Nov. 17, 1959 S. V. PRESKITT 2,912,868

FORCE AMPLIFIER

Filed March 18, 1958 2 Sheets-Sheet 1

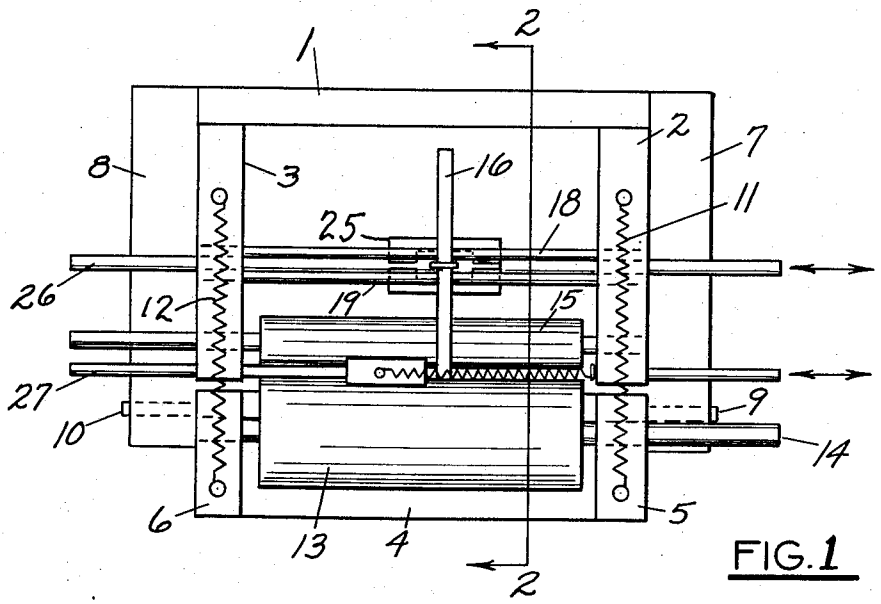


FIG. 1

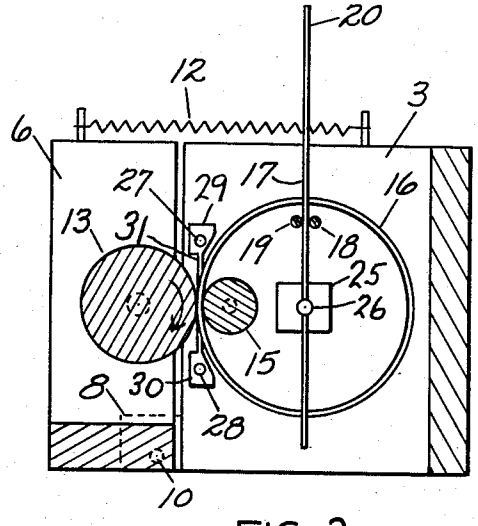


FIG. 2

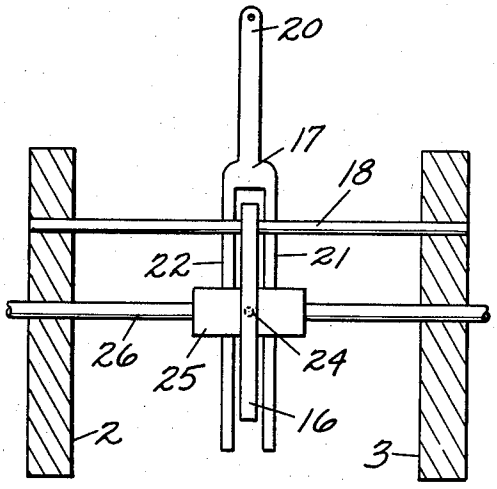


FIG. 3

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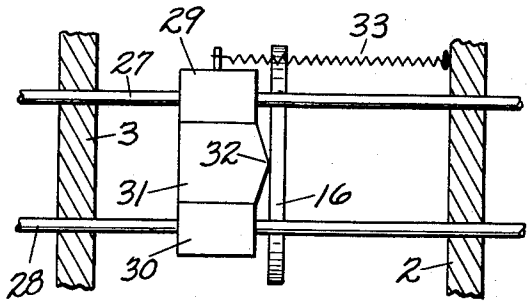


