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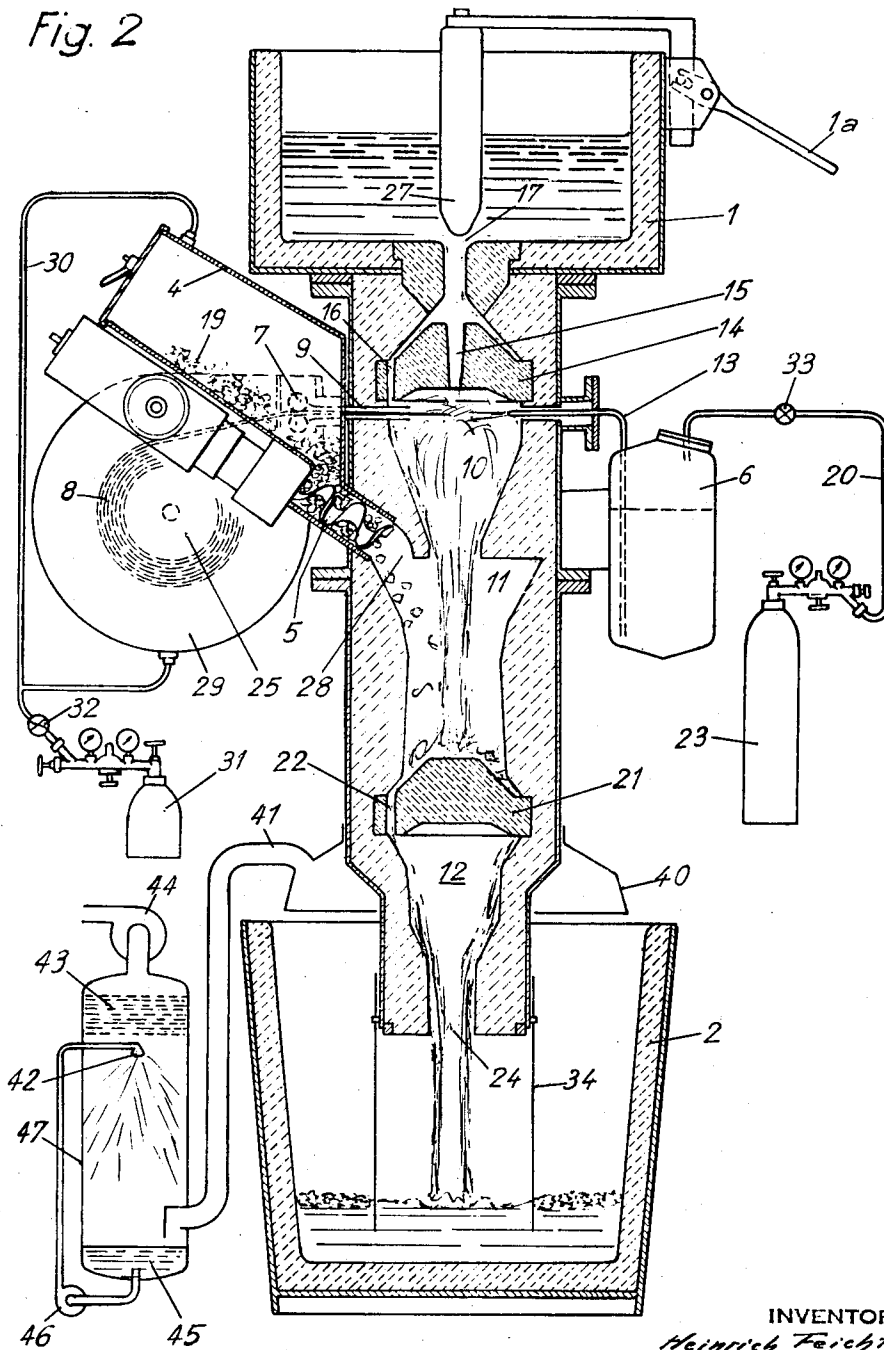
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METHOD AND APPARATUS FOR TREATING METALLIC MELTS

