United States Patent

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[33] **Germany**
[31] **P1,653,872.0**

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[54] **SCREW CONVEYOR**
6 Claims, 10 Drawing Figs.

[52] **U.S. Cl.** **198/213,** 165/87, 198/229
[51] **Int. Cl.** **F28f 5/06**
[50] **Field of Search** 198/213, 76, 229; 165/87, 92

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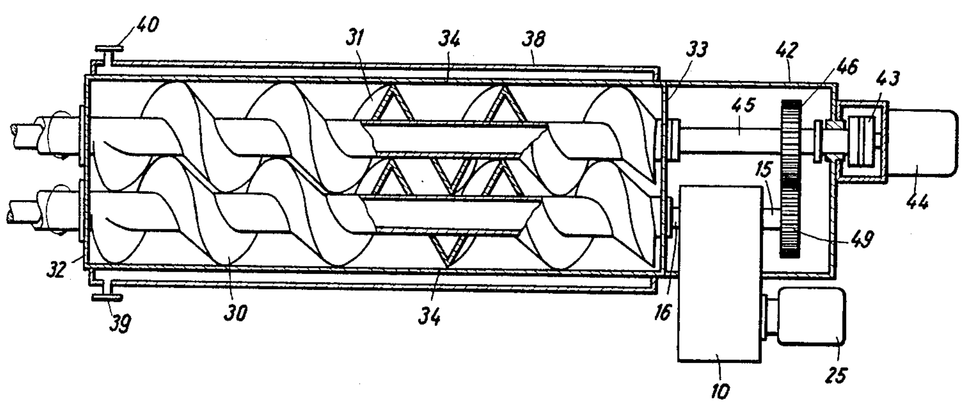
ABSTRACT: One of two parallel screws rotatable in the same direction in a screw conveyor is rotatable at different speeds from the other screw. This periodically brings the threads of one screw into wiping and cleaning engagement with the threads of the other screw.



