# United States Patent [19]

**Vissers et al.**

[11] **3,910,563**

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[54] **APPARATUS FOR MIXING, SEPARATING OR SORTING DRY SUBSTANCES OR ARTICLES**


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[51] **Int. Cl.²** ..... **B01F 9/06**

[58] **Field of Search** ..... 259/3, 81 R, 89; 51/164; 118/418



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[57] **ABSTRACT**

An apparatus for mixing, separating or sorting dry substances or articles, which comprise a horizontal rotary drum having inlet and outlet ends and constructed or disposed in such a way that an underlying descriptive line of the drum when viewed in the direction from the inlet end to the outlet end slopes upwardly for at least a part.


**7 Claims, 5 Drawing Figures**

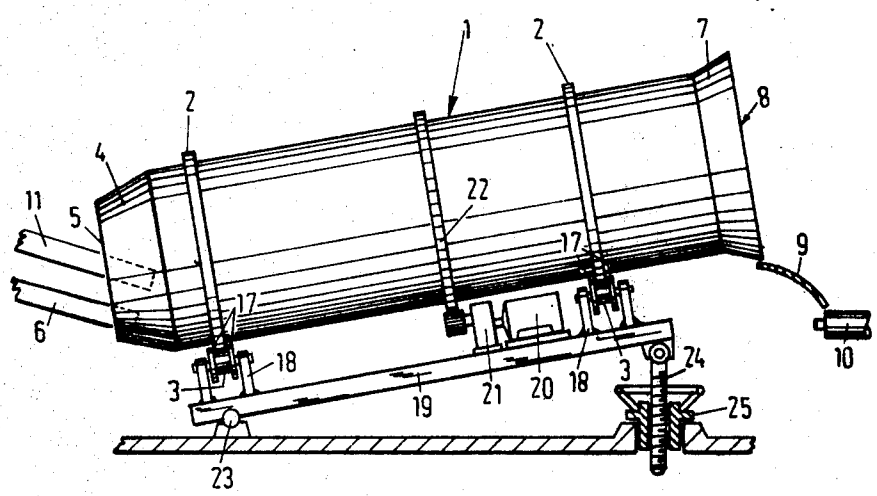
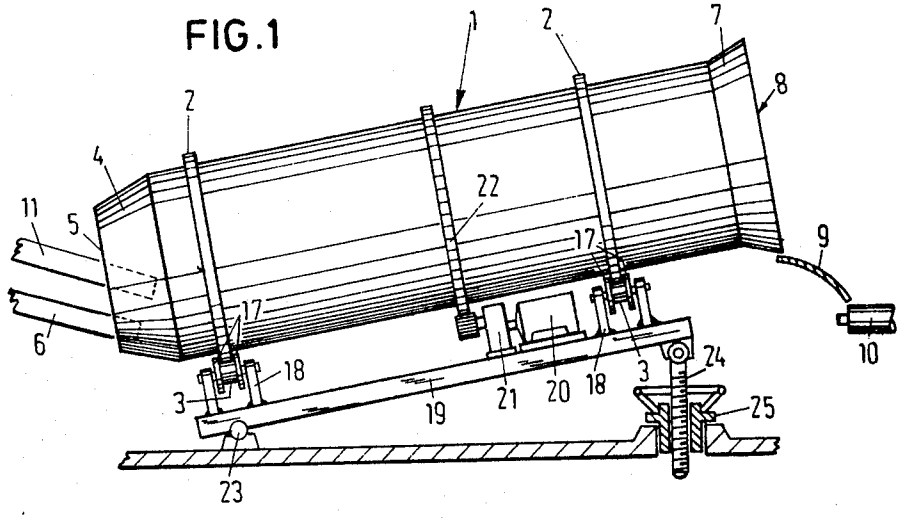


