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(71) Applicant: **COMPAGNIE DES SERVICES
DOWELL SCHLUMBERGER**
20, rue Jean-Jaurès
F-92800 Puteaux(FR)

(72) Inventor: **Sherwood, Ronald**
9, quartier Gaillard
F-42100 Terrenoire(FR)
Inventor: **Althouse, James**
Eculieu La Rivoire
F-42480 La Fouillouse(FR)

(74) Representative: **Richebourg, Michel François**
Etudes et Fabrication Dowell Schlumberger
Z.I. Molina La Chazotte B.P. 90
F-42003 Saint-Etienne Cédex 1(FR)

(54) **Mixer for pulverous and liquid materials, or liquid-liquid materials.**

(57) The invention consists of a centrifugal mixer (3,4) in which the powder feed (21) relies on recirculation (25) of the mixture through a circuit containing a jet pump.

This produces a very high quality mix whose density can be readily controlled, even when fine powders such as cement are used. The invention has applications for oil field services.

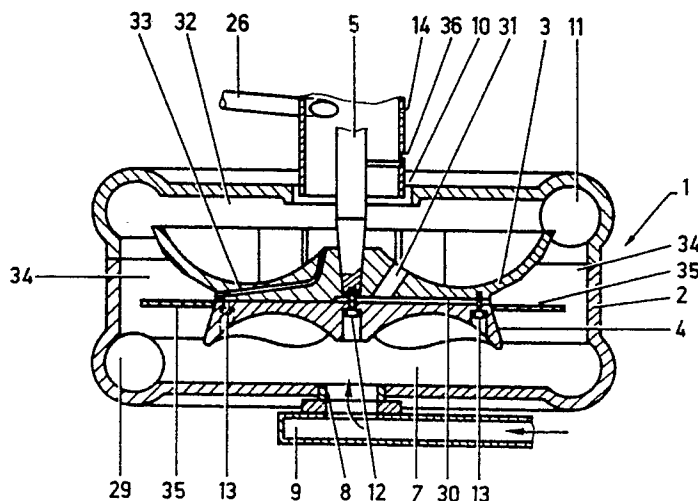


FIGURE-1

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MIXER FOR PULVEROUS AND LIQUID MATERIALS, OR LIQUID-LIQUID MATERIALS

The invention consists of a device for mixing a pulverous material with a liquid, essentially powdered cement and water. The application most particularly envisaged is the cementing of oil wells, gas wells, geothermal or other wells.

Such devices have existed for a long time, such as covered by patent US-A-1486883 dating from 1922. The search for improved mix quality and refined production techniques has led to numerous publications, the most noteworthy certainly being patent US-A-4453829.

The present document discusses a mixer with two rotors coupled within a single casing: an upper rotor receives granular material at its center by simple gravity feed through a central opening in the casing upper part, and projects this material towards the motor rim, while liquid arrives through a central opening in the underside of the lower rotor, to be projected by centrifugal action towards the rotor periphery. Mixing of the granular material and the liquid occurs in the peripheral area between the two rotors, the mixture being drawn off through the casing by a suitable discharge system. The mixer thus described operates to full satisfaction when the granular material is sand and the liquid is a gel.

However, operation of the mixer is found to be less satisfactory with very fine pulverulents such as cement, and water.

In the first case, fine powders entrap a sizeable volume of air, which is freed in the peripheral mixing area of the equipment. This air cannot be centrifuged by the upper rotor, and thus cannot be evacuated from the casing with the finished mix; it thus collects in this area and gradually prevents correct operation of the mixer.

In the second case, materials such as sand lend themselves well to simple gravity feeding into the upper rotor, but the same is not true for fine powders, whose lower densities render them prone to pressure imbalances in this zone.

Furthermore, the equipment in question does not allow easy adjustments to the density of the mix obtained, while it is an established fact that successful cementing of oil wells depends on precise and easy density control of the cement used.

The purpose of the invention presented herein is to offer a mixer meeting the type requirements outlined above, but ensuring satisfactory operation even with fine powders.

The invention is in particular intended to cater for cement powders and in the preferred design, allows for extremely simple yet highly precise density adjustment.