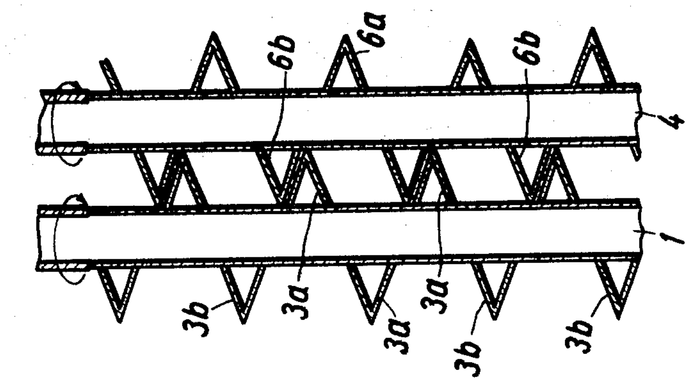


Fig. 3

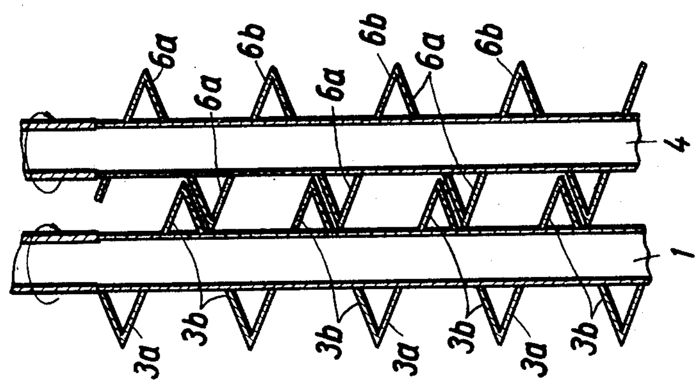


Fig. 2

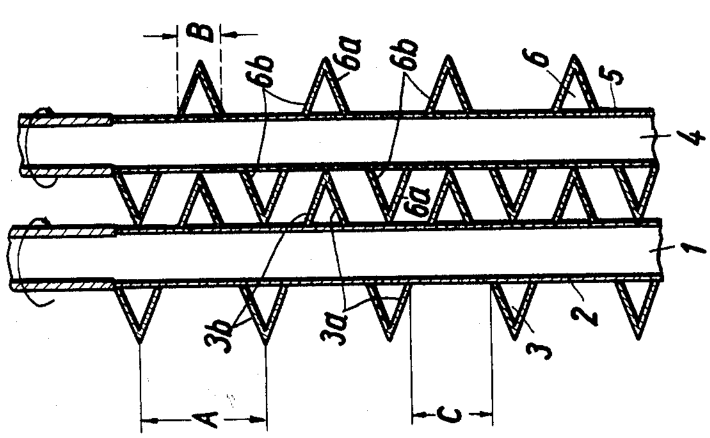


Fig. 1

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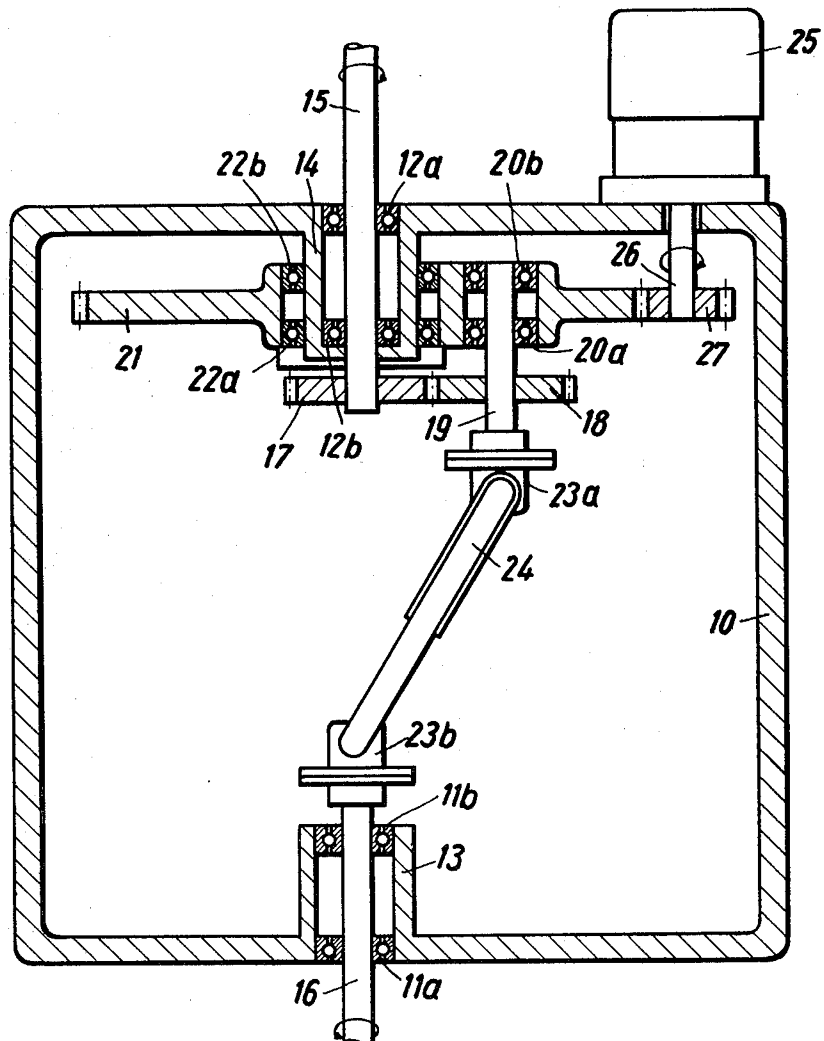

