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Benatt et al.

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[54] **COOLING, CONDENSATION AND PURIFICATION OF VAPOURS AND GASES**

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[52] **U.S. Cl.** **75/71,** 75/88

[51] **Int. Cl.** **C22b 17/00,** C22b 19/04

[58] **Field of Search** 75/14, 71, 67, 86–88; 55/72; 261/118; 266/15–19

[56] **References Cited**

UNITED STATES PATENTS

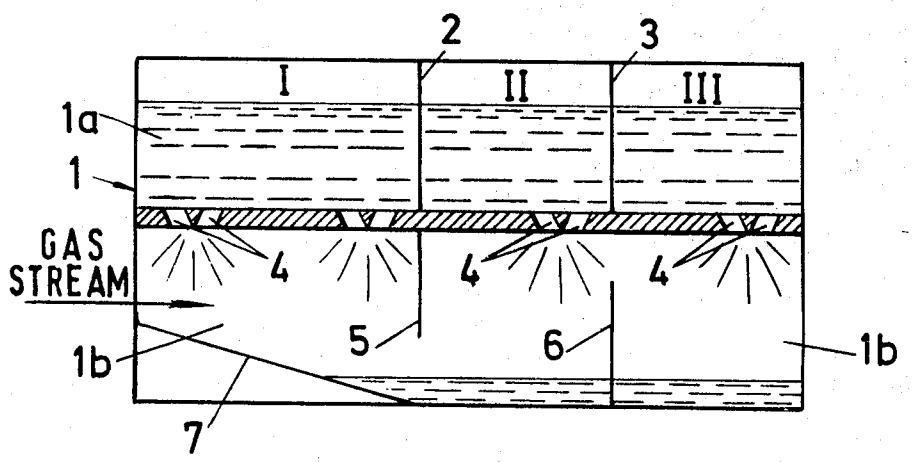
2,065,709	12/1936	Kemmer	75/67
2,416,255	2/1947	Griswold, Jr. et al.	75/67
2,464,262	3/1949	Robson et al.	75/86
3,592,631	7/1971	Cattelain	75/88

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Assistant Examiner—M. J. Andrews
Attorney, Agent, or Firm—Holman & Stern

[57] **ABSTRACT**

Method of condensing a vapour, particularly zinc vapour originating from a zinc smelting blast furnace, by passing the vapour through a spray of molten metal droplets, usually molten lead, the spray being produced by the mutual impingement of at least two continuous streams of the molten metal which emerge from the roof of a chamber through which the vapour to be treated is passed. Conveniently, the impinging streams of molten metal emerge from the roof of a cross-over duct connecting the upper part of the shaft of a zinc smelting blast furnace with a conventional lead-splash condenser.

6 Claims, 3 Drawing Figures



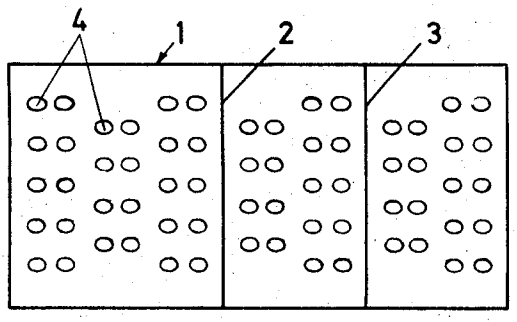


FIG. 1.

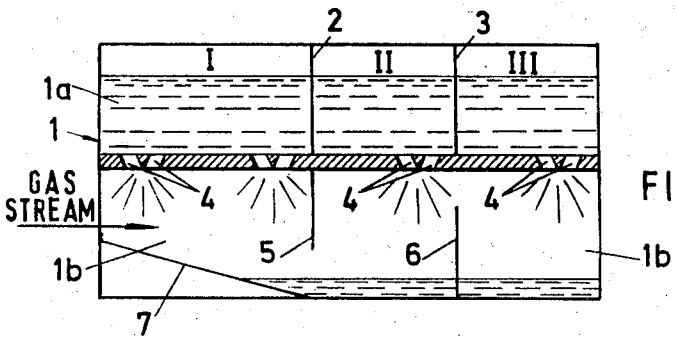


FIG. 2.

