2.75

The normal density of the gas-free alloy is 2.7 to 2.75 and hence it is apparent that the degassing treatment was highly effective in removing gas from the metal.

In a third test made on an Al-0.7% magnesium-0.4% silicon alloy which was cast in tilt molds to produce extrusion ingots, 8 inches in diameter and 27 inches long, the metal was treated at a rate of 4,000 pounds per hour with 5 pounds of chlorine per hour. Again, both aluminum and magnesium chlorides were generated. The following density values were obtained under the foregoing conditions, as shown by the vacuum test method where in the pressure was 2 to 3 mm.

Table III.—Density of Al-0.7% Mg-0.4% Si alloy

Run No.	Density (g./cc.)	
	Before Degassing	After Degassing
1	1.8	2.65
2	2.3	2.65

This alloy when gas-free has a density of 2.6 to 2.65 and hence it is apparent that the metal subjected to the degassing treatment was also free from gas.

Reference has been made to the additional advantage gained from the degassing treatment in removing sodium impurity from molten metal. The following test results illustrate the effect of this treatment upon the sodium content of commercially pure aluminum and an alloy containing 2% magnesium. In these tests 6,000 pounds per hour of metal were passed through the degassing unit and 5 pounds of chlorine per hour were introduced into the molten metal to form aluminum chloride. The results of the tests are given in Table IV.

Table IV.—Sodium content of metal

Metal Treated	Percent Sodium	
	Before Degassing	After Degassing
Commercial Aluminum	0.005	0.002
Al-2% Mg	0.004	0.002

Although the sodium was not completely removed by the degassing process the amount was considerably reduced. Such a reduction is important in cases where a maximum sodium impurity value is specified for a given alloy. It is thus possible to obtain both a gas-free and a low sodium content metal by the invention herein described.

The effect of introducing boron trichloride along with gaseous chlorine is to be seen in the following two examples where commercially pure aluminum was treated. In the first case a mixture of 7.9 pounds of chlorine and

1.9 pounds of boron trichloride per hour was employed while in the second case 7.9 pounds of chlorine and 2.1 pounds of boron trichloride per hour were used. The metal was passed through the unit at a rate of 3,600 pounds per hour. The boron content of the resulting metal is given in Table V below.

Table V.—Addition of boron to aluminum

Run No.	Percent Boron	
	Before Degassing	After Degassing
1.-----	0.000	0.002
2.-----	0.000	0.004

It was noted that the metal treated with the mixture of chlorine and boron trichloride was thoroughly degassed. In addition, the boron trichloride reacted with the aluminum to lave a small quantity of boron. Such a quantity is of importance where grain refinement of the casting is desired.

Having thus described our invention and certain embodiments thereof, we claim:

1. The method of degassing and purifying molten aluminous metal preliminary to casting the same comprising filling a confined space at substantially atmospheric pressure with an atmosphere containing aluminum chloride as the essential degassing component, introducing more aluminum chloride to said space while simultaneously withdrawing previously introduced aluminum chloride whereby a continuously changing atmosphere is provided in said space at substantially atmospheric pressure, subdividing the molten metal as it enters the confined space containing said atmosphere, passing said subdivided liquid metal through the atmosphere whereby the gas content of the metal is reduced and the metal is purified without substantial change in the aluminum content of the melt, collecting the treated liquid metal and thereafter discharging it while molten from said confined space.

2. The method of continuously degassing and purifying molten aluminous metal preliminary to casting the same comprising filling a confined space at substantially atmospheric pressure with a mixture of an inactive gas and aluminum chloride as the essential degassing component, introducing more of the gas and aluminum chloride to said space while simultaneously withdrawing previously introduced gas and aluminum chloride whereby a continuously changing atmosphere is provided in said space at substantially atmospheric pressure, subdividing the stream of molten metal at the top of said confined space containing said gas and aluminum chloride and allowing it to drop through the said gaseous mixture without substantial change in the aluminum content of the melt, collecting the subdivided liquid metal at the bottom of said confined space and thereafter discharging the treated liquid metal therefrom.

