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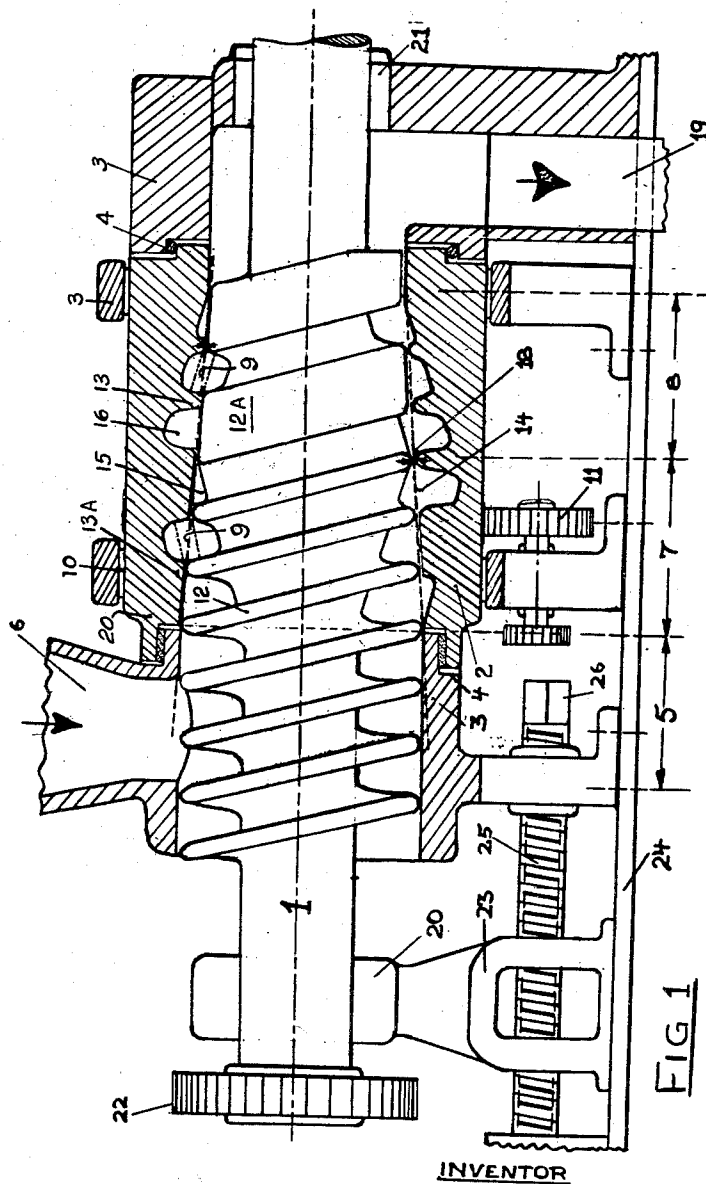
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3,102,694