Fig.4

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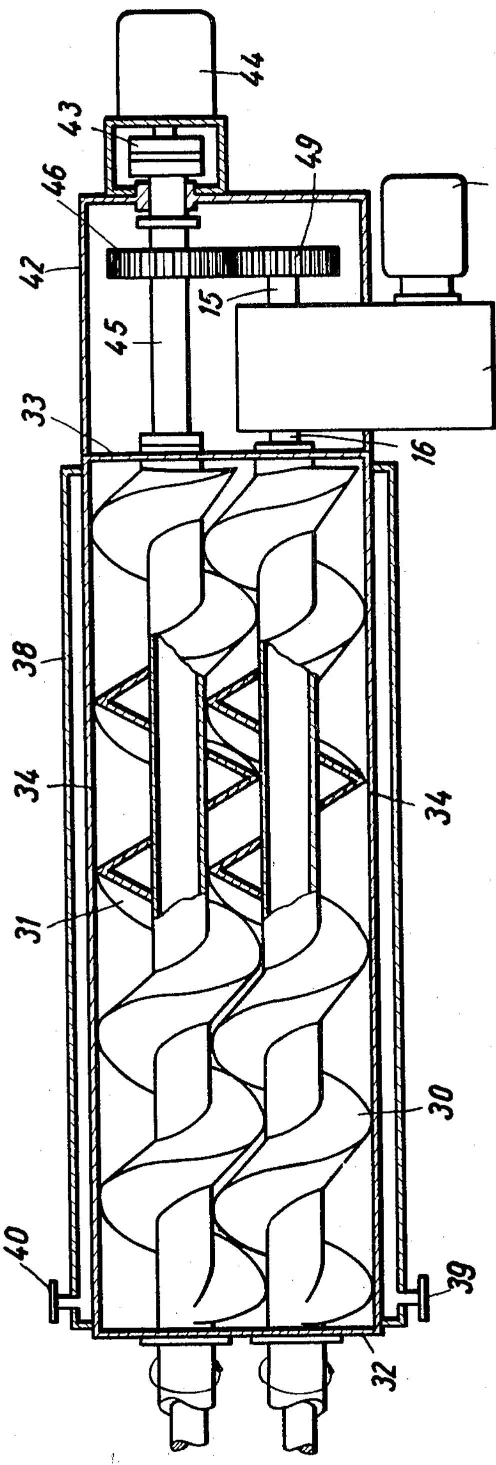

Fig. 5

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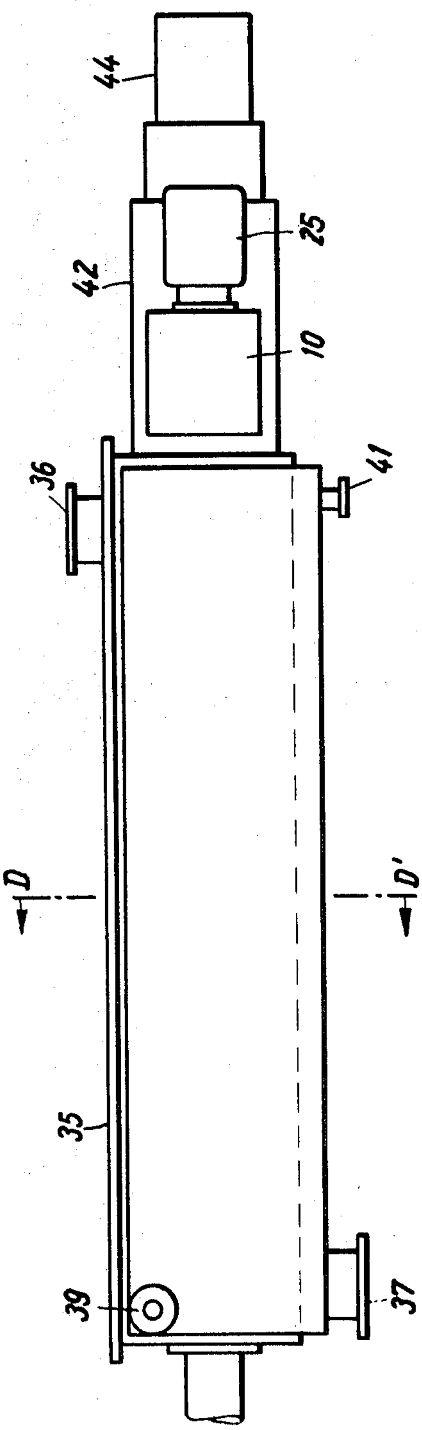