The invention assures these aims by proposing a centrifugal mixer with a casing containing a high speed rotor and into which the fluid feed is discharged via an inlet. A pulverous material (or second liquid) feed system is also provided, together with an outlet for evacuating the mix at a pressure greater than atmospheric pressure. In this mixer, the pulverous material feed system comprises a jet pump receiving the pumping fluid through the finished mix return line.

The mixer advantageously features air evacuation means in the mixing area, and a second rotor for pressurizing the fluid by centrifugal action.

This architecture is noteworthy for the following reasons. Firstly, the jet pump drive fluid is provided by internal recirculation (via a line tapped into the mixer pressure zone), therefore avoiding additional material requirements. As a result, the density of the mix can be adjusted by simple control of the pulverous material feed (via a valve controlling opening of the powder hopper run-off).

The term "mixer pressure zone" (area into which the recirculating line is tapped) for the purposes of the invention refers to either the pressurized part of the mix, or to a zone rich in pressurized fluid (partially mixed). Such a zone will exist particularly if the peripheral area around the rotors is partly divided by a plate mounted on the rotors. Such a separation is not indispensable, but ensures that the mixture passing through the jet pump is not denser than the mix obtained around the periphery of the centrifuging rotor ("slinger"). On the other hand, this separator plate leads to a slight drop in efficiency.

Although it is difficult to fully document certain of the phenomena occurring inside the mixer, it would appear that in the absence of the above separator plate, the mixer operates to such a high level of efficiency that the density of the mix in all areas of the peripheral mixing area (i.e. top or bottom) - and therefore the density of the delivered mix - is constant.

Again, use of a jet pump has distinct advantages for feeding cement powders - patent US-A-1486883 has already recommended this. Unfortunately, this approach is accompanied by considerable increases in the volume of air brought in by the powder, thus earlier equipment could only make use of this type of pump if the latter had a degassing tank installed downstream, and from which the mix was re-pumped. Thus prior to the present invention, the possibility of using a jet pump with the type of mixer described in patent US-A-4453829 directly - that is, without employing the degassing tank - could not be considered, yet

more so given the fact that this type of mixer already experienced air-accumulation problems. The present invention surmounts this difficulty by allowing for evacuation of air from the mixing zone.

In general terms, all types of fluid jet pump are suitable for the purposes of the invention. Reference is made, for example, to the "Pump Handbook" published in 1976 by the McGraw Hill Book Company, U.S.A., section 4 concerning classic jet pumps, i.e. those featuring a central fluid jet providing high-pressure drive towards a low-pressure nozzle, thus entraining the material for delivery by the creation of a low-pressure area. Also included under the general heading of "jet pumps" are annular-jet pumps where the drive fluid is injected in the form of a conical vortex sheet (or individual filaments) surrounding the pulverous material feed. Pumps with central jets are normally installed transversally below the run-off of the pulverous material hopper, whereas annulartype pumps are most advantageously installed if the reservoir is located directly above the central upper opening of the mixer, with which it communicates via a vertical cylindrical chamber containing one or more individual slots that produce the vortex sheet or the driving filaments.

Apart from the advantages already cited, the proposed system has other benefits discussed below. Other than the powder regulating valve, the system contains no more moving parts than existing systems. Maintenance, including cleaning, is simple and equipment reliability is excellent.

Contrary to what might be expected, feeding the jet pump with a fluid whose density can vary (in relation to the mix) does not disturb the powder feed rate setting.

Quality of the mix is excellent, which is all the more surprising since the system represented by this invention upsets the established principles which state that cement mixing should proceed through increasing density levels until the required density is attained. On the contrary, the invention allows for cement mixing at high density levels in the jet pump, then density reductions to a lower level in the mixer.

Since the jet pump is connected directly to the mixer inlet area (which is at a relatively low pressure), there is no risk of blocking the pump: this is not the case with certain set-ups employing the earlier technology, where the jet pump was required to deliver sufficient pressure to lift the mix, for example, up to the degassing tank.

Other advantages and characteristics of the invention will be seen from the following description. Reference is made to the figures given in the annex, i.e.:

- Figure 1: cross-section of a mixer covered by the invention. To avoid unnecessary repetition of illustrations, the one drawing shows two different designs, as follows:

(on left) - one version of a powder feed system and one solution for air evacuation;

(on right) - alternative versions of the above.

