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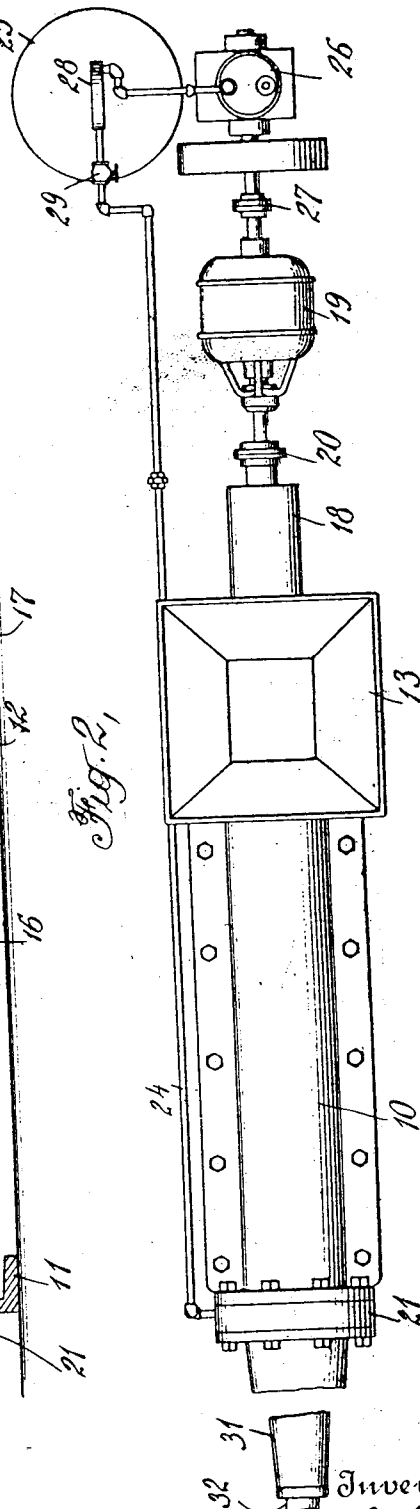
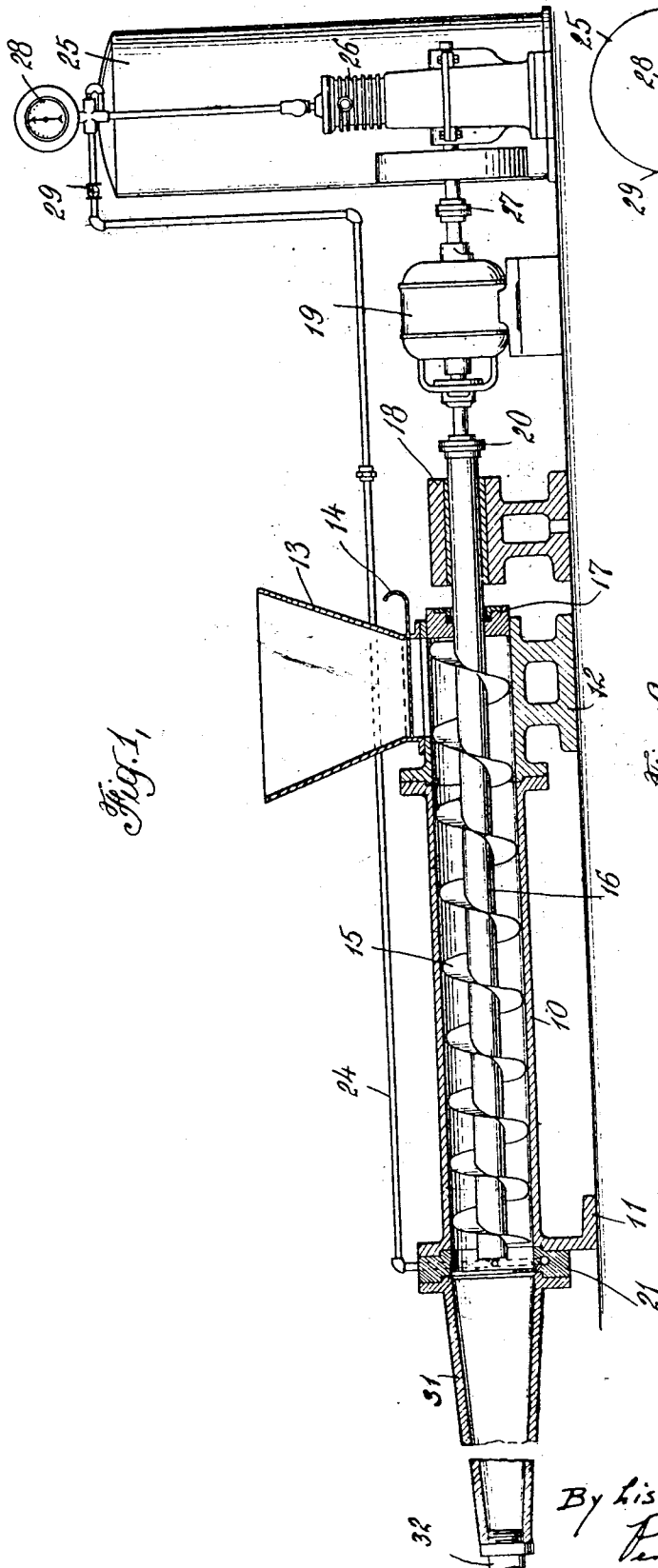
1,553,539

A. G. KINYON

CONVEYING PULVERIZED MATERIAL

Filed Oct. 8, 1919

3 Sheets-Sheet 1



Inventor
A. G. Kinyon,
By his Attorneys
Perrin, Davis, Martin & Edwards.

Sept. 15, 1925.

