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Declarations under Rule 4.17:

- as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))
- as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))

Published:

- with international search report (Art. 21(3))

[Continued on next page]

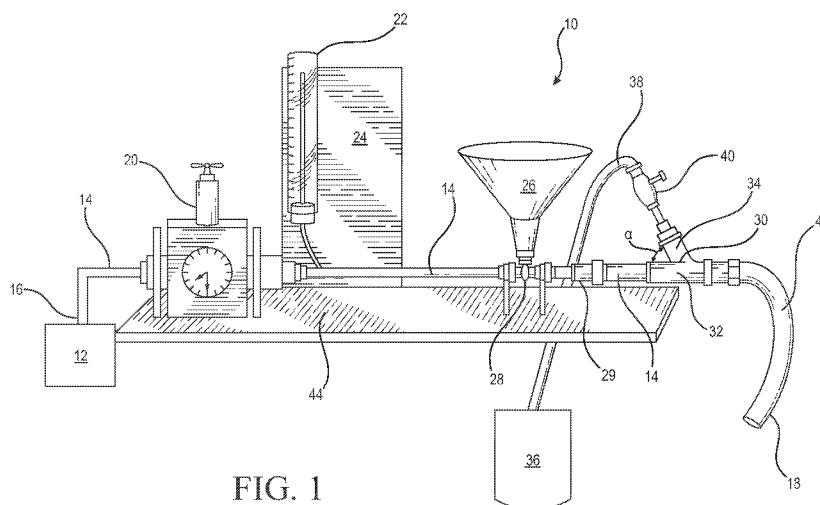
(54) Title: **EDUCTOR BASED MIXER FOR MIXING STUCCO AND WATER**

FIG. 1

(57) Abstract: A mixing assembly includes a main flow conduit (14) having an inlet end (16) and an opposite outlet (18), a source (12) of pressurized air at the inlet end (16), a container of stucco (26) in fluid communication with the flow conduit (14), and a source (36) of water in fluid communication with the flow conduit (14) between the outlet (18) and the container (26). The pressurized air draws stucco from the container (26) into the flow conduit (14), and also draws water into the flow conduit (14) to form an atomized slurry.



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- *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

EDUCTOR BASED MIXER FOR MIXING STUCCO AND WATER

RELATED APPLICATIONS

This application claims 35 USC 119(e) priority from US Serial No. 61/981,324 filed April 18, 2014 and US Serial No. 14/670,228 filed March 26, 2015.

BACKGROUND

The present invention relates to equipment for handling slurries, and more specifically to a mixer used for mixing particulate material, such as stucco or the like, with an aqueous slurry, and often combined with other constituents.

For mixing stucco in water, generally rotary mixers are used. A suitable example of a stucco mixer, of the type used producing gypsum-based products, such as in a wallboard production line, is described in US Patent No. 6,494,609 incorporated by reference. These mixers, employing a rotating impeller to mix the slurry, are dimensionally quite large, which makes the operation inconvenient. A common problem with conventional mixers is that since the velocity of the slurry within the mixer is not uniform, there is a tendency for slow flowing slurry at the periphery of the mixer to prematurely set. This premature setting causes clogging or disruption of the desired high velocity, steady flow of the slurry, in some cases resulting in stopping the whole production line and thereby causes significant loss of revenue.

While mixing, due to the fluid dynamic conditions, the shear is not equally distributed across the slurry. Besides, residence time during mixing is low (~3 seconds) owing to the demand of the production line. In some cases, this problem is addressed by adding pins to the mixer. However, this has not been an effective solution. Because gypsum slurry is a shear thinning fluid, upon application of higher shear, the viscosity of the slurry decreases. The relationship governing the viscosity (η), shear rate ($\dot{\gamma}$) is given as

$$\eta = k\dot{\gamma}^{n-1} \quad (1)$$

where $n < 1$ and k is the flow consistency index. According to this formula, an application of high shear rate can dramatically reduce viscosity. This relationship also illustrates the possibility of usage of slurry with low water stucco ratio by reducing the effective viscosity at a very high shear rate.

Another aspect of conventional stucco technology is that a hopper providing the powdered stucco, gypsum or dry wallboard ingredients should not prematurely contact water prior to entering the mixer. If such premature contact occurs, the tube or passageway used to transmit the dry ingredients to the slurry can become clogged, also interfering with slurry production. Thus, there is a need for an improved slurry mixing apparatus for creating stucco and/or gypsum slurries.

