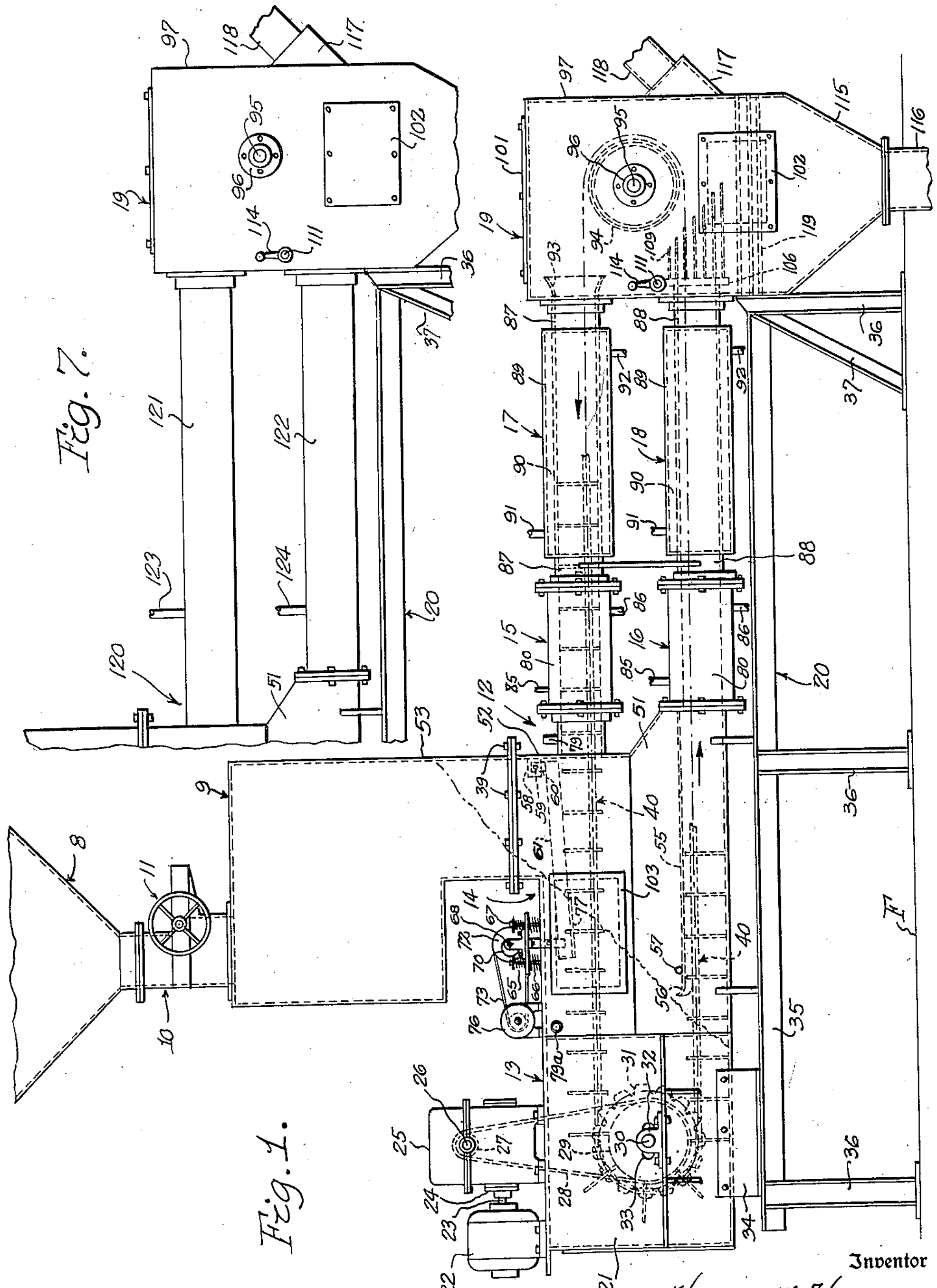
Jan. 6, 1953 H. W. HAPMAN 2,624,474

GRANULATED MATERIAL FEEDING APPARATUS

Filed Aug. 15, 1949 3 Sheets-Sheet 1



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GRANULATED MATERIAL FEEDING APPARATUS

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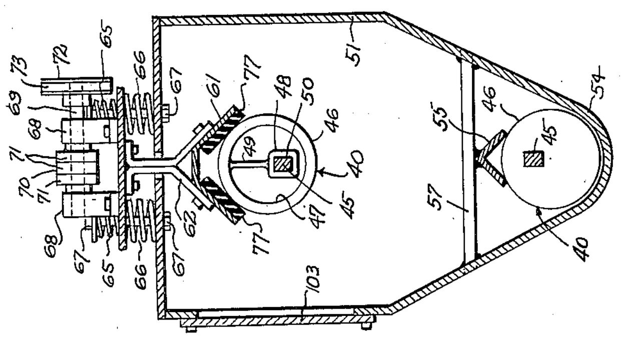

Fig. 3.

