United States Patent [19]

Rock

[11] **3,773,098**

[45] **Nov. 20, 1973**

[54] **METHOD OF STATIC MIXING TO PRODUCE METAL FOAM**

[75] Inventor: **Edward J. Rock,** Blue Mounds, Wis.

[73] Assignee: **Johan Bjorksten,** Madison, Wis.

[22] Filed: **Feb. 4, 1972**

[21] Appl. No.: **223,547**

[52] **U.S. Cl.** ..... **164/79,** 164/133, 164/337, 75/20 F, 222/145, 259/180

[51] **Int. Cl.** **B22d 27/00**

[58] **Field of Search** ..... 75/20 F; 164/79, 164/133, 337; 222/145; 259/180

[56] **References Cited**

UNITED STATES PATENTS

2,983,597	5/1961	Elliott	164/79
2,930,767	3/1960	Novak	75/20 F
2,354,807	8/1944	Fox et al.	75/20 F
2,322,581	6/1943	Lytle	75/20 F
2,895,819	7/1959	Fiedler	75/20 F
3,055,763	9/1962	Kreigh	106/71
3,224,846	12/1965	Fiedler et al.	29/183.5
3,617,594	11/1971	Willy	264/45

OTHER PUBLICATIONS

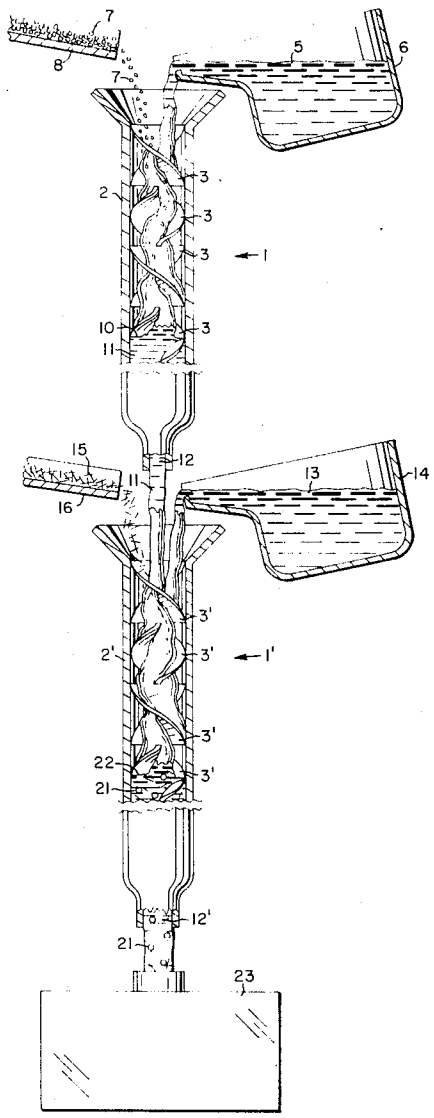
"Fiber Metallurgy" Steel, 10 Aug. 1959, pp. 126–128, "Chemical Engineering," Pattison, May 19, 1969, p. 94.

Primary Examiner—J. Spencer Overholser
Assistant Examiner—Vernon K. Rising
Attorney—Johan Bjorksten

[57] **ABSTRACT**

Ingredients required to make metal foam having particulate members such as glass beads or steel wires embedded therein are mixed in a static mixer having no moving parts.