SUMMARY

The above-listed needs are met or exceeded by the present eductor based mixer for mixing stucco and water, which features a bladeless mixer instead of the conventional rotating impeller technology. In the present assembly, a motive fluid is provided, such as air or water, which carries stucco particles, and eventually mixes together to form the gypsum slurry. When air is the motive fluid, water is delivered upstream of a mixer outlet to form the gypsum slurry. In the present assembly, when air is the motive fluid, the slurry is somewhat atomized by the pressurized air stemming from the turbulent nature of the flow, which promotes flowability and prevents unwanted premature clogging or setting of stray slurry particles. In the embodiment where water is the motive fluid, the air is introduced into the system with the dry stucco particles. In the present system, there are no moving parts, unlike conventional mixer systems. The lack of moving parts helps reduce buildup of gypsum inside the mixer. Besides, gypsum slurry being a shear thinning fluid and the eductor facilitating creation of turbulence, the effective viscosity of the slurry produced by the present system will be lower, and will facilitate improved slurry mixing as well as reducing water demand.

Features of the present system include improved mixing of stucco with water, a stucco mixer requiring less maintenance than conventional impeller-based stucco mixers, and having reduced water demand compared to conventional stucco mixing systems. In use, the present system has reduced gypsum slurry water:stucco ratio in the approximate range of 6-40%.

More specifically, the present invention provides a mixing assembly including a source of pressurized air; a main flow conduit having an inlet end and an opposite outlet, the source of pressurized air at the inlet end, a container of stucco in fluid communication with the flow conduit, and a source of water in fluid

communication with the flow conduit between the outlet and the container. The pressurized air draws stucco from the container into the flow conduit, and also draws water into the flow conduit to form an atomized slurry.

5 In another embodiment, a stucco slurry mixing system is provided including a source of pressurized motive fluid, a container of dry particulate in fluid communication with the source of pressurized motive fluid using an eductor such that the dry particulate is drawn into a flow conduit of the pressurized fluid as the fluid passes the container. An outlet is provided at one end of the flow conduit; and a source of liquid is in communication with the flow conduit at a junction located
10 between the outlet and the container.

In the latter embodiment, the preferred motive fluid is water, and air is supplied to the system mixed with the dry, particulate.

In still another embodiment, a building panel is provided that is made using a slurry created using a mixing assembly. The mixing assembly includes a
15 source of pressurized motive fluid, a container of dry particulate in fluid communication with the source of pressurized fluid through an eductor.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side schematic view of a first embodiment of the present
20 mixer system; and

FIG. 2 is a side schematic view of a second embodiment of the present mixer system.

DETAILED DESCRIPTION

Referring now to FIG. 1, a schematic is presented of the present
25 eductor based mixer system, generally designated 10. As depicted, the system is laboratory based, but is contemplated as being readily convertible to production use with larger scale components. A compressor 12 provides a source of pressurized motive fluid, in this case air, to a flow conduit 14, having an inlet end 16 connected to and in fluid communication with the compressor 12, and an opposite outlet 18. In the
30 present embodiment, the flow conduit 14 is a tube or pipe suitable for carrying pressurized air, particulate matter and liquid, and may be assembled using multiple sections fitted together as is well known in the art.

Downstream of the compressor, an adjustable pressure regulator 20 is preferably mounted in fluid communication with the flow conduit 14 for maintaining the pressure in the conduit within desired values. In one embodiment, the compressor 12 has an output of 20-80 psi, and the regulator 20 is set at approximately 60 psi. It is contemplated that the setting of the regulator 20, and the output of the compressor 12 may vary to suit the situation.

A flow meter 22 is optionally connected to, and in fluid communication with the flow conduit 14 and is preferably mounted on a generally vertical support panel 24 or other substrate for proper operation. Next, the flow conduit 14 is connected to, and is in fluid communication with a container of particulate matter 26, such as a hopper or the like filled with dry stucco, optionally provided with other dry ingredients, including but not limited to starches, clays, setting agents, accelerators, set retarders, perlite, cellulose and other dry additives well known to practitioners in the wallboard formulation art. Examples of such formulations are disclosed in, among others, US Patent Nos. 4,009,062; 5,922,447; 8,197,952 and 8,618,445, all of which are incorporated by reference.