Fig.6

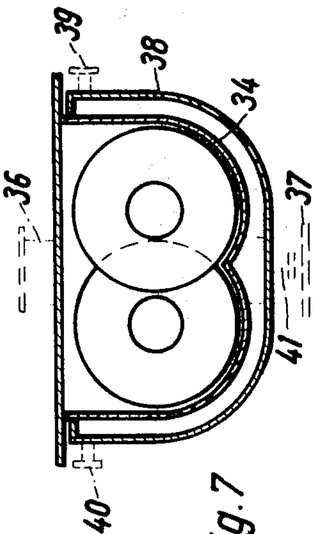

Fig.7

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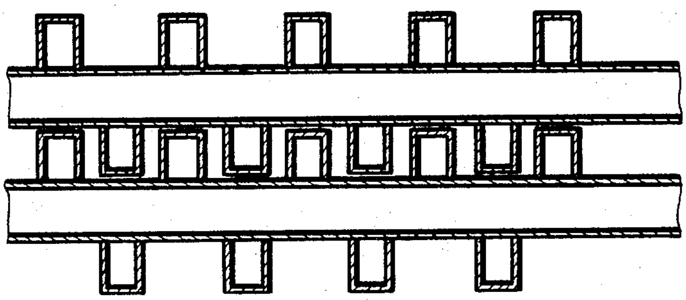

Fig. 10

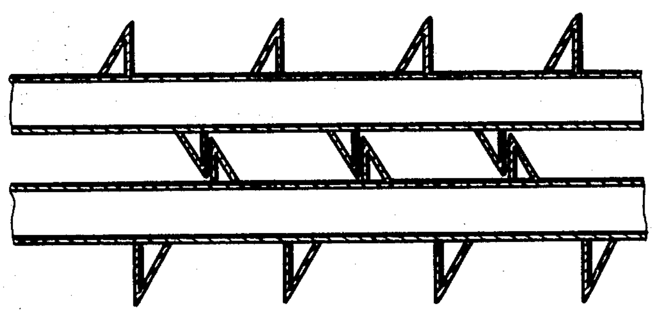

Fig. 9

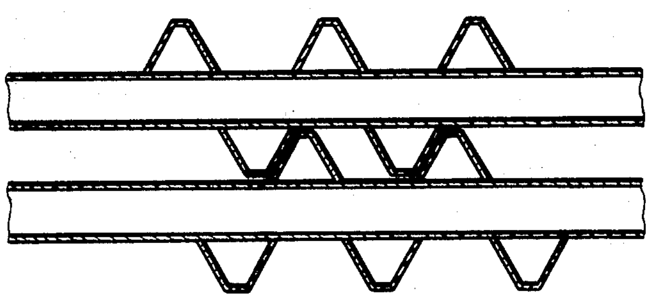

Fig. 8

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SCREW CONVEYOR

This invention is an improvement upon the screw conveyor disclosed in my copending application, Ser. No. 692,117, filed Dec. 20, 1967, now U.S. Pat. No. 3,506,066 and which relates to apparatus for a mechanical and/or thermal treatment of substances which are liquid, conveyably semisolid or solid, in a housing which has a product inlet at one end and a product outlet at the other end and which contains a screw having a right-handed screw and a left-handed screw, which are parallel and rotate in opposite senses and at least partly interengage. In such apparatus, the angular velocity or speed of at least one screw s varied during the rotation of the screws.

One screw usually rotates at a constant angular velocity whereas the other screw is driven by a summing differential gear unit, which temporarily adds an angular velocity component to the constant angular velocity or subtracts said component from said constant velocity. The relative change of the angular velocity will cause the sides of the threads of the screw to approach or move apart from each other. In two extreme positions, the sides of the screw threads perform a self-cleaning action. Thus, the temporary change in angular velocity results in an automatic cleaning of the screws. There is no axial displacement of the screw shafts.

It has now been found that it may be desirable also in screw extruders having screws of equal hand and the same sense of rotation, to change the angular velocity of at least one screw during the rotation of the screws.

This invention relates to apparatus, as in my aforesaid application, for a mechanical and/or thermal treatment of substances which are liquid or conveyably semisolid or solid, but is characterized in that the screws have the same hand, the same sense of rotation and a certain axial clearance between the sides of their threads.