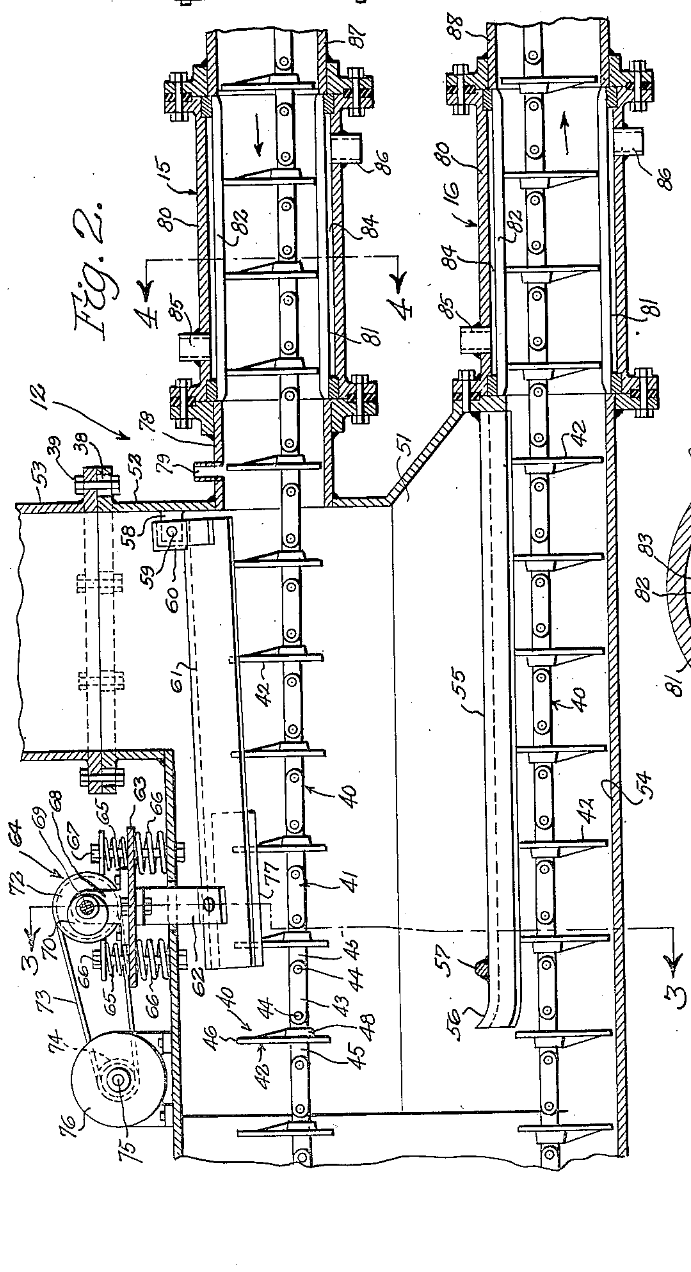

Fig. 2.

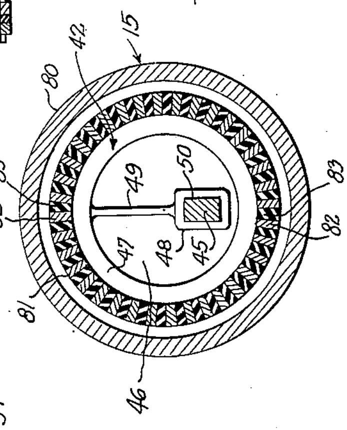

Fig. 4.