In the preferred embodiment, the container 26 is connected to the flow conduit 14 using an eductor fitting 28, configured to receive dry particulates by gravity feed from the container. The pressurized air flow in the flow conduit 14 draws or sucks the particulates into the air flow from the container 26. Downstream of the eductor fitting 28, a diffuser 29 with an increased diameter relative to the eductor slows the velocity of the pressurized air and stucco particles. For example, the internal diameter of the flow conduit at the eductor is approximately 1/2 inch, and at the diffuser 29 is approximately 3/4 inch. Next, or downstream of the diffuser 29, a Wye fitting, or junction 30 is connected to and is in fluid communication with the flow conduit 14. The reduced velocity of the pressurized air and particles downstream of the diffuser 29 facilitates the mixing which occurs at the junction 30. The junction 30 includes a first leg 32 in line with the flow conduit 14. A second leg 34 defines an acute angle α with the first leg 32. In other words, the angle α is less than 90° in relation to a longitudinal axis defined by the flow conduit 14. While a variety of acute angles are contemplated, in the preferred embodiment, α is approximately 40°.

A supply of liquid 36, preferably water, is provided under pressure or via gravity feed to the second leg 34 via a feed tube 38. While a container is

depicted for the supply 36, it is contemplated that the liquid source could be a conventional tap water source. A suitable control valve 40 is provided in fluid communication with the feed tube 38 and the second leg 34 for controlling the liquid flow as needed. It is important that the liquid be added to the flow conduit 14 between the outlet 18 and the container 26 to prevent the liquid from flowing backward to prematurely mix with the particulate compounds in the container. Such unwanted mixing could cause setting and/or clogging of the Tee fitting 28 or the flow conduit 14. It is contemplated that the selection of the angle α promotes the flow of the liquid towards the outlet 18. At the outlet 18, an optional flexible tube section 42 is used for directing the flow of the resulting pressurized, and atomized slurry. It is contemplated that the present system 10 is usable for producing a variety of cementitious or settable slurries, including but not limited to gypsum slurries used for producing wallboard and other building panels.

In the present system 10, air runs through the flow conduit 14, and the eductor 28 creates a suction force, which pulls the stucco particles from the container 26 incorporates them into the flow of pressurized air and once the flow reaches the junction 30, the air and stucco eventually mix with the water from the tube 38 to form an atomized slurry as shown in FIG. 1. As shown, the system 10 is mounted on a substrate 44 such as a table or the like, but it is contemplated that other substrates are suitable, depending on the scale of the assembly 10.

Referring now to FIG. 2, a second embodiment of the present mixing system is generally designated 50. Components shared with the system 10 are designated with identical reference numbers. It has been found that under some circumstances, the system 10 is susceptible to back pressure created by the water stream supplied through the water feed tube 38. Such back pressure has been found to lead to premature mixing with water and setting of the slurry, which causes unwanted clogging. As is known in the art, stucco is relatively fast setting, in many cases setting begins within 10 seconds of contact with water.

A main difference between the embodiments 10 and 50 is that the latter uses water as the motive fluid, replacing air, used in the former. Water is provided under pressure in the flow conduit 14, which is connected to the eductor 28. In the present embodiment, the educator 28 is a 1 1/4 inch NPT educator, however other sizes are contemplated depending on the application, including, but not limited to 1/2

inch NPT.

In the hopper 26, it is preferred that a mixer 52, such as a rotating helical or screw mixer is used to stir the particulate stucco, causing turbulence such that air is incorporated with the stored particulate. Similar to the embodiment 10, as the motive fluid in the flow conduit 14 passes the eductor 28, a vacuum is created and the particulate and air is drawn into the flow of motive fluid. As a result, the particulate stucco, the air and water mixes together in a mixing chamber 54. The mixing chamber 54 is relatively short compared to the length of the conduit 14, and has a length in the general range of 1-2 inches. In the preferred embodiment, the mixing chamber 54 has a diameter:length ratio of 1:2, however other ratios are contemplated. The shorter mixing chamber 54 provides for rapid mixing of the slurry.

It has been found that the entrained air, once mixed with the flow of motive fluid, significantly enhances shear in the mixing chamber 54, resulting in a more uniform mixing of particulate and water. Further, the increased shear provided by the entrained air reduces the viscosity of the slurry without requiring additional water. As such, the Water:Stucco ratio of the resulting slurry was 75:1, without the use of any dispersant or retarder, using a 1/2 inch NPT eductor. This ratio relatively lower than slurries created with conventional pin-type mixers, where Water:Stucco ratios typically range between 80-100. It is contemplated that modifications to the hopper 26, particularly in a lower region 56 where the geometry of the hopper narrow abruptly, and combined with the use of dispersants and/or retarders as known in the art, the Water:Stucco ratio is contemplated to be reduced in the general range of 50.