Filed Feb. 24, 1965

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Fig. 2



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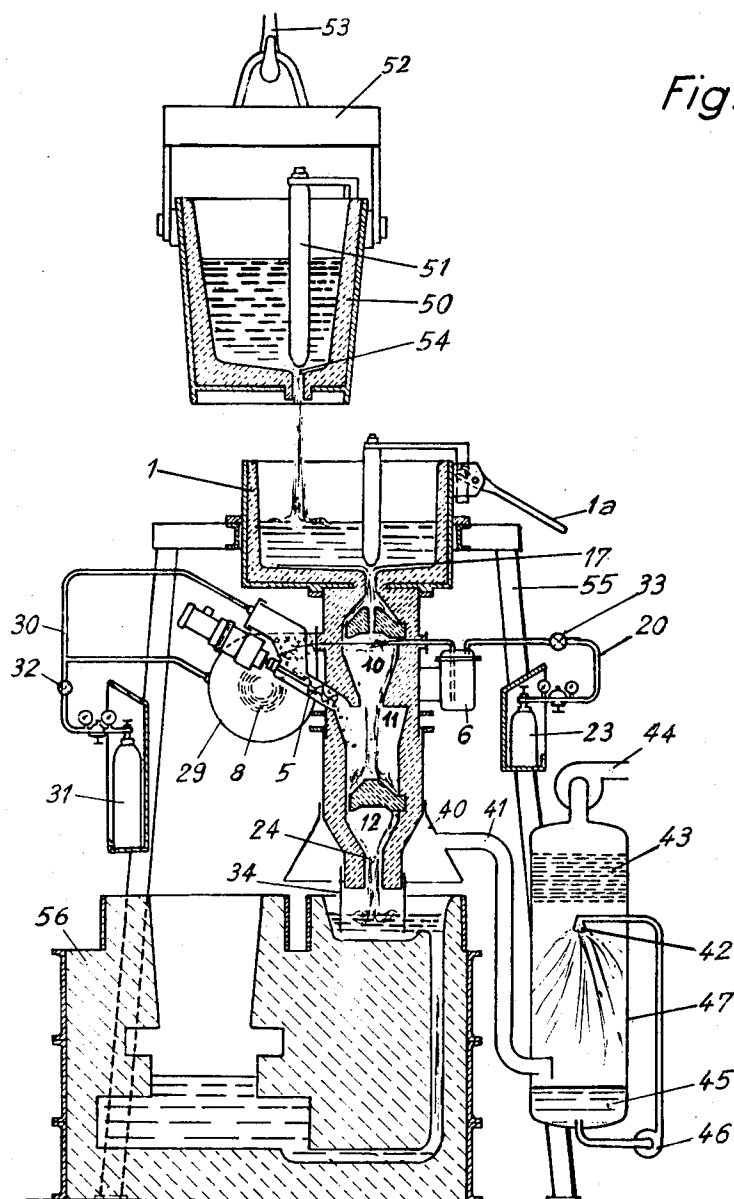


Fig. 3

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3,356,489

METHOD AND APPARATUS FOR TREATING METALLIC MELTS

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Filed Feb. 24, 1965, Ser. No. 434,856

Claims priority, application Switzerland, Feb. 28, 1964, 2,478/64

10 Claims. (Cl. 75—46)

ABSTRACT OF THE DISCLOSURE

The present invention relates to a method of and apparatus for treating molten metallic charges, especially steel melts, with a reactive material for purposes of degasifying, deoxidizing, the formation of finely and uniformly distributed crystal nuclei, and the uniform introduction and distribution of alloying elements into the melt while excluding air.