9 Claims, 4 Drawing Figures



3 Sheets-Sheet 1

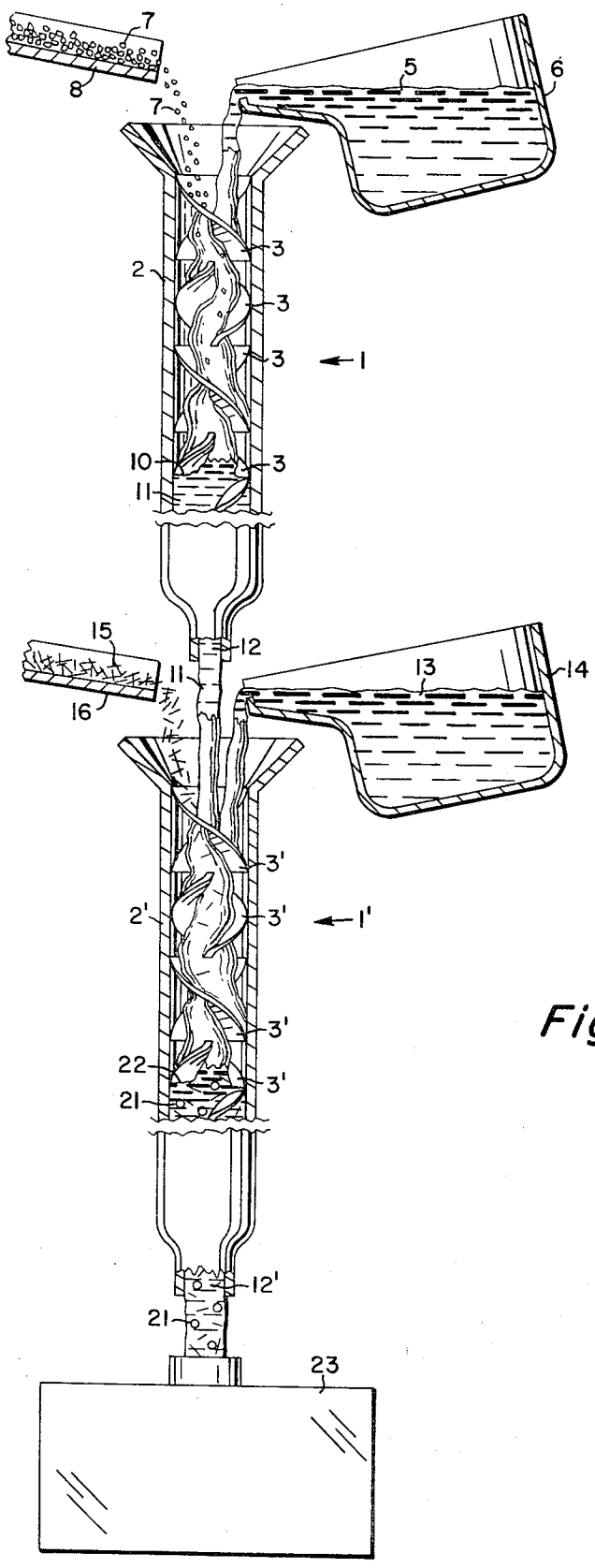


Fig. 1.