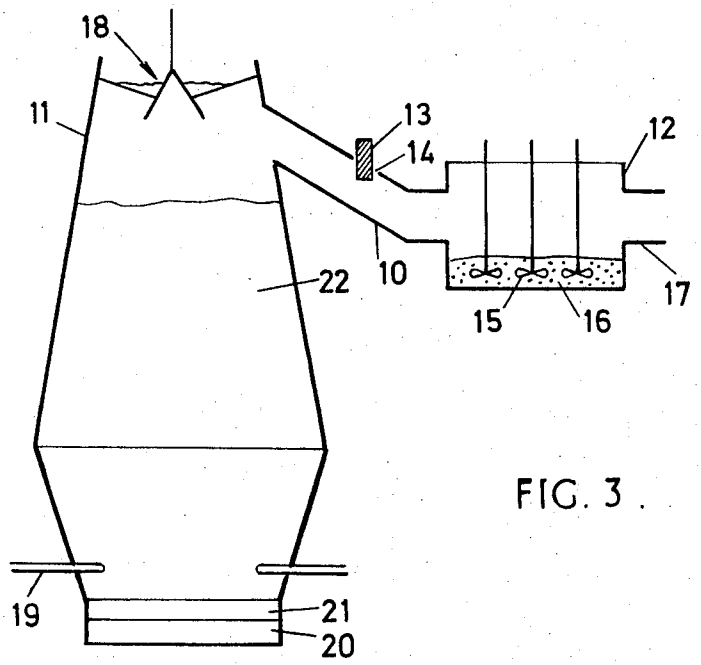


FIG. 3.

COOLING, CONDENSATION AND PURIFICATION OF VAPOURS AND GASES

This invention relates to the condensation, cooling, or purification of vapours or gases, particularly the vapours of metals of relatively low-boiling point, such as zinc or cadmium.

It is well known to cool and condense metal vapours by means of apparatus which utilizes a molten metal as the condensing medium; for example, zinc vapour leaving the top of a zinc smelting blast furnace may be condensed using molten lead as the condensing medium. However, in the past, the condensation has been achieved by passing the vapour through a chamber in which a spray of the molten metal is proudced by means of a series of impellers or paddles which are rotated while immersed in a pool of the molten metal in the condensation chamber.

Typical condensers which throw up a spray of molten metal by a rotary paddle wheel which dips into a pool of molten metal as it rotates are described in British Patent Specification Nos. 572,961 and 611,929. An improved condenser which utilizes a series of impellers having arms of different length to throw up a spray of molten metal is described in British Patent Specification No. 1,263,165.

While such known forms of apparatus are satisfactory, they suffer from various disadvantages, as follows:

1. There is a degree of wear on the impellers due to erosion and corrosion by the high temperature molten metal.

2. It is difficult to satisfactorily design impellers which will provide a uniform and dense curtain of spray droplets within the condensation chamber, and which will give efficient cooling and condensation of the metal vapour and will efficiently irrigate the space within the condensation chamber.

3. Droplets of the molten metal condensation medium are carried over from the condensation chamber by the stream of gas leaving the condenser.

A further disadvantage of using rotors is that a hollow cone of spray is generated which is thrown upwards and outwards from the rotor. This has meant that the relative positions of furnace offtake and condenser inlet, together with the design of the connecting cross-over duct, has been dictated by the need to prevent lead spray from being thrown into the furnace.

The invention in one aspect consists in a method of condensing, cooling, or purifying a vapour or gas, comprising passing the vapour or gas through a spray of molten metal droplets produced by the mutual impingement of at least two continuous streams of molten metal.