The present invention is characterized primarily in that the melt enters the treatment chamber or reaction chamber broken up in such a way that it on one hand flows down along the wall of said chamber, which represents a pear-shaped downwardly tapering chamber, whereas on the other hand a portion of the melt is passed as a jet through the central part of said pear-shaped chamber. While this last mentioned jetlike part flows through the central portion of said chamber, reaction and alloying materials in gaseous, liquid or solid condition are added thereto. At the respective temperature of the melt, the reaction and alloying materials thus added to the melt will in an explosion-like manner be thrown in a finely distributed condition in the form of particles in all directions and against the melt which flows downwardly along the wall of said chamber.

The present invention relates to a method and apparatus for treating molten metallic charges, especially steel melts, with a reactive material for purposes of degasifying, deoxidizing, the formation of finely and uniformly distributed crystal nuclei and the uniform introduction and distribution of alloying elements into the melt while excluding air.

Methods and devices of the above general character are already known in which the introduction of reactive material and alloying elements is effected in two vertical flow-through reaction chambers which are interconnected and are provided with a refractory lining.

It is an object of the present invention to improve the above-mentioned method and device in order to obtain a better mixing of the melt and the reaction and alloying materials introduced into the chambers.

It is also an object of this invention to provide a method of and apparatus for treating metallic melts as set forth above, which will permit introducing the required quantities of alloying elements and reaction materials in a precisely measured and controlled manner.

These and other objects and advantages of the invention will appear more clearly from the following specification in connection with the accompanying drawings, in which:

FIG. 1 illustrates a section through an apparatus according to the present invention with a treatment chamber,

FIG. 2 represents a section through the same apparatus as shown in FIG. 1 but with an additionally alloying chamber,

FIG. 3 represents the application of the inventive apparatus in casting a normal production mould.

The present invention is characterized primarily in that the melt enters the treatment chamber or reaction chamber broken up in such a way that it on one hand flows

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down along the wall of said chamber, which represents a pear-shaped downwardly tapering chamber, whereas on the other hand a portion of the melt is passed as a jet through the central part of said pear-shaped chamber. While this last mentioned jetlike part flows through the central portion of said chamber, reaction and alloying materials in gaseous, liquid or solid condition are added thereto. At the respective temperature of the melt, the reaction and alloying materials thus added to the melt will in an explosion-like manner be thrown in a finely distributed condition in the form of particles in all directions and against the melt which flows downwardly along the wall of said chamber. This explosion-like reaction is furthermore aided by the fact that in the upper portion of the treatment chamber there is provided a conical body which divides the melt in such a way that part of the melt covers the wall of the treatment chamber to a major extent.

The said conical body has its central portion provided with a bore to permit treatment of that part of the melt which passes therethrough.

Referring now to the drawings in detail, as outlined above, the apparatus of FIGS. 1 and 2 is the same with the exception that FIG. 2 contains an additional alloying chamber and, therefore, all corresponding parts in FIGS. 1 and 2 have been designated with the same reference numerals.

The apparatus shown in the drawings comprises an upper ladle 1 adapted to receive a melt to be treated from an electric arc furnace. This melt is supplied to said upper ladle 1 in such a way that during the entire treatment process said ladle remains filled with liquid steel at an approximately uniform level. The bottom of ladle 1 is provided with an opening 17, the lower end of which flares and is adapted to be closed by a stopper 27 which may be lowered and raised selectively through the intervention of a handle 1a. Within the flared out section of opening 17 there is provided a conical body or divider 14 having a central bore or first passage means therethrough and also having openings or second passage means 16 therethrough near the periphery of the body 14. This body 14 serves for dividing the melt flowing downwardly from opening 17. The bore or first passage means 15 through which the melt is able to pass into a treatment chamber 3, is substantially coaxial with opening 17. It will thus be appreciated that the melt passing through opening 17 will on one hand flow through the openings 16 and on the other hand flow through the central bore 15 into treatment chamber 3. The melt passing through openings 16 will flow downwardly along the inner wall of the pear-shaped chamber 3 and shortly before reaching the bottom opening 18 of chamber 3 will mix with the treated melt which passed through bore 15 and will together therewith in a single jet pass through an opening 24 into a collecting ladle 2. While the openings or second passage means 16 are shown as a straight bore, they may include a spiral path for imparting a twist upon the melt passing therethrough.

