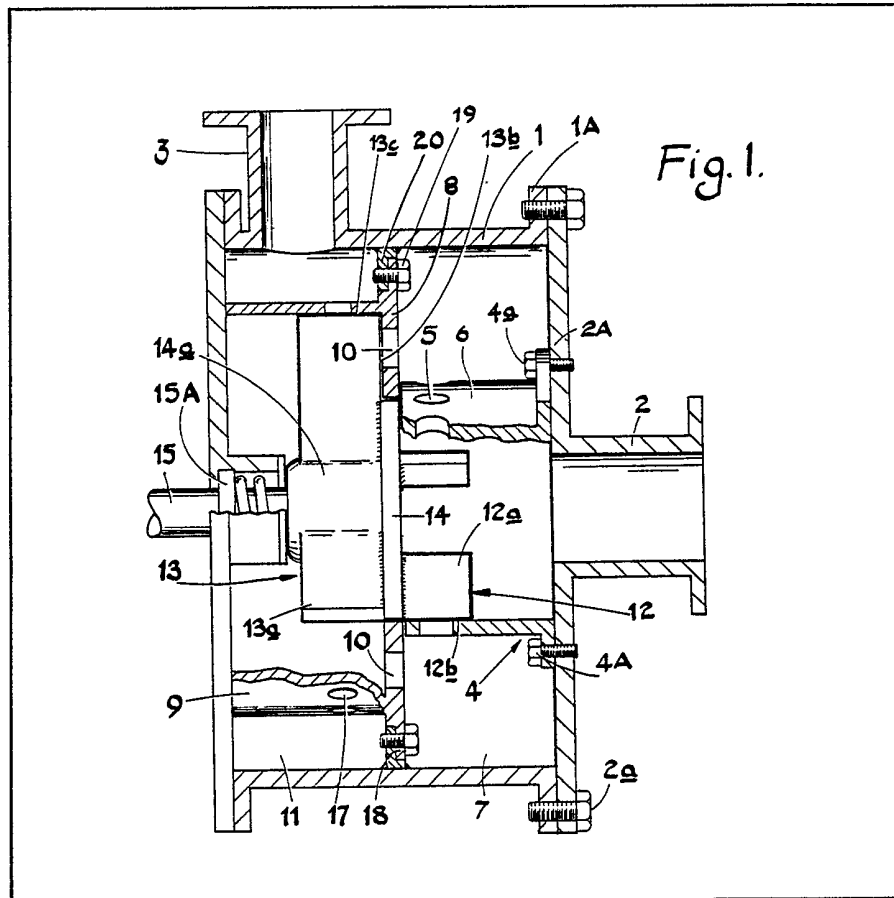


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(54) **Mixing apparatus**

(57) A mixing apparatus has a housing (1) containing a pair of apertured stators (6, 8) permitting flow therethrough respectively in different directions, and a bladed rotor having first and second rotors (12, 13) each co-operating with a respective stator. Rotation of the rotors forces material to be mixed through the stators and, because of the arrangement of the rotor blades relative to the stator apertures (5, 10), produces a shearing action on the material in two different non-parallel planes.