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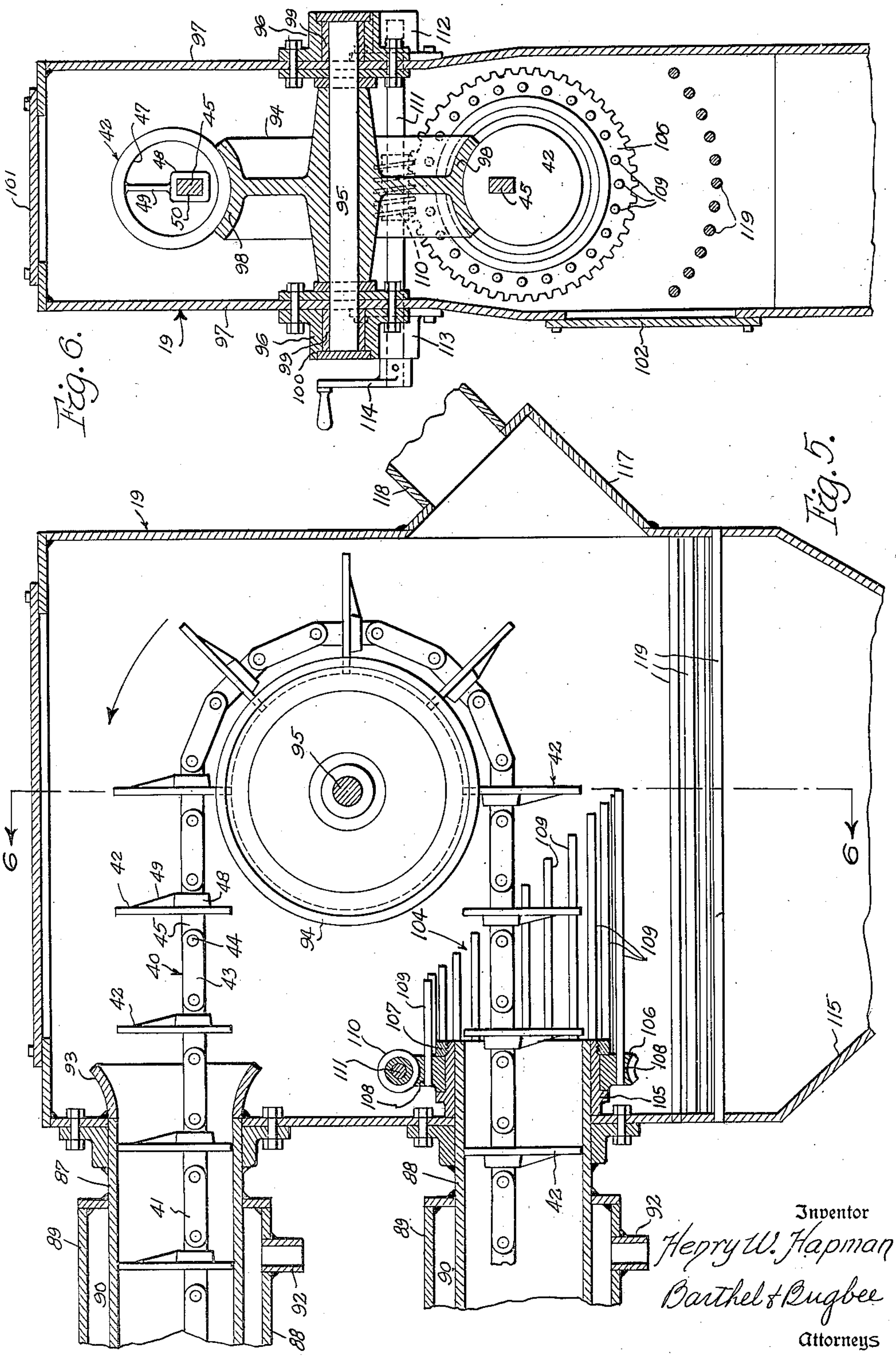

Fig. 6.

Fig. 5.

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GRANULATED MATERIAL FEEDING APPARATUS

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Application August 15, 1949, Serial No. 110,315

1 Claim. (Cl. 214—17)

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This invention relates to feeding apparatus, and in particular to apparatus for feeding granular material, either wet or dry.

One object of this invention is to provide apparatus for feeding granular material, such as particles of coal, gravel, wheat and other materials, wherein means is provided for preventing "arching over" of the material so that it does not feed properly in the desired quantities.

Another object is to provide apparatus of the above character, which is adapted to the feeding of granular material to a pressurized container, and wherein means is provided for preventing escape of pressure while feeding is taking place.

Another object is to provide apparatus of the above character which is especially adapted to the feeding of inflammable material, such as coal, to a material treating chamber, such as a combustion chamber, means being provided for preventing not only the escape of pressure through the feeder but also for preventing the transmission of flame or other products of combustion or explosion through the feeder.

Another object is to provide apparatus of the above character which feeds granulated material smoothly and evenly to a material-treating chamber, even though the material is damp and sticky and tends to collect in chunks, means being provided for insuring regularity of flow of the material and preventing pulsation in the combustion chamber by breaking up these chunks into smaller particles and by causing the particles to drop at the outlet in a smooth, continuous flow even though they are delivered rhythmically to the outlet in a pulsating flow arising from the successive arrival of the flights at the outlet.