The previously known screw feeders having screws which have the same hand and the same sense of rotation are fitted one into the other with a minimum clearance so that the sides of the threads scrape on each other during rotation. Different from that known embodiment, the screw extruder according to this invention comprises screws which have the same hand and the same sense of rotation and which are designed so that the sides of their threads are spaced a certain distance apart in the intermediate position and a change of the angular velocity of one or both screw shafts can be effected to change the distance between the sides of the threads adjacent screws without need for an axial displacement of the screw shafts. As a result, the screw shafts may be mounted in conventional bearings.

A change of the angular velocity or speed of one screw or a change of the relation between the angular velocities or speeds of both screws may be effected to change the position of the two screws relative to each other until adjacent thread sides contact each other. This will be the case in two extreme positions, namely, the rear and forward extreme positions. When the two screws rotate at the same angular velocity, they will retain their instantaneous relative position. The terms "intermediate position, forward and rear end positions" are explained in my aforesaid application for screws which have different hands and different senses of rotation. These terms are analogously applicable in connection with the present invention. The difference in the arrangement of the screws compared to the apparatus according to the aforesaid application resides in that according to this invention the screws have the same hand and the same sense of rotation.

The means by which the objects of this invention are obtained are described more fully with reference to the accompanying drawings, in which:

FIG. 1 is a horizontal axial sectional view of the two screws of a self-feeding screw machine in a position referred to hereinafter as a center position;

FIG. 2 is a view similar to FIG. 1 showing the two screws in a position referred to hereinafter as a rear end position;

FIG. 3 is a view similar to FIGS. 1 and 2 showing the two screws in a position referred to hereinafter as a front end position;

FIG. 4 is a horizontal section through the gearing for the machine shown in FIGS. 1 to 3;

FIG. 5 is a sectional plan view of a screw machine provided with the gearing shown in FIG. 4, with the cover of the machine removed;

FIG. 6 is an elevation view of the apparatus shown in FIG. 5;

FIG. 7 is a section through the apparatus according to D–D′ as indicated in FIG. 6; and

FIGS. 8 to 10 are horizontal views showing schematically two screw shafts each.

FIG. 1 is a horizontal transverse sectional view taken through two screw shafts of a screw conveyor according to this invention. The left side screw **1** of FIG. **1** consists of the screw shaft **2** and the thread **3**, which is secured to the screw shaft **2**. The screw is a right-handed single-thread screw and rotates also in the clockwise sense. The screw **4** consists of the screw shaft **5** and the screw thread **6**. The threads of the two screws having the same hand have the shape of a triangle in cross section. The pitch A of the crests of one screw is larger than the base width B of the triangular profiles on the screw shaft. In this case, the distance C between two adjacent thread sides of a screw, measured on the shaft, is greater than zero. Both screws interengage throughout the depth of their screw channel. Each of the screw threads **3** and **6** has two exposed sides, which are referred to as the forward and rear sides in this disclosure. The forward sides of the screw threads are designated *3a* and *6a* and the rear ones *3b* and *6b*. When rotating in the sense which is indicated in the drawing, the screws feed the material from the top end to the bottom end in the drawing. When both screws rotate at the same constant angular velocity, the same arrangement as in FIG. **1** will be obtained in longitudinal section after each rotation of the screws through 360°. In this specification, this position will be referred to as an intermediate position because each thread crest which enters the thread channel of the other screw bisects the distance C on the other screw shaft.

If the angular velocity or speed of the right side shaft is sufficiently reduced relative to the left side screw **1**, which continues to rotate at a constant speed, a rotation of the left side screw **1** through 360° will result in a position which is shown in FIG. **2** in a horizontal longitudinal sectional view taken through the two screws. This position will be described as a rear end position. When the two screws are in this rear end position and the right side screw **4** is accelerated to the angular velocity of the left side screw **1** so that the two screws rotate again at the same angular velocity, the thread side *6b* of screw **4** will slide on the thread side *3a* of the other screw **1**. As the two threaded sides *6b* and *3a* approach each other, the material which adheres to the two thread sides *6b* and *3a* is scraped off. To cause a contact also between the two other thread sides *3b* and *6a*, which do not perform a self-cleaning action as they approach the rear end position, the angular velocity of the right side screw **4** is accelerated relative to the angular velocity of the left side screw **1** until the screws are in their forward end position, shown in FIG. **3**, relative to each other. When this forward end position has been reached, the speed of the right side screw **4** will be reduced until the two screws rotate again at the same angular velocity so that the thread sides *3b* and *6a*, which are not cleaned in the rear end position, slide one on the other. As the thread sides *3b* and *6a* approach the forward end position, the material which adheres to them is scraped off.