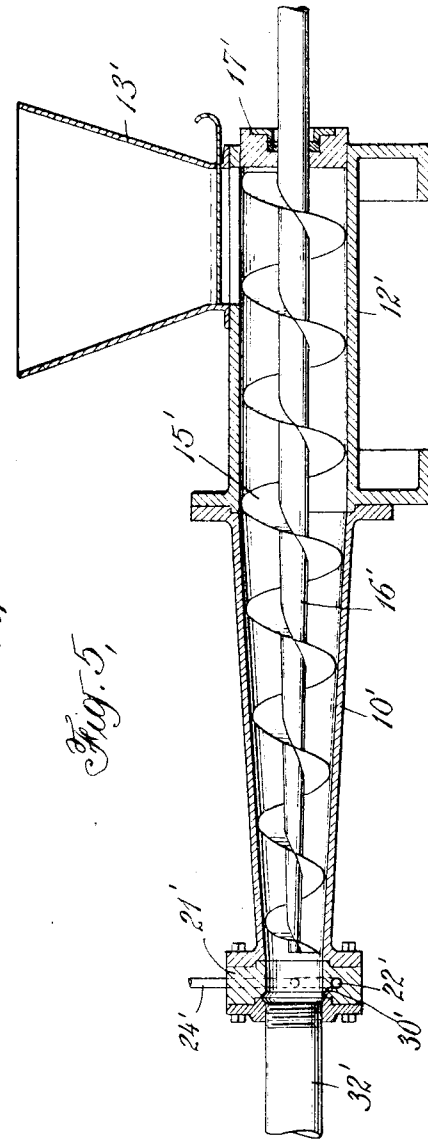
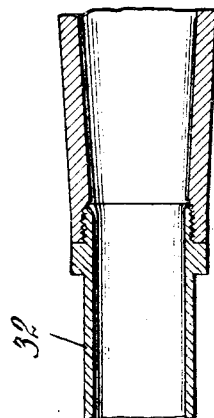
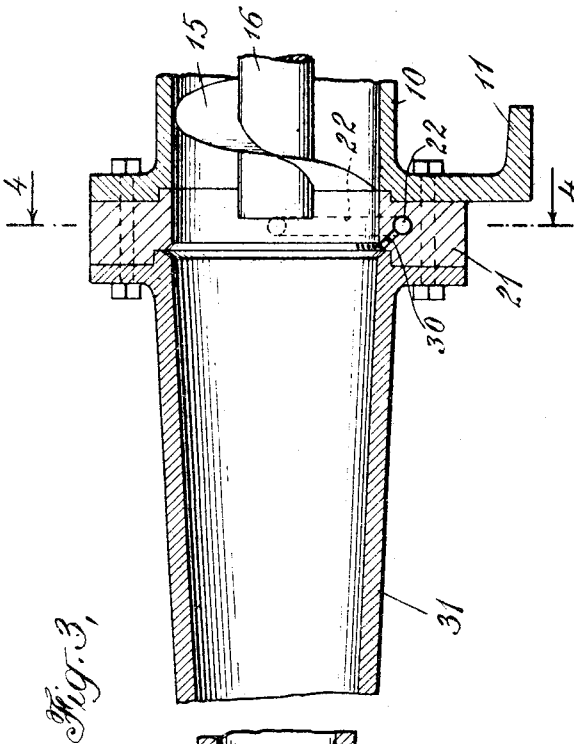
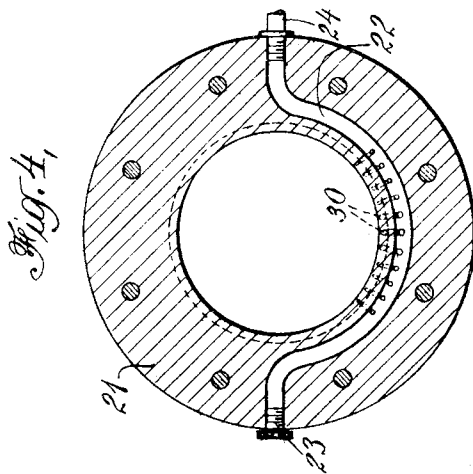
1,553,539

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CONVEYING PULVERIZED MATERIAL

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3 Sheets-Sheet 2



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Sept. 15, 1925.