The invention in another aspect consists in apparatus for the condensation, cooling or purification of a vapour or gas by passing the vapour or gas through a spray of molten metal droplets, comprising a treatment chamber in the roof of which are a number of pairs of converging jets arranged to direct at least two continuous streams of molten metal to mutually impinge on each other to generate the said spray, and a second chamber for holding molten metal arranged above the said treatment chamber, the said second chamber communicating with the vapour treatment chamber by orifices formed in the vapour treatment chamber roof to

comprise the said jets, the chamber roof constituting the floor of the second chamber.

In this specification, the term "jet" is to be understood to include within its scope holes, orifices, spouts and tubes and the like through which molten metal may be allowed to flow.

In a preferred aspect, the vapour being condensed comprises zinc vapour which originates from a zinc smelting blast furnace and will usually be mixed with oxides of carbon and with nitrogen condensed in molten lead. Conveniently, the impinging streams of molten metal emerge from the roof of a cross-over duct connecting the upper part of the shaft of a zinc smelting blast furnace with a lead-splash condenser which may be of conventional construction, that is a condenser wherein sprays of molten lead droplets are formed by rotation of immersed impellers.

The spray of molten metal will usually be formed as one or more spray curtains, the shape and intensity of each of which will depend upon several factors including the flow rates and converging angle of the mutually impinging streams. Furthermore, any obstruction in or near the area of impingement may alter the characteristics of the spray curtain. The size and proportions of the spray droplets produced will be dependent on the physical characteristics, for example the surface tension, of the impinging metal streams.

It is envisaged that a complete condenser unit will consist of a large number of such spray units, for example of the order of 100 or more pairs of mutually impinging molten metal streams.

Usually the vapour or gas to be treated will comprise a vapour of a metal of relatively low-boiling point, for example zinc or cadmium.

The molten metal comprising the spray is preferably molten lead or a predominantly lead alloy at a temperature of between 430° and 650°C. Where there are a number of spray units each consisting of a plurality of mutually impinging streams, then the molten metal, usually molten lead, generating the spray curtains may be at different temperatures in the range 430° to 650°C for each spray curtain.

The vapour or gas may optionally be passed through a conventional lead-splash condenser having up to four rotors after, or even before, being passed through the spray curtains.

The streams of molten metal which impinge on one another preferably emerge from jets angled at 30° (± 10) to the horizontal.

The invention will be further described, by way of example only, with reference to the accompanying drawings, in which:

FIG. 1 is a schematic plan view of an apparatus for condensing a vapour or gas;

FIG. 2 is a schematic side view, partly in section of the apparatus shown in FIG. 1; and

FIG. 3 is a schematic side view illustrating a jet-impingement spray condenser positioned in the cross-over duct connecting the upper part of the shaft of a zinc smelting blast furnace with a conventional lead-splash condenser.

The apparatus shown in FIGS. 1 and 2 comprises a vessel 1 divided into an upper chamber 1*a* and a lower chamber 1*b*; the chamber 1*a* is divided into three sections by vertical partitions 2, 3. The three sections comprising the upper chamber contain molten lead at temperatures which may be:

Section I	560°C
Section II	510°C
Section III	450°C.

The base of each section comprising a zinc vapour condenser in the form of a rectangular chamber approximately 9 feet wide × 8 feet long × 8 feet high, provided with a total of **88** spray units. Each spary unit consists of a pair of 1 inch diameter mutually inclined holes, orifices, spouts or tubes **4,** hereinafter referred to generally as jets, in the roof of the chamber **1***b*, these pairs of jets being arranged 18 inches apart in staggered rows which are 6 inches apart. Molten lead passes through the jets **4** from the upper chamber **1***a* into the lower chamber **1***b* of the vessel **1.**

The lower chamber **1***b* is divided by vertical baffles **5, 6** into sections respectively arranged below sections I, II and III comprising the upper chamber. The lower chamber **1***b* has an inclined floor **7** to give a downwardly inclined inlet for gases to the length of the chamber, conveniently in a direction at right angles to the planes of the spray curtains produced by the spray units.