The lower end 1b of the apparatus has connected thereto a cylindrical tubular body 34 which extends approximately to the bottom of the collecting ladle 2. When the melt flows into collecting ladle 2, said tubular body 34 will prevent the spray of the melt from hitting the inner wall of the collecting ladle 2. That portion of tubular body 34 which is immersed into the melt in ladle 2 will gradually melt and combine with the melt in the ladle. Therefore, each time ladle 2 has been filled, it will be necessary to connect a new tubular body 34 to the lower end 1b surrounding opening 24 of the apparatus.

In order to bring the apparatus according to FIGS. 1 and 2 into readiness for operation, first opening 17 is closed by stopper 27, whereupon all chambers communi-

cating with the treatment chamber 3 and/or 11 (FIG. 2) are scavenged with argon or another suitable gas, such as helium or nitrogen.

To this end, the inner chambers of a container 4 for alloying materials 19 and a container 29 for receiving coiled metal strands (one container only being shown) are through the intervention of a connecting conduit 31a, 30 scavenged with gas from a source of gas stored for instance in a container 31. From the inner chambers of containers 4 and 29 the gas passes through openings 9 and 28 into treatment chambers 3 and 11 while the air escapes through openings 24. After the inner chambers have been scavenged, the gas supply from container 31 is shut off by corresponding manipulation of shut-off valve 32, and the treatment process for the melt is initiated. In connection with the scavenging of the above mentioned inner chambers by gas, it is to be noted that containers 4 and 29 are sealed completely air-tight.

Over the embodiment of FIG. 1, merely the supply of alloying materials or metallic salts is effected differently in the arrangement of FIG. 2. Whereas said supply in the arrangement of FIG. 1 is effected in the same manner as that of the reaction materials in the form of a metallic strand (not shown) of the melt, the supply of alloying material to the melt according to the embodiment of FIG. 2 is effected within a second treatment chamber 11.

According to the embodiment of FIG. 1, the melt introduced into the upper ladle 1 is in treatment chamber 3 in a manner known per se treated with deoxidizing metallic elements of the first, second and third group of the periodic system and with metallic salts, especially halides, and the mixtures thereof of the third, fourth and fifth group of the periodic system, especially carbon, silicon, titanium, zirconium, vanadium, niobium, tantalum, molybdenum and tungsten.

The conical body 14 with its bore 15 and passages 16 is instrumental in the treatment of the melt in treatment chamber 3. Furthermore, for purposes of treating the melt in the upper range of chamber 3 there is provided a nozzle 26 through which a mixture of reaction material and gas hits the melt leaving bore 15 at such a speed that said melt will be split up by the kinetic energy of said jet through said nozzle 26. The over-pressure built up in the chambers sealed against the atmosphere will escape together with the downwardly flowing melt. Furthermore, above chamber 3 approximately at the level of nozzle 26 there are provided two openings 9 through which in a manner known per se a wire 8 of deoxidized metallic elements and a further wire (not illustrated) of alloying materials are fed against the melt leaving bore 15. Wire 8 composed of reaction materials, and in a similar manner the non-illustrated wire of alloying materials, are wound upon a roller 25 rotatably arranged in container 29. The feeding of wire 8 and similarly of the non-illustrated wire of alloying materials is best effected by rotating roller 25 through the intervention of a non-illustrated infinitely variable transmission.