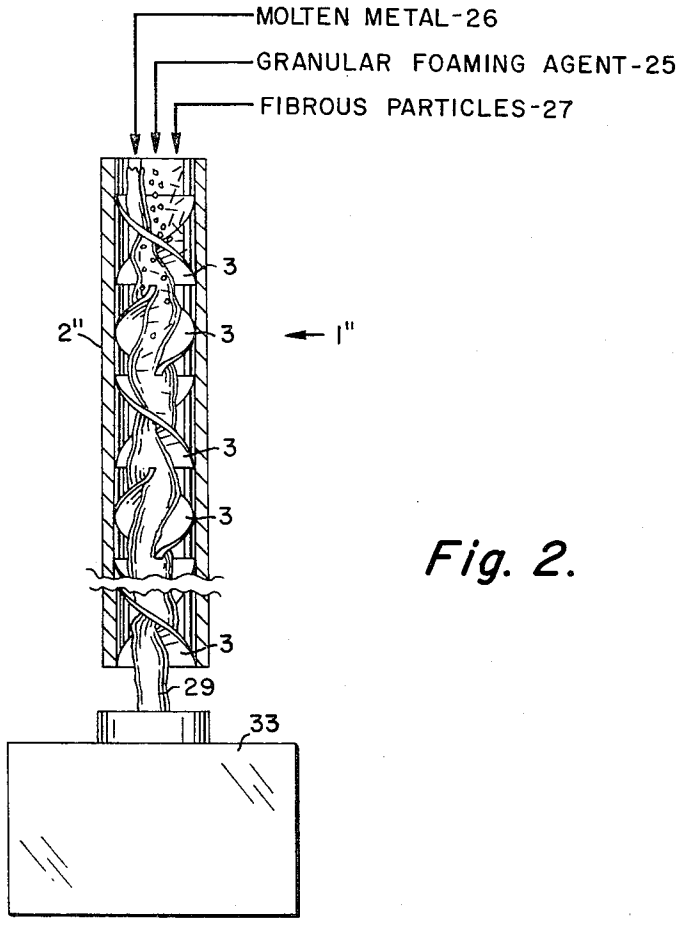

MOLTEN METAL-26
GRANULAR FOAMING AGENT-25
FIBROUS PARTICLES-27
3
2"
3
1"
3
3
3
29
33

Fig. 2.

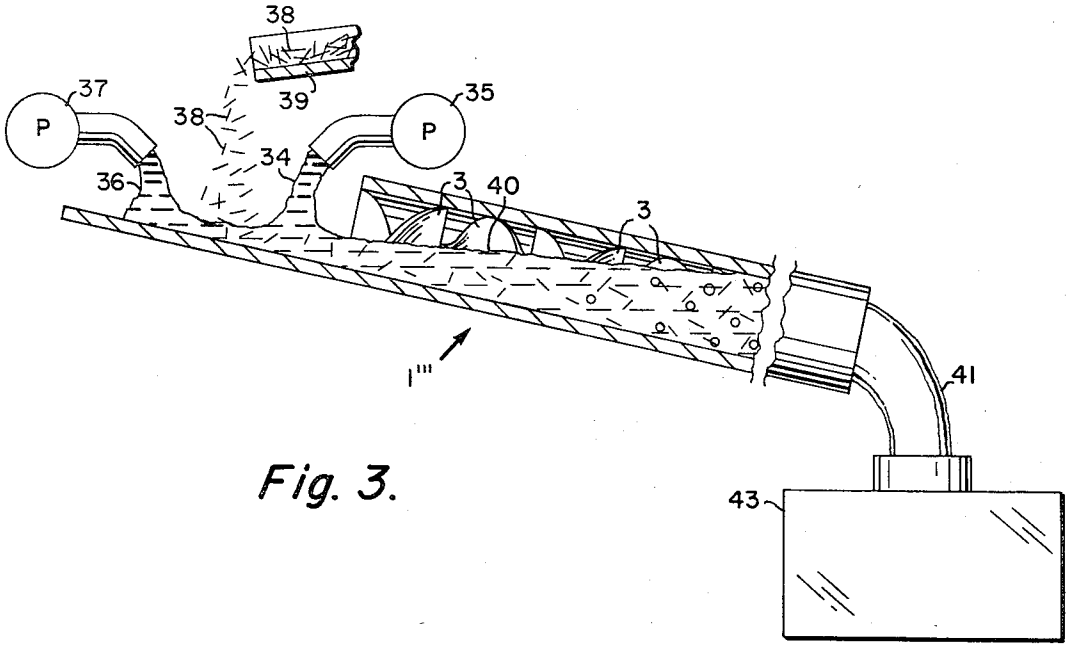

38
37
39
35
P
38
P
34
36
3
40
3
1'''
41
43

Fig. 3.

