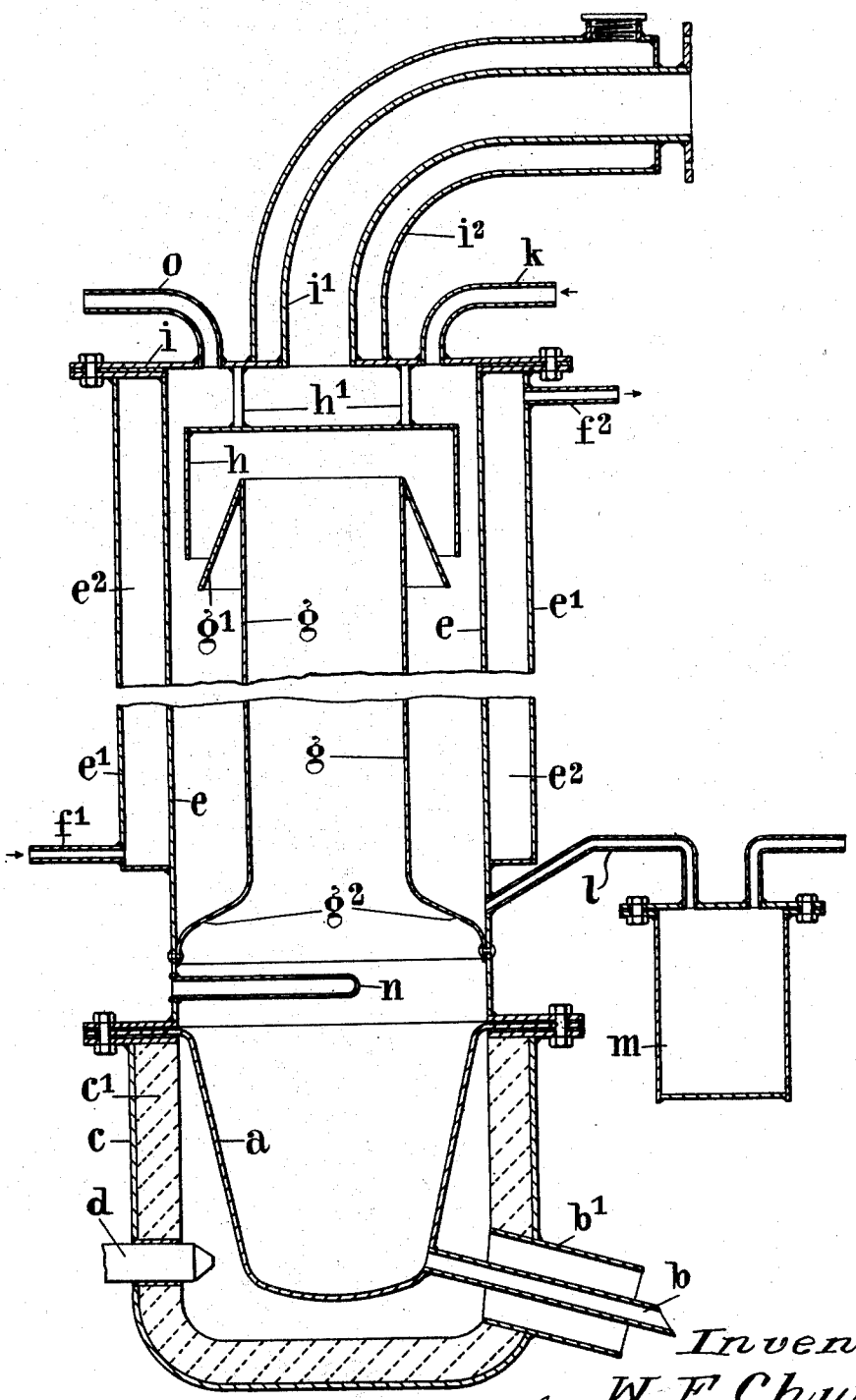
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APPARATUS FOR THE CONDENSATION OF METALLIC VAPORS

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Inventor
W. F. Chubb
By Glascock Downing & Seibold
Attys

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APPARATUS FOR THE CONDENSATION OF METALLIC VAPORS

William Frederick Chubb, London, England

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This invention relates to the condensation of metallic vapours and has for its object to devise simple and efficient methods and apparatus for such purpose.