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1,553,539

CONVEYING PULVERIZED MATERIAL

Filed Oct. 8, 1919

3 Sheets-Sheet 3

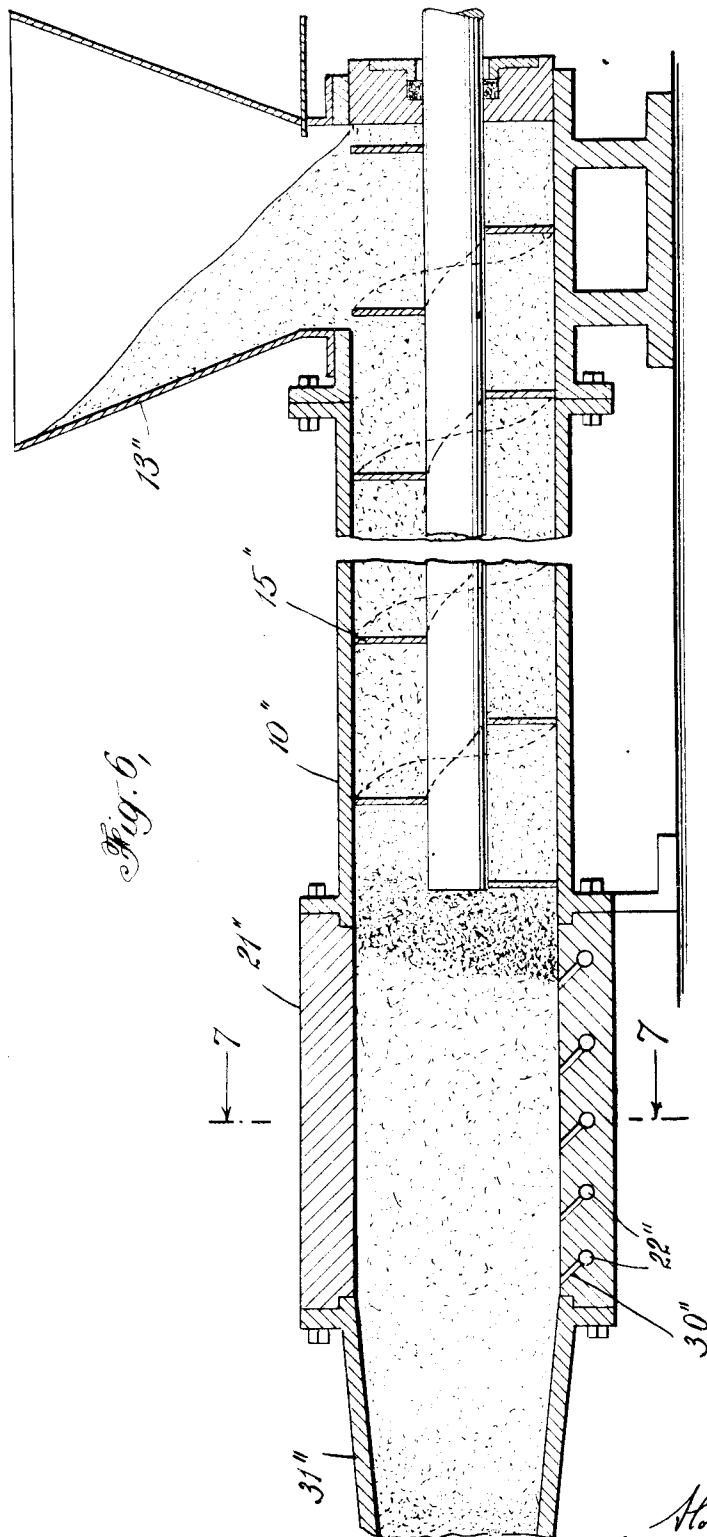


Fig. 8.

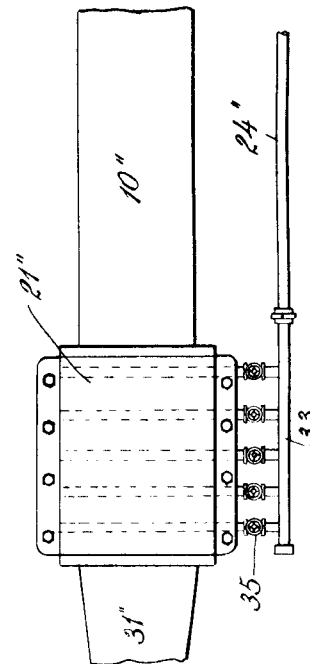
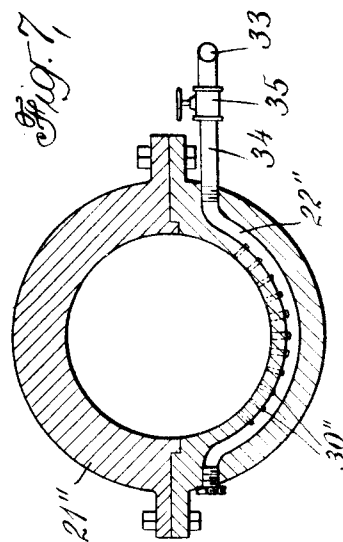


Fig. 7.



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UNITED STATES PATENT OFFICE.

ALONZO G. KINYON, OF ALLENTOWN, PENNSYLVANIA, ASSIGNOR TO FULLER-LEHIGH COMPANY, A CORPORATION OF PENNSYLVANIA.

CONVEYING PULVERIZED MATERIAL.

Application filed October 8, 1919. Serial No. 329,209.

To all whom it may concern:

Be it known that I, ALONZO G. KINYON, a citizen of the United States, residing at Allentown, in the county of Lehigh, State of Pennsylvania, have invented certain new and useful Improvements in Conveying Pulverized Material; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

This invention relates to a method of treating and mechanically conveying materials in finely divided condition or substances which in their natural state are in the form of small particles.

As illustrations of prior methods of conveying pulverized material, the systems commonly employed for transferring pulverized coal may be cited. In some cases, a worm or screw conveyor rotatably mounted in a suitable trough or pipe is frequently employed, the fuel being carried through the trough or pipe by the action of the worm. This method is not only expensive in its initial cost, but is cumbersome and difficult to apply in many cases, and the moving parts of the apparatus are subject to constant wear and require frequent repairing.

In cases where pulverized fuel is to be conveyed for considerable distances, as when a number of furnaces located throughout a plant are to be fed, a method quite commonly employed is to convey the fuel in suspension in a current of air. The large volume of air required to keep the fuel in suspension may produce a mixture that is explosive in its nature, and care must be exercised that it is not accidentally ignited. Furthermore, the cost of the apparatus and the power required to supply the large volume of air render the system expensive to install and operate. The large volume of air required also entails the use of a more or less cumbersome system of conveying pipes.

Systems have been devised in which the fuel is projected through pipes by impulses of compressed air, but these arrangements require the use of cyclone separators, or similar pieces of apparatus, at the points where the fuel is to be delivered and ex-

pensive units which consume considerable power are necessary for supplying the compressed air, so that these systems are expensive both in installation and operation.