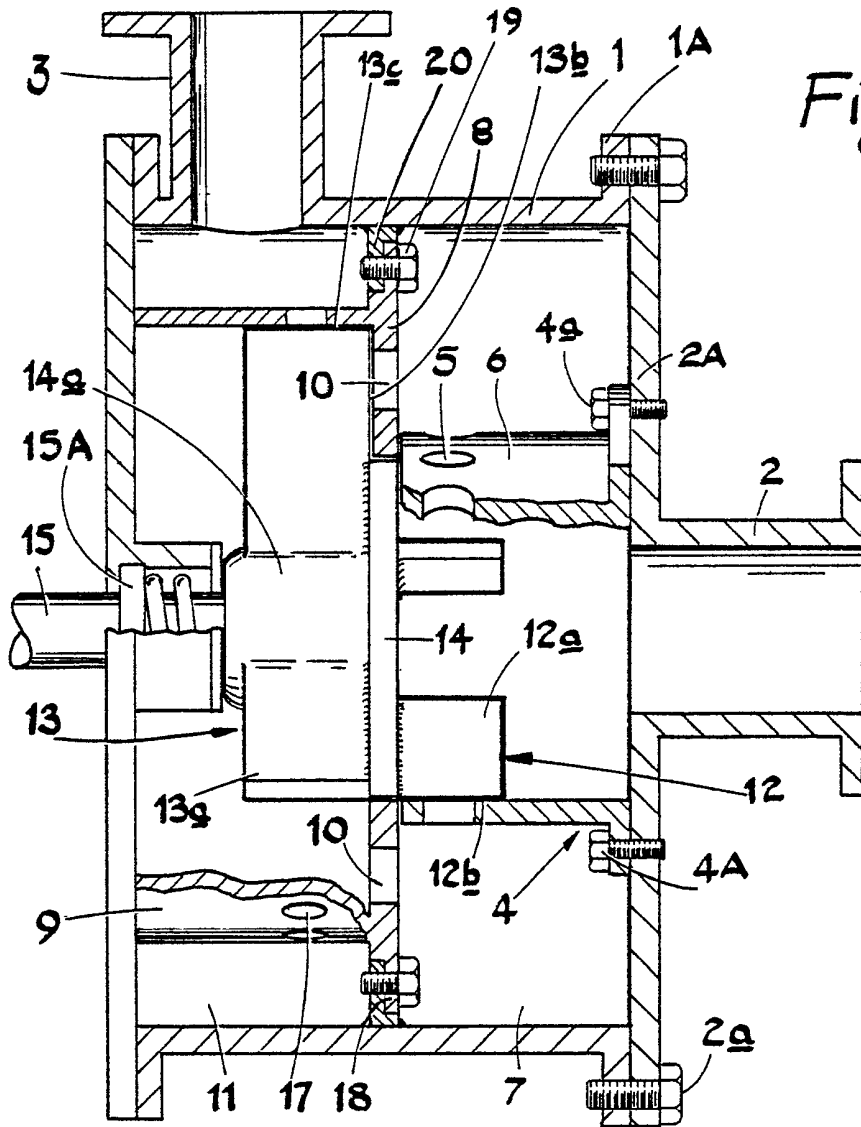


Fig. 1.

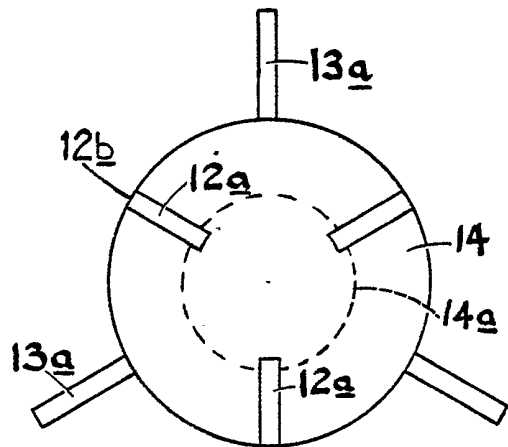


Fig. 2.

## SPECIFICATION

## Mixing apparatus

5 This invention relates to multi-purpose mixing apparatus for mixing together materials in liquid and solid form and primarily for breaking down and mixing solid material with liquid. An object of the invention is to provide an apparatus of more compact dimensions relative to its mixing capacity and of increased efficiency as compared with some conventional apparatus.

10 According to the present invention, a mixing apparatus comprises a housing having a material inlet and outlet and containing a pair of apertured stators, the apertures of each of which respectively permit fluid flow therethrough in different directions, and a bladed rotor arranged with first and second bladed parts thereof respectively in co-operative relationship with the stators, whereby rotation of the rotor forces material introduced through the inlet successively through the stators and in so doing, by co-operation of the blades and stator apertures, subjects said material to shearing actions in different non-parallel planes.

15 In one convenient arrangement, one of the stators has a cylindrical apertured wall closely surrounding a first bladed part of the rotor, the apertures being arranged so that rotation of the rotor brings said first bladed part into co-operation with said apertures successively.

20 One of the stators may conveniently be a flat plate extending generally perpendicularly to the rotational axis of the rotor and co-operating with a second bladed part of the rotor. The plate is preferably arranged to divide the housing into two chambers, each containing a respective one of said rotor parts each for co-operation with one of the stators, said chambers communicating respectively with the inlet and outlet.

25 The rotor portions may conveniently be mounted on a common drive shaft and are preferably carried on opposite sides of a common support driven by the shaft.

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

35 *Figure 1* is a side elevation, partly in longitudinal cross-section and partly broken away for clarity of illustration, and

40 *Figure 2* is an end elevation of part of the apparatus of *Figure 1*.