The threads are thus cleaned as the screws rotate temporarily at different angular velocities until the forward or rear end position is reached. As one of these end positions is reached, one side of each screw thread is cleaned. During the approach to the other end position, the other two thread sides are cleaned because the product which adheres to the thread sides is scraped off during the mutual approach of the thread sides. When each thread enters the thread channel of the other screw throughout the depth of such channel, as is shown in FIGS. **1** to **3**, the rotation of the screws from one end position to the other will cause adhered product to be scraped also from each of the two screw shafts by the thread crest of the other screw.

The rotary speeds of the two screws can be changed to effect a change of the relative position of the two screws. As has been explained hereinbefore, it is suitable to drive one screw at a constant angular velocity and to increase or reduce only the angular velocity of the other screw for a change of the relative position of the screws. The angular velocity of that screw may be increased or reduced in a simple manner by summing differential gear unit. Such gear unit is shown by way of example in FIG. 4 in a diagrammatic horizontal sectional view. The gear unit is accommodated in the totally enclosed housing **10**, in which the bearings **11***a*, **11***b*, **12***a* and **12***b* are secured in the bearing brackets **13** and **14** of the housing **10**. The shaft **15** is mounted in the bearings **12***a* and **12***b* and the shaft **16** in the bearings **11***a* and **11***b*. The shaft **15** is driven at a constant angular velocity. The shaft **15** carries a gear **17**, which is in mesh with another gear **18**. The two gears **17** and **18** have the same number of teeth. The gear **18** is secured to the shaft **19**, which is mounted in the bearings **20***a* and **20***b* carried by the gear **21**. The gear **21** is mounted in the bearing **22***a* and **22***b*, which are mounted on the bracket **14** of the housing **10**. The shaft **19** is connected to the shaft **16** by the two universal joints **23***a* and **23***b* and the universal joint shaft **24**. Secured to the housing **10** is the electric motor **25**, which is reversible and the speed of which can be infinitely controlled. The motor shaft **26** extends through a bore into the interior of the housing **10** and carries the pinion **27**, which is in mesh with the gear unit **21**. The gear unit operates as follows: It is first assumed that the motor **25** is deenergized and locked so that the shaft **26** cannot rotate. The shaft **15** is driven at a constant angular velocity by a motor or gear train, not shown in FIG. 4, and drives via gears **17** and **18** the shaft **19**, which is coupled by the joints **23***a*, **23***b* and the shaft **24** to the shaft **16**. The shaft **16** rotates in a sense which is opposite to that of the shaft **15** but at the same constant angular velocity as the latter. When the motor **25** is now energized, the gear **21** begins to rotate too because it is driven from the motor shaft **26** by the pinion **27**. The shaft **19** thus rotates out of the plane of the drawing and is given an additional rotary movement, which is added to or subtracted from the existing rotation of the shaft **19**. When the shaft **15** and the shaft **26** rotate in the clockwise sense shown in FIG. 4, the shaft **19** rotates at a higher angular velocity than the shaft **15** and so does the shaft **16**. When the shaft **15** rotates in the clockwise sense and the motor shaft **26** rotates in the counterclockwise sense, the shaft **19** and with it the shaft **16** rotates at an angular velocity which is smaller than the angular velocity of the shaft **15**.

In the apparatus according to the invention, that screw shaft which has a variable angular velocity is driven by the shaft **16**. The shaft **15** which rotates at a constant speed can be driven by gears from the other screw shaft which rotates at a constant speed. Such an arrangement is diagrammatically shown by way of example in FIGS. 5 to 7. FIG. 5 is a top plan view showing an apparatus according to this invention with the trough cover removed.