APPARATUS FOR MIXING AND CRUSHING

Filed May 29, 1961

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

FIG. 2

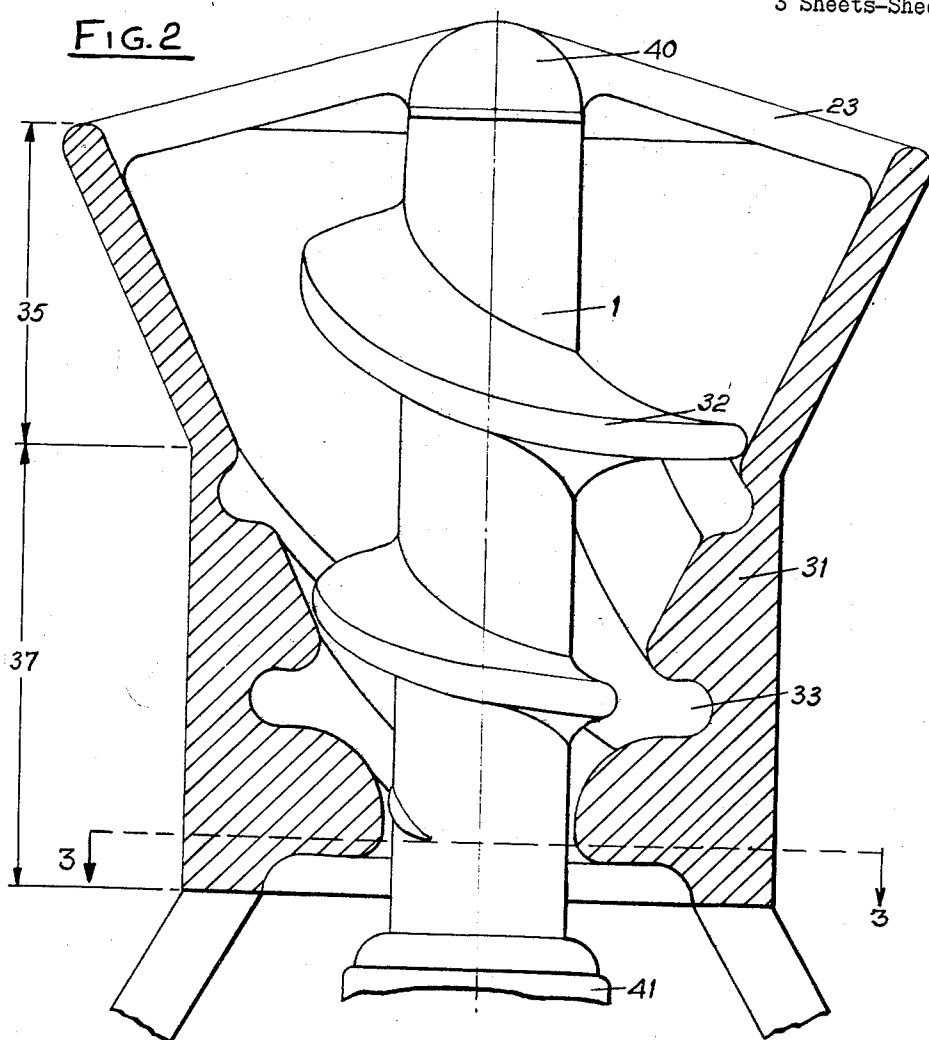
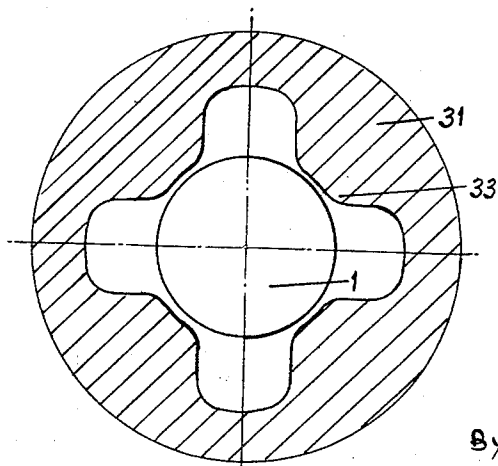