45 The mixing apparatus shown in *Figure 1* comprises a generally cylindrical housing 1 having an inlet 2 and an outlet 3 directed in mutually perpendicular directions. The inlet 2 is formed in an end cover 2A secured to a radially outward flange 1A of the housing by bolts 2a. The housing contains a first cylindrical stator 4 secured to the cover 2A around the inlet 2 by bolts 4a passing through a radially outward flange 4A of the stator around the inlet 2 and having a series of radial holes 5 through its circumferential wall 6, opening into a first chamber 7. A second stator is in the form of an apertured flat plate 8 formed as a radially inward flange on a further cylindrical stator 9 which will be

50 further described hereinafter. The plate 8 extends at right angles to the circumferential wall 6 of the stator 4, the apertures 10 of the plate 8 being arranged in a circular formation surrounding the stator 4. These apertures 10 provide communication between the chamber 7 and a second chamber 11 formed at the opposite side of the plate 8 to the first chamber 7 and communicating with the inlet 3, the chamber 11 containing the further stator 9.

55 The housing 1 contains two bladed rotors 12, 13 disposed respectively at either side of the plate 8. As can be seen more clearly from *Figure 2*, the rotors, in this embodiment, share a common support in the form of a central plate 14, to opposite sides of which the blades 12a, 13a respectively of the rotors 12 and 13 are secured, as by welding for example. The radially innermost edges of the blades 13a are secured to an axial boss 14a projecting from a central region of the appropriate side of the plate 14. The rotors are driven in rotation from a motor (not shown) by a shaft 15 drivingly connected to the boss 14a by a key or other suitable means (not shown). The plate 14 lies within a central aperture of the stator plate 8 so as to lie substantially co-planar with the latter and a spring-loaded seal 15A acts between the shaft 15 and an axially directed flange 11a of the casing in order to prevent leakage of material outwardly along the shaft.

60 As can be seen from *Figure 2*, the blades 12a extend radially outwardly from locations spaced from the centre of the plate 14, to the peripheral extremity of the plate and their outermost radially extending edges 12b lie in close proximity to the inner surface of the stator wall 6 and thus to the edges of the apertures 5, their axial extent being such that they span the apertures 5. The blades 13a extend radially outwardly of the plate 14 by a distance greater than the radially outermost extent of the apertures 10 of the stator plate 8. The edges 13b of the blades 13a closest to the plate 8 thus lie in close proximity to the adjacent surface of the plate 8 and their rotational path is very close to the peripheral edges of the apertures 10 of that plate.

65 The further apertured stator 9 referred to above is similar in form to the cylindrical stator 4 and of diameter such as closely to surround the radially outermost edges 13c of the blades 13a. The stator 9 has an annular row of apertures 17 disposed at an axial location such as to lie along the rotational path of said blade edges 13c. A peripheral outwardly directed radial flange 18 of the stator 9 is secured, as by bolts 19, to an internal inwardly directed radial flange 20 of the housing which is recessed to facilitate location of the stator. A radially inwardly directed flange of the stator 9 forms the apertured stator plate 8 and extends into close proximity with the central plate 14 of the rotor. It will be seen that by removing the end cover 2A of the housing, which removes also the stator 4, access is provided to the bolts 19, the removal of which then enables the stator 9 to be withdrawn axially without disturbing the rotor. This provides the advantage of facilitating assembly of the apparatus in production, and dismantling the stators for cleaning or repair or in order to substitute stators having different numbers, sizes, shapes and

arrangements of apertures. Such characteristics may thus be readily changed as desired according to the type of material to be mixed and the degree of breakdown of solids required. For example, square or

5 triangular apertures increase the shearing action by virtue of their increased useful peripheral edges and multiple rows of apertures may be employed in or to increase the action even further.

10 In order to prepare the apparatus for use, it is desirable to remove as much air as possible from within the housing 1 and this is achieved by priming the housing with a suitable liquid, such as water, the air being expelled through drain taps (not shown) opened for the purpose and subsequently closed.

15 With the rotors driven in rotation, a mixing operation can then be performed by feeding material to be mixed via the inlet 2 into the interior of the stator 4, such material being urged radially outwardly towards and through the stator apertures 5 by rotation of the blades 12a. The outer edges of the blades 12a move in close proximity to the peripheral edges of the apertures 5 and as the material, which may be a mixture of lumpy solids and a liquid, is expelled through these apertures, a shearing action takes place between the

25 aforesaid edges of the blades and apertures, which breaks down the solid lumps to enhance mixing thereof with the liquid.