3. The method of degassing and purifying molten aluminous metal preliminary to casting the same comprising filling a confined space at substantially atmospheric pressure with aluminum chloride vapor, introducing more aluminum chloride while simultaneously withdrawing previously introduced chlorine vapor whereby a continuously changing atmosphere is provided in said confined space at substantially atmospheric pressure, subdividing the molten metal as it enters the confined space containing said aluminum chloride vapor, passing said subdivided liquid metal through the aluminum chloride vapor whereby the metal is degassed and purified without substantial change in the aluminum content of the melt, collecting the treated liquid metal and thereafter discharging it while molten from said confined space.

4. The method of simultaneously degassing and purifying an aluminous metal melt and adding an alloying

element thereto by decomposition of a halide of said element preliminary to casting the alloy comprising filling a confined space at substantially atmospheric pressure with an atmosphere containing aluminum chloride as the essential degassing component and the vapor of a decomposable halide of the element to be added to the melt, introducing more aluminum chloride and decomposable halide while simultaneously withdrawing previously introduced aluminum chloride whereby a continuously changing atmosphere is provided in said space at substantially atmospheric pressure, subdividing the molten metal as it enters the confined space containing said atmosphere, passing said subdivided liquid metal through the atmosphere whereby the metal is degassed, purified and alloyed without substantial change in the aluminum content of the melt, collecting the treated liquid metal and thereafter discharging it while molten from said confined space.

5. The method of simultaneously degassing and purifying an aluminous metal melt and adding boron thereto preliminary to casting the alloy comprising filling a confined space at substantially atmospheric pressure with an atmosphere consisting of aluminum chloride and boron trichloride vapors, introducing more aluminum chloride and boron trichloride vapor while simultaneously withdrawing previously introduced aluminum chloride whereby a continuously changing atmosphere is provided in said space at substantially atmospheric pressure, subdividing the molten metal as it enters the confined space containing said atmosphere, passing said subdivided liquid metal through said atmosphere whereby the metal is degassed, purified and boron added thereto without substantial change in the aluminum content of the melt, collecting said treated liquid metal and thereafter discharging it while molten from said confined space.

6. The method of degassing and purifying molten aluminous metal preliminary to casting the same comprising initially partially filling a confined space with sufficient molten metal to form a pool therein, introducing gaseous chlorine below the surface of said pool of metal whereby aluminum chloride in vapor form is generated, filling said confined space above the pool of molten metal with an atmosphere at substantially atmospheric pressure containing said aluminum chloride as the essential degassing component, continuing the introduction of gaseous chlorine while simultaneously withdrawing aluminum chloride from said space whereby a continuously changing atmosphere is provided in said confined space at substantially atmospheric pressure, the rate of introduction of chlorine only being sufficient to form additional aluminum chloride to replace that withdrawn from said confined space, subdividing the remainder of the molten metal to be treated as it enters said confined space, passing said subdivided liquid metal through said flowing atmosphere without substantial change in the aluminum content of the melt, collecting said subdivided metal in said molten metal pool and thereafter discharging said treated liquid metal from said confined space.

7. The method of degassing and purifying molten aluminous metal preliminary to casting the same comprising initially partially filling a confined space with sufficient molten metal to form a pool therein, introducing a gaseous mixture of chlorine and an inactive gas below the surface of said pool of metal whereby aluminum chloride in vapor form is generated, filling said confined space above said pool of molten metal with a mixture of aluminum chloride and said inactive gas at substantially atmospheric pressure, continuing the introduction of said gaseous mixture while simultaneously withdrawing aluminum chloride from said space whereby a continuously changing atmosphere is provided in said confined space at substantially atmospheric pressure, the rate of introduction of chlorine only being sufficient to form additional aluminum chloride to replace that withdrawn from said confined space, subdividing the remainder of the

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molten metal to be treated as it enters said confined space, passing said subdivided liquid metal through said flowing atmosphere without substantial change in the aluminum content of the melt, collecting said subdivided metal in said molten metal pool and thereafter discharging said treated liquid metal from said confined space.