FIG. 3



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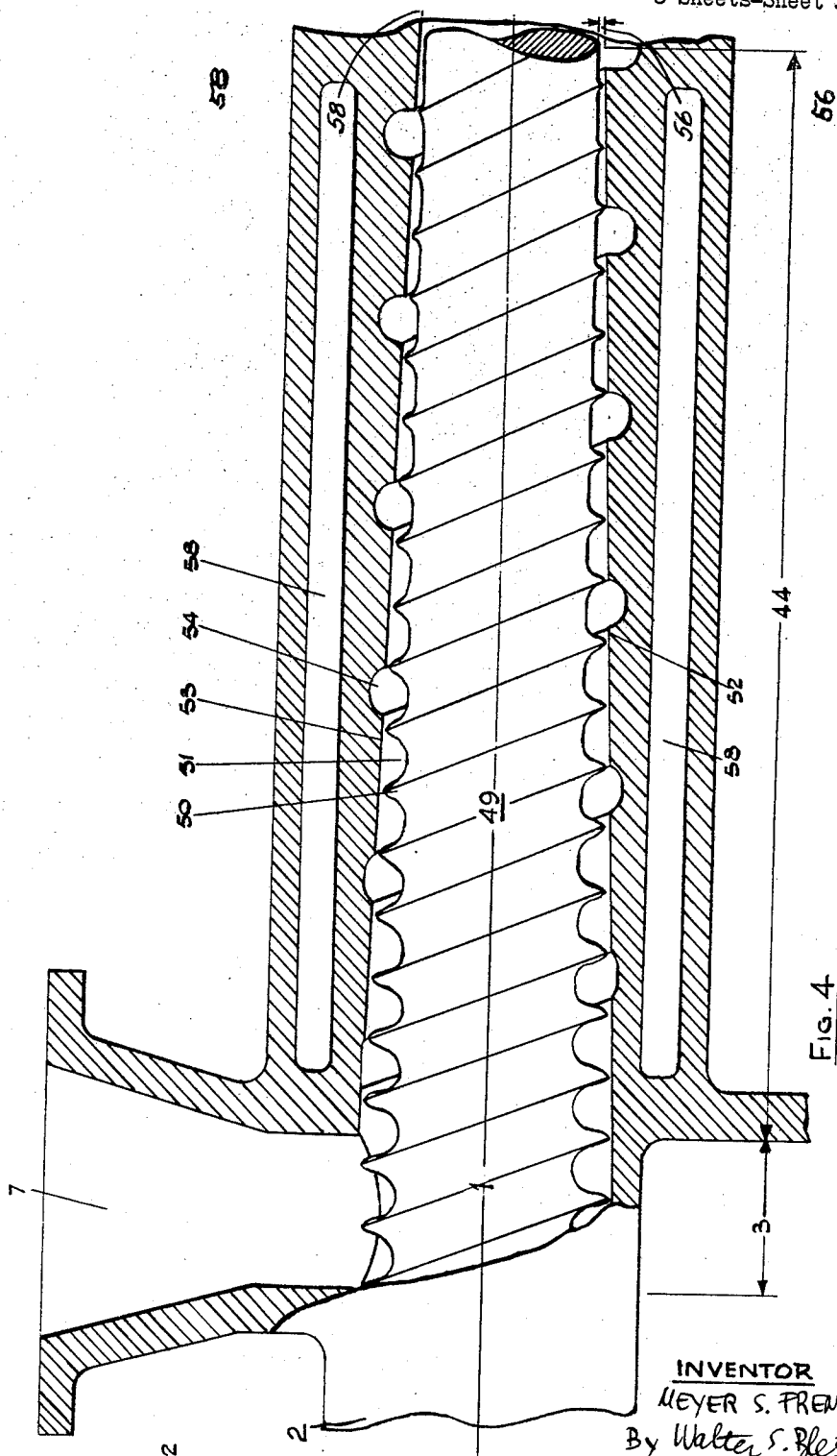
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APPARATUS FOR MIXING AND CRUSHING

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3 Sheets-Sheet 3



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1

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APPARATUS FOR MIXING AND CRUSHING
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This invention relates to apparatus for mixing and crushing.

In crushers presently used in industry the internal surface-area actually usefully applied for crushing is a minute fraction of the total internal surface area. This concentrates wear on those small portions which necessitate frequent replacement of worn parts. Also this property makes crushers a type of machine which is very bulky in relation to their specific throughput.

It is an object of this invention to provide apparatus for crushing and mixing in which a substantial portion of the interior surface is utilised in the crushing operation. This is in order to spread wear and to increase availability, i.e. the period between replacement of worn parts. Furthermore, this is in order to provide reduced sizes of apparatus relative to their specific throughput. Various other objects and advantages will become apparent in the course of the following description.

This application is a continuation-in-part of my prior, copending application Ser. No. 592,472, filed June 18, 1956.

According to the present invention, the apparatus for mixing and crushing may comprise at least two components, such as an at least partly interiorly threaded barrel and a male threaded member or worm, the one surrounding and being axially shiftable relatively to the other one, each with lands between adjacent thread groove convolutions, said grooves of said barrel and worm facing one another and defining a passage for a medium, the minor radii of the barrel thread convolutions and the major radii of the worm convolutions being respectively located on an internal and external envelope which is preferably conical. The envelopes are preferably parallel to each other and have their axes co-incident with the barrel axis. They taper towards the exit or entry so that by a relative axial displacement of the components the radial clearance between the said envelopes can be adjusted. The areas of cross-sections of the thread grooves vary at least over a part of the length of the passage between a maximum and a minimum value, so that the cross-section of the one groove increases while that of the other groove decreases whereby, when in operation a medium moves in the said passage, material is transferred between the grooves in the components as giver and taker, where in the giver screw of decreasing cross-sectional area of groove the land of said helical thread is narrower than said groove, and where in the taker screw of increasing groove cross-sectional area the land of said helical thread is wider than said groove.