FIG. 6 is a side elevation showing the same apparatus as FIG. 5, and FIG. 7 is a vertical transverse sectional view taken on line D–D′ in FIG. 6. The two screws **30** and **31** are disposed in an elongated housing, which consists of the two end walls **32** and **33** and the sidewall **34**. As is apparent from FIG. 7, the bottom of the sidewall **34** conforms to the screws. The apparatus is closed by the cover **35**, which is not shown in FIG. 5. The product inlet **36** extends through the cover **35** into the interior of the apparatus. The product which is treated in the apparatus leaves the apparatus through the product outlet **37**, which is secured to the bottom of the apparatus at the opposite end. The shell **3** surrounds the sidewall **34** and is closely spaced from it. Parts **34** and **38** form a double wall system for conducting a heat exchange fluid. Connecting pipes **39**, **40** and **41** are for supplying and discharging the heat exchange fluid are provided in the shell **38**. Steam used for heating can be supplied to the apparatus by the connection pipes **39** and **40**, for instance. The condensate which forms in the double shell is discharged by the connection pipe **41**. A liquid heat exchange fluid, such as cooling water, is supplied through the connection pipe **41** and discharged through the connection pipes **39** and **40**. The screws **30** and **31** are right-handed single-thread screws and rotate in the clockwise sense. The gear box **42**, which carries the summing differential gear unit **10**, the auxiliary motor **25**, the clutch **43** and the drive motor **44**, is secured to the end wall **33** of the apparatus. The shaft **45** of the screw **31** is driven at a constant speed by the drive motor **44** via the clutch **43**. The shaft **45** of the screw **31** carries a gear **46**, which is in mesh with the gear **49**, which is carried by the shaft **15** of the summing differential gear unit **10**. For this reason, the shaft **15** is driven at the same angular velocity as the shaft **45** but in the opposite sense of rotation. The input and output shafts **15** and **16** of the summing differential gear unit **10** rotate in the opposite direction so that both screws **30** and **31** rotate in the clockwise sense. When the auxiliary motor **25** for driving the summing differential gear unit **10** is deenergized and locked, the rotating screws **30** and **31** will remain in the same relative position, i.e., the distances between the thread sides of one screw to the thread sides of the other screw remain constant. As soon as the auxiliary motor **25** is energized, the thread sides of one screw approach those of the other screw. This approach will be the faster the higher is the speed of the auxiliary motor **25**. When an end position of the screws has been reached, the auxiliary motor **25** is deenergized and locked and the screws **30** and **31** then continue to rotate in that end position until the auxiliary motor is started to rotate in the opposite sense so that the then contacting thread sides of the two screws move apart until the other end position is reached, in which the two other thread sides of the screws contact each other. In a view toward the end where the gear unit is provided, the screws **30** and **31** rotate in the clockwise sense. During a rotation of the screws in this sense, the product to be treated is fed from the product inlet **36** to the left and is discharged downwardly through the product outlet **37** at the left side end of the apparatus in FIG. 7. The screws and the housing may be hollow, in known manner, to enable the flow of a heat exchange fluid therethrough. This is indicated, e.g., in FIG. 5, for the screw **31**, which is partly shown in horizontal section. The heat exchange fluid is supplied through the hollow screw shaft and discharged through the hollow screw thread, or vice versa.

In cross section, the screw threads may have a shape other than a triangle, e.g., a rectangle, trapezoid or sawtooth. FIGS. 8 to 10 show diagrammatically and by way of example two screws in horizontal sectional views. The thread channels of the screws shown in FIG. 8 have a trapezoidal shape in cross section and the thread channel of the screw shown in FIG. 9 has the shape of a sawtooth in cross section, FIG. 10 shows two screws which have threads that are rectangular in cross section. Adjacent thread sides of the two screws must be spaced a certain finite distance apart in the intermediate position because a change of the relative position of the screws is not possible otherwise. A screw thread having sides which form the sides of a isosceles or equilateral triangle is desirable in many cases and can be made at low cost. It will be desirable if the thread of each screw enters the channel of the other screw throughout the depth of said channel because this will ensure that the shafts of the screws will also be scraped clean as the screws move from one end position to the other.