The jets **4** are fed with molten metal from the chamber **1***a* which holds at least 2 feet head of metal, preferably about 3 feet head, above the jets. The jets **4** may be formed as orifices angled at 30° to the horizontal and drilled in a plate of at least 2 inches thickness. The centres of the jets **4** of each pair should preferably be at least 3 inches apart in the plate on the outlet side. Alternatively, the jet outlets can be merged together so that inpingement occurs partially within the roof of the chamber **1***b*.

The molten lead, containing condensed zinc, which collects on the floor of the chamber **1***b* is passed to a conventional cooling launder or channel in which the lead is cooled by contact with water-cooled panels or plates either in the walls or in the centre of the launder. The cooling of the molten lead results in separation of a layer of zinc on the surface of the molten lead. This is run off for casting and the cooled lead may be pumped back into sections I, II or III or chamber **1***a* of the condenser. Suitably cooling launders are described for example in British Patent Specification Nos. 735,043 and 981,546.

Thus a cyclic transfer of lead between the condenser and the cooling launder and back to the condenser may be achieved. It may be necessary to arrange that the lead going into sections I, II and III is at different temperatures and this may be achieved either by means of heaters within these sections or by recycling some hot lead from the bottom of the condenser **1***b* back into sections I, II or III.

In one particular envisaged arrangement, the zinc vapour originates from the top of a zinc smelting blast furnace and may ultimately be passed to a conventional lead-splash condenser having up to four rotors, in which case the jet impingment spray condenseer may be arranged in the cross-over duct between the top of the blast furnace and the rotary spray condenser.

FIG. **3** shows a blast furnace plant wherein a cross-over duct **10** connects the upper part of the shaft **11** of a zinc smelting blast furnace with a conventional lead-splash condenser **12.** In the roof of the cross-over duct **10** is a jet-impingement spray condenser **13** as described above with reference to FIGS. **1** and **2.** The spray condenser **13** is insertable into and removable from the cross-over duct through an opening **14.** The spray condenser may be completely removed from the cross-over duct for maintenance by means of a hoist (not shown), when required.

The zinc vapour which originates from the top of the blast furnace shaft **11** will usually be mixed with oxides of carbon and with nitrogen condensed in molten lead. The vapour passing through the cross-over duct **10** is partially condensed by the molten lead spray produced by the jet-impingement spray condenser **13,** and the uncondensed vapour passes to the conventional rotary condenser **12** where a further molten lead spray is formed by a series of impellers **15** rotating in a pool of molten lead **16.** The condenser offtake is indicated by reference **17.**

FIG. **3** also shows schematically the blast furnace charging gear **18** and tuyeres **19.** Lead collects at the bottom of the blast furnace shaft, as indicated by reference **20,** and a layer of slag **21** collects above the lead. Reference **22** indicates the furnace charge. Photographic studies have shown that the drop size distribution is comparable with that of rotor generated spray, but because the impinging jet spray is directed downwards rather than upwards and outwards it will be possible to install a number of sprays in the roof of the cross-over duct between the furnace and the rotary spray condenser without throwing lead into the shaft. This would have the advantages of improving condenser efficiency by about 1.5 percent and of restricting accretion growth in the cross-over duct and condenser inlet by irrigating the walls with molten lead in areas which are inaccessible to rotor generated spray. Because the spray can be generated closer to the furnace offtake using the impinging jet system the distance travelled by the gas before contacting lead spray is considerably reduced, and because the impinging jet spray is more compact than rotor generated spray the gas will be cooled more rapidly than at present. The distance travelled by furnace gas before meeting lead spray would be reduced, resulting in a decrease in the amount of re-oxidation in the cross-over duct. With rotor spray systems at present used, up to 5 percent of the zinc vapour in the furnace reverts to zinc oxide, mostly in the cross-over duct and in the first part of the condenser.