At least one of the components may be rotatable about the barrel axis, or may comprise a section extending throughout at least a part of the length of the passage and being rotatable about the barrel axis. In such apparatus, the variations of the areas of facing groove-cross-sections along the length of the passage may form at least one cycle in that the cross-sectional areas of the groove in one component varies from a maximum value to a minimum value and back again to a maximum value, while in the other component the cross-sectional area of the groove facing the first one varies from a minimum to a maximum value and back again to a minimum value. With one of the components or a section thereof rotating, when a medium moves in the passage, material transfer takes place from the one component as giver

2

to the other component as taker in one section of the said passage and back again from the other component as giver to the first mentioned component as taker in an adjoining section, to form a complete cycle. According to the invention, the taker thread in each case has the lands of greater width than the grooves, while the giver thread has the lands narrower than the grooves.

The minimum values of groove-cross-section may be zero.

According to the invention, such apparatus is suitable for heat transfer with viscous fluids, the heat transferring wall being in that case preferably the taker component, the broad lands of which are positively swept by the narrow lands of the giver component, thereby promoting substantially scraped surface heat exchange.

Apparatus according to the invention may be arranged with the barrel axis vertical. In that case preferably either the barrel or the worm will be rotated, not both. When arranged with its axis horizontal, and used for crushing, both components may be rotated, in which case the rotations are preferably in opposite directions, in the directions of the leads of the respective helical threads, to provide transport of the throughput to the exit-end of the said passage.

As the minimum size of lump which will be crushed is determined by the set clearance between the lands, apparatus of this invention is very suitable to crush to a required feed size for apparatus for finer comminution, say grinding. It can also be adapted for air-sweeping to promote drying where that may be required.

The invention will now be described by way of example and in some detail with reference to the accompanying drawing in which:

FIGURE 1 is a section through an embodiment of the basic mixer-construction as a crusher for hard materials with its axis horizontal;

FIGURES 2 and 3 are sectional elevation and plan of a crusher with vertical axis;

FIGURE 4 is a section through a screw device of this invention specifically adapted for heat transfer through the casing, for instance, for acting as a melt section for a plastics granular feed, but also as a heat transfer device for viscous fluids.

The general apparatus according to this invention shown in FIGURE 1 comprises an inner worm component 1 and an outer barrel component 2, defining between their facing helical threads 12 and 13, a passage for a medium to be mixed, between the entry-funnel 6 and the exit-chute 19. Both components are rotatably mounted in casing 3, the worm component 1 in thrust block 20 and end bearing 21 and the barrel component in bearings 10. The glands 4 seal the joint between barrel 2 and the casing 3. The worm is driven by spur gear 22 and the barrel by spur gear 11.

The operating surfaces of components 1 and 2 are in the shape of helical threads 12 and 13, of opposite hand, the components being adapted for opposite rotation so as to effect transport in both screws towards the common exit. From the entry funnel 6, the inner screw 1 comprises a feed-section 5 in which the thread 12 extends with its lands to the inner surface of the casing 3, which is substantially cylindrical here. This is followed by at least one crushing and mixing cycle 7-8, where in the first sector 7 the cross-sectional area of the groove 15 of the inner screw reduces from the initial maximum to zero, while facing this the cross-sectional area of the groove 16 in the outer rotatable screw component increases from zero to maximum in complementary fashion, so that in operation the material originally in the inner screw grooves is transferred into the outer screw-grooves at the end of sector 7. In sector 8, the cross-sectional area of outer groove 16 decreases from maximum to zero, while

3

the inner groove 15 increases from zero to maximum, providing in this sector material-transfer back from the outer to the inner screw. All this material transfer between oppositely rotating screws proceeds with mixing as described later, which to a considerable extent takes place in transit-zones 9. The changes in groove cross-section may be effected by variation of the characteristics of pitch, pitch circle diameter, groove-depth and profile shape of thread either singly or in any combination.