Another object is to provide apparatus of the above character wherein provision is made for expansion and contraction due to heating and cooling of the apparatus, by slidably supporting the apparatus upon a frame and securing the apparatus to one end of that frame.

Another object is to provide apparatus of the above character wherein the granular material, such as coal, is unconfined on one side, so that it may pile up in a mound at its natural angle of repose, thereby further tending to prevent packing and arching over of the material in the receiving hopper or casing.

In the drawings:

Figure 1 is a side elevation of a granulated material feeding apparatus, according to one form of the invention;

Figure 2 is a central vertical longitudinal section through the lower middle portion of Figure 1, showing the interior of the material-receiving hopper and the mechanism associated therewith;

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Figure 3 is a cross-section through the material-receiving hopper taken along the line **3—3** in Figure 2, showing details of the material-deflecting and feed proportioning devices;

Figure 4 is an enlarged cross-section through one of the conveyor sealing devices employed for preventing escape of pressure from the pressurized material-treating chamber into which the material is fed, taken along the line **4—4** in Figure 2;

Figure 5 is a central vertical longitudinal section through the material discharge hopper at the right-hand end of Figure 1, showing the material flow regulating device for preventing fluctuation in the flow of the conveyed material;

Figure 6 is a cross-section taken along the line **6—6** in Figure 5; and

Figure 7 is a fragmentary side elevation of a modification of the apparatus shown in Figure 1.

General arrangement

The feeding of granular materials, particularly when wet and sticky, has hitherto presented serious problems to the material-handling engineer. Dry granular materials in falling will normally arrange themselves in a mound, the sides of which slope at an angle known as the angle of repose and shown in the inclined dotted lines in Figure 1. Wet, sticky materials, however, come to rest at a steeper angle of repose than dry materials, and also tend to arch over the path of a conveyor so as to partially or wholly prevent the conveyor from reaching and conveying the materials. Prior feeding devices in feeding such materials have required auxiliary feeders or agitators to break up this arching over tendency, but the feeding apparatus of the present invention uses the return course of the main feeding conveyor itself to do this, thus eliminating the need for such auxiliary feeders or agitators.

These problems are aggravated when it is desired to feed granular materials to a material treating chamber which is under pressure, particularly if the material is inflammable, such as particles of coal, and the chamber is at a high temperature. Under such circumstances, the use of ordinary feeding devices is hazardous because the material occasionally ignites with explosive violence, causing a blowback or flareback to occur in ordinary conveyors, such as screw conveyors. The flame thus carried back through a screw conveyor, when partially or completely empty, sometimes ignites the main body of material, and at the least requires the shutting down of the apparatus and sometimes causes considerable damage to it as well as injury to the operator. Another problem of this character arises when granular inflammable material, such as coal, is fed to the firebox of a boiler. Unless the particles are fed at a smooth, even and continuous rate, combustion is irregular and pulsation occurs. This pulsation, unless halted, causes damage to the boiler. Uneven feeding of the coal particles also occurs when coal is wet so that particles tend to adhere to one another in lumps.

The feeding apparatus of the present invention successfully solves all of these problems. It consists of a material-receiving hopper through which the feeding and return courses of a flight conveyor both pass, with the return course arranged above both courses. One side of the material-receiving hopper opens into the drive chamber containing the drive sprocket for the conveyor, so that the material cannot pack in that direction, but falls downward until it reaches the angle of repose previously referred to. In order to prevent the falling material from being carried over the drive sprocket by the return course of the conveyor, and also to insure that the lower or feeding course of the conveyor carries material faster into the material treating chamber than material is moved by the return course in passing through the receiving hopper, an elongated deflector is arranged above the return course of the conveyor. This deflector is inverted V-shaped and acts like a roof to prevent material from reaching the upper portions of the conveyor flights in the return course of the conveyor. This deflector is also connected to a vibrating device which causes it to oscillate vertically and tap the flights rapidly so as to dislodge material which might otherwise cling to them and pass over the drive sprocket. The lower or feeding course of the conveyor is provided with an elongated holddown member, but this is much narrower in width than the upper member or deflector and consequently does not prevent material from reaching the lower or feeding course of the conveyor, hence the lower or feeding course of the conveyor conveys material at a faster rate than the upper or return course thereof.