FIG.1



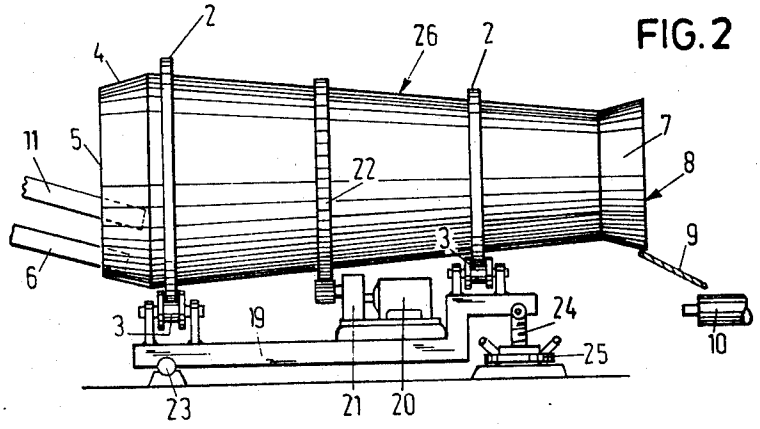




FIG.2

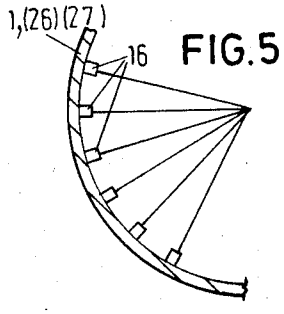



FIG.5

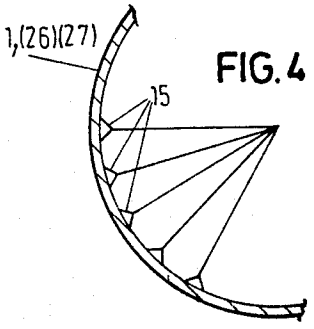



FIG.4

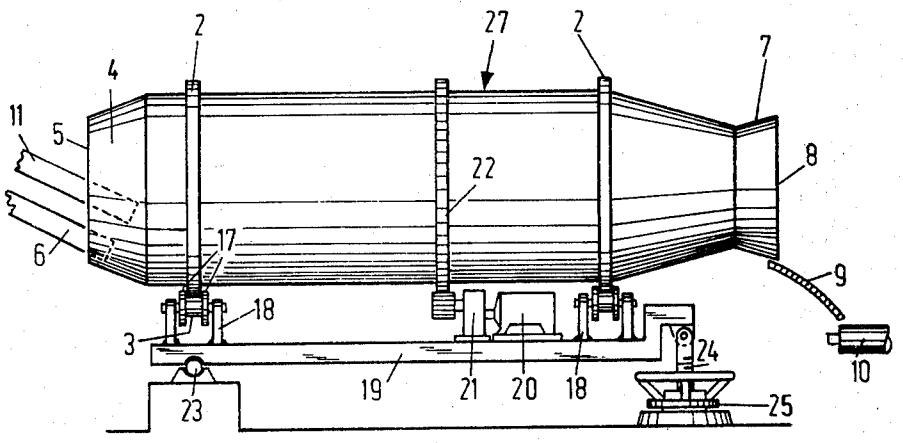



FIG. 3

# APPARATUS FOR MIXING, SEPARATING OR SORTING DRY SUBSTANCES OR ARTICLES

This invention relates to the mixing, separating or sorting of dry substances or articles.

Mixing apparatus has already been disclosed consisting of a horizontal drum which is rotatable about its longitudinal axis and which has an inlet opening for the substances for mixing at one end and an outlet opening for the resulting mixture at or near the other end. Such apparatus is used mainly for mixing concrete, for which purpose a water supply pipe is provided in the drum and the latter slopes downwards from the inlet to the outlet end.

It has now been found that apparatus of the above type can also be used satisfactorily by mixing dry substances, for example sand with soot, sand with lime and cement or the like, provided that special precautions are taken to ensure good mixing. It has also been found that the resulting apparatus in certain cases also offers the possibility of separating or sorting dry substances or articles, as the user requires.

The invention provides an apparatus of the above type, which is characterised in that an underlying descriptive line of the drum viewed in the direction from the inlet end to the outlet end slopes upwardly at least for a part. With such a construction, the drum contents are compelled during operation to move up against an incline, so that the speed of discharge is retarded under the influence of gravity and the residence time of the material in the drum is extended. Where two or more substances or articles are to be mixed this means that the material cannot leave the drum at an excessive speed and hence in an unmixed state, so that better mixing is obtained than with a downward slope of the drum.