The lands of threads 12 and 13 approach from either side a frusto-conical interface 14, 18 denoting the clearance between opposite lands. On account of the frusto-conical shape of this interface, or more generally of the shape of interface whose radius to the axis of rotation varies in one direction along the passage defined between the inner and outer component, the construction permits of adjustment of the axial relative position of the two components, whereby the magnitude of the clearance 18 is adjustable, say to take up wear, and for other features of performance treated later. To effect this adjustment, the thrust block 20 is mounted on carriage 23 slidably resting on the base 24. Carriage 23 can be moved axially along base 24 by means of screw 25 engaging it. For such adjustment a key has to be applied at 26—otherwise screw 25 holds carriage 23 firmly in position.

According to the special features of the present invention, in section 7 where the worm thread as giver transfers material into the barrel thread as taker, the worm thread 12 is made with the grooves 15 wider than the lands, while the barrel thread 13 is made with the lands 13A wider than the grooves 16.

Conversely, in section 8, where the material transfer proceeds from the barrel thread 13 as giver into the worm thread 12 as taker, the barrel thread 13 is made with the grooves 16 wider than the lands and the worm thread 12 is made with the lands 12A wider than the grooves 15.

In this particular example, both helices are basically double threaded and the effect of the land broader than the groove is achieved where required by having what would be the groove of one thread left solid to form the broad land.

In operation, hard lumps being transported in the groove of the "giver" thread cannot be directly transferred into the taker thread while the broad land of the taker thread sweeps across the groove and the lumps are compressed and crushed therein. Such compression and crushing occurs only momentarily, and then a layer of the crushed material is immediately transferred into the taker groove.

In this way, even with the crusher running far from full, or for the sake of an extreme example with only a single lump in it, this lump will be subjected to crushing in its passage, and its debris will be subjected to further crushing as the giver groove reduces in size to substantially zero. The minimum lump size of material which will pass through uncrushed will be effectively set by the clearance 18—although material of this size will not, of course, escape the bulk crushing effects in the giver grooves.

The present example shows two crushing sections 7 and 8, whereas often one such section will do. Also, whereas screws with narrow lands will also exert crushing effects, these are to a considerable extent against the flanks of the thread, and only to a small extent radially against the lands. The latter kind of crushing effect is preferable, however, as it applies hoop stress to the barrel component, i.e., uses its greatest strength, and radial load on the bearings which will largely balance out against other such crushing loads.

FIGURES 2 and 3 show an example of a crusher with its axis vertical. It comprises worm component 1 and fixed barrel component 31. Here the worm component 1, having thread 32, and mounted in top bearing 40 held on spider 23 in casing and bottom bearing 41, is rotated, being driven in a way well-known in the art. The barrel and worm feed section 35 for lumps, and the crushing

4

proceeds in section 37. The helical thread 33 in the barrel is a four-start thread, while the worm thread is single start. The worm thread being the "giver" in the material transfer, has its lands narrow compared with the grooves. The barrel thread, being the "taker" has its lands broad compared to the groove width.

Compared to conventional types of crusher, say gyratory or cone crushers, which with gaps large enough to be able to take large lumps yet do their effective crushing in a very small zone, the crusher according to this invention utilizes a far greater operative surface for crushing. This spreads the wear and must bring down the wear rate. It has the further advantage that when the set clearance between opposite lands has increased excessively owing to wear, the clearance can be reset by axial displacement of the worm.

FIGURE 4 shows a development of a screw-device having the basic components of this invention but specifically adapted for heat transfer through the casing for instance for acting as a melt-section for plastics granular feed preceding an intensive working section.

FIGURE 4 shows a screw 1 which is rotatably mounted on bearings which are not shown, in casing 2. The apparatus comprises a feed-section 3 and the heat-transfer section 44 as well as a convenient outlet-section which may lead into the said intensive working section. In this example the feed-section comprises a helical thread on screw 1 while the casing 2 provides the cylindrical surface for the helix to rotate in and also the hopper 7 for feeding the material in. The whole feed-section is mounted and operated as, for example, is well-known in plastics extruder practice.

The heat transfer section 44 comprises a screw-thread 49 on screw 1 which has narrow lands 50 and relatively wide grooves 51. From the entry to the exit of section 44 the grooves reduce from a maximum cross-sectional area to substantially zero cross-sectional area in the screw 49. Corresponding to this, the casing 2 has a screw-thread 52, having contrariwise lands 53 which are wider than the grooves 54 and which thread is of opposite hand to thread 49 of the male screw 1. The interface between the male and female threads is of frusto-conical shape and there is a clearance 56 between opposite lands of the male and female helices. A device as shown, for example on FIGURE 1, enables the screw 1 to be displaced axially relative to casing 2 whereby the clearance 56 can be adjusted.