The melt leaving bore 15 collides within a narrow limited range simultaneously with the gas jet leaving nozzle 26 and with the two metallic strands. Due to the kinetic energy of the gas jet and in view of the reaction of the melt with the metallic strands, the melt is split up into fine particles whereby the ability of the melt to absorb the ingredients contained in the gas jet and the metallic wire is materially enhanced. When the melt collides with the gas jet leaving nozzle 26 and with the metallic wires continuously advanced during the treatment of the melt, there will take place in the collision range of the four media a strong reaction so that the melt will be vehemently split up into fine particles and thrown against the wall of treatment chamber 3. To avoid damaging the lining of the inner wall of treatment chamber 3, passages 16 of conical body 14 are so designed that the melt while flowing through treatment chamber 3 covers the inner wall of chamber 3 to a major

extent thereby forming a protective cover against the particles sprayed around in the collision chamber 10 of the said four media.

With regard to the gas leaving nozzle 26 and intermixed with reaction material, it is to be noted that a steel container 23 serves as gas source, said container communicating through a conduit 20 and shut-off valve 33 with a pressure container 6. Pressure container 6 is filled with a reaction material enriched liquid which when valve 33 is open will, due to the gas pressure in container 23, be conveyed through conduit 13 to nozzle 26. The melt treated in the above outlined manner then flows through opening 24 into collecting ladle 2.

According to the embodiment shown in FIG. 2, the melt treated in treatment chamber 3 and containing reaction material passes from opening 18 of chamber 3 in the form of a jet into a second treatment chamber 11 in order to be intermixed with alloying substances 19, such as halides. The lower portion of treatment chamber 11 is provided with a closure body 21 which has passages 22 therethrough. Closure body 21 brings about an accumulation and mixture of the melt with alloying substances 19. The upper portion of chamber 11 has an opening 28 through which by means of a conveyor worm 5 alloying substances 19, such as halides, are conveyed to the melt.

The alloying substances 19 are conveyed from container 4 in predetermined measured quantities into treatment chamber 11 while the melt passes through chamber 11. The alloying substances 19 due to their weight drop upon the closure body 21 and are subjected to an intermixture with the melt flowing over the closure body 21. A highly satisfactory intermixture of the melt with the halides is assured, particularly in view of the fact that the melt will as a single jet leave chamber 3 through opening 18 and will impact upon closure body 21 where it temporarily accumulates together with the halides. After the halides have intermixed with the melt, the thus obtained mixture is conveyed through passages 22 of body 21 and through chamber 12 and opening 24 into collecting ladle 2 of the device.

As has been mentioned above, during the treatment of the melt in treatment chambers 3 and 11, freed gases may together with the melt flowing into ladle 2 escape toward the outside. However, in a manner known per se, it is also possible at suitable sections in the walls of the treatment chambers to provide venting passages for releasing the freed gases. In addition thereto, filtering installations of any standard design may be provided through which the freed and outwardly flowing harmful gases will be made harmless.

As will be evident from the above, an arrangement according to the present invention presents a considerable improvement over heretofore known arrangements of the type involved with two treatment chambers inasmuch as a considerably improved intermixture of the melt with the reaction and alloying materials introduced therinto will be obtained. This permits the feeding of any desired quantity of reaction and alloying materials into the melt.

Example 1

An example of the treatment of a steel melt (13% chrome steel) with the apparatus as shown in FIG. 1. A melt of the following composition was carried out as follows:

	P.p.m.
65 C -----	0.08
Mn -----	0.5
Si -----	0.45
Cr -----	12.5
70 Ni -----	3.9
Mo -----	0.5
Fe -----	Remainder
H ₂ -----	5.8

The complete apparatus as shown in FIG. 1 was placed by crane in the pouring pit below the pouring spout of

a 10 ton electric arc furnace. The molten steel from the furnace had a temperature of 1660° C. and was teemed in to ladle 1.

The stopper 27 was so regulated by the lever 1a that 45 tons of molten steel flowed through the apparatus in 90 seconds. The furnace was tilted so that the level of molten steel in ladle 1 was held at about half full. At the same time the motor drive was switched on delivering the Mg wire into chamber 10.