The material passing through the stator 4 enters the chamber 7 and creates an over-pressure in this chamber which tends to force the material to pass through the apertures 10 of the stator plate 8. Rotation of the blades 13a assists in drawing material through these apertures and a second shearing action then takes place between the peripheral edges of the apertures 10 and the closely adjacent edges 35 of the rotating blades 13a. This results in a more finely divided and thoroughly mixed material being introduced into the interior of the stator 9 whence, under the action of the rotating blades 13a and an overpressure created within this stator, the material is ejected through the apertures 17 and is subjected to a further shearing action between the radially outermost edges 13c of the blades 13a and the peripheral edges of the apertures 17. This action produces an even

45 finer breakdown of the solid material and more thorough mixing thereof with the liquid, the mixture leaving the apertures 17 entering the chamber 10 and thereby producing an overpressure in that chamber, causing the mixture to be expelled from the outlet 3.

50 The apparatus described may be used to mix material fed from a tank and the mixed material can either be recirculated to the tank from the outlet 3 or conducted by suitable piping from the outlet to a desired location. Alternatively, material to be mixed may be fed under metered conditions into the inlet 2 so that a known quantity may be discharged, as for example into a tanker for subsequent delivery. The apparatus may alternatively be connected into a pipeline in order to treat material flowing along such pipeline.

60 It will be appreciated that the different shear planes may be achieved by using separate blades for co-operation respectively with a pair of stators, as exemplified by the stators 4 and 8 and the blades 12a and 13a; alternatively, the different shearing planes 65 may be obtained by using different edges of the

blades of a single rotor to co-operate respectively with a pair of stators, as exemplified by the blades 13a and their edges 13b and 13c co-operating respectively with the stator plate 8 and stator 16. The numbers and shapes of blade in each rotor may be varied as desired, as may be the sizes and shapes of the various stator apertures. The apparatus of the invention is of compact dimensions but nevertheless provides a thorough and effective mixing action on a wide variety of solids in liquids and can have a greater compactness relative to its mixing effectiveness than some conventional mixers.

70 Although for reasons of compactness and simplicity it is convenient for the rotor to have first and second bladed parts which are rigidly interconnected and driven by a common shaft as described, it will be understood that the rotor may comprise separate independently rotatable parts, which could be driven, for example by a pair of drive shafts conveniently arranged co-axially one within the other, or alternatively extending separately into the housing from the same or different directions.

#### CLAIMS

90 1. A mixing apparatus comprising a housing having a material inlet and outlet and containing a pair of apertured stators, the apertures of each of which respectively permit fluid flow therethrough in different directions, and a bladed rotor arranged with first and second bladed parts thereof respectively in co-operative relationship with the stators, whereby rotation of the rotor forces material introduced through the inlet successively through the stators and in so doing, by co-operation of the blades and stator apertures, subjects said material to shearing actions in different non-parallel planes.

95 2. An apparatus according to Claim 1 wherein one of the stators has a cylindrical apertured wall closely surrounding a first bladed part of the rotor, the apertures being arranged so that rotation of the rotor brings said first bladed part into co-operation with said apertures successively.

100 3. An apparatus according to Claim 1 or Claim 2 wherein one of the stators is a flat plate extending generally perpendicularly to the rotational axis of the rotor and co-operating with a second bladed part of the rotor.

105 4. An apparatus according to Claim 3 wherein said flat plate stator is arranged to divide the housing into two chambers, each containing a respective one of said rotor parts each for co-operation with one of the stators, said chambers communicating respectively with the inlet and outlet.

110 5. An apparatus according to Claim 3 or Claim 4 wherein the second rotor part is closely surrounded by a second cylindrical apertured wall of a further stator, the arrangement being such that radially extending blade edges of the second rotor part co-operate with the flat plate stator and axially extending blade edges of the second rotor part co-operate with said further stator.

115 6. An apparatus according to any one of the preceding claims wherein the first and second rotor parts are mounted on a common drive shaft.

7. An apparatus according to Claim 6 wherein the rotor parts are formed on opposite sides of a common support driven by the drive shaft.

8. An apparatus according to any one of Claims 2 to 8 wherein the stator having the cylindrical wall is fast with a detachable end closure member of the housing and may be withdrawn from the housing without disturbing any other stator or the rotor.

9. An apparatus according to any one of Claims 5 to 8 wherein the second cylindrical wall has a radially outward flange secured to a radially inward flange of the housing and is removable from the housing without disturbing the rotor, following detachment of the end closure member and the stator fast with the latter.

10. An apparatus according to Claim 9 wherein a radially inwardly directed flange of the second cylindrical wall is axially apertured and forms the flat plate stator.

11. A mixing apparatus substantially as hereinbefore described with reference to the accompanying drawings.