

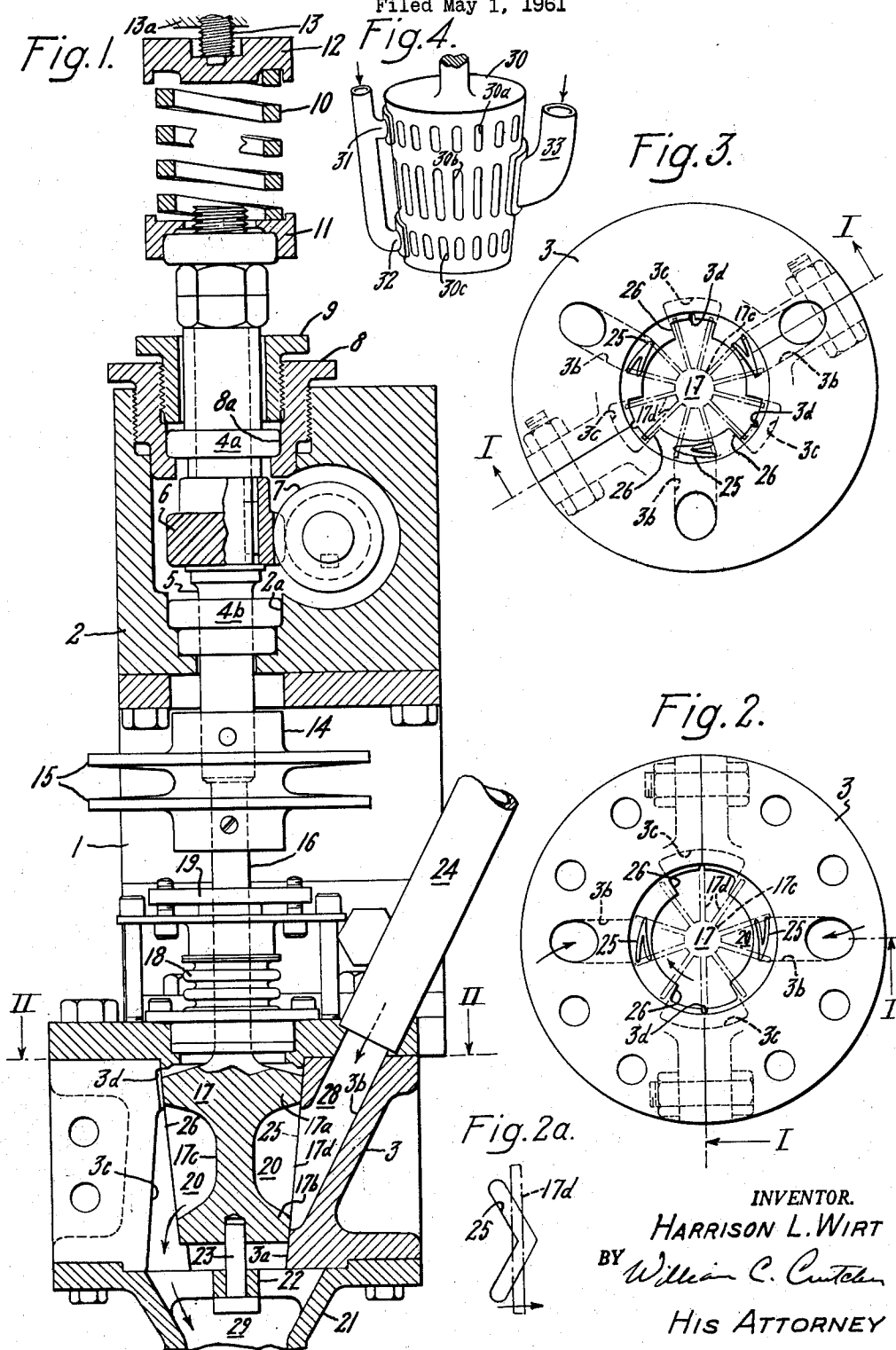
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H. L. WIRT