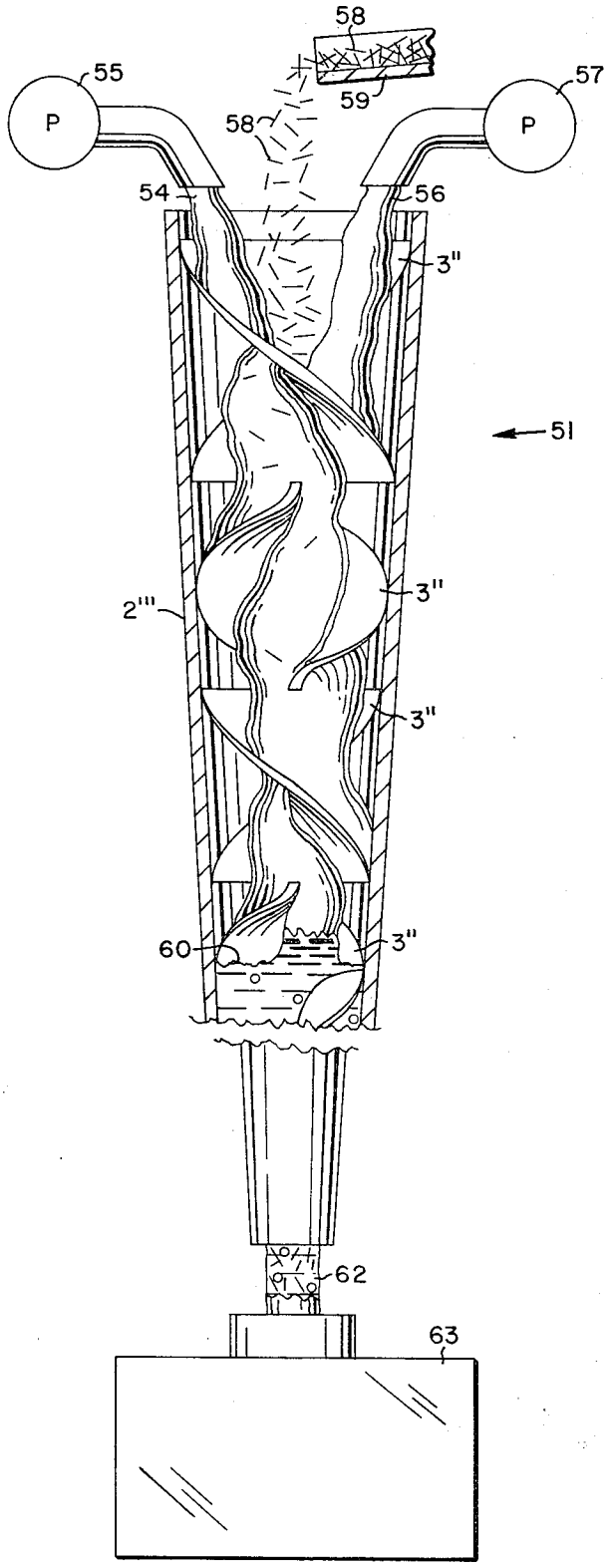


Fig. 4.

METHOD OF STATIC MIXING TO PRODUCE METAL FOAM

This invention relates to processes for producing metal foam bodies.

SUMMARY

Heretofore it has been regarded as necessary to introduce a large amount of energy into the mixing of molten metal and foaming agent in order to provide a suitable mixture for the production of metal foam bodies. Thus, the use of high shear forces has been described in the Elliott U.S. Pat. No. 2,751,289 and the use of high intensity mixers, rotating at rapid rates for short periods of time, has been described in other references, e.g., Elliott U.S. Pat. No. 2,983,597.

In accordance with the present invention, foam metal and, more particularly, foam metal having high concentrations of particulate fibrous or non-fibrous material incorporated therein, may be prepared without need for such high energy inputs. In accordance with the present invention only very gentle mixing is necessary.

In accordance with the invention a mixer is used which contains no moving parts and consists in the most general case of a hollow tube having a plurality of baffles extending across the interior. Particularly suitable embodiments are described in the cited prior art references. A preferred embodiment comprises a hollow cylindrical tube provided with baffles, each of which is a flat sheet twisted through one-half turn with the axis of the twist lying on the axis of the tube. Each baffle member is installed with ts leading edge oriented at 90° to the trailing edge of the next previous baffle member.

Insuperable difficulties may be encountered in attempting to utilize such a mixing device in accordance with the descriptions of the prior art. Such descriptions call for introducing components to the mixing means by pumping or the like to entirely fill the mixing means.

In accordance with the invention, as a critical step, such a mixing device is operated partly empty as more fully described hereinafter to obviate difficulties encountered with such sharp particulate material as the foaming agent and with fibrous material such as steel or glass fibers which may be added.

OBJECTS

It is therefore an object to provide an improved method for providing metal foam bodies.

Another object is an improved method for mixing ingredients for providing metal foam bodies.

Another object is an improved method for incorporating high proportions of high melting fibrous members in metal foam bodies.

Further objects will be apparent from the following detailed description.