In the case of a given difference in specific gravity, particle size or particle shape of the treated substances, the retardation in discharge speed will be greater for one substance than the other. The same also applies to articles. In the case of mixing substances or articles, this difference in speed of discharge can be compensated for by a greater quantity by weight or volume of the other substance with respect to the first substance, so that the total quantity of material of an introduced charge or the total quantity of material introduced per unit of time always leaves the drum practically simultaneously. The effect of the slope in the underlying descriptive line is then a more uniform discharge of material together with better mixing.

In the case of separation or sorting of substances or articles, no compensation will be applied and efficient use will be made of the difference in discharge speed. By appropriate selection of operating conditions, which will of course be different from the case of mixing, the difference in discharge speed will be de-centred and thus good separation or sorting will be possible with the same apparatus as in the other case.

The total effect of the inclination in the underlying descriptive line is therefore better mixing or separation of the treated materials.

The upward inclination of an underlying descriptive line of the drum can be obtained in various ways. For example, a cylindrical drum can be disposed at an angle, or alternatively a frusto-conical drum can be used, having a diameter decreasing in the direction from the inlet end to the outlet end. Both drums result in an extension of the residence time, but the first drum has a greater distance for the same inlet diameter. The advantages of extended residence time and high capacity are combined in a drum which is substantially cylindrical and which just by the outlet end has a frusto-conical part having a diameter decreasing in the direction of said outlet end. The angle of inclination of the underlying descriptive line to the horizontal need not be identical for these three types, but is usually between **0°** and **20°**.



Preferably, care is taken to ensure that the angle of inclination of an underlying descriptive line to the horizontal is adjustable, for example by mounting the entire drum on an adjustable base plate. In this way the drum can be adapted to all possible operating conditions and, more particularly, a greater or smaller extension of the residence time can be used according as the relative specific gravities, relative quantities, particle size and particle shape of the substance for mixing vary.

According to a following feature of the invention, the axial length of the drum wall is several times greater than the diameter. This results in a relatively long contact time between the particles of the substances for mixing and hence a good mixing or separation.

A following feature of the invention is that the drum is rotated by a transmission having a variable speed of revolution. As a result of this step, the drum can be rotated selectively at higher or slower speed so that the circulation of the material in the drum can be varied transversely and the linear speed of said material can be varied longitudinally as circumstances require. This step can also contribute in influencing the contact time between the substances for mixing. In many cases in practice a speed of **6** revolutions per minute will be adequate, but in other cases a variable speed is better.

According to a last feature of the invention, the drum wall is internally provided with longitudinal ribs having a triangular or rectangular section. The effect of this is that the drum contents are circulated more in the transverse direction, the speed of conveyance of the material in the longitudinal direction of the drum being checked. Triangular ribs lift the material to a limited degree during the rotation of the drum while rectangular ribs lift the material higher.

All these steps alone or in combination result in good regulation of the contact and residence time and of the circulation of the materials for treatment in the drum, so that optimum mixing or separation is possible for any relative specific gravities, quantity, particle size and particle shape of the substance for mixing.

The invention is illustrated in detail in the drawing which shows some embodiments of the apparatus according to the invention by way of example.

FIG. **1** illustrates a first embodiment of the apparatus in side elevation.

FIG. **2** shows a second embodiment of the apparatus in side elevation.

FIG. **3** shows a third embodiment of the apparatus in side elevation.

FIGS. **4** and **5** are partial cross-sections to an enlarged scale showing specific details.

The embodiment shown in FIG. **1** comprises a horizontal cylindrical drum **1** which rests on supporting rollers **3** by means of peripheral rails **2** so as to be rotatable about its longitudinal axis. Said drum is intended primarily for mixing dry substances.

At one end, the drum **1** has a widening inlet zone **4** with an inlet opening **5**, into which lead vibratory chutes **6** and **11** to supply the dry substances for mixing. At the other end, the drum has a widening outlet zone **7** with an outlet opening **8** followed by a discharge chute **9** and a conveyor belt **10** for the resulting mixture. The axial length of the drum is generally several times larger than the diameter.

The interior of the drum **1** may be smooth or bear longitudinal ribs **15** or **16** having a triangular or rectangular cross-section (FIGS. **4** and **5**).