Between the material-receiving hopper and the material discharge hopper, the apparatus is provided with a pair of conveyor sealing devices and also with a pair of water cooling devices, the discharge hopper being at a relatively high temperature. The sealing devices hug the flights of the conveyor and prevent pressure and flame from being transmitted from the discharge hopper into the receiving hopper, and the cooling devices reduce the temperature of the conveyor so as to prevent damage thereto. Located within the discharge hopper at the outlet of the conveyor conduit is a flow regulating device which breaks up the tendency of the particles to drop in lumps and causes them to descend in an even flow, thereby feeding the material smoothly and evenly to the material-treating chamber, such as the firebox of a boiler or other combustion chamber. This device is adjustable so that its action may be varied to conform to different conditions of use.

General construction

Referring to the drawings in general, Figure 1 shows a coal bunker, generally designated **8**, which contains granular coal and supplies it to an automatic weighing apparatus, generally designated **9**, ordinarily known as a coal scale or coal valve. Arranged between the coal bunker **8** and weighing apparatus **9** is a gate **10** controlled by a handwheel **11**. Located below the coal scale **9** is the material feeding apparatus of the present invention, generally designated **12**. The coal scale or valve **9** is conventional and its details form no part of the present invention. Its construction and operation are well-known to combustion engineers, hence it is sufficient for the purposes of the present description to state that it receives granular coal from the coal bunker **8** and weighs it out automatically in predetermined quantities which it supplies intermittently to the material feeding apparatus **12**. The coal scale or valve **9** operates automatically according to the demand for fuel set up in the combustion chamber or firebox of the boiler, and therefore supplies material more rapidly during peak load periods than at other times when the demand is less.

The material feeding apparatus **12** consists generally of a drive unit **13**, a material receiving unit **14**, a pair of pressure-sealing devices **15** and **16**, a pair of cooling devices **17** and **18**, and a material discharge unit **19**. The entire apparatus is supported on a frame structure, generally designated 20.

Detailed construction

Referring to Figure 1 of the drawings in detail, the drive unit **13** consists of a casing **21** of box-like construction, one side of which opens into the material-receiving unit **14** without any partition therebetween. Mounted on the casing **21** is a drive motor **22**, the armature shaft **23** of which is coupled to the input shaft **24** of a speed reduction unit **25** of conventional design. In actual practice, a variable speed drive unit is used in place of the motor **22** to vary the feeding rate of the apparatus according to demand, but this has been omitted for purposes of simplification. The output shaft **26** of the speed reduction unit **25** carries a sprocket or pulley **27** which is connected by a belt or chain **28** to a drive pulley or sprocket **29**. The latter is mounted on a drive shaft **30** carrying a conveyor drive sprocket **31** and journaled in journal bearings **32** mounted outside the casing **21**. The journal bearings **32** are mounted for adjustment to and fro relatively to the casing **21** by means, such as adjusting screws (not shown) so as to tighten or loosen the conveyor, and slots **33** are formed in the side walls of the drive casing **21** to permit the drive shaft **30** to move to and fro. The drive unit casing **21** is bolted or otherwise secured to supporting members **34** which in turn rest upon and are slidable relatively to the horizontal members **35** of the supporting frame **20**. The horizontal members are in turn supported on vertical members or legs **36**, the lower ends of which rest upon the floor F, inclined braces **37** being provided to prevent weaving of the frame **20**. The slidable mounting of the members **34** upon the frame **20** permits the apparatus to expand freely as it becomes heated up, since it is connected to the frame **20** only at the end carrying the discharge unit **19**. To further facilitate expansion, the bolt holes **38** for the bolts **39** at the joint between the automatic weighing apparatus **9** and the material-receiving unit **14** are elongated (Figure 2) to permit such expansion.

Trained around the drive sprocket **31** and meshing with the teeth thereof is an endless flight conveyor, generally designated **40**, and consisting generally of a chain **41** carrying disc-like flights 42. The chain 41 consists of laterally spaced links 43 connected by pivot pins 44 to bar links 45. The flights 42 consist of disc-like members 46 (Figure 4) having rims 47 and hubs 48 interconnected by reinforcing webs 49. The hubs 48 are bored as at 50 to receive the bar links 45 and are preferably welded thereto to secure them in position. The flights 42 are preferably made of cast steel to enable them to withstand high temperatures. The opposite end of the flight conveyor 40 is supported by an idler pulley located in and described in connection with the construction of the discharge hopper 19.