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DEVICE FOR FEEDING PULVERIZED MATERIAL

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INVENTOR.
HARRISON L. WIRT
BY *William C. Cuthbert*
HIS ATTORNEY

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DEVICE FOR FEEDING PULVERIZED MATERIAL
Harrison L. Wirt, Schenectady, N.Y., assignor to General
Electric Company, a corporation of New York
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This invention relates to a device for feeding pulverized, granular or comminuted material from one chamber to another at a controlled rate, where a substantial pressure difference exists between chambers, and including means for automatically clearing any obstructions which might arise. More particularly, the device as described and illustrated relates to a device for feeding hot abrasive coal char from a high-pressure zone to a low-pressure zone.

It is well known that pulverized or granular or comminuted solid material can be fed by gravity flow at a controlled rate by allowing the material to enter the pockets of a revolving "starwheel" at one point on the circumference of the starwheel, and to discharge the material at a circumferentially spaced location. Such feeders are usually constructed with horizontal shafts so that material will fall by gravity into the pocket and then fall out again as it turns. It is also known that the starwheel and its casing can be constructed in such a manner to provide a rotating seal between the inlet and discharge zones.

Where the feeder is operating across a substantial pressure differential, the side forces exerted on the projected area of the pockets exposed to the pressure can result in unbalance. For a simple one inlet, one outlet arrangement, an uncompensated side force is imposed on the starwheel shaft, its severity depending on the difference in inlet and outlet pressures, pocket area, and the angular displacement between inlet and outlet. This unbalance force can lead to increased bearing wear, rubbing or leakage between pressure zones. Additional transverse force results if the shaft is mounted horizontally in the conventional manner.

Additional difficulties are encountered when feeding abrasive or hard material which can cause wear or jamming of the parts. Provisions for wear compensation and automatic "freeing" of obstructions are an important feature of this invention.

Accordingly, one object of the present invention is to provide a device for feeding pulverized or granular material between chambers, where substantial pressure differentials exist.

Another object of the invention is to provide an improved starwheel feeder which minimizes unbalanced forces on the rotor due to the pressure differences at starwheel inlet and outlet pockets.

Another object of the invention is to provide a gravity flow feeding device for granular and abrasive material having a self-clearing feature in case an obstruction forms.

Another object of the invention is to provide a vertically disposed starwheel feeder which can be easily balanced.

Another object of the invention is to provide a feeding device which maintains a continuous seal between inlet and outlet zones, while compensating for wear due to rubbing of the parts.

A more specific object of the invention is to provide

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an improved device for feeding hot coal char by gravity flow from a high-pressure zone to a low-pressure zone with a transversely balanced starwheel feeder, while maintaining a wear-compensating seal between zones, and while providing means for clearing any obstructions that form.

The invention, in one form, is practiced by providing a tapered starwheel rotating in a casing and having both the inlets for feeding the starwheel pockets and the outlets for emptying the starwheel pockets located so that the side forces on the starwheel are balanced. The taper provides for wear compensation. The starwheel is biased into the casing bore with means to withdraw the starwheel from the pocket against the bias to clear any obstruction.

The subject matter which is regarded as the invention is particularly pointed out and distinctly claimed in the concluding portion of the specification. The invention, however, both as to organization and method of practice, together with further objects and advantages thereof, may best be understood by reference to the following description, taken in connection with the accompanying drawing in which:

FIG. 1 is an elevation drawing, partly in section, illustrating the starwheel and sealing assembly, the drive mechanism, and the biasing means;

FIG. 2 is a plan view of the feeder casing with the cover removed, taken along lines II-II in FIG. 1;

FIG. 2a is an enlarged view of an inlet port showing its actual rather than its projected shape;

FIG. 3 is a plan view similar to FIG. 2, illustrating a modified arrangement; and

FIG. 4 is a perspective view of a modification in diagrammatic form.