A study of the phenomena that occur in the case of flooding or flushing of pulverized material shows that under certain conditions the material possesses many of the characteristics of a liquid. Flooding or flushing of pulverized material usually occurs when a mass of the material in a hopper above a worm conveyor is undermined, thus forming a pocket filled with air, above which the material bridges. In time, due to the continued action of the screw conveyor, this bridge will be weakened to a point where the weight of the material on the top of the bridge will cause it to collapse. The momentum developed by the falling material will produce a propelling force, while the air in the pocket beneath the bridge will intermingle with the particles of material as they fall, and the material is brought into a condition where it possesses many of the characteristics of a liquid, the fluidity of which depends upon the amount of air mixed with the material, the intimacy of the mixture and other factors. Cases have been noted where pulverized material in the condition described has flowed through a pipe containing a worm conveyor more rapidly than it would have been moved under the influence of the conveyor, and in some instances the material has been observed to flow after the conveyor had been stopped in an effort to stop the flow.

The behavior of pulverized material under the conditions noted above has led to the conclusion that, if such material can be brought into a sufficiently fluent condition, it may be forced or pumped through pipes by mechanical means, in much the same way as water, oil or other liquids are conveyed. In other words, a method would then be provided by which pulverized fuel or other material may be conveyed cheaply and efficiently without the production of dust and in quantities which can be closely regulated in the same manner that the flow of ordinary liquids is controlled.

This can be accomplished by injecting a fluid into the material within the conveying

system in an amount which will suffice to prevent packing of the material and render it sufficiently fluent so that it may be propelled throughout a system of considerable length by pressure applied to the material at one end of the system. The injection of the fluid gives to the material a sluggishly fluent condition which makes it possible to effect the movement of the material as described. This condition of the fuel is, however, quite distinct from that which obtains in those systems heretofore used in which the particles of material are held in suspension in a relatively large volume of moving air.

The material into which the fluid has been injected may be said to be saturated with fluid or aerated, with the result that a unit volume of it weighs considerably less and is substantially more fluent than the same volume of material without the injected fluid. The material so treated may be moved along through a system of conveying conduits and may even be made to rise to considerable heights with marked freedom in a continuous and uniform stream and without the expenditure of a great amount of power. The freedom of flow is due to the saturation of the material with the fluid which fills the multiplicity of interstices between the particles or units, and a uniformity of the flow of the material results from the prevention of packing by reason of the presence of the injected fluid.

Preferably a screw conveyor to which the material is fed from a hopper is employed for effecting the movement of the material, and the fluid is injected into the material at a point beyond the end of the screw.

To prevent the fluid from flowing through the conveyor to the supply hopper and prematurely saturating the material, the conveyor may be constructed so that the material becomes more closely packed as it approaches the discharge end so that it will act as a seal, or the fluid may be introduced at a sufficient distance from the hopper to cause compression of the material to produce the required sealing effect. The pressure on the fluid should be just sufficient to carry it into the material at the rate which will produce the desired degree of saturation and thus produce the requisite state of fluency without being enough to produce a condition in which the particles of material are held in suspension in the fluid. In this state, the material may be forced along by the thrust of the screw through a system of piping of very considerable length, as for instance a system for the supply of pulverized coal to any desired number of furnaces.

An apparatus which may be employed in the practice of the invention is illustrated in the accompanying drawings in which—

Fig. 1 is a side elevation of the entire apparatus with parts shown in section;

Fig. 2 is a plan view of the apparatus;

Fig. 3 is a sectional view on a larger scale showing particularly the device for introducing gas into the pulverized material;

Fig. 4 is a transverse section along the line 4—4 of Fig. 3;

Fig. 5 is a longitudinal sectional view of a modified form of apparatus;

Fig. 6 is a similar view of another form of apparatus;

Fig. 7 is a transverse section along the line 7—7 of Fig. 6; and

Fig. 8 is a plan view of part of the apparatus.

In the form of apparatus shown in Figs. 1 and 2, 10 is a cylindrical casing provided at one end with a supporting foot 11 and connected at the other end to a standard 12, having a cylindrical bore of the same diameter as the interior of the casing. Above the bore is a hopper 13 of any suitable shape and capacity provided with a valve or other form of controlling device 14 by which the discharge of pulverized material from the hopper may be regulated. Extending through the casing 10 and the bore of the standard 12 is a screw conveyor 15, the shaft 16 of which projects through a suitable bushing 17 which also serves as a closure for the outer end of the bore. The shaft is continued through a bearing 18 which constitutes the main support for the shaft. The end of the shaft is connected to an electric motor 19 or other source of power, and preferably the connection should be in the form of a flexible coupling 20 of any suitable type.

As appears most clearly in Fig. 1, the pitch of the screw conveyor 15 decreases from the end at which material is supplied to the end from which it is discharged. The purpose of this arrangement is to compress the pulverized material as it approaches the discharge end of the screw, so that the material will act as a seal to prevent the fluid which is introduced into the material as it leaves the screw from flowing through the casing toward the hopper and aerating the material before it has been discharged from the screw.

For the purpose of introducing fluid into the material there is attached to the forward end of casing 10 an annular casting 21, the lower portion of which is provided with a semicircular passage 22 as shown most clearly in Fig. 4. This passage is substantially concentric with the bore of the casting and its ends are brought out to the exterior of the casting, preferably at diametrically opposite points. One end of the passage may be closed by a screw plug 23, while into the other end there is screwed one end of a pipe 24 leading to a tank 25 in which the fluid

that is to be injected into the material may be compressed by a suitable compressor 26 which may be driven by the motor 19 that drives the screw conveyor, the connection between the motor and the compressor preferably being in the form of a flexible coupling 27 of any suitable type. The tank 25 may be provided with a pressure gauge 28, and a suitable regulating valve 29 should be inserted in the pipe 24 to control the amount of fluid supplied to the material.