Through an infinitely variable drive, the rollers 7 were turned to deliver the Mg wire at a controlled rate of 2.1–2.2 cm./second. The diameter of the Mg wire was 3 mm. At the same time as the inlet of molten steel, the pressure container 6 of fluid reagents was also brought into action.

This contained 3.5 kg. TiCl_4 at a temperature of 25° C. By opening the electro-magnetic valve 33, an initial pressure of 0.2 atmosphere, later building up to about 0.5 atmosphere, was formed. For this, argon was used from the pressure bottle 23 which was supplied through the conduit 20.

Argon from the pressure cylinder 31 was supplied over the nozzle 13 spraying the TiCl_4 as well as through the openings 9 for the Mg wire and surrounding the Mg wire so that the part of melt which passed through the bore 15 was immediately sprayed into fine droplets. From the above reaction, Mg vapour and smoke are produced which harm the operators. Therefore the fumes are extracted by a filter plant 40–47, as in FIG. 2.

The chemically reactive materials as well as dust are, to the greater part, washed away.

The filter plant requires an extraction fan 44 with a capacity of 30 m.³/min. being drawn through the cowl 41. A fine spray is produced inside the filter by the jets 42, the outlet liquid 45 being circulated continuously back through the jets by a pump 46. This pump has a capacity of 12 m.³/hr. at a pressure of approx. 3 atmospheres, caustic soda is added to the circulating water to react with the acids and reactive products of the extracted gases.

In the reaction column comprising parts 1b, 3 and 10 the process is as follows: The metal which flows through the bore 15 is sprayed into fine droplets in chamber 10 and mixes at 18 with the remainder of the melt which flows through the openings 16 and down over the walls of the chamber. Finally, the melt accumulates in ladle 2 where the shield 34 is dissolved as the level rises.

As a result, a melt was produced which contained only 2.5 p.p.m. of hydrogen from a charged melt which had contained initially 5.8 p.p.m. of hydrogen and can be taken as a very high degree of degasification. Also the O_2 was reduced from 95–35 p.p.m. By this method, using TiCl_4 treatment, Mg reduced steel gave a fine structure and sound castings.

Example II

Example of the treatment of a stainless steel melt in the apparatus, as shown in FIG. 2.

A stainless steel melt of the following composition was treated:

	P.p.m.
C -----	0.07
Mn -----	0.45
Si -----	0.9
Cr -----	15.5
Ni -----	13.5
Mo -----	2.65
Wb -----	0.6
S -----	0.012
Fe -----	Remainder
H ₂ -----	6.2

The process was so carried out that:

- (1) A decrease in H_2 and O_2 content occurred.
- (2) A decrease in the S content was obtained.
- (3) Special grain refinement was produced.

The treatment was carried out on a 5 ton melt. The flow-through time was 122 seconds, the inlet and regulation of the melt was carried out with lever 1a in the same manner as in Example I. The temperature of the melt was 1650° C.

While the deoxidation in Example I was with Mg, in Example II a mixture of reagents was fed in by a screw feed 5.

This consisted of 1 part granulated Ca-Si (approx. 33% Ca-65% Si) 1 part sodium borate, 2 parts of granulated CaO and 2 parts CaO (in powder form). Hopper 4 contained 30 kilo of this mixture. In Example II the rollers 7 were regulated to give a feed of 1–1.2 mm./second so that only 14 kilo Mg wire was delivered during the total treatment time of 122 seconds into the reaction chamber.

The screw feed 5 was rotated at such a speed as to disperse 22 kilo of the above mixture into the reaction chamber 11 in 122 seconds. The container for the fluid reaction material was filled with niobium chloride



at a temperature of 260° C. The niobium chloride was sprayed through a 2.2 mm. nozzle into the chamber 10 at a pressure of 0.8 atmosphere. The steel stream which flowed through the bore 15 was disintegrated into small droplets by explosive reaction of the Mg wire, led in through inlet 9. Also the NbCl_5 fed through the nozzle 13 produced further dispersion of the steel stream into fine droplets.