The material-receiving unit 14 or receiving hopper consists of a box-like casing 51 connected by the spout 52 to the downspout 53 of the automatic weighing apparatus 9. On its left-hand side, the casing 51 is completely open, and, as previously stated, opens directly into the casing 21 of the drive unit 13, as shown in Figure 2. The lower portion of the casing 51 is provided with a trough-shaped portion 54 (Figure 3) to facilitate supplying the material to the lower course of the conveyor 40. An elongated holddown member 55 of inverted V-shaped cross-section (Figure 3) is mounted above the lower or feeding course of the conveyor 40 so as to prevent the flights thereof from moving upward, and near its flared end 56 is welded to a cross rod 57 which in turn is welded to the side walls of the trough portion 54 of the casing 51. The opposite end of the holddown member 55 is welded to the end wall of the trough portion 54 (Figure 2). The holddown member 55 also guides the flight conveyor 40 so that the flights 42 thereof properly enter the conveyor sealing device 16.

Secured to the inner wall of the inlet spout 52 of the casing 51 is a lug or boss 58 which carries a pivot pin 59. Pivotally engaging the pivot pin 59 is an arm 60 welded to one end of a material deflector 61 of elongated form and approximately inverted V-shaped cross-section. The deflector member 61 is wider than the holddown member 55 so as to overhang the upper or return course of the conveyor 40 like a roof, thereby permitting the material to only partially fill the spaces in the upper flights 42 and thus prevent them from conveying as much material to the left as the lower course feeds to the right. In order to prevent material from adhering to the flights 42, the member 61 is vibrated by a V-shaped bracket 62 bolted to the free end thereof.

The upper end of the bracket 62 is bolted to the platform 63 of an oscillating device, generally designated 64. The platform 63 (Figures 2 and 3) is mounted between the upper and lower coil springs 65 and 66 respectively encircling retaining bolts 67 passing loosely through the platform 63. Bolted to the platform 63 are spaced journal bearings 68 (Figure 3) in which a rotary shaft 69 is journaled. Mounted on the shaft 69 between the bearings 68 is an eccentric flywheel 70 consisting of three eccentrically bored discs 71, the positions of which may be varied relatively to one another to vary the wobbling effect of the assembly. Mounted on the outer end of the shaft 69 is a pulley 72 encircled by a belt 73 which in turn encircles the drive pulley 74 on the armature shaft 75 of a motor 76 (Figure 2). When the motor 76 is energized, and the shaft 69 is rotated, the eccentric flywheel 70 causes the platform 63 to oscillate up and down, carrying with it the bracket 62 and swinging the member 61 upward and downward around its pivot pin 59. In order to soften the blows imparted to the flights 42, the vibrating and deflecting member 61 is lined with resilient pads 77 of synthetic rubber or other suitable material. The vibrating device 64 is similar in principle although of slightly altered design, to that described and claimed in my copending application, Serial No. 129, filed January 2, 1948 for Conveyor Vibrator, now Patent No. 2,547,462.

The pressure-sealing devices 15 and 16 are generally similar to those described and claimed in my co-pending application Serial No. 83,008 filed March 23, 1949 for Flight Conveyor Pressure-Sealing Device, now Patent No. 2,556,183, and are for the purpose of snugly engaging the rims 47 of the flights 42 to prevent gas or other pressurized material from passing around the rim of the flights. The sealing device 16 is bolted directly to the end wall of the casing 51 whereas the sealing device 15 is bolted to a short conduit 78 (Figure 2) extending outward from the casing 51 and containing a vent pipe 79. A similar vent pipe 79a is located in the side wall of the receiving hopper casing 51 (Figure 1).

Each sealing device 15 or 16 consists of a tubular casing 80 within which is mounted a tubular assembly 81 consisting of alternate strips or bars of metal 82 and resilient material 83 (Figure 4) such as synthetic rubber or a silicone derivative capable of sustaining high temperatures. The tubular assembly 81 is separated from the casing 15 by an inflation chamber 84 having inlet and outlet pipes 85 and 86 through which gas or liquid under pressure may be supplied to the chamber 84 to cause the tubular assembly 81 to contract around the flights 42 and snugly grip them while still permitting them to move, as more fully described in my above-mentioned co-pending application.

The cooling devices 17 and 18 are interposed between the pressure sealing devices 15 and 16 and the material discharge unit 19. Each cooling device 17 or 18 consists of a conduit 87 or 88 surrounded by a tubular casing 89 (Figure 5) to form a cooling chamber 90 having inlet and outlet pipes 91 and 92 for the admission and discharge of a cooling fluid. The ends of the conduits 87 and 88 extend into the material discharge unit 19, the end of the conduit 87 being flared as at 93 (Figure 5) to guide the flights 42 into the conduit 87.