-Figure 2: schematic representation of a mixer covered by the invention. The figure shows two possible configurations for the recirculating line that feeds the jet pump its drive fluid.

In Figure 1, mixer (1) has a casing (2) containing upper rotor (3) (also known as a "slinger") and lower centrifuging rotor (4) ("impeller"). Casing (2) can consist of an upper and a lower shell assembled by parts that are not illustrated. Rotors (3) and (4) are mounted on the end of shaft (5) which is driven by motor (6) mounted on support (15) (see Figure 2).

Centrifuging rotor (4) is so designed that its rotation generates a vortex that in turn produces a zone of suction (7) in the region of lower orifice (8); inlet (9) (for water or more generally, fluids) is mounted at this orifice and water is drawn in through orifice (8) then delivered under pressure towards the outer edge of the lower rotor, and generally distributed around the full outer limit of the mixer.

Upper rotor (3) is so configured that pulverous material fed in through chamber (14) adjacent to upper inlet orifice (10), is thrown towards the peripheral zone of the rotor and generally projected around the full outer limit of the mixer, where it is integrally mixed with the water (itself in full agitation). The (pressurized) mix is evacuated through outlet (11) located in the mixer outer limit.

Rotors (3) and (4) are assembled with the attached parts (12) and (13).

Mixer (1) is integrated into a mixing circuit (Figure 2) comprising mixing water tank (20) that delivers into inlet (9) in the lower part of the mixer; feed hopper (21) holding pulverous material and connecting with chamber (14) that feeds into the upper part of the mixer; high-pressure pump (22) which receives the mixture fed from outlet (11) via delivery line (28). Pump (22) delivers the finished mix (for example, liquid cement for cementing an oil well).

The above layout is a known method, and is described in patent US-A-4453829; mention of it is made here for reference.

The invention allows for a forced pulverulent feed system employing a fluid jet pump (23) located upstream of valve (24) controlling the run-off of hopper (21); the jet pump drive fluid is obtained via recirculating line (25) that draws from the high-pressure zone of the mixer (that is, around the rotor peripheries). Recirculating line (25) can draw from

(29) in the rotor lower zone (where the mix is heavier in water) if separator plate (35) is fitted between rotors (3) and (4) (installed on rotor (4)), although as indicated above, such a plate is not indispensable. Alternatively, the fluid drive can be picked directly off outlet (11) or delivery line (28); in this case, the jet pump drive will be the water/cement mix proper.

The jet pump entrains the powder; the flowrate of the latter is controlled by valve (24) (butterfly valve or slide valve, for example) located inside line (26) that arrives tangentially inside chamber (14). The top of the chamber is left open for admission of air, and the chamber itself fits into mixer upper opening (10), leaving another air passage. Line (26) and chamber (14) must form a single part. If the jet pump is of the annular type, the assembly consisting of (23) and (26) is replaced by annular slot (36), or a series of circumferentially spaced slots, cut directly into chamber (14); in this case, the latter is placed immediately below the adjustable bottom run-off of the hopper.

Hopper (21) is of the pneumatic or gravity feed type, or both.

In view of the fact that the jet pump drive fluid is a circulatory feed, the equipment flow schedule is written simply as:

water inflow (8) + cement inflow (10) = mixer offtake (11).

During, for example, cementing of an oil well or similar, the volume of cement delivered by pump (22) to the upstream well is constant and is determined by the pump speed. The rate of offtake of mixed material through (11) is therefore constant, or can easily be maintained so.

As a result of the foregoing argument, the mixer flow schedule dictates that water inflow (8) is a direct function of powder inflow (10), which can easily be controlled by valve (24).

It should be noted that it is in effect possible to control the flow of cement rather than the flow of water, since delivery of the former is forced, whereas water feed is not. The cement flow thus has priority over the water flow.

Density meter (27) is mounted in the recirculation line and/or on delivery line (28), particularly if the recirculation line is tapped into the latter. Where this is the case, the pick-off is downstream of the density meter. It is an advantage to install valve (37) also in line (28) to allow full recirculating of the mix through jet pump (23) at start-up (when the cement content of the mix is somewhat low).