It will be noted that the male screw-thread 49 and the female screw thread 52 are both single-start, but that the female screw thread 52 has a much larger pitch.

58 indicates heating or cooling elements arranged in casing 2.

In operation, the material to be heated or cooled, having entered through hopper 7, is transferred in the heat transfer section 44 from the male into the female screw. This proceeds layer by layer, which layers are each individually smeared across the wide lands 53 of the female screw where they take intensive part in the heat transfer, and then collect in the grooves 54. Grooves 54, having a large pitch, transport the material—if it is viscous—forward at a greater speed of flow than in the male screw, so that its contact with the heated or cooled sides of the groove is minimised, and it is quickly discharged. For granular material, such as plastics being melted, the broad lands of the female screw also impose a certain compression which aids melting. The layer by layer treatment makes the heat transfer uniform, and by keeping up the temperature difference through the wall, makes the heat transfer more intensive than it could be if the layer just having taken part in the heat transfer was not removed from the wall. The adjustability of the clearance makes it possible to adjust for the thickness of the layer being taken off the wall. Alternatively, in case of wear, it enables increase of clearance to be taken up so that a required

5

thickness of layer can be removed from the heat transferring lands.

I claim:

1. In apparatus for mixing and crushing, a barrel component and a worm component coaxial with said barrel, said barrel having an inner and said worm having an outer helical thread each with lands between adjacent thread groove convolutions so that the lands of the worm face the lands of the barrel, said threads being of opposite leads, the cross-sectional areas of opposite thread groove portions varying the one from a maximum to a minimum value and the other one from a minimum to a maximum value so that said portions complement each other to form a continuous passage having an entrance and an exit end for a medium to be mixed, the lands of said barrel thread being located on a first substantially conical surface and the lands of the worm thread being located on a second substantially conical surface parallel to the first one, said worm being axially shiftable in relation to said barrel thereby to vary the spacing of said surfaces from each other, at least one of said components being rotatable in the direction of the lead of its thread so as to convey the medium towards said exit end, and the thread groove portion varying in cross-section area from a maximum to a minimum having its lands narrower than its groove formed therebetween, and the thread groove portion on said other component varying in cross-sectional area from a minimum to a maximum having its lands broader than its groove formed therebetween.

2. Apparatus as claimed in claim 1, in which the said minimum value of groove-cross-sectional area in either helical thread is zero.

3. Apparatus as claimed in claim 1 in which both the said components are rotatable about the barrel axis in the directions of their leads respectively.

4. In a mixing apparatus, a barrel component and a worm component coaxial with said barrel, said barrel having an inner and said worm having an outer helical thread each with lands between adjacent thread groove convolu-

6

tions so that the lands of the worm face the lands of the barrel, said threads being of opposite leads, each of two adjoining groove portions of thread of one of said components varying in the cross-sectional area from a maximum to a minimum and from that to another maximum, and each of two adjoining groove portions of said other component and coextensive with said first mentioned portions varying in the cross-sectional area from a minimum to a maximum and back to a minimum, so that the portions of the one component complement the portions of said other component to form a continuous passage having an entrance and an exit end for the medium to be mixed, the sections of each thread having reducing groove cross-sectional area having their lands narrower than the said groove formed therebetween, and the sections of each thread having increasing groove-cross-sectional area having their lands broader than the said groove formed therebetween, the lands of said barrel thread being located on a first conical surface and the lands of the worm thread being located on a second conical surface parallel to the first one, one of the said components being axially shiftable in relation to said other component whereby to vary the spacing of said surfaces from each other, at least one of the said components being rotatable in the direction of the lead of its thread so as to convey the said medium towards said exit end.

5. Apparatus as claimed in claim 4, in which the said minimum value of groove cross-sectional area in either helical thread is zero.

6. Apparatus as claimed in claim 4 in which both the said components are rotatable about the barrel axis in the directions of the leads of their threads respectively, so as to convey said medium towards said exit end.

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