Through inlet 9 a further mixture of 10% CF_3Cl and 90% argon was blown in against the finely dispersed steel stream. This CF_3Cl -argon mixture was supplied from cylinder 31. Experiments show a particularly strong hydrogen reducing action.

The finely dispersed particles of the steel stream flowed into chamber 11 where it met and mixed with the desulphurising and deoxidising reagents which were fed in uniformly through the screw feed 5.

Finally, the steel was similarly collected in ladle 2, as in Example I, from which it was later poured into moulds.

The lining of the column which consisted of Al and MgO bricks, must have a strong resistance to the attack of the slag forming constituents from the hopper 4. The complete column is so constructed that the lining can be easily replaced.

The final results of the experiment showed:

- (1) That the H_2 content was lowered to 1.8 p.p.m., the O_2 to 12 p.p.m.
- (2) The S content was decreased from 0.012 to 0.006%.

The addition of the material from the hopper 4 formed a highly fluid slag which protected the melt in ladle 2 from the atmosphere allowing further transport. The fumes that were produced during the process were extracted by the filter plant as described previously. This consisted of 40 an extraction hood, 41 extraction conduit, 42 spray jets, 43 a filter bed of ceramic, 44 an extraction fan with an intake of 30 m.³/minute, 45 a circulating liquid mixed, in the previous case, with 10% KOH, 46 a liquid centrifugal pump with an output of 12 m.³/minute and 47 the filter container made from 18/8 steel plate. The finely dispersed form in which the NbCl_5 is fed as well as the deoxidation with Cu and Mg produce under the conditions existing in the reaction column (i.e. completely air tight) a melt which gives a fine, uniformly distributed grain size. After pouring, the castings produced were completely sound and free from porosity.

The examples describe here the use of the reaction column for the treatment of steel melts in connection with an electric arc furnace. They show that the reaction column can also be used for the addition of other

melt additions during treatment. The short cycle processes carried out here could also be used for continuous treatment.

Example III

In a third example the installation of the reaction column is described whereby the steel is poured from a ladle 50 above the column 1b and into a mould. In the ladle 50, which was supported by a crane 53, were 3.6 tons of molten steel.

The most important elements in this melt were:

	Percent
C -----	0.22
Mn -----	0.65
Ni -----	0.21
Si -----	0.32

By opening the stopper 51, the flow of molten steel was regulated through the opening 51 so that the level in ladle 1 was held at half full. The flow of metal was controlled by lever 1a, so that the 3.6 tons required 160 seconds to flow through.

The melt was deoxidised by Mg wire 8 additions as well as granulated CaSi fed in by the screw feed 5. For grain refinement, a mixture of carbon tetrachloride 70% and titanium chloride 30% was dispersed into the reaction chamber 10 from the container 6. The addition of these reagents was carried out in a similar manner to that described in Example I and II. The extraction of the fumes produced was similar to Examples I and II using the filter plant 40-47. The temperature of the steel in the ladle 50 was 1660° C., the temperature at the exit of the column at 24 was 1590° C. As in the previous experiments, the melt was thoroughly deoxidised, the hydrogen as well being substantially reduced. The oxygen was lowered from 75 to 12 p.p.m., the hydrogen reduced from 5.2 p.p.m. to 2.8 p.p.m. The casting produced in the mould 56 showed a uniform structure which was due to the uniform deoxidation as well as to the titanium carbide additions. The titanium carbide was obtained from the mixture of carbon tetrachloride and titanium chloride (2.5 kg. of this mixture was used). 1.3 kg. of Mg was added in the form of 3 mm. diameter wire as well as 1.2 kg. of CaSi.