The conveyor chain 41 of the flight conveyor 40 is supported upon an idler pulley 94 (Figure 5) mounted on a shaft 95 which in turn is supported in bearings 96 mounted in the side walls of the casing 97 of the material discharge unit 19. The pulley 94 is provided with a grooved rim 98 for receiving the flights 42 (Figure 6). The bearings 96 (Figure 6) consist of heat-resisting carbon sleeves 99 held within flanged collars 100 which in turn are bolted to the side walls of the casing 97. Access to the material discharge unit 19 is obtained by access plates 101 and 102 (Figures 1 and 6) bolted to the top and side wall of the casing 97. A similar access plate 103 is bolted to the side wall of the receiving hopper casing 51 (Figure 1).

A material discharge regulating device, generally designated 104 and including the end of the conduit 88 within the material discharge unit 19 carries a flanged sleeve 105 (Figures 5 and 6) upon which an annular worm wheel 106 is journaled and held in place by a retaining ring 107 threaded upon the sleeve 105. The worm wheel

106 is provided with a multiplicity of circumferentially spaced horizontal or axial bores 108 (Figure 8) in which rods 109 are seated. The rods 109 are of progressively varying lengths, so that in assembly their ends lie approximately in a plane inclined at an oblique angle relatively to the axis of rotation of the worm wheel 106 (Figure 5). The worm wheel 106 is rotated by a worm 110 mounted upon a worm shaft 111, the ends of which are journaled in bearings 112 and 113 bolted to the opposite side walls of the casing 97. A hand crank 114 mounted on the outer end of the shaft 111 enables the latter to be rotated, consequently rotating the worm wheel 106 and rods 109 and thereby varying the effect of the material discharge regulating device 104, as explained in connection with the operation thereof.

The lower portion of the casing 97 is tapered as at 115 and opens into a pipe or conduit 116 which extends downward to the place of utilization of the material being fed, such as, for example, the combustion chamber of a boiler. The casing 97 is also optionally provided with a connection 117 for the attachment of an air duct 118 (Figure 1).

In order to further intercept lumps of material which might pass by the material discharge regulating device 104, the material discharge unit 19 is additionally provided with arcuately-disposed spaced rods or bars 119 (Figures 5 and 6) located immediately below the device 104. The action of these rods 119 is likewise described in connection with the operation.

Operation

In the operation of the invention, let it be assumed that the granulated material, such as coal, falls from the bunker 8 through the gate 10 into the automatic weighing device or coal scale 9, where a predetermined quantity of the material is automatically weighed out and supplied through its discharge spout 53 to the inlet spout 52 of the material-receiving unit 14, according to the demand of the boiler or other installation served by the apparatus. The material falls downward (Figures 2 and 3) over the deflector 61 and holddown member 55, and tends to fill up the casing 51. Since the material is granular, and since there is no partition between the casings 51 and 21, the particles of material slide downward until they form a mound having a side inclined at the angle of repose of the particular material, depending upon its nature and condition, whether wet or dry and smooth or sticky.

Meanwhile, the conveyor driving motor 22 and vibrator driving motor 76 have been energized, causing the flight conveyor 40 to travel in an orbital path while the deflector 61 moves up and down, tapping the flights on the return course as they pass beneath it. The deflector 61 thus serves the double purpose of preventing the material from reaching the upper portions of the flights 42 and at the same time of dislodging the conveyed material from these flights as they pass to the left into the teeth of the sprocket 31. The material, however, falls freely into the trough portion 54 of the casing 51 and is therefore conveyed to the right (Figure 2) at a quantity rate which exceeds the rate at which the upper portion of the mound of material is pushed to the left by the only partially filled upper flights 42 of the return course of the conveyor. This occurs because the deflector 61 extends roof-like over the flights of the return course of the conveyor 40, whereas the holddown member 55, being very narrow, does not prevent the material from falling into the spaces between the flights of the lower or feeding course of the conveyor 40. Thus, the upper course of the conveyor 40 serves to agitate the mass or mound of material and prevent it from arching over the lower or feeding course of the conveyor and at the same time assists the material in falling into its natural angle of repose at the edge of the mound. It thus does not matter whether the conveyed material is wet or dry and smooth or sticky, since the apparatus of the present invention entirely takes care of these varying conditions.

The material falling between the discs 42 of the lower or feeding course of the conveyor 40 is carried to the right through the sealing device 16 and cooling device 18 to the material discharge unit 19. At the same time, the holddown device 55 prevents excessive filling of the spaces between the flights so that they might otherwise not freely enter the sealing device 16. The cooling device 18 prevents the heat generated within the material discharge unit 19 from reaching the sealing device 16 and the latter prevents flame or explosive gases from reaching the material receiving unit 14.