For the purpose of introducing the fluid from the passage 22 into the pulverized material, there is provided a series of forwardly directed ports 30 between the passage 22 and the interior of the casting. As shown most clearly in Fig. 4 the central ports of the series are of somewhat greater diameter than the end ports, as it has been found in practice that better results can be obtained with such an arrangement. It has also been found that it is an advantage to introduce the fluid into the bottom of the column of pulverized material, as the material in this region has a greater density as it is delivered from the conveyor than the material in the upper portions of the column. It will be understood, however, that the ports 30 are not limited to the particular number or arrangement shown, and may extend over a greater or lesser arc, and in fact may be arranged around the entire circle, in which case the passage 22 will surround the bore of the casting. The ports 30 may be located at a distance from the end of the screw conveyor determined with reference to certain other features of the installation. As the distance through which the material is to be conveyed increases, there should be a greater packing or sealing effect behind the jets in order that the higher pressure fluid which is necessary for such increased distances should be forced into the material and prevented from flowing through the screw conveyor toward the hopper. This result may be obtained by locating the ports at a greater distance from the end of the screw conveyor.

Attached to the front face of annular casting 21 is a tapering casing or chamber 31 to the outer end of which is connected a pipe 32 through which the pulverized material is distributed. The pipe 32 may be provided with branches in case the material is to be conveyed to a number of points, and may be brought back to the supply hopper to return any surplus material. The length and taper of the casing 31 and the relation between the diameter of the screw conveyor and that of the distributing pipe 32 depend upon a number of factors, such, for instance, as the character of the material, the distance to which it is to be conveyed, its velocity, and its volume.

In the embodiment of the invention de-

scribed above the increased compression of the pulverized material as it approaches the discharge end of the screw is produced by decreasing the pitch of the screw, but it is possible to attain the same result by providing a screw conveyor which is of uniform pitch, but of decreasing diameter towards its discharge end and which is placed within a tapered casing. In Fig. 5 there is shown such a modification of the apparatus, in which there is a tapered casing 10' connected at one end to a standard 12', similar to that shown in Fig. 1 but with a somewhat longer bore. Within the casing and bore is a screw conveyor 15' of uniform pitch, but the part within the casing is of gradually decreasing diameter toward the discharge end, and preferably the portion of the conveyor shaft 16' which carries the tapered part of the screw should also be tapered. The shaft 16' may be driven by a motor, and pulverized material may be supplied from a hopper 13' as in Fig. 1. Attached to the forward end of casing 10' is an annular casting 21' of substantially the same construction as the corresponding member of Fig. 1, but on account of the lesser diameter of this portion of the apparatus, the distributing pipe 32' may be connected directly to the casting 21' without the use of a tapering casing 31, but it will be understood that such a casing may be employed in case the casting 21' is of greater diameter than the distributing pipe that is adapted to give the best results. It will also be understood that any other modifications, such as the number and arrangement of the ports in the casting 21' and the distance of these ports from the forward end of the screw conveyor, may be made in the apparatus of Fig. 5, in accordance with the requirements of the service in which the apparatus is to be employed.

In the arrangement of the apparatus shown in Figs. 6, 7 and 8, there is a screw conveyor 15'' of uniform pitch and diameter placed within a cylindrical casing 10'' into which material may be fed from a hopper 13'', the screw conveyor being driven by a motor or other source of power, as in the case of the previous modifications of the apparatus. In the arrangement of Fig. 6 the casting 21'' is extended in length and provided with a number of passages 22'' each communicating with the interior of the casting through a series of inclined ports 30''. The several passages are connected to a header 33 by means of branch pipes 34, each provided with a valve 35. The fluid to be introduced into the material is supplied to the header 33 by a pipe 24'' leading to a tank, as in the other modifications of the apparatus. Attached to the front end of the casting 21'' is a tapering casing 31'' similar to the corresponding member of the previously described modifications and to

the outer end of which is connected the distributing conduit.

In this arrangement of the apparatus the packing or sealing effect is produced by the compression of the material after it leaves the screw conveyor and before the fluid is introduced through one of the passages 22" and its associated ports, and this packing or sealing effect will be determined by the distance from the end of the screw conveyor at which the fluid is introduced, as regulated by the passage and ports which are opened. If the material is to be conveyed a comparatively short distance the fluid will be introduced through the ports nearest the end of the screw conveyor, in which case the sealing plug of compact material will be comparatively short. On the other hand, if the material is to be conveyed for a considerable distance the fluid will be supplied to the material through ports more distant from the end of the screw conveyor, so that a longer plug of material will be formed to resist the increased pressure of the fluid required to overcome the greater pressure exerted upon the material by the screw conveyor in forcing the material the greater distance. By means of the valves 35 the fluid pressure and its point of admission may be controlled. The arrangement permits the use of screw conveyors of uniform pitch and diameter, and by providing for the formation of sealing plugs of different lengths, according to the conditions of operation, the power expended in driving the screw conveyor will vary in accordance with the distance to which material is to be conveyed.

In the operation of the apparatus of the invention the hopper 13 is filled with the material to be conveyed, and by adjustment of the valve 14 the discharge of material to the screw conveyor can be properly controlled. The screw 15 is rotated by the motor 19 and takes the material as it is discharged from the hopper and carries it through the casing 10. In either form of apparatus, shown in Figs. 1 to 5, there will be an increased compression of the material as it approaches the discharge end of the screw. In the case of the arrangement shown in Fig. 5 there will be in addition to the pushing effect produced by the screw conveyor a further movement of the material due to the decreasing cross-sectional area of the casing 10', so that there results an increased velocity of the material which may be of advantage in certain cases. In the arrangement of Fig. 6 the increased compression will occur beyond the end of the screw.

Experiments show that best results are obtained with a relatively high speed of the screw conveyor. As a specific illustration, it has been found that with a screw

conveyor having a diameter of 6" and a distributing pipe having approximately one-half the diameter of the conveyor, the speed of the conveyor should be at least 700 revolutions per minute to give good results. These figures are illustrative and will vary with variations of weight, characteristics of the material to be conveyed, its moisture content, the length of the system, the height to which the material is to be delivered and the diameter of the conveyor conduits, the three latter factors being factors of resistance. Experiments also indicate that there is a relation between the velocity of the material in the distributing pipe and the tendency for the pipe to become clogged with material. With relatively high velocities of the material there is an apparent rolling effect of the particles which overcomes this tendency by maintaining the aerated condition of the material, and higher velocities also insure that the entire column of material will be kept in motion.