Referring now to FIG. 1 of the drawing, a mounting bracket 1 supports a rotor drive housing 2 at the top, and a feeder casing 3 at the bottom. Arranged to rotate in housing 2 by means of bearings 4a, 4b is a rotor shaft 5; keyed to shaft 5 is a helical gear 6 driven by a helical worm gear 7 connected to a motor (not shown). The angle on the helical gears 6, 7 and the direction of rotation thereof is such as to tend to raise shaft 5 upward in housing 2 when the reactive or resisting torque of shaft 5 increases. Upper bearing 4a is held in an adjustable bearing housing 8 and is free to move upward in a recess 8a until restrained by an adjustable bearing housing stop 9. Lower bearing 4b is similarly free to move upward in its recess 2a in housing 2.

Biasing shaft 5 downward is a compression spring 10 held between lower spring guide 11 attached to shaft 5 and upper spring guide 12. A means for adjusting the downward bias of spring 10 consists of bolt 13 attached to a stationary structure 13a which can be screwed up or down to adjust the compressive force of spring 10.

Attached to the lower end of shaft 5 is a heat dissipating coupling 14 with heat radiating fins 15, which serves to couple shaft 6 to a vertical starwheel shaft 16. The starwheel, shown generally as 17, is driven by starwheel shaft 16 and turns in a tapered or frusto-conical bore 3a of feeder casing 3. The bore 3a is sealed from the outside by means of a bellows 18 sealingly connected to feeder casing 3 and to a gland ring 19 forming a rotating seal between the bellows 18 and the shaft 16.

Starwheel 17 is a roughly spool-shaped member, formed

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on a taper corresponding with that of bore 3a so as to define upper and lower circumferential frusto-conical sealing flanges 17a, 17b respectively, joined by a central connecting portion 17c. Circumferentially spaced about the starwheel are radial webs 17d which separate circumferentially-spaced pockets 20. An outlet casing 21 is bolted tightly to the bottom of feeder casing 3 and includes a central supporting "spider" bracket 22 for a starwheel centering pin 23.

Carrying the incoming supply of comminuted or granulated material are inlet pipes, one of which is seen at 24. Inlet pipe 24 is connected to an internal inlet passage 3b formed in the walls of feeder casing 3 which, in turn, terminates in an inlet port 25 in the frusto-conical wall of the feeder casing. The casing wall also includes outlet ports, one of which is seen at 26, and which connects with an internal outlet passage 3c in feeder casing 3. Passage 3c in turn empties into the outlet casing 21 and, from there, to the points where the material will be utilized. In the case of a char feeder, these would be the fuel pipes leading to a combustion chamber. A groove 3d connecting the outlet passage 3c with the sealed space over starwheel 17 equalizes pressure above and below the starwheel.

When the char feeder is used in a gas turbine power plant, there will be a substantial pressure difference between inlet pipes 24 and the inside of outlet casing 21. The material, in this case, is fed from a high pressure zone designated generally as 28, shown in passage 3b, to a low-pressure zone 29 in outlet casing 21. It should be understood, however, that the material is primarily fed by gravity, and that the pressure zones could be reversed from that shown for some applications. It should be particularly noted in FIG. 1 that if a single inlet and outlet were used, so that high-pressure zone 28 communicated with pocket 20 on the right side of the starwheel, and so that low-pressure outlet zone 29 communicated with pocket 20 on the left-hand side of the starwheel, a transverse force to the left would take place, the magnitude of which would depend upon the pressure differential and the projected surface area of pocket 20. FIG. 1 has been drawn, however, with portions of the starwheel 17 and feeder casing rotated into the plane of the drawing, in order to indicate this potentially unbalanced condition, and to indicate the direction of travel of the material from inlet pipe 24 to outlet casing 21, as shown by the arrows. The actual circumferential placement of feed pipes and outlets will be seen by reference to FIGS. 2 or 3 of the drawing.