For the sake of clarity, the supporting rollers **3** have been disposed beneath the drum in the drawing plane, although it will be apparent that in actual fact they are disposed in pairs somewhat laterally of the drum. They bear double flanges **17** in order to obviate lateral displacements of the rails **2**. The rollers **3** are mounted in brackets **18** on a base plate **19**. The latter also bears a motor **20**, which drives the drum **1** by means of a transmission **21** with a change-speed gear, and also a gear rim **22**.

At one end (corresponding to the inlet end of the drum **1**), the base plate **19** bears on the floor by means of a pivot connection **23** while the other end (corresponding to the outlet end of the drum **1**) rests on a vertical screw spindle **24** which can be screwed up and down by means of a nut **25** bearing on the floor. As a result of this construction, the base plate **19** and hence the drum **1** can be given an inclined position. The angle of inclination between the base plate **19** and the horizontal can generally vary between **0°** and **20°** and is adjustable.

The system shown in FIG. **2** differs from the system shown in FIG. **1** only in that it comprises a drum **26** which is not cylindrical but frusto-conical, with a diameter decreasing towards the outlet end. The other components are the same. The angle of inclination between the drum wall and the longitudinal axis of the drum **26** is approximately **5°** in the drawing, although values from **0°** to **20°** are generally possible. This drum is also disposed on an adjustable base plate **19**.

The system shown in FIG. **3** differs from that shown in FIGS. **1** and **2** in that it comprises a drum **27** which is substantially cylindrical (part **11***a*) and has near the outlet end a frusto-conical part **12***a* having a diameter decreasing in the direction of the said outlet end. The other parts are the same. The angle of inclination between the drum wall and the drum longitudinal axis in the part **12***a* is greater than the inclination in the drums shown in FIGS. **1** and **2** and according to the drawings is about **15°**, although generally values from **0°** to **20°** are possible. This drum is also disposed on an adjustable base plate **19**.

The drum shown in FIG. **1** has a greater capacity than that shown in FIG. **2**, while conversely the increase in the residence time of the material in the drum embodiment shown in FIG. **2** can be controlled more sharply than with that shown in FIG. **1**. The embodiment according to FIG. **3** combines the advantages of both drums.

Prior to the operation of the system shown in FIG. **1**, the base plate **19** is first brought into an inclined position by means of the screw spindle **24** so that an underlying descriptive line of the drum viewed in the direction from the inlet to the outlet end always slopes upwards. The value of the angle of inclination depends on the required residence time of the substances for mixing in the drum, and this is in turn dependent upon the relative weights, specific gravities, particle size and particle shape of the substances for mixing. Although values between **0°** and **20°** are generally possible, an angle of **10°** has been assumed in the drawing.

In the system shown in FIG. **2**, an underlying descriptive line of the drum **26** will have an upward inclination even when the base plate **19** is in a horizontal position. Nevertheless, it is again possible prior to operation to bring the base plate **19** into an inclined position in order to increase the angle of inclination of the underlying descriptive line of the drum. The total range of possible values for the angle of inclination is still between **0°** and **20°**.

In the system shown in FIG. **3**, an underlying descriptive line of the drum **27** will have an upward inclination in its last part even when the base plate **19** is in a horizontal position. Nevertheless, it is again possible prior to operation to bring the base plate **19** into an inclined position in order to increase the angle of of inclination of the underlying descriptive line. The range of angles of inclination as a whole is still restricted to values between **0°** and **20°**.

In all three systems, the change-speed gear of the motor transmission **21** is so adjusted that the drum is driven at a speed (for example **7** revolutions per minute or generally **5–10** revolutions per minute) corresponding to the required circulation conditions of the material in the drum.

During operation, the drum **1** or **26** or **27** rotates about its longitudinal axis at the speed to which it has been adjusted. The dry substances for mixing, for example sand and cement, are fed to the drum continuously or intermittently via the vibratory chutes **6** and **11**. The substances remain in the drum for some time, are turned over and over therein and are also gradually conveyed in the direction of the outlet end. As a result, there is a circulation in the transverse direction and a circulation in the longitudinal direction, these together ensure good mixing of the dry substances.