8. The method of degassing and purifying molten aluminous metal while adding an alloying element thereto by decomposition of a halide of said alloying element preliminary to casting the alloy, comprising initially partially filling a confined space with sufficient molten metal to form a pool therein, introducing a mixture of gaseous chlorine and decomposable metal halide in vapor form below the surface of said pool of molten metal whereby aluminum chloride in vapor form is generated, and the metal halide is decomposed leaving the metal portion alloyed with the melt, filling said confined space above the pool of molten metal with an atmosphere at substantially atmospheric pressure containing said aluminum chloride as the essential degassing component, continuing the introduction of the mixture of chlorine and halide while simultaneously withdrawing aluminum chloride from said space whereby a continuously changing atmosphere is provided in said confined space at substantially atmospheric pressure, the rate of introduction of chlorine and metal halide vapor only being sufficient to form additional aluminum chloride to substantially replace that withdrawn from said confined space, subdividing the remainder of the molten metal to be treated as it enters said confined space, passing said subdivided liquid metal through said flowing atmosphere without substantial change in the aluminum content of the melt, collecting said subdivided metal in a pool at the bottom of said confined space and thereafter discharging said treated liquid metal from said confined space.

9. The method of degassing and purifying molten aluminous metal while adding boron thereto by decomposition of boron trichloride preliminary to casting the alloy comprising initially partially filling a confined space with sufficient molten metal to form a pool therein, introducing a mixture of gaseous chloride and boron trichloride vapor below the surface of said pool of molten metal whereby aluminum chloride in vapor form is generated and the boron trichloride is decomposed leaving boron in said melt, filling said confined space above the pool of molten metal with an atmosphere at substantially atmospheric pressure consisting of said aluminum chloride and any unreacted chlorine and boron trichloride, continuing the introduction of chlorine and boron trichloride while simultaneously withdrawing aluminum chloride from said space whereby a continuously changing atmosphere is provided in said confined space at substantially atmospheric pressure, the rate of introduction of said chlorine and boron trichloride only being sufficient to form additional aluminum chloride to substantially replace that withdrawn from said confined space, subdividing the remainder of the molten metal to be treated as it enters said confined space, passing said subdivided liquid metal through said flowing atmosphere without substantial change in the aluminum content of the melt, collecting said subdivided metal in a pool at the bottom of said confined space and thereafter discharging said treated liquid metal from said confined space.

10. The method of degassing and purifying a molten aluminum base alloy containing magnesium preliminary to casting the alloy comprising filling a confined space at substantially atmospheric pressure with an atmosphere containing aluminum chloride as the essential degassing component, introducing more aluminum chloride to said space while simultaneously withdrawing previously introduced aluminum chloride whereby a continuously changing atmosphere is provided in said space at substantially atmospheric pressure, subdividing the molten metal as it enters said confined space, passing said subdivided liquid metal through said atmosphere without substantial change

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in the aluminum content of the melt, collecting said subdivided liquid metal in a pool at the bottom of said confined space, forming a layer of molten magnesium chloride on top of the body of said collected liquid metal, and thereafter discharging said treated liquid metal from said confined space.

11. The method of degassing and purifying a molten aluminum base alloy containing magnesium preliminary to casting the alloy comprising partially filling a confined space with sufficient molten metal to form a pool therein, introducing gaseous chlorine below the surface of said pool whereby aluminum chloride vapor is generated and liquid magnesium chloride is formed, filling said confined space above the pool of molten metal with an atmosphere at substantially atmospheric pressure containing said aluminum chloride as the essential degassing component, continuing the introduction of gaseous chlorine while simultaneously withdrawing aluminum chloride from said space whereby a continuously changing atmosphere is provided in said confined space at substantially atmospheric pressure, the rate of introduction of chlorine only being sufficient to form additional aluminum chloride without substantial change in the aluminum content of the melt to replace that withdrawn from said confined space and to form additional magnesium chloride, forming a layer of molten magnesium chloride on top of said pool of metal subdividing the remainder of the molten alloy to be treated as it enters said confined space, passing the subdivided liquid alloy through said flowing atmosphere and the layer of liquid of magnesium chloride, collecting said subdivided alloy in said pool and thereafter discharging said treated liquid metal from said confined space.