DRAWINGS

In the drawings like reference numerals refer to like parts and:

FIG. 1 is a schematic cross-sectional elevation of one embodiment;

FIG. 2 is a schematic cross-sectional elevation of another embodiment;

FIG. 3 is a schematic cross-sectional elevation of another embodiment;

FIG. 4 is a schematic cross-sectional elevation of another embodiment.

DESCRIPTION

Referring now to FIG. 1 a mixing device indicated generally as **1** comprising hollow cylindrical tube **2** containing baffles **3** which, as shown, may be retained within tube **2** by any suitable means such as by use of an adhesive such as an epoxy resin, by furnace brazing, by sweating or the like. Each of baffles **3** may as shown consist of a flat piece of metal twisted through 180°, that is, given ½ turn of twist, with the axis of each being coincident with the axis of the tube. Other shapes of baffles may suitably be used.

In a preferred embodiment, molten eutectic alloy 5 of 65 percent aluminum and 35 percent magnesium is poured from crucible **6** into the top of mixer **1** and granular titanium hydride **7** in the ratio of 1 part of hydride to 10 parts of alloy is fed from vibratory feeder **8.**

The flow rate of alloy and hydride is so adjusted in conjunction with the size of orifice **12** at the bottom of tube **2** that the liquid level **10** of the mixture **11** of alloy and hydride within tube **2** is below the uppermost three of baffles **3.** By suitable choice of flow rates and orifice size the liquid head above the orifice and consequently the liquid height may be maintained relatively stable. In this manner the first three stages of mixing of alloy and hydride take place in conjunction with baffles which are not submerged so that by the time the ingredients reach liquid level **10** the hydride is sufficiently wetted and dispersed that it does not flat on the surface of the alloy.

The mixture **11** thus produced may be fed to mixer **1'** which may correspond to mixer **1** and may comprise tube **2'** having orifice **12'** and baffles **3'** which may correspond to tube **2,** orifice **12** and baffles **3.** Into mixer **1'** may also be fed molten metal **13,** such as aluminum (in a preferred embodiment in the ratio of 9 parts to one part of mixture **11**) from crucible **14.** Fibrous particulate members **15** such as **28** gauge steel wires having an average length of 3/8 inches may be added to mixer **1'** from vibratory feeder **16** in any suitable ratio such as 25 parts to 90 parts of aluminum.

As with mixer **1,** input flow rates to mixer **1'** may be adjusted in conjunction with the size of orifice **12'** to provide a relatively static head and therefore relatively stationary liquid level **22** which is preferably located below at least three of baffles **3'.**

In this manner, as a critically desirable step, molten materials **11** and **13** are mixed with fibers **15** in at least three stages provided by three of non-submerged baffles **3'** prior to reaching liquid level **22** so that fibers **15** are sufficiently wetted and dispersed in molten metal prior to reaching liquid level **22** that they do not form "birds-nests" and do not float on the liquid surface.

The mixture **21** produced in mixer **1'** may partially foam in the mixer.

Mixture **21** may be fed from orifice **12** to mold **23** wherein it may further foam and then may cool and solidify to form a molten metal body having the above described fibers incorporated therein.

In another embodiment, as shown in FIG. **2,** a mixer indicated generally as **1''** utilized in the process of the invention may correspond to mixer **1** with the exception that no orifice is provided at the bottom of tube **2''** which otherwise corresponds to tube **2.**

In operation, as shown, foaming agent **25,** molten metal **26** and fibrous particles **27** may be added at such

rates that tube 2'' is never filled and none of baffles 3 therein are at any time entirely submerged and thus all possible problems with floating of either granular foaming agent or fibrous particles on a molten metal surface are entirely eliminated

Mixture 29 thus produced may be introduced to mold 33 and may then foam, then cool and solidify therein to provide a suitable molten metal body having fibrous particles disposed therein.

Referring now to FIG. 3, a mixer 1''' may be similar or identical to mixer 1'' or mixer 1. As shown, no orifice may be provided at its lower end or in certain instances an orifice such as orifice 12 may be provided. Mixer 1''' is oriented slantwise as shown and is provided with baffles 3.