As explained above, a determining factor in correct operation of the equipment is the provision of satisfactory means for evacuating the air brought in via jet pump (23) with the powder feed.

To this end, and as shown in Figure 1 (right side), air evacuation cavity (30) is provided between rotors (3) and (4) - this communicates with mixer upper central zone (32) via ducts (31) drilled obliquely through upper rotor (3). Air can escape from zone (32) via the passage left between orifice (10) and chamber (14). Air evacuation cavity (30) could be formed by spacers on attach parts (12) and (13).

In an alternative version (slightly more complicated to produce as shown in the left part of Figure 1, no inter-rotor air evacuation cavity is provided. Instead, ducts (33) are cut through rotor (3), directly linking upper central zone (32) with high-pressure zone (34) adjacent to the two rotors.

If inter-rotor separator plate (35) is to be fitted, the air evacuation system allows for a passage between the upper part of the mixer peripheral zone, and zone (32). In this case, provision would be made for a number of orifices in plate (35) to allow for evacuation of air entrapped beneath the plate.

Claims

1 - Mixer for liquid and pulverous material, comprising a casing (2) containing a high-speed rotor (3 and 4) and into which liquid is fed through inlet (9) and pulverous material is fed via a system comprising (21) and (14); the liquid/pulverulent mix is evacuated through offtake (11) at a pressure greater than atmospheric pressure. The equipment is characterized by the inclusion of a jet pump (23) in powder feed system (21) and (14), the jet pump receiving its drive fluid through mixture recirculating line (25).

2 - Mixer for liquid and pulverous material, comprising a casing (2) containing a high-speed rotor (3 and 4) and into which liquid is fed through inlet (9) and pulverous material is fed via a system comprising (21) and (14); the liquid/pulverulent mix is evacuated through offtake (11) at a pressure greater than atmospheric pressure. The equipment is characterized by the inclusion of a jet pump (23) in powder feed system (21) and (14) (receiving its drive fluid through mixture recirculating line (25), and by the provision of evacuation means (30, 31 and 33) for air brought in with the mixer feed.

3 - Mixer complying with Claims 1 or 2 above for the mixing of a pulverous material with a liquid, of the following design:

-Mixer proper (1) with upper centrifuging rotor (3) ("slinger") (for powder) coupled with lower centrifuging rotor (4) ("impeller") (for liquid), these two being installed in casing (2) which has an upper central orifice (10) for powder inlet, a lower central orifice (8) for liquid inlet, and a peripherally moun-

ted offtake (11) for the mix; mixer has zone (34) (under pressure) around the rotor periphery; liquid inlet (9) connecting with orifice (8); and pulverous material feed system comprising (21) and (14) which feeds into upper orifice (10) and which contains a pulverous material feed hopper (21). 5

This mixer is characterized by inclusion in feed system (21 and 14) of jet pump (23) located downstream of valve (24) controlling opening of the feed hopper, and directly connected (via (26) and (14)) with upper orifice (10); and by the provision of evacuation means (30, 31 and 33) in mixer zone (34) for air brought into the said zone (34). 10

4 - Mixer complying with Claim 3 above, and characterized by the fact that the fluid feed for jet pump (23) is provided by recirculating line (25) tapped into high-pressure zone (29) of mixer (1). 15

5 - Mixer complying with Claim 4 above, and characterized by tapping of recirculating line (25) into offtakes (11) and (28) of mixer (1). 20

6 - Mixer complying with Claim 4 above, and characterized by the provision of plate (35) for partial separation between the peripheral areas of lower rotor (4) and upper rotor (3), and by the fact that recirculating line (25) is tapped into (29) in the lower rotor peripheral area. 25

7 - Mixer complying with any of Claims 3 through 6 above, and characterized by use of a central drive flow in jet pump (23).