The invention consists of an apparatus for condensing metallic vapour according to which the vapour is caused to mix with vapour from the same metal boiling at low pressure and directed against a cooled surface upon which it condenses.

The invention is particularly applicable to the continuous production of magnesium metal under accurately known and controllable conditions, but it is also capable of general application to the condensation of metallic vapours, and may also be used for the separation wholly or in part of two or more metals of different boiling points.

Further features of the invention will be apparent from the description given hereafter.

The accompanying drawing illustrates in sectional elevation one convenient form of apparatus in accordance with the invention.

In carrying my invention into practical effect I arrange to boil a metal at low pressure as a means of causing metallic vapours entering the condensation apparatus to be transformed from vapour to liquid by the usual physical process known as condensation. For this purpose the metal in molten condition is made to boil at a predetermined pressure in a vessel exhausted by an external pump and it is important to observe that the metal so boiling is the same metal as that entering the apparatus as vapour. The vapour produced by boiling is directed against a cooled surface upon which it condenses.

In the specific form of apparatus illustrated the apparatus is formed in three sections bolted together, in order to ensure ease of assembling and dismantling. The metal entering the apparatus as vapour which it is desired to condense to the liquid state is ultimately caused to collect as molten metal in a heated container *a* which is provided with a tapping spout *b* for the removal of molten metal as required. In order that any metal remaining or residing in the tapping spout may be always completely molten, this tapping spout is surrounded by an outer concentric case *b'* and through the intervening passages the exhaust gases heating the metal in the container are allowed to escape, or alternatively, heating of the spout may be undertaken by any known means. The container is encased by an outer vessel *c* which is lined internally with suitable refractory *c'* to minimise heat losses, and for maintaining the metal in the container in a boiling condition heat is applied in any suitable manner

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and the source of heat may be either an oil-burner *d*, town gas, natural gas, or the waste heat from other apparatus, or alternatively, known electric heating devices, including induction heating, may be adapted for heating this vessel.

Superimposed on the container and casing surrounding the same is erected a tower or column which consists of an inner cylinder *e* concentric with an outer case *e'*, the intervening space e^2 serving as a channel for the passage of cooling fluid entering through an inlet port *f'* and emerging through an outlet port f^2. Within the cylinder *e* is an inverted funnel-shaped tube *g* which is fastened at its lower extremity to the vertical cylinder either by riveting, welding, or by other known means. Surrounding the top of the tube is a deflecting device *g'* in the form of a truncated cone, while above the funnel-shaped tube is suspended by suitable straps *h'* or otherwise an inverted cup *h*, which may be of rectangular or other shape in cross-section and which allows the hot metallic vapours arising from the container *a* to be deflected downwards and outwards against the internal surface of the cylinder *e* surrounding the funnel-shaped tube. After condensation to liquid form on the internal wall of said cylinder, the vapours entering the apparatus from outside and mixing with those rising up from the container flow downwards and enter the container through the holes g^2 cut in the base of the funnel.