There may be introduced to the upper end of mixer 1''' a stream of molten aluminum 34 from pump 35, a stream 36 of molten eutectic alloy of aluminum and magnesium having 12 percent zirconium hydride foaming agent incorporated therein from pump 37 and a stream of fibrous glass particles 38 from vibratory feeder 39.

The rates of introduction of the ingredients are preferably adjusted in relation to the pressure drop across baffles 3 such that an inclined liquid level 40 is provided and less than all, specifically at least 3 of baffles 3 are not fully submerged, accordingly, the ingredients are sufficiently thoroughly mixed prior to reaching the area at which the baffles are entirely submerged that problems of separation of ingredients prior to undergoing initial mixing are obviated.

The mixture 41 thus produced may foam in part within mixer 1'''. Mixture 41, after passing through mixer 1''', may be introduced into mold 43 wherein it may further foam and may then cool and solidify to provide a metal foam body as above described.

Referring now to FIG. 4, another embodiment is shown wherein a mixing device indicated generally as 51 comprises a tube 2''' which corresponds to tube 2'' except that it is conical. Baffles 3'' therein may, if desired, correspond to baffles 3 except for being shaped to conform to the internal conical walls of tube 2'''.

Molten metal 54 from pump 55, molten eutectic alloy 56 from pump 57 and fibers 58 from vibratory feeder 59 may be introduced into the top of tube 2''' at such rates that a relatively stationary liquid head and corresponding liquid level 60 is provided, leaving at least three of baffles 3'' partially exposed and less than entirely submerged to obviate problems of one ingredient floating on the surface of another in such manner as to reduce mixing effectiveness. Foaming agent may be incorporated in alloy 56.

Mixture 62 flowing from mixer 51 may be introduced to mold 63 wherein it may foam and may then cool and solidify to provide a molten metal body as above described.

In accordance with the invention, one may operate either mixer 1'', mixer 1''' or mixer 51 in place of mixer 1 or mixer 1''. In other words the invention is not restricted to either the operation of two mixers in series as described in connection with FIG. 1 nor to the operation of only one mixer as described in conjunction with FIG. 2, 3 or 4.

The invention relates critically and particularly to the method of operating a mixer of the general type herein described in the manner herein described, namely, so that all or at least some and more particularly at least 3 of the baffle members are partially exposed or not completely submerged. Such operation may be facilitated by providing the mixer with an output orifice, by providing the mixer in conical form or by orienting the mixer slantwise. In any event, as described above, ingredients are mixed by flowing them over unsubmerged baffles either for a portion of their travel or for the entirety of their travel through the device.

The process of the invention is particularly applicable for particulate materials which cannot be pumped and especially applicable for mixing particulate materials with liquids in instances where the particulate materials are fibrous or sharp-cornered and not only cannot be pumped but are difficult to feed in any manner whatever and furthermore tend to birds-nest and tend to float on the surface of the liquid with which they are to be mixed. Such floating need not be by reason of being lighter in density than the liquid but may result from slowness in wetting whereby surface tension supports the particulate material.

Having thus described the invention, I claim:

1. In the process of making metal foam bodies having fibrous particles incorporated therein which includes mixing the ingredients molten metal, fibrous particles and foaming agent, the step of mixing said molten metal, fibrous particles and foaming agent by continuously introducing them into and through a baffled tube with at least three baffles therein such that the portion of the tube containing said at least three baffles is not entirely filled by said ingredients while they flow over said baffles.

2. The process of claim 1 wherein no part of said tube is entirely filled by said ingredients.

3. The process of claim 1 wherein a portion of said tube is entirely filled by said ingredients.

4. The process of claim 3 wherein said tube is oriented substantially vertically and the level in said tube is controlled in part with an orifice at the outlet of said tube.

5. The process of claim 3 wherein said tube is substantially conical.

6. The process of claim 3 wherein said tube is oriented slantwise.

7. The process of claim 6 wherein said tube is substantially conical.

8. The process of claim 6 wherein said tube is substantially cylindrical.

9. The process of claim 9 comprising the additional step of controlling in part the level in said tube with an orifice at the outlet thereof.

* * * * *