12. Apparatus for degassing and purifying molten aluminous metal at substantially atmospheric pressure comprising a metal treating chamber having a top, side walls and a floor, the top consisting of a shallow open top receptacle for receiving the molten metal and dispersive means in the base of said receptacle for forming droplets or thin streams of molten metal, said receptacle being removable but sealable to the side walls of said chamber, the floor of said chamber providing a complete bottom closure thereof, a discharge well juxtaposed laterally of said chamber and communicating therewith through at least one aperture in the side wall adjacent the bottom thereof whereby the molten metal collected in the lower portion of the chamber flows into the discharge well and fills it to substantially the same level as that in the chamber, means for introducing gas or vapor to said chamber at not less than atmospheric pressure and means for receiving said gas or vapor discharged from said chamber.

13. Apparatus for degassing and purifying molten aluminous metal at substantially atmospheric pressure comprising a metal treating chamber having a top, side walls and a floor, the top consisting of a shallow open top receptacle for receiving the molten metal and dispersive means in the base of said receptacle for forming droplets or thin streams of molten metal, said receptacle being removable but sealable to the side walls of said chamber, the floor of said chamber providing a complete bottom closure thereof, a discharge well juxtaposed laterally of said chamber and communicating therewith through at least one aperture in the side wall adjacent the bottom thereof whereby the molten metal collected in the lower portion of the chamber flows into the discharge well and fills it to substantially the same level as that in the chamber, an opening in the side wall of the chamber above the level of the pool of molten metal accumulating therein and communicating with means for introducing gas or vapor at a pressure not less than atmospheric pressure and a second opening in the side wall above the level of the molten metal communicating with condensing means for receiving said gas or vapor.

14. Apparatus for degassing and purifying molten aluminous metal at substantially atmospheric pressure comprising a metal treating chamber having a top, side

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walls and a floor, the top consisting of a shallow open top receptacle for receiving the molten metal and dispersive means in the base of said receptacle for forming droplets or then streams of molten metal, said receptacle being removable but sealable to the side walls of said chamber, the floor of said chamber providing a complete bottom closure of the base thereof, a discharge well juxtaposed laterally of said chamber and communicating therewith through at least one aperture in the side wall adjacent the bottom thereof whereby the molten metal collected in the lower portion of the chamber flows into the discharge well and fills it to substantially the same level as that in the chamber, a tube entering the treating chamber and terminating adjacent the floor thereof, said tube being adapted to pass chlorine into the pool of molten metal accumulating in the bottom portion of the treating chamber and an opening in the upper portion of the chamber connected to a condenser for receiving aluminum chloride.

15. Apparatus for degassing and purifying molten aluminous metal at substantially atmospheric pressure comprising a metal treating chamber having a top, side walls and a floor, the top consisting of a shallow open top basin for receiving the molten metal, the base of said basin being perforated to discharge the metal in the form of droplets or thin streams, said basin being removable but sealable to the side walls of said chamber, the floor of said chamber providing a complete bottom closure there-

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of, a discharge well juxtaposed laterally of said chamber, the floor of which is an extension of the chamber floor, at least one aperture at the base of the side wall for discharge of the molten metal from the chamber to the discharge well, said aperture being of such size that it allows a free flow of metal therethrough and extends to a height such that it is completely covered by the molten metal accumulating in the chamber and discharge well, an opening in the wall of said chamber above the level of the pool of molten metal accumulating therein connected to pressure source of gas or vapor capable of introducing said gas or vapor into the chamber at not less than atmospheric pressure, and a second opening in the side wall of said chamber also above the level of the molten metal pool connected to a condenser for receiving said gas or vapor.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 2,840,463

June 24, 1958

Philip T. Stroup et al.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 2, line 23, after "given" insert -- serving --; column 3, lines 14 and 15, for "modifiield" read -- modified --; column 4, line 31, for "bases" read -- gases --; line 44, for "from" read -- form --; column 5, line 65, for "0.116" read -- 0.166 --; column 7, line 38, for "Gaseus" read -- Gaseous --; column 9, line 21, for "lave" read -- leave --; column 12, line 2, strike out "liquid"; column 13, line 4, for "then" read -- thin --.

Signed and sealed this 26th day of August 1958.

(SEAL)

Attest:

KARL H. AXLINE

Attesting Officer

ROBERT C. WATSON
Commissioner of Patents