When the conveyed material reaches the spaced bars 109 of the material discharge regulating device 104, some of the particles immediately fall between the bars 109 and thence pass downward through the pipe 116 into the combustion chamber or other material treating apparatus. Other particles, however, are pushed along the rods 109 and fall at different locations along these rods. Still other particles or lumps pass entirely along the rods 10 and drop off the ends. Some of these lumps, if sufficiently large, are stopped by the bars 119 while others pass downward through the spaces between these bars 119. The larger lumps which are stopped, are broken up either by the heat arising from the heat combustion chamber below or by dropping of other lumps of material therein. In this manner, an even flow of particles of material is supplied to the combustion chamber, and pulsation therein is effectively prevented.

After the particles of material have been thus discharged within the material discharge unit 19, the return course of the conveyor 40 passes through the cooling device 17 and pressure sealing device 15 and re-enters the material receiving unit 14, completing the cycle.

Thus, the invention prevents the packing of the coal or other granular material within the receiving casing 51 and, assisted by the vibrating deflector 61, causes the material to accumulate in a mound at its natural angle of repose. Thus, since the material is not confined, arching over is prevented. The deflector 61 also prevents material from being carried too rapidly to the left toward the drive sprocket 31. The temperature of the apparatus is effectively controlled by the cooling devices 17 and 18 which are preferably controlled by the circulation of a cooling liquid, such as water. Pulsation in the combustion chamber is prevented by the action of the material discharge regulator 104 in providing an even flow of particles, assisted by the rods 119 for controlling the dropping of large lumps. The expansion and contraction of the apparatus is facilitated by its being mounted on the frame 20, on which it is free to slide lengthwise as it expands or contracts, since it is secured thereto only adjacent one end thereof. The transmission of flame through the apparatus is prevented by the provision of pressure-sealing devices engaging the peripheries of the flights of a flight conveyor in a sealing contact, avoiding the danger and fire hazard arising in a screw conveyor which, when empty, merely acts as a spiral passageway which is open from one end to the other.

Modified feeding apparatus for low-pressure installations

The apparatus shown in Figures 1 to 6 inclusive will handle installations involving explosive or highly inflammable gases or high working pressures. Figure 7 shows a simplified apparatus which is satisfactory where the pressures to be handled are relatively low or where the gases developed are not highly explosive, or where the working temperatures are low, or where combustion is not involved. In the modified apparatus, the portion of the apparatus to the left of the vent 79 in Figure 1 remains unchanged, and the conduit system only is changed. In this modification, the pressurized conveyor sealing devices 15 and 16 are omitted, and the cooling devices 17 and 18 also omitted. In place of these, the modified apparatus, generally designated 120 of Figure 7, provides plain upper and lower conveyor conduits 121 and 122 for the return course and forward course of the flight conveyor respectively. Each of these conduits 121 and 122 is provided with a compressed air inlet pipe 123 and 124 respectively. Compressed air sufficient to balance the pressure existing in the discharge casing 97 is admitted through the pipes 123 and 124 and passes through the clearance spaced between the conveyor flights and the inner walls of the conduits into the discharge casing 97. This compressed air not only counteracts the gases under pressure which would otherwise tend to escape through the conduits 122 and 121 from the discharge casing 97, but also serves to cool the flights as it passes over them. Moreover, if the temperatures existing in the discharge unit 19 are not excessive, the conveyor flights do not accumulate much heat in the short period of time that they are passing around the idler pulley 94 within the discharge casing 97, hence the compressed air is frequently sufficient without the cooling devices 17 and 18. Moreover, as soon as the flights on the return course of the conveyor re-enter the material receiving casing 52, they encounter fresh coal which is in a cool state and which therefore further cools the conveyor flights, especially if the coal is wet.

Aside from the foregoing variations, the operation of the modified feeding apparatus 120 shown in Figure 7 is substantially the same as that of the feeding apparatus 12 shown in Figures 1 to 6 incusive.

What I claim is:

A granulated material feeding apparatus comprising a material receiving casing, a material discharge casing, a conduit system including vertically-spaced upper and lower conduits interconnecting said casings, an endless flight conveyor mounted in said conduit system and traversing said casings with its forward course disposed near the bottom of said receiving casing and its return course disposed thereabove, said receiving casing having an inlet in the upper portion thereof and having a horizontally-elongated chamber extending away from said inlet to a location remote therefrom whereby to effect fall of material from said inlet into a mass in said receiving casing having an unconfined side inclined at its natural angle of repose, an elongated material deflector overhanging a portion of said return course for preventing direct fall of material thereon, and vibrating mechanism operatively connected to said deflector and arranged to oscillate said deflector into and out of engagement with said flight conveyor.

HENRY W. HAPMAN.

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