The substantial reduction or elimination of transverse side forces due to a high pressure differential between inlet and outlet zones is illustrated more clearly by reference to FIG. 2 of the drawing. There the plan view of feeder casing 3, looking down into bore 3a, illustrates that inlet ports 25 are located diametrically opposite so that they subtend equal angles between them. Outlet ports 26 are similarly located 180 degrees apart. Since the inlet ports 25 and the outlet ports 26 which are the only locations where transverse forces can be exerted on the starwheel are disposed opposite one another, any transverse forces will be cancelled.

It should be noted that where, as in this case, there are two inlet ports and two outlet ports, the number of pockets 20 provided on starwheel 17 is also divisible by two, so that equal areas of pockets 20 will be opposite inlet ports 25 or outlet ports 26 simultaneously. It should also be noted that some of the pockets are closed off by the casing wall between inlet and outlet ports in order to maintain the pressure seal between inlet and outlet.

The inlet ports 25 defined by the frusto-conical wall are actually "chevron-shaped" as seen in FIG. 2a, in order to give a gradual "cut-off" of the incoming material. The movement of starwheel web 17d (shown in phantom lines) in the direction indicated by the arrow, provides a scis-

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sor action as cutoff, thus reducing the possibility of jamming.

A modified form of the invention is seen in the plan view of FIG. 3, where the same subscripts are used as in FIG. 2. It will be observed that in FIG. 3 there are three inlet ports 25, and also that there are three outlet ports 26. Both the inlet ports and outlet ports subtend equal angles between them or, in this case, 120 degrees. It will also be observed that the number of pockets 20 in the starwheel is divisible by three, so that the same pocket area coincides with the same port area simultaneously as the starwheel 17 turns.

Another modified form of the invention is seen in FIG. 4, which is shown in simple diagrammatic view. There, in addition to the inlet ports being separated circumferentially 180°, they are also separated axially. There the starwheel 30 has three axially spaced rows of pockets 30a, 30b and 30c. The top and bottom rows of pockets 30a, 30c are supplied by inlet pipes 31, 32 respectively. The middle row of pockets 30b is supplied by an inlet pipe 33. The projected area of pockets 30b exposed to the pressure in inlet pipe 33 is designed to be equal to the total projected area of pockets 30a, 30b exposed to the pressure in pipes 31, 32. The location of the inlet pipes can readily be ascertained by one skilled in the art so as to substantially balance all of the transverse forces.

The operation of the device shown in FIG. 1 is as follows. Since the starwheel is turning about a vertical axis, the flow of the pulverized char takes place essentially under the action of gravity, as seen in FIG. 1. As the starwheel turns, the material will flow into pockets 20 through the balanced inlet ports 25, and as pocket 20 registers with outlet ports 26, the material will be discharged to the outlet casing. The fact that inlet zone 28 is at a substantially higher pressure than outlet zone 29 will accelerate the flow of char, since as pockets 20 come into coincidence with inlet ports 25, pockets 20 still are at a relatively low pressure, corresponding to the discharge pressure which they have just been exposed to. Hence the higher pressure behind the entering material will accelerate the flow of char into pockets 20. Similarly, as the starwheel continues to turn, the full pockets 20 are now at a relatively high pressure and as the starwheel brings the pockets into coincidence with outlet ports 26, the high pressure in the pockets will accelerate the discharge of material from the starwheel. The sealing flanges 17a, 17b and the edges of the circumferentially spaced webs 17d in rubbing contact with the frusto-conical wall of the housing bore 3a preserve the seal between pressure zones 28, 29.

It should be noted that the high-pressure zone need not be on the inlet side. Since the flow is by gravity, material will flow even if the higher pressure zone happens to be on the outlet side, although at a somewhat slower rate. Even if there is no pressure difference, the vertical disposition of the rotor serves to balance transverse forces resulting from the inflowing material, and eliminates any unbalance due to the weight of the material which would be present with a horizontal starwheel.