What I claim is:

1. A method of treating metallic melts in a continuous flow through a treatment chamber having an inlet and an outlet, which includes the steps of: introducing the melt to be treated into said treatment chamber while splitting said introduced melt into a first portion and a second portion, passing said first portion along the wall surface of said treatment chamber in the direction toward said outlet while passing said second portion likewise in the direction toward said outlet in the form of a central stream through a portion of said chamber in spaced relationship to said second portion, prior to said central stream reaching said outlet introducing material to be added to said melt into said stream so as to cause said material in an explosion-like manner to break up into fine particles and to be thrown into said second portion flowing along said wall surface for intermixture therewith, and uniting said first and second portions prior to their leaving said outlet.

2. A method of treating metallic melts in a continuous flow through a treatment chamber having an inlet and an outlet, which includes the steps of: introducing the melt to be treated into said treatment chamber while splitting said introduced melt into a first portion and a second portion, passing said first portion along the wall surface of said treatment chamber in the direction toward said outlet while passing said second portion likewise in the direction toward said outlet in the form of a central stream through a portion of said chamber in spaced relationship to said second portion, prior to said central stream reaching said outlet introducing reaction material to be added

to said melt into said stream so as to cause said material in an explosion-like manner to break up into fine particles and to be thrown into said second portion flowing along said wall surface for intermixture therewith, uniting said first and second portions prior to their leaving said outlet and passing the thus reunited portions in the form of a stream through said outlet, and subsequently intermixing said last-mentioned stream with an additional material to be added to the melt.

3. A method according to claim 2, which includes the step of temporarily accumulating said last-mentioned stream for feeding alloying material thereto.

4. A method according to claim 1, which includes preventing atmospheric air from entering said chamber means.

5. An apparatus for treating metallic melts in a continuous manner, which includes: a vessel for receiving the melt to be treated, said vessel having a discharge opening in the lower portion thereof, a chamber arranged below said vessel and having an upper inlet for communication with said discharge opening and also having a lower outlet for discharging treated melt, said chamber including an upper section flaring downwardly and a lower section tapering downwardly in the direction toward said outlet, and dividing means arranged in said upper section and having its central portion provided with first downwardly directed passage means and having its marginal area provided with second downwardly directed passage means for splitting the melt entering said upper section into a marginal flow along the wall surface of said upper section and into a central flow spaced from said marginal flow, said chamber being provided with passage means arranged below said dividing means and extending into said chamber below said dividing means for feeding material to be added to the melt into said lower section.

6. An apparatus according to claim 5, in which said dividing means is formed by a frusto-conical body with a central downwardly tapering bore.

7. An apparatus according to claim 5, in which the said lower section tapers toward said outlet to such an extent that the said lower section will during the passage of the melt therethrough act as a closed chamber.

8. An apparatus according to claim 5, in which said second passage means include a spiral path for imparting a twist upon the melt passing therethrough.

9. An apparatus for treating metallic melts in a continuous process, which includes: a vessel for receiving the melt to be treated, said vessel having a discharge opening in the lower portion thereof, first chamber means arranged below said vessel and having an upper inlet for communication with said discharge opening and also having a lower outlet for discharging melt treated in said first chamber means, said first chamber means including an upper section flaring downwardly and a lower section tapering downwardly in the direction toward said outlet, dividing means arranged in said upper section and having its central portion provided with first downwardly directed passage means and having its marginal area provided with second downwardly directed passage means for splitting the melt entering said upper section into a marginal flow along the wall surface of said first section and into a central flow spaced from said marginal flow, said first chamber means being provided with first passage means arranged below said dividing means and extending into said first chamber means below said dividing means for feeding a material to be added to the melt into said lower section, second chamber means arranged below said first chamber means and communicating therewith through said outlet, said second chamber means having its lower portion provided with a discharge outlet for the melt treated in said second chamber means, and flow restricting means arranged in said second chamber means preceding said discharge outlet for accumulating

the melt prior to its passing through said discharge outlet, said second chamber means being provided with second passage means for feeding additional material to be added to the melt into said second chamber means.

10. An apparatus according to claim 9, which includes a cylindrical body surrounding said discharge outlet in spaced relationship thereto and extending downwardly for immersing into a vessel for accumulating the treated material.

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