At an outlet 58 of the mixing chamber 54 is connected a slurry delivery conduit 60, which in one embodiment is a flexible hose for delivery to a wallboard fabrication conveyor line, well known in the art.

It will be seen that the present mixer system 10, 50 is usable as a replacement for a traditional rotary impeller mixer in the production of gypsum wallboard panels or other gypsum-based structural panels, boards, tiles and the like, collectively referred to as building panels. Processes and ingredients of such products are well known in the art, and representative patents are listed above and incorporated by reference herein. A construction panel made from the slurry produced by the present mixer includes upper and lower layers of face paper sandwiching a thickness of set slurry produced as described above. The present

system 10, 50 is used for creating the initial gypsum slurry that forms the primary component of such products.

While a particular embodiment of the present eductor based mixer for mixing stucco and water has been described herein, it will be appreciated by those skilled in the art that changes and modifications may be made thereto without departing from the invention in its broader aspects and as set forth in the following claims.

CLAIMS:

1. A mixing assembly, comprising:
a source of pressurized air;
a container of dry particulate in fluid communication with said source of pressurized air such that said dry particulate is drawn into a flow conduit of said pressurized air as said air passes said container;
5 an outlet at one end of said flow conduit; and
a source of liquid in communication with said flow conduit at a junction located between said outlet and said container.
2. The system of claim 1 wherein said junction is a Wye junction connector defining an angle less than 90 degrees relative to a longitudinal axis of said flow conduit and said flow conduit extends from a source of said pressurized air to said outlet.
3. The system of claim 1 wherein said container is connected to said flow conduit by an eductor fitting.
4. The system of claim 1 wherein said particulate is stucco and said liquid is water.
5. A stucco slurry mixing system, comprising:
a main flow conduit having an inlet end and an opposite outlet;
a source of pressurized motive fluid at said inlet end;
a container of stucco in fluid communication with said flow conduit
5 using an eductor;
said pressurized motive fluid drawing stucco from said container into said flow conduit, to form a slurry.
6. The system of claim 5 wherein said motive fluid is water.

7. The system of claim 6 further including a mixer associated with said container for causing turbulence in the stucco so that air is mixed with the particulate.