As mentioned previously, in order to substantially remove any transverse forces on the starwheel, the inlet and outlet ports are arranged so the forces cancel each other. The arrangement of FIG. 2 illustrates the inlet ports arranged diametrically opposite, and the outlet ports also arranged diametrically opposite. Thus, the transverse forces exerted are cancelled and greatly improved operation results. In the modified arrangement of FIG. 3, both inlet ports and outlet ports are disposed 120 degrees apart. A static analysis of the transverse forces existing both at the inlet ports and at the outlet ports will indicate that the sum of the forces is substantially zero, and again the forces on the starwheel are balanced. It will be observed that in FIG. 2, where there are two inlet or two outlet ports, the number of starwheel pockets

should be divisible by two or an integral multiple thereof; in the modification of FIG. 3, where there are three sets of inlet and outlet ports, the number of starwheel pockets should be divisible by three or an integral multiple thereof.

In the modification of FIG. 4, both circumferential and axial spacing is employed. The ports are arranged so that the transverse forces are balanced in the manner indicated above.

Since the sealing action between inlet and outlet pressure zones 28, 29 is accomplished by the starwheel turning in close contact with feeder casing 3, some wear will naturally take place. The provision of a tapered starwheel biased into a frusto-conical bore automatically compensates for this wear. The spring 10 continuously biases starwheel 17 downward. Then, as wear takes place, starwheel 17 will simply settle farther down in bore 3a, and the seal will be maintained as before.

A very important feature of the invention is the "self-clearing" action effected by tapered starwheel 17, helical gears 6, 7 and the biasing spring 10. The tooth helix angle of the helical gears 6, 7 is such that when the torsional resistance on starwheel 17 increases to a preselected value, as when a large piece of char "jams," the reaction on the gears will lift the shafts 5, 6 and attached starwheel 17 upward in housing 2 and feeder casing 3. This upward movement increases the clearance between starwheel and casing and allows any obstruction to fall into outlet casing 21. The biasing spring 10 is adjusted by screw 13 so that a predetermined reactive torque is required before the starwheel will lift from its seat. As soon as the obstruction is removed, the biasing spring 10 forces the starwheel back snugly into bore 3a and re-establishes the seal between pressure zones 28, 29.

The fact that the char may be at a high temperature, on the order of 800 or 900° F., necessitates some means to isolate this high temperature from the bearings. Hence, the heat dissipating coupling 14 effectively dissipates heat by radiation from the fins 15.

Those skilled in the art will recognize that many modifications, such as still other arrangements of inlet and outlet ports, are possible. For instance, by providing several tiered rows of circumferentially spaced pockets, in the starwheel, as shown in FIG. 4, a single inlet pipe can feed into each tier, and circumferential displacement of the inlet pipes in the manner suggested in FIG. 2 or 3, or adjustment of the pocket areas in each tier of pockets can be carried out in the design so as to substantially balance transverse forces on the shaft. Such an analysis to produce an equilibrium of the pressure forces is within the scope of one skilled in the art, once the basic principle of the invention as disclosed herein is understood. The primary departure from prior art horizontally mounted starwheels, i.e., utilizing vertical rotor, enables the balancing structure to be successfully employed.

It will also be appreciated that several separate starwheels in tandem could be disposed on a single shaft to increase the volume flow of material. Other mechanical equivalents of helical gears can be used to raise the starwheels automatically in the event of increased torque on the shaft, due to jamming of the flowing material. Other means of biasing the starwheels into the feeder casing are of course possible, in lieu of the compression spring 10.