Alternatively, the jet impingement spray condenser may be arranged downstream of the rotary spray condenser or may be used in place of the latter.

It has been calculated that 18 (±3) pairs of spray units each consisting of a pair of jets of one inch diameter are equivalent to one conventional rotor.

The apparatus described above has the advantage that there are no moving parts to be corroded or to wear out and that the intensity and extent of the curtain of molten metal can be altered by adjusting the flow rates of the molten metal and/or the sizes of the jets through which the streams emerge into the impingement area.

Any tendency for the jets to be blocked by accretions or impurities may be countered by either increasing the size of the jets or the flow rate of the molten metal streams or by rodding the orifices clear with suitably dimensioned and positioned rods without taking the condenser off line.

A spray curtain from a pair of one inch diameter jets with a three foot head gives over twice the surface area

of spray per unit volume of molten metal compared with an equivalent rotor produced spray.

Further advantages of the apparatus described above are as follows:

1. Unlike most spray nozzles the jets are constructed of straight, simple, tubes of relatively wide bore.

2. The simple outer shape of the jets, when used in preference to orifices, gives minimal dross build up.

3. The outer surfaces of the jets tend to be self cleaning due to a certain amount of the lead being splashed back.

The lead flow rate through a pair of 19 mm diameter jets was 64 tonnes/hr. at a head of 840 mms lead. It is easily calculated that the velocity of the lead leaving the jets was 2.8 m/sec. With the jets inclined at 30° to the horizontal it follows that the initial velocity in a vertical plane was 1.4 m/sec. Times for spray to travel various distances may be calculated using the formula:

$$s = ut + t^2$$

Where s = distance travelled by spray — m
u = initial velocity of spray — m/sec.
a = acceleration and being due to gravity in this case = 9.81 m/sec.
t = residence time.

This permits calculation of minimum residence times of spray in the spray chamber, in the furnace cross-over and in various zones of those spaces. Results of these calculations are tabulated below:

Zone	Distance (m)	Residence Time (secs)
Spray Chamber - full height	1.8	0.48
Spray Chamber - zone prior to development of spray	0.3	0.14
Spray Chamber - zone following development of spray	1.5	0.34
Furnace Crossover - full height	2.5	0.59
Furnace Crossover - zone prior to development of spray	0.3	0.14
Furnace Crossover - zone following development of spray	2.2	0.45

We claim:

1. A method of condensing a vapour selected from the group consisting of zinc vapour and cadmium vapour, comprising: producing a spray of molten lead droplets by causing at least two continuous streams of molten lead to mutually impinge on each other, and passing the vapour through the lead spray thus produced.

2. A method as claimed in claim **1**, wherein the molten lead spray comprises a plurality of successive spray curtains each produced by at least one spray unit consisting of at least two mutually impinging streams of molten lead.

3. A method as claimed in claim **1**, wherein the vapour to be treated originates from a zinc smelting blast furnace and is mixed with oxides of carbon and with nitrogen.

4. A method as claimed in claim **1**, wherein the molten metal comprising the spray is molten lead at a temperature of between 430° and 650°C.

5. A method as claimed in claim **1**, comprising causing the impinging streams of molten lead to emerge from converging jets in the roof of a chamber, and passing the vapour to be treated through the chamber.

6. The method of claim **5** wherein the jets are angled at approximately 30° to the horizontal.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3841862 Dated October 15, 1974

Inventor(s) Frank George Simon Benatt, et al

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

[73] Assignee:

METALLURGICAL PROCESSES LIMITED

Nassau, Bahamas

Signed and sealed this 17th day of December 1974.

(SEAL)
Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

FORM PO-1050 (10-69)

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* U.S. GOVERNMENT PRINTING OFFICE : 1969 O—366-334.