8. The system of claim 6, wherein said slurry has a water:stucco ratio of approximately 75.

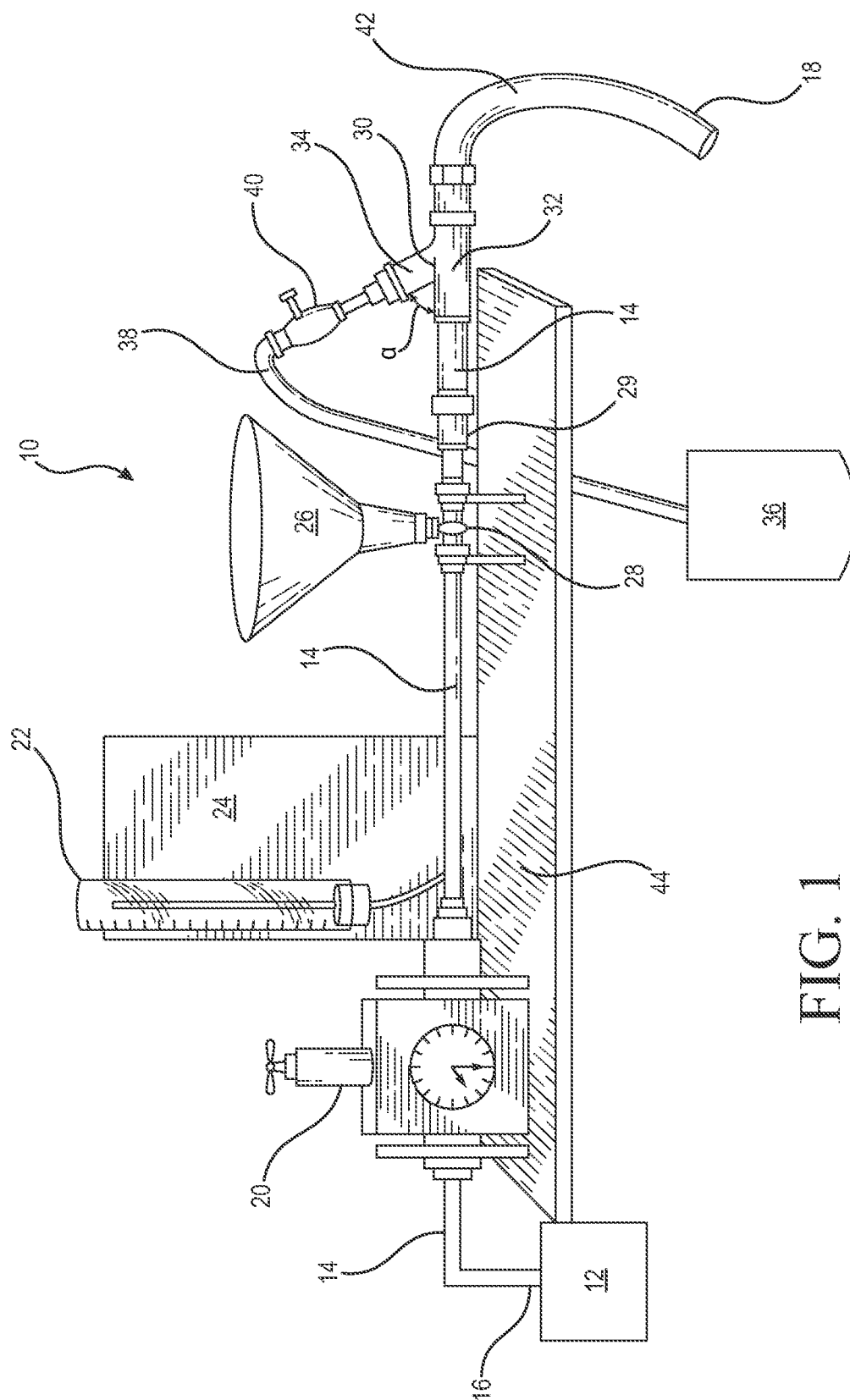
9. The system of claim 6 further including a mixing chamber located downstream of said eductor, said mixing chamber having a diameter:length ratio of approximately 1:2.

10. A building panel made using a slurry created using a mixing assembly, comprising:

a source of pressurized motive fluid; and

a container of dry particulate in fluid communication with said source of pressurized motive fluid through an eductor such that said dry particulate is drawn into a flow conduit of said pressurized motive fluid as said fluid passes said container in said eductor.

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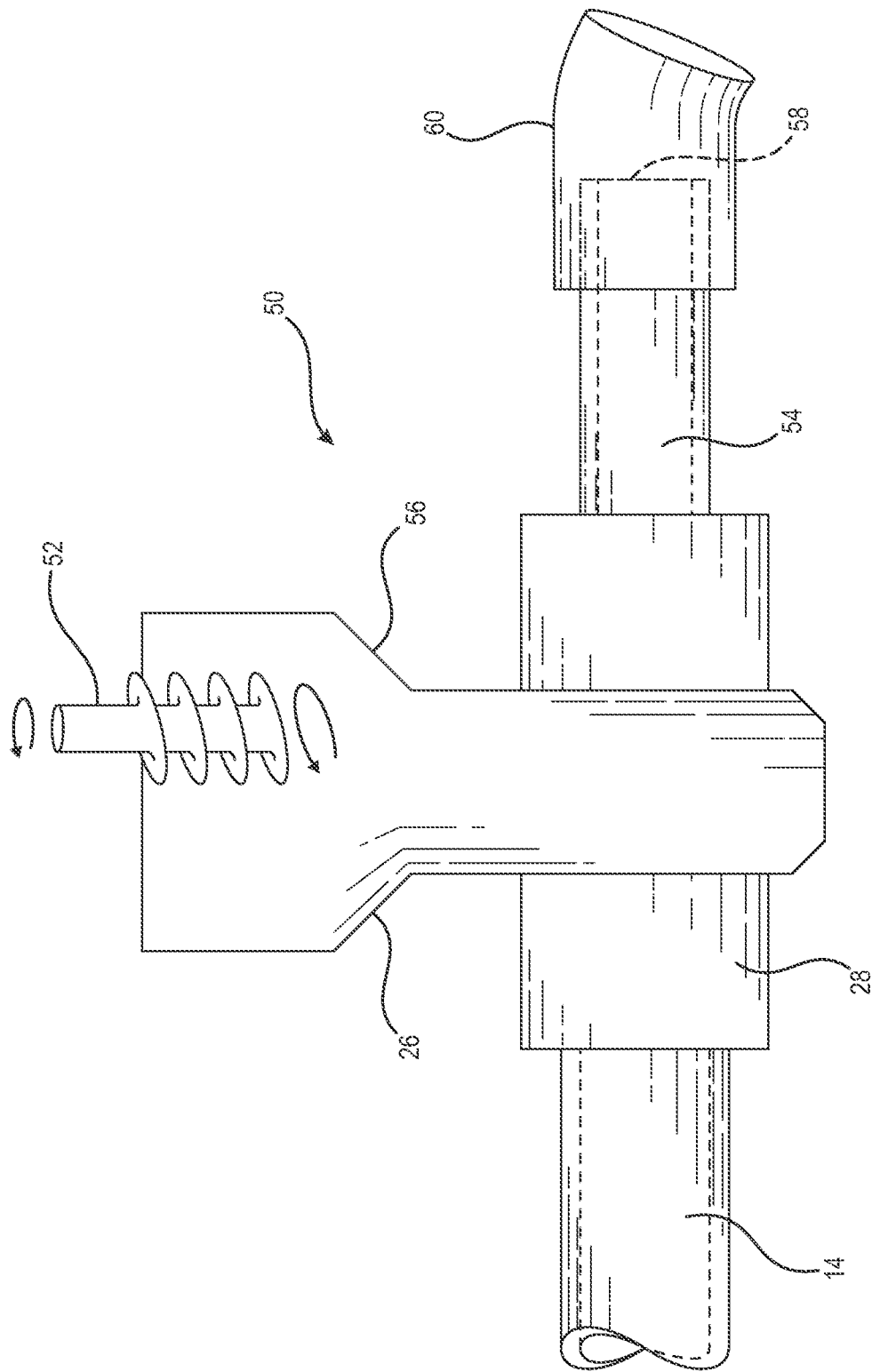