While there has been described what is at present considered to be the preferred embodiment of the invention and one modification thereof, it will be understood that various other modifications may be made therein, and it is intended to cover in the appended claims all such modifications as fall within the true spirit and scope of the invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A device for feeding pulverized material, comprising

a casing, a vertical rotor having a tapered starwheel disposed in said casing and mounted for rotation therein, said starwheel defining circumferentially-spaced feed pockets, some of which are closed off by portions of said casing, inlet conduit means carrying pulverized material and discharging into said pockets at at least two circumferentially-spaced symmetrically disposed locations on the starwheel, outlet conduit means receiving pulverized material from said pockets at at least two circumferentially-spaced symmetrically disposed locations, means drivingly connected to rotate said starwheel in said casing, means for automatically lifting said starwheel in the casing as the torque resisting rotation of the starwheel increases, and adjustable biasing means resisting lifting of the starwheel, whereby when a preselected reactive torque occurs, the starwheel will be lifted in the casing enough to clear the obstruction.

2. A device for feeding pulverized material comprising a casing defining a frusto-conical bore, a vertical rotor having a tapered starwheel disposed in said bore and mounted for rotation therein, said starwheel defining circumferentially spaced feed pockets, some of which are closed off by portions of said casing, inlet conduit means carrying pulverized material and discharging into said pockets at at least two circumferentially-spaced symmetrically disposed locations on the starwheel, outlet conduit means receiving said pulverized material from said pockets as the starwheel rotates at at least two circumferentially spaced symmetrically disposed locations, the average pressure of said outlet conduit means being substantially different from that of said inlet conduit means, both said inlet and outlet conduit means being arranged with respect to the starwheel pockets to substantially balance the transverse forces due to said pressure difference in the inlet and outlet conduit means, means drivingly connected to rotate the starwheel, means for lifting said tapered starwheel in the bore as the torque resisting rotation of the starwheel increases, and adjustable biasing means resisting lifting of the starwheel, whereby when a preselected reactive torque occurs, the starwheel will lift in said bore to clear the obstruction.

3. A device for feeding pulverized material comprising a casing, a vertical rotor having a tapered starwheel disposed in said casing, and mounted for rotation therein, said starwheel defining a plurality of circumferentially spaced pockets, a plurality of inlet conduit means circumferentially spaced about said starwheel and subtending equal angles of arc therebetween, each of said inlet conduit means registering with one or more of said starwheel pockets and defining close clearances with the starwheel, outlet conduit means receiving pulverized material from said pockets as the starwheel rotates, said inlet conduit means being at a substantially higher pressure than said outlet conduit means, means drivingly connected to rotate the starwheel, means for lifting said tapered starwheel in the casing to increase its clearance with the inlet conduit means as the torque resisting rotation of the starwheel increases, and adjustable biasing means resisting lifting of the starwheel, whereby when a preselected reactive torque occurs, the starwheel will lift in said bore to clear the obstruction.

4. A device for feeding pulverized material comprising a casing defining a frusto-conical bore, a vertical rotor having a tapered starwheel disposed in said bore and mounted for rotation therein, said starwheel defining circumferentially spaced feed pockets, some of which are closed off by portions of said casing, a plurality of inlet ports defined in said casing frusto-conical bore and subtending equal angles of arc therebetween, a plurality of circumferentially spaced outlet ports defined in said casing wall and subtending equal angles of arc therebetween, inlet conduit means carrying pulverized material to said inlet ports by gravity flow, outlet conduit means receiving said pulverized material from said outlet ports, the average

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pressure of said inlet conduit means being substantially higher than that of said outlet conduit means, both said inlet and outlet ports being arranged with respect to the starwheel pockets to substantially cancel any transverse forces due to the pressure difference between the inlet and outlet conduit means, means drivingly connected to rotate said starwheel rotor, means for lifting said tapered starwheel as the torque resisting rotation of the starwheel increases, and adjustable biasing means forcing the starwheel downward in the bore, whereby when a preselected reactive torque occurs, the starwheel will withdraw from

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said bore to clear the obstruction and subsequently reseal to maintain the pressure in the inlet conduit means.

5. The combination according to claim 4 wherein said starwheel lifting means comprises a helical tooth gear on said starwheel rotor meshing with a helical tooth gear on said rotor driving means.

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