While the material is being fed by the screw conveyor, the compressor 26 is in operation to maintain the fluid under the desired degree of pressure in tank 25, from which it flows through pipe 24 and is discharged through the ports 30 or 30' as the case may be and becomes thoroughly intermingled with the pulverized material as the latter leaves the end of the screw conveyor, or if an apparatus like Fig. 6 is being used the fluid will be discharged through any one of the series of ports 30" that is opened. Owing to the packing action produced at the discharge end of the screw or immediately beyond it, the fluid will be prevented from passing through the casing to the hopper, so that the material will not be aerated until after it has been discharged from the conveyor. The quantity and pressure of the fluid may be regulated by means of the valves to the proper amount to produce an aerated mixture having the required fluency. Taking as an illustration the case of pulverized coal, experiments have shown in general that approximately 16 per cent of air by volume may be injected into the fuel to impart to the resulting mixture the degree of liquidity required to permit it to be forced or pumped through the conveying system. This may be said to represent an ideal condition, but due to the difficulty of introducing air to the infinite number of interstices between the particles of coal so as to avoid packing of the coal, a much greater quantity of air should be admitted than that which is represented by the final fluidized or "liquefied" condition when delivered from the conduit at its ultimate destination. In practice and varying in accordance with the variation of several factors, such as weight, characteristics, moisture content of the material and the resis-

tance or head of the system, the air required will vary from 4 to 10 cubic feet per 1 cubic foot of material such as pulverized coal. If the amount of air is in any substantial excess of the figures stated it may escape from the mass and carry particles of the material with it so that a condition approaching that which occurs when the material is held in suspension is produced. As a specific example of the above final result, it has been found that pulverized coal weighing about 38 pounds per cubic foot before aeration, will, when properly treated, weigh about 32 pounds per cubic foot or approximately 15.8 per cent less by volume. It has also been found that this percentage will vary with different materials substantially in proportion to their variations in weight per cubic foot. As about 150 cubic feet of air are necessary to burn 1 pound of coal, 5700 cubic feet of air are necessary to burn 1 cubic foot of coal weighing 38 pounds per cubic foot. An amount of air for aeration and transportation varying from approximately 4 to 10 cubic feet per cubic foot of coal, would be approximately .0007 minimum and .0017 maximum, by volume, of the air required for combustion, so it is apparent that there would be no element of danger by reason of the formation of a combustible mixture, as is the case with the suspension systems.

In practice the supply of fluid must be turned on before the screw conveyor is started into operation in order to avoid the possibility of material being fed for some distance beyond the discharge end of the screw conveyor before being aerated which would prevent the conveyance of material through the system. Under the influence of the pressure exerted upon the aerated material by the rotating screw conveyor, the mixture may be forced into the distributing pipe 32 and be conveyed for a considerable distance and may even be elevated to a substantial height.

Due to the aerated condition of the material its discharge from the distributing system may be controlled by suitable valves in a manner analogous to that employed in controlling the discharge of liquids from conduits, and the material will be free from the dust which accompanies material when it is conveyed in suspension in a relatively large volume of rapidly moving air. In general the method possesses all of the advantages attending the conveyance and distribution of material in liquid condition and may be practiced by comparatively simple and inexpensive apparatus, and without excessive power consumption.

While the method is particularly adapted for conveying pulverized coal through a distributing system, it may also be employed

for handling any other finely divided substances, such as raw materials of various kinds, cement, sand, flour, and the like, as well as substances which occur in nature in small sizes, such as wheat, barley and other grains. It will be understood, therefore, that such terms as "finely divided material" as used in the foregoing specification and in the appended claims include within their scope any or all of such substances.

In most cases, it will be most convenient and least expensive to use air for rendering the material fluent, but any suitable gas may be employed for this purpose.

The mechanisms shown and described illustrate certain embodiments of the invention that may be employed for treating finely divided material and forcing it by mechanical pressure through a distributing system, but it will be understood that other types of apparatus may be employed for practicing the invention and that various changes in the details of construction of the mechanism disclosed herein may be made without departing from the principle of the invention as defined in the appended claims. That principle involves supplying the material to be conveyed to the conveyor system, subjecting the material to pressure, and introducing a gas into the material in the system to render it fluent or mobile so that the pressure will be effective to cause the conveyance of the material throughout the system. The gas admitted to the system to aerate the material is admitted under pressure, and, of course, it expands within the system and to the extent that it expands it aids in effecting the conveyance; but the application of pressure to the material is an essential of the operation. This pressure is also utilized to supply the material to the system and compact it adjacent to the point of aeration so that the air admitted will not work back from the point of admission to any considerable extent. When the pressure is applied mechanically as by a rotatable feed screw such as that above described, it is applied over a very short length of the conveyor system and is effective throughout the system; for instance, the feed screw may be ten feet long and the system through which the material is conveyed may be hundreds of feet long or even thousands. Also, when such a feed screw is employed, the material is introduced into the system, compacted and advanced to and beyond the point of aeration continuously. However, other means may be employed, either continuous or intermittent, for supplying the material to the system and subjecting it to pressure to advance it to the aeration point. All such alternative constructions I consider to be within the scope of my invention and I

aim to cover them by the terms of the claims appended hereto.

I claim:

1. The method of conveying pulverized material which comprises continuously supplying the material to be conveyed to one end of a conveyor conduit, continuously applying pressure to the material as it is so supplied which pressure is transmitted through the material itself so that all of the material throughout the entire length of the conduit is subjected to pressure applied to the material at one end only of the conduit, and injecting a gas into the material at a point immediately beyond the point of application of the pressure to increase the mobility of the material.