FIG. 2

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2015/025274

A. CLASSIFICATION OF SUBJECT MATTER		
INV.	B28C7/00	B01F5/04
	B28C5/06	
		B01F3/06
		B01F3/12
		B28C9/00
ADD.		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols)		
B01F B28C E04F		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
EPO-Internal, WPI Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 765 217 A (WHITLEY MORAN & COMPANY LTD) 9 January 1957 (1957-01-09) figures 1-4 page 2, lines 69-89 page 2, line 123 - page 3, line 25 -----	1,3-5
X	DE 15 09 455 A1 (HOELTER HEINZ) 9 January 1969 (1969-01-09) figure 1 page 4, paragraph 3 -----	1,3-5
X	WO 2008/135503 A1 (LHOIST RECH & DEV SA [BE]; DEV CHANVRE SOC A ACTION SIMPL [FR]; GOUDET) 13 November 2008 (2008-11-13) figures 1,4 page 17, lines 17-24 page 18, lines 3-24 page 21, lines 27-30 ----- -/-	1,2,4,5
☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
* Special categories of cited documents : "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search		Date of mailing of the international search report
24 September 2015		01/10/2015
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer Voltz, Eric

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2015/025274

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 039 170 A (CORNWELL CHARLES E ET AL) 2 August 1977 (1977-08-02) figures 2-4 column 3, lines 7-16 -----	1,3-5
X	US 2007/241204 A1 (OHATA HIROKI [JP] ET AL) 18 October 2007 (2007-10-18) figures 1-3 paragraphs [0075] - [0077], [0083] -----	1,2,4,5
X	US 6 494 609 B1 (WITTBOLD JAMES R [US] ET AL) 17 December 2002 (2002-12-17) cited in the application figure 10 column 9, lines 25-33 -----	10
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X	WO 2013/156792 A2 (PURSUIT DYNAMICS PLC [GB]) 24 October 2013 (2013-10-24) figures 1-3 page 17, lines 12-27 page 18, lines 7-31 -----	5-9
X	DE 20 2006 001759 U1 (IDS GMBH INSTANDHALTUNG DIENST [DE]) 7 September 2006 (2006-09-07) figures 1-5 paragraphs [0019], [0023] -----	5-9

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2015/025274

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☒ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-3, 10

A mixing system with a source of liquid in communication with the flow conduit and a building panel obtained using a slurry produced by said mixing system.

2. claims: 4-9

A mixing system for preparing a gypsum slurry

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2015/025274

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
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