8 - Mixer complying with any of Claims 3 through 6 above, and characterized by use of annular flow for driving jet pump (23). 30

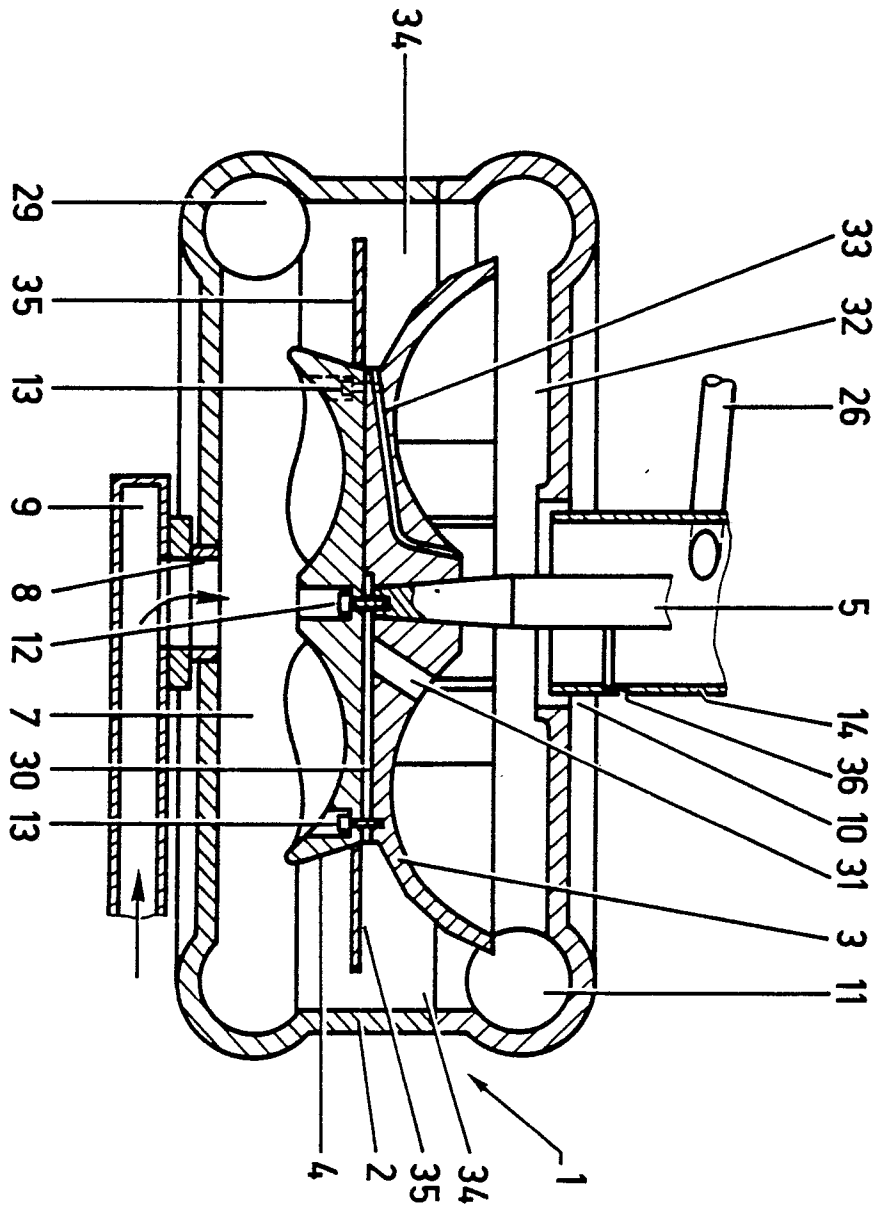
9 - Mixer complying with any of Claims 3 through 8 above, and characterized by use of gravity feed for pulverous material feed hopper (21). 35

10-Mixer complying with any of Claims 3 through 9 above, and characterized by the fact that air evacuation means (30, 31 and 33) comprise ducts through upper rotor (3) linking central mixing zone (34) of mixer (1) with upper mixing zone (32), the latter communicating to atmosphere. 40