2. The method of conveying pulverized material through a conveyor conduit which consists in continuously supplying the material to the conduit at a point near one end thereof, injecting a gas into the material in the conduit at a point adjacent to said point to increase the mobility of the material, and applying pressure to the material in the conduit between the said two points which pressure is transmitted through the material itself so that all the material throughout the length of the conduit and extending a long distance beyond the point of injection of the gas is subjected to the pressure applied to the material only at that end of the conduit which is adjacent to the point of injection of the gas.

3. The method of conveying pulverized material which consists in continuously supplying the material to be conveyed to a conduit, applying pressure to the material adjacent to the supply point to advance the material within the conduit and cause it substantially to fill the conduit, and injecting gas under pressure into the conduit at a point removed from the supply point, the pressure so applied being transmitted through the material itself so that all of the material throughout the entire length of the conduit is subjected to the pressure applied to it at the point adjacent to the supply point, whereby the material beyond the point of application of pressure is aerated to make it mobile and whereby the gas is prevented from escaping at the point of supply to the conduit and the entire body of material is moved through the conduit by the pressure applied to it and expansion of the gas.

4. The method of conveying pulverized material through a conduit which comprises maintaining a column of the material in the conduit from the inlet to the discharge outlet thereof by continuously supplying material at the inlet of the conduit as it is discharged at the outlet, advancing the column through the conduit by subjecting it

to pressure throughout its entire length by the continuous application of pressure to the material at the inlet end of the conduit, and injecting a gas into the advancing material to render it more fluent at a point adjacent to the point of application of the pressure.

5. The method of conveying pulverized material, which comprises propelling the material through a conveyor conduit by subjecting the material at one end of the conduit to progressively increasing pressure and injecting a gas into the material substantially at the point at which the material has been compacted to the maximum extent by the application of the pressure.

6. The method of conveying pulverized material which consists in applying pressure to the material at one end of a conveyor conduit and thereby subjecting the material throughout the entire length of the conduit to pressure thus applied and injecting a gas into the material at a point in advance of the point of application of the pressure to increase the mobility of the material, the material being compacted by the pressure applying means to the rear of the point of admission of the gas to prevent backward flow of the gas.

7. The method of conveying pulverized material through a long conveyor conduit which consists in applying pressure to the material at one end of the conduit, substantially continuously supplying the material to be conveyed to the conduit at the point where the pressure is applied, injecting a gas into the material in the conduit at a point in advance of the point of application of the pressure and thereby increasing the mobility of the material and causing the material in the conduit to be compacted between the point of supply of the material and the point of gas injection.

8. The method of conveying pulverized material which consists in supplying the material to the conveyor conduit, admitting the gas to the conduit to render the material more fluent, and compacting the material in the conduit between the point of supply and the point of admitting the gas.

9. The method of conveying pulverized material through a long conveyor conduit which consists in supplying material to the conduit at one end thereof, admitting a gas to the conduit adjacent to said end to increase the mobility of the material and compacting the material between the points of supply and admission of the gas to prevent flow of the gas from the point of admission toward the point of supply.

10. The method of conveying pulverized material which consists in supplying the material to a conveyor conduit adjacent to one end thereof, applying pressure to the

material in the conduit to compact it and move it along in the conduit, and admitting a gas to the conduit at a point in advance of the pressure-applying means to increase the mobility of the material.

11. The method of effecting the conveyance of pulverized material through a conduit which consists in subjecting the material to pressure to move it through the conduit while progressively diminishing the space occupied by the material to increase the density thereof, and injecting a gas under pressure into the material at a point beyond the zone of increased density to make the material mobile, so that it may be conveyed through the conduit under the pressure applied to it.

12. The method of conveying pulverized material through a conduit which consists in substantially filling the conduit with pulverized material, supplying pulverized material substantially continuously to the conduit at a supply point therein, subjecting the material adjacent the supply point to pressure and injecting a gas into the conduit at a point removed from the supply point whereby the material in advance of the point of application of pressure is aerated to make it mobile, the gas is prevented from escaping at the point of supply of material to the conduit, and the entire body of material is moved through the length of the conduit in a continuous stream.

13. The method of conveying pulverized material through a closed conduit which consists of supplying the material to the conduit, advancing the material in the conduit by applying pressure to it, compacting the material in the conduit near the point of admission to form a seal, and admitting a gas under pressure to the conduit at a point beyond the point of formation of the seal to render the material fluent, thereby conveying the material through the remainder of the conduit by the pressure applied to it.

14. The method of conveying pulverized material through a closed conduit which consists in supplying the material to the conduit, applying pressure to the material to compact it near the point of admission to form a seal, admitting a gas under pressure at a point beyond the point of formation of the seal to aerate the material and thus increase its mobility, and conveying the material through the remainder of the conduit by the pressure applied to it and the expansion of the gas admitted to the conduit under pressure.

15. The method of conveying pulverized material through a conduit which consists in admitting the material to the conduit and advancing it therein, compacting the material by applying pressure upon it and thereby forming a densely packed seal of material within the conduit to prevent a

counterflow of gas toward the admission end of the conduit, and injecting a gas under pressure into the packed material at a point closely adjacent to but slightly beyond the point of formation of the seal to disrupt the compacted material and render it mobile, whereby the material is forced through the conduit by the pressure applied to it.

16. The method of conveying pulverized material through a conduit which consists in admitting the material to a short length of the conduit substantially continuously, applying pressure to the material to form a seal of closely compacted material, and admitting a gas under pressure at a point slightly beyond but closely adjacent to the point of formation of the seal, whereby the latter will function as a continuous check to the counterflow of the gas toward the point of admission of the material, and the material will be conveyed through the conduit by the pressure applied to it.