The system according to the invention provides good facilities for increasing or reducing the residence time and changing the circulation. The inclined position of an underlying descriptive line of the drum - which inclined position is also selectively adjustable - ensures that the dry substances for mixing must move against an inclination during conveyance through the drum, and this gives a reliable retardation and hence an increase in the residence time as compared with conditions having a purely horizontal or downwardly sloping descriptive line. The relatively considerable axial length of the drum helps in this respect. The same effect is obtained by the longitudinal ribs in the drum, which transversely lift the material to a varying extent and thus check conveyance through the drum. The longitudinal ribs also ensure a change of circulation in the transverse direction so that the contact between the particles of the substance for mixing changes. A similar change can be also obtained by varying the speed of revolution of the drum by means of the change-speed gear of the motor transmission. In this way it is possible to adjust to various circumstances and mixing can always be carried out in the correct way.

The inclined position of an underlying descriptive line of the drum causes the conveyance of one substance of higher specific gravity to be retarded more intensely than the other of lower specific gravity but his

difference can be compensated by the greater quantity by weight of lighter substance as compared with the heavier, so that the total quantity of material of a charge or the quantity of material supplied per unit of time nevertheless leaves the drum practically simultaneously.

When the resulting mixture reaches the outlet end of the drum, it is discharged via the aperture **8**, the discharge chute **9** and the conveyor belt **10**. The mixture is homogeneously mixed and can immediately be used for all kinds of application.

Although the above description of the drawings refers solely to the mixing of dry substances, it will be apparent that the embodiments illustrated can also be used without difficulty for mixing shaped articles and that the same phenomena occur in such conditions. The apparatus according to the invention also appears suitable for other purposes.

If a mixture of substances or articles is involved with highly divergent specific gravities, quantities, particle sizes or particle shapes, the apparatus according to the invention also offers the possibility of separating or sorting these materials. In that case, the mixture is fed to the inlet end and efficient use is made of the fact that the upward slope of the underlying descriptive line of the drum causes a difference in the retardation of the components of the mixture. It is then a simple matter to control the residence time and the circulation conditions by variation of the above-mentioned parameters so as to achieve good separation or sorting. The only alteration necessary to the embodiments illustrated in that case is the provision of more than one discharge chute at the drum outlet end.

The apparatus of the invention may further be used for granulating substances. In that case, the drum is provided with a spray conduit introduced through one of its ends. Water or another fluid is dispensed in the drum during operation and this fluid together with the rotative movement of the drum will result in an effective agglomeration of particles to form granules.

The apparatus may also be used for drying pulverulent substances introduced in wet state. This drying process may be promoted by connecting an air suction device to the inlet end of the drum.

In general, the drum may be provided with several additional appliances such as spray conduits, air suction devices, gas feeding devices and the like. Further, the drum may have been made of corrosion-resistant material in order to withstand agressive substances. All these variants are within the scope of the invention.

What we claim is:

**1.** Apparatus for treating dry materials comprising the combination of:

an elongate, generally horizontal drum having an inlet end of diverging cross section to define a material-receiving space, and having an outlet end defining an outlet throat of selected diameter, said drum being mounted such that the lowest point of said outlet throat is higher than said material-receiving space whereby dry material disposed in said material-receiving space must be elevated in order to pass through said outlet throat, said drum having a section between its inlet and outlet ends, and leading to said outlet throat, which inclines upwardly to said outlet throat; and

means for rotating said drum about its longitudinal axis at a rotational speed causing migration of said dry materials upwardly within said section of the drum to pass out said outlet throat.

**2.** Apparatus as defined in claim **1** including longitudinally extending ribs on the inner surface of said drum for retarding migration of dry materials to said outlet throat.

**3.** The apparatus as claimed in claim **1**, wherein said drum is cylindrical and is disposed so as to slope upwardly in respect of an underlying descriptive line viewed in a direction from said inlet end to said outlet end.

**4.** The apparatus as claimed in claim **1**, wherein said drum is frusto-conical having a diameter decreasing in a direction from said inlet end to said outlet end.

**5.** The apparatus as claimed in claim **1**, wherein said drum is substantially cylindrical and said section is of frusto-conical configuration.

**6.** The apparatus as claimed in claim **1**, wherein said drum has an angle of inclination to horizontal between **0°** and **20°**.

**7.** The apparatus as claimed in claim **1**, wherein said drum has an axial length which is several times larger than its diameter.

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