The cover for the apparatus consists of a circular or other plate *i* carrying an inlet tube or pipe *i'* through which the metallic vapours enter the condensing chamber. If desired, this inlet may be surrounded by a tube i^2 and the intervening space may be filled by some insulating material as an aid to ensuring that the hot metallic vapours entering the apparatus do not become unduly cooled. Alternatively, the said intervening space may be exhausted to minimise heat losses, or a cooling fluid may be arranged to flow therethrough if for any purpose it is required to cool the vapours before passing into the apparatus. Similarly, in the case of the cooling chamber e^2 surrounding the condensation vessel it is possible that in some cases extremely rapid cooling for the vapours to be condensed might be essential. In such instances the cooling chamber may be equipped if desired with a refrigerating coil actuated by known refrigeration devices. In another alternative, a simple coil may be wound round the external surface of the cylinder *e'* surrounding the inner tube or such a coil may be provided in addition to the cooling chamber. In

the last case, one type of coolant, for example oil, may be arranged to flow for instance through the cooling chamber itself while another type of coolant, for example water, may be made to flow through the coil described, or vice versa. Then, by suitably controlling the rates of flow of the two cooling fluids intermediate rates of cooling can be obtained and accurately controlled. In fact, the control of cooling rates would be much more accurate than could be obtained when only one type of coolant is employed.

In practice it may often be necessary to prevent the oxidation of the metallic vapours entering the condensation apparatus, and with this in view hydrogen or other gas or vapour which does not react with the hot metallic vapour may be introduced in some appropriate manner and under appropriate conditions of temperature and pressure through a suitable inlet tube *k*. Also, practice may frequently demand that the vapours themselves be reduced in pressure before condensation and to attain this condition the condenser may be connected through an appropriately positioned tube *l* to a suitable vacuum pump. As a means of preventing condensation and choking of this tube and as an aid in preventing metallic vapours being sucked into the vacuum pump, a suitable trap *m* may be attached to this tube or otherwise suitably arranged in the system and, as required by operating conditions, the said tube may be itself either heated or cooled by known means. Thus, both the trap and the tube may be lagged to prevent heat losses or they may be heated by electric heaters or by the waste gases from other plant or equipment. Similarly, the tube *k* allowing the entry of an inert gas may if desired be lagged, heated or cooled.

In practice the apparatus is operated by attachment to the generator supplying the metallic vapour which it is desired to condense to liquid form, and heat is applied to the container *a* in order to bring the metal contained therein to a boiling condition. The pressure within this apparatus is reduced and similarly the inert gas may or may not be caused to enter the apparatus, depending of course in each instance upon the conditions required within the condensing chamber. The hot metallic vapour entering the apparatus passes round the inverted cup *h* and then meets and mixes with the metallic vapour which has risen up through the funnel tube *g* and which has been directed downwards by the cup *h* and outwards by the deflector *g'* on the tube. The mixed vapours condense against the internal surface of the vertical cylinder *e*, and they then flow downwards as molten metal and ultimately re-enter the container *a* through holes or slots g^2 near the base of the funnel.

It will be clear that conditions of operation can be so chosen that the density of the incoming metallic vapour entering the apparatus is less than that of the vapour rising through the funnel. These conditions will obviously prevail when the temperature of the incoming vapour is much higher than that of the metallic vapour rising through the funnel. Indeed, if the temperature difference be sufficiently great the conditions thereby created within the vessel, coupled with the fact that in condensation to liquid the volume of the metal forming the vapour is substantially reduced, are such that the internal pressure of the vessel will be gradually and progressively lowered as time goes on below that to which it was originally reduced by the auxiliary pump. In other words, the vessel maintains its own low pressure. This is indeed an important advantage over former designs of methods of producing metallic magnesium which are devoid of this distinguishing feature, and it will also be clear that, once reduced to some conveniently low pressure, the apparatus will in service gradually and progressively create its own low pressure. This condition need not be changed essentially or materially when molten metal is withdrawn from the container through the tapping spout, or it may be readily re-established subsequently to tapping off any molten metal required.

As to the application and uses of this apparatus or of its possible modifications, one such application has already been mentioned, namely, its attachment to a vessel or apparatus generating or supplying the metallic vapour which it is required to condense. This generator may, for example, be any known apparatus or equipment for the reduction from their ores of volatile metals, such as zinc or magnesium, or the generator or vessel providing the metallic vapour to the condenser may simply be an apparatus for distilling or re-distilling a volatile metal previously produced by known methods of manufacture.