17. The method of conveying pulverized material through a conduit which consists in advancing the material through a short length of the conduit and applying pressure to the material to form a zone of maximum density and pressure and admitting a gas under pressure at a point closely adjacent but slightly beyond the point of formation of said zone of maximum density and pressure to aerate the material and render it fluent, whereby the material through the remainder of the length of the conduit is moved along through the conduit by the pressure exerted by the expanding gas and the material advancing and compacting means.

18. The method of conveying pulverized material through a conduit which consists in substantially continuously admitting material to the conduit at one end thereof, subjecting the material to pressure to form a zone of densely packed material, admitting a gas under pressure at a point closely adjacent to but slightly beyond the point of formation of said zone to intimately aerate the material and make it fluent, and conveying the material through the remainder of the conduit by the resultant pressure thus applied.

19. The method of conveying material through a long conduit which consists in continuously admitting material to and advancing the material through a short length of said conduit and continuously increasing the pressure applied to the material as it is advanced to form a zone of maximum density in which the material is closely compacted to form a continuous seal of material to check the counterflow of a gas under pressure toward the point of admission of the material, admitting a gas under pressure to said zone to render the material fluent at a point closely adjacent to but slightly be-

yond the point of formation of said seal and conveying the material through said conduit by the resultant pressure thus applied to it.

5 20. The method of conveying pulverized material through a closed conduit, which consists in admitting the material to the conduit, advancing the material under pressure through a progressively diminishing space
10 to form a zone of compacted material, admitting a gas under pressure at said zone to aerate the material, and conveying the material through the conduit by the pressure thus applied.

15 21. The method of conveying pulverized material through a closed conduit which consists in supplying material to the conduit, advancing the material and continuously diminishing the space occupied by it, admitting a gas to the material to form an
20 aerated mixture of gas and material, and permitting the aerated mixture to expand throughout the remainder of the conduit whereby the material will be conveyed
25 through the conduit by the pressure thus applied.

22. The method of forming a seal within a conduit in which gas is introduced into pulverized material as it leaves a propelling
30 mechanism, which consists in supplying the gas to the material in the conduit at such a distance beyond the end of the propelling mechanism that the material will be packed between the point at which gas is admitted
35 and the end of the mechanism to prevent the entrance of gas into the mechanism.

23. A conveying system for pulverized material comprising the combination of a conveyor conduit, means for admitting material to the conduit, means for applying
40 pressure to the material to form a zone of compacted material beyond said means, and means for admitting a fluid under pressure to the compacted material in said zone at a point beyond but closely adjacent to the
45 formation point of the zone, whereby the material is conveyed throughout the system by the pressure thus applied to it.

24. A conveyor system for pulverized material comprising the combination of a conduit, means for admitting pulverized material to the conduit, means for advancing the material through the conduit and subjecting it to pressure to form a seal of closely
50 packed material, and means slightly beyond the point of formation of said seal for admitting a gas under pressure to the compacted material to aerate it and render it mobile, whereby the material will be transported through the conveyor system by the
60 pressure applied to it.

25. A conveyor system for pulverized material comprising the combination of a conduit, a screw conveyor within the conduit,
65 means for admitting material to the screw,

means on the screw for compacting the material as it is advanced toward the end of the said screw to form a zone of compacted material, and means for admitting a gas under pressure at said zone to aerate the material and render it mobile, whereby the material is conveyed through the conduit by the pressure applied to it.

26. A conveyor system for pulverized material comprising the combination of a conduit, means for admitting material to and advancing it within the conduit, differential pressure means for progressively increasing the pressure on the material as it is advanced to form a zone of maximum pressure, and means for injecting a gas under pressure to the material in said zone to aerate the material, whereby the material will be conveyed through the remainder of the conduit by the pressure thus applied.

27. A conveyor for pulverized material comprising the combination of a conduit, a differential screw rotatably mounted within the conduit, means for rotating the screw, means for supplying material to the screw, whereby the material will be compacted as it is advanced by the screw by the differential effect, and means for admitting a gas under pressure to the compacted material to render it fluent whereby the material will be conveyed through a long conduit by the pressure thus applied.

28. A conveyor for pulverized material comprising the combination of a conduit, means for admitting material to the conduit, a differential screw conveyor within the conduit for advancing the material and subjecting it to progressively increasing pressure as the material is advanced along the screw conveyor to form a seal of material adjacent to the end of the screw conveyor, and means for injecting a gas under pressure at a plurality of points into the seal of material closely adjacent to but slightly beyond the formation point of said seal to aerate the material and render it fluent, whereby the material will be conveyed through the conduit beyond the screw and the seal by the pressure thus applied to the material.

29. A conveying system for pulverized material, comprising the combination of a casing, a screw conveyor rotatably mounted within the casing, an annular member connected to the discharge end of the casing, and provided with a passage, means for supplying a gas under pressure to the passage, and ports leading from the passage to the interior of the member through which the gas may be introduced into the material as it is discharged from the conveyor.

30. A conveying system for pulverized material, comprising the combination of a casing, a screw conveyor rotatably mounted within the casing, an annular member con-

5 nected to the discharge end of the casing, and provided with a passage, means for supplying a gas under pressure to the passage, and ports leading from the passage to the interior of the member at the bottom thereof through which the gas may be introduced into the material as it is discharged from the conveyor.

10 31. A conveying system for pulverized material, comprising the combination of a casing, a screw conveyor rotatably mounted

within the casing, an annular member connected to the discharge end of the casing, and provided with a plurality of passages. means for supplying a gas under pressure to any one of the passages, and a series of ports leading from each passage to the interior of the member through which the gas may be introduced into the material as it is discharged from the conveyor.

20 In testimony whereof I affix my signature.
ALONZO G. KINYON.