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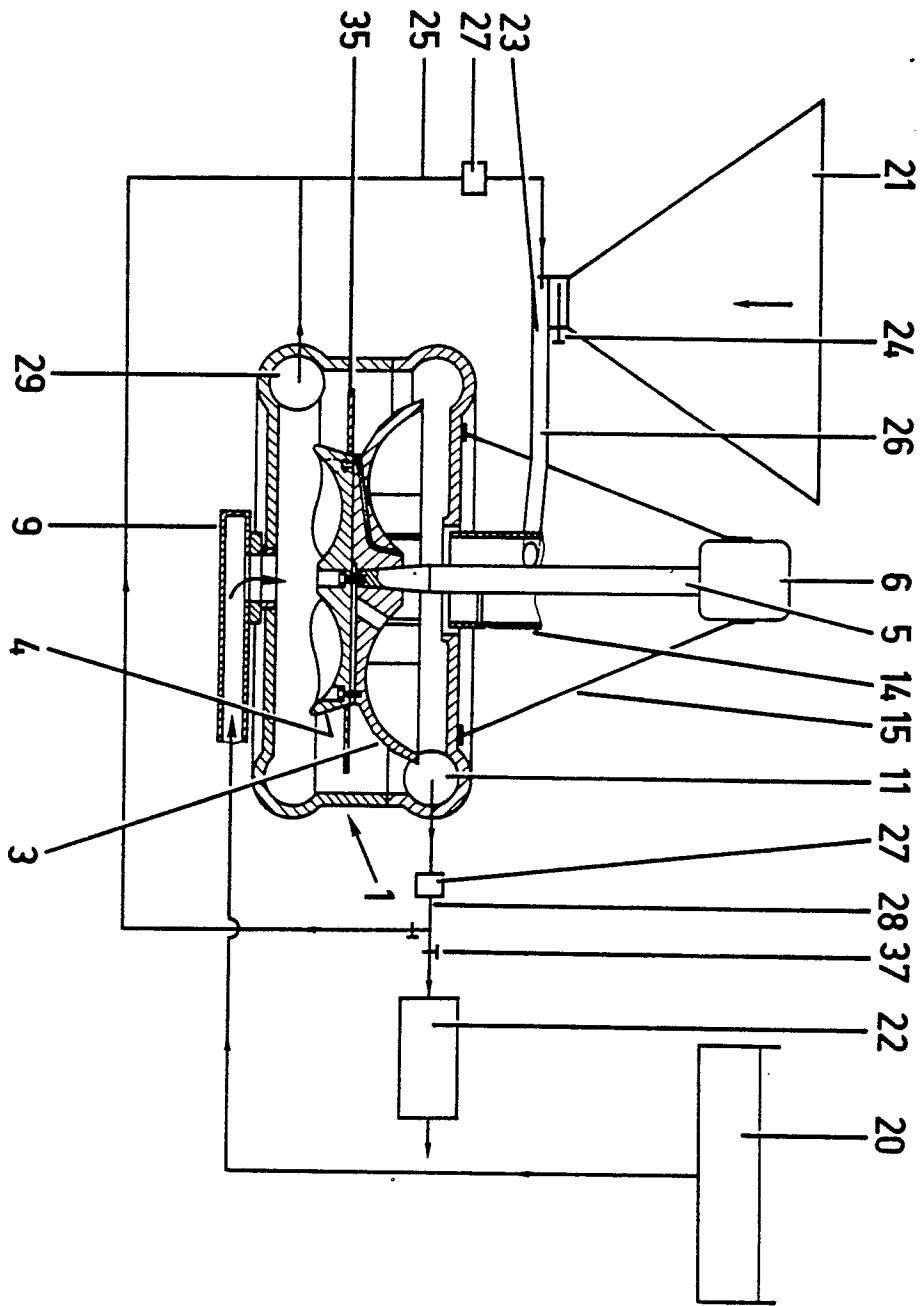


FIGURE-2



DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
Y,D	US-A-4 453 829 (ALTHOUSE) * Figure 1 *	1,4-9	B 01 F 5/16
Y	US-A-4 099 005 (FULLINGTON) * Figures *	1,4-9	
A	US-A-4 426 156 (ADAMO) * Figures *	6-8	
A	US-A-3 326 536 (ZINGG)		
			TECHNICAL FIELDS SEARCHED (Int. Cl.4)
			B 01 F
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 08-07-1987	Examiner PEETERS S.
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone. Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	