The apparatus according to this invention will be particularly desirable when strong pressing and kneading forces are to be exerted on the material to be treated. To this end, the two screws are quickly shifted from one end position to another by a high-speed operation of the auxiliary motor **25**. Contrary to the apparatus of my aforesaid application having screws which have different hands and different senses of rotation, the apparatus according to this invention enables the performance of highly intense pressing, mixing and kneading actions because adjacent thread sides contact each other in the two end positions on a larger area than in an apparatus having oppositely handed screws. A rapid approach of the sides of the screw threads to one end position in the apparatus according to this invention will result in a strong kneading action on the material to be treated. Contrary to oppositely handed screws, there is a particularly high velocity difference between approaching thread sides because one thread side which has entered the channel of the other screw revolves downwardly and the thread side of the other screw revolves upwardly. This is desirable for a good mixing action. When the two screws are shifted most rapidly from one end position to the other because the auxiliary motor **25** is operated at high speed, a kneading or pressing action will be exerted on the material between the screws. Such action may be desirable in some cases.

The various nodes of operation of the apparatus according to this invention may be performed in a simple manner with the aid of the summing differential gear unit under control of the auxiliary motor **25**, which is energized or deenergized or changed in speed. The auxiliary motor **25** may be automatically energized or deenergized, if desired.

Two- or multiple-thread screws having the same hand and the same sense of rotation may be combined, e.g., two two-thread right-handed screws. Alternatively, screws having different numbers of threads may be combined in an apparatus according to this invention, e.g., a left-handed single-thread screw and a left-handed multiple-thread screw.

In an apparatus according to this invention, screws having the same number of screw threads do not change their relative position when they rotate at the same angular velocity, as has been mentioned. When two screws Q and P having the same number of threads are combined in an apparatus according to this invention, q is the number of threads of screw Q, p is the number of threads of the other screw P, W_q is the angular velocity of the screw Q and W_p is the angular velocity of the screw P, the screws will not change their relative position during their rotation is the following relation exists between the angular velocities of the screws P and Q:

$$W_p/W_q=q/p$$

The relation

$$n_p/n_q=W_p/W_q=q/p$$

exists between the speeds n_p and n_q of screws P and Q and indicates that the relative position of the two screws will remain constant when the ratio between the speeds or angular velocities of the screws is inverse to the ratio between the numbers of threads of the screws. When the speed of one screw or both screws is changed so that the relation

$$n_p/n_q=W_p/W_q\neq q/p$$

exists, the relative position of the screws will be changed and the sides of the threads will approach until the forward or rear end position is reached. When two thread sides of the screws are then in contact, the screws are caused to continue their rotation at such angular velocities that there is again

$$W_p/W_q=q/p$$

and the relative position of the screws is not changed.

Having now described the means by which the objects of this invention are obtained:

I claim:

1. Apparatus for subjecting liquid, conveyable semisolid or solid substances to a mechanical or thermal treatment, comprising a casing formed with a feed opening at one end and a product exit at the other end, two parallel and at least partly interengaging conveyor screws mounted within said casing, said screws having the same hand and rotatable in the same direction, the distance (A) between the crests of consecutive convolutions in each screw exceeding the length of the base (B) on the shaft for forming a space (C) on the shaft between the convolutions, drive means for rotating said screws, and means for temporarily changing the angular speed of at least one of the screws while the two screws are rotating to bring opposite pairs of the facing flanks of the blade helices into selective wiping and cleaning engagement.

2. Apparatus as in claim **1**, said means for changing the speed being such that the ratio between the angular velocity W_q of one screw Q having q threads and the angular velocity W_p of the other screw P having p threads temporarily meets the relation

$$W_q/W_p=p/q$$

and temporarily meets the relation

$$W_q/W_p\neq p/q$$

3. Apparatus as in claim **2**, said means for changing the speed being such that the screws rotate at such angular velocities that the ratio W_q/W_p differs from the ratio p/q until adjacent thread sides of the two screws contact, whereafter the screws rotate at such angular velocities that the ratio W_q/W_p equals the ratio p/q.

4. Apparatus as in claim **3**, one screw being rotated constantly at a constant angular velocity.

5. Apparatus as in claim **4**, said other screw, which is not constantly driven at a constant angular velocity, having a higher or lower angular velocity imparted to it by a summing differential gear unit.

6. Apparatus as in claim **5**, the main drive motion being imparted to the summing differential gear unit by the screw shaft which is driven at a constant angular velocity.