As a particular example of use, the application of this apparatus to the condensation of magnesium vapour may be referred to, but it will be understood that the principle embodied in this design is equally applicable to the condensation of other metallic vapours under appropriate conditions of temperature and pressure. As commonly produced by known methods magnesium may be caused to enter the condenser under such conditions of temperature and pressure as to be wholly in the vapour state. At normal pressures the boiling point of magnesium is in excess of 2,000° F. but by reducing the pressure to 0.1 mm. of mercury the boiling point is reduced very considerably, and according to known authorities is then of the order 1,300° F. This means that in order that the apparatus may function in the manner visualised the metal must be heated to 1,300° F. to cause it to boil and so pass as vapour up the funnel tube. Now, the melting point of magnesium at ordinary atmospheric pressures is approximately 1,200° F. so that if the metal can then be tapped off through the tapping spout it will be immediately ready for casting into ingots, sticks, or slabs, as required, and a continuous system for the production of magnesium metal then becomes possible. This, however, cannot be achieved in the form of apparatus described without increasing the pressure sufficiently within the condenser to allow metal to flow out through the tapping spout. This desirable result can nevertheless be achieved by suitable modification of the particular form of apparatus. One such modification, for instance, may consist in connecting the condenser through its tapping spout to a second vessel or ladle so constructed that the pressure of its contained atmosphere can be reduced to equal that being maintained in the condenser. Then by opening a valve the metal will flow from the condenser to the second ladle or vessel until the levels of the two liquids are identical, and by closing the valve the metal which has passed into the second ladle can be removed for casting at any desired time, while allowing further condensed metal to collect continuously in the ladle or container of the condenser. Alternate systems or modifications of

this procedure are of course possible, but in the instance quoted above it is not to be assumed that the very low pressure of 0.1 mm. of mercury is imperative for the successful production or condensation of magnesium vapour, for clearly any desired or attainable condition can be maintained within the apparatus, and the example quoted is thus an example only.

An incidental advantage claimed for this particular design of condenser lies in the fact that in operation it is continuously generating its own low pressure by the condensation of the vapour rising up through the funnel. This action, indeed, proceeds so long as heat is applied to the container and the metal therein is caused to boil. The conditions are obviously such as to aid materially the passage of the metallic vapour from its source into the condenser.

It is also possible that if the magnesium vapour entering the condenser contains another metal of lower boiling point this second metal will pass as vapour either wholly or in part through the apparatus without being condensed to liquid form. It will then pass out through the vacuum line into the trap provided. Much will here depend, however, upon the characteristics of the second metal and upon the conditions prevailing within the condenser, but a separation may nevertheless be attempted by appropriate choice and control of internal operating conditions.

As refinements for this apparatus, a thermocouple or recorder may be inserted in the tube *n* to provide a continuous record of the temperature conditions within the apparatus. Similarly, pressure indicators and recorders may also be adapted to the apparatus for the purpose of indicating and/or controlling and recording the internal pressure, so that complete control over operating conditions can very readily be obtained in practice. Connection *o* shows, for example, where a vacuum gauge may be applied.

I claim:

1. Apparatus for the condensation of metallic vapour comprising a container in which metal is boiled to form vapour, a condensing surface above said container, an inverted funnel shaped tube above the container and passing up through the condenser, means for introducing from an outside source vapour of the same metal as that in the container, and guide means at the upper end of said tube for directing the mixture of vapours from the container and outside source respectively into contact with the condensing surface.

2. Apparatus for the condensation of metallic vapour comprising a container in which metal is boiled to form vapour, a condensing surface above said container, an inverted funnel shaped tube above the container and passing up through the condenser, means for introducing from an outside source vapour of the same metal as that in the container, an inverted cup at the upper part of the tube, and a baffle adjacent said cup, said cup and baffle acting to direct the vapour passing through the tube into admixture with the incoming vapour and against the condensing surface.

WILLIAM FREDERICK CHUBB.

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