FIG. 4

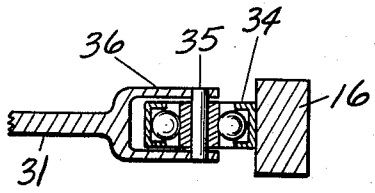


FIG. 6

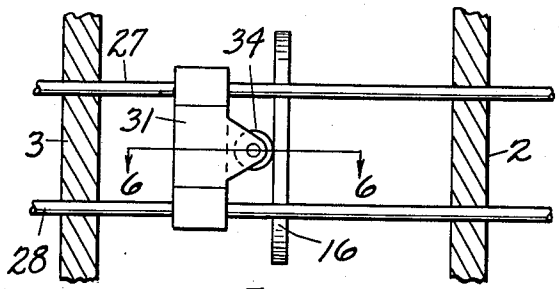


FIG. 5

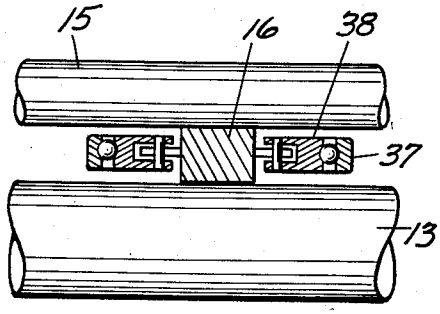


FIG. 8

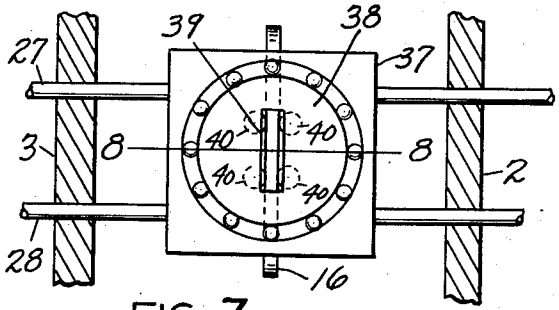


FIG. 7

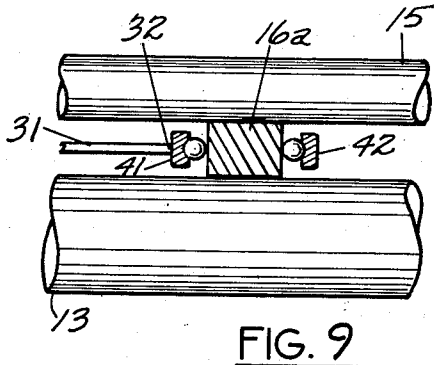


FIG. 9

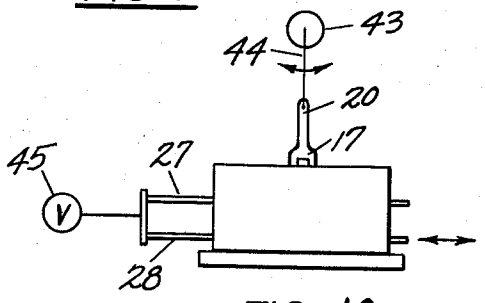


FIG. 10

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United States Patent Office 2,912,868
Patented Nov. 17, 1959

2,912,868

FORCE AMPLIFIER

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Application March 18, 1958, Serial No. 722,232

6 Claims. (Cl. 74—25)

This invention is a device for amplifying forces. It operates on the principle that a wheel tends to move in the direction it is steered. The input is the relatively small force required to steer the wheel while the output is the relatively large force generated as the wheel moves. In a preferred form, the wheel is a ring passing between the bite of two cylindrical rolls, one of which is the driving roll. The ring may encircle either of the rolls. So long as the axis of the ring is parallel to the axes of the rolls, the wheel remains stationary and tracks in a fixed path on the surfaces of the rolls. When the wheel is tilted, it moves bodily along the bite of the rolls in the direction of the tilt and continues to so move until it is returned to a position in which its axis is again parallel to the axes of the rolls. The force required to tilt the roll can be very slight. The force moving the ring along the bite of the rolls can be very substantial.

In the drawings, Fig. 1 is a top view of a force amplifier; Fig. 2 is a section on line 2—2 of Fig. 1; Fig. 3 is a back view of the force amplifier; Fig. 4 is a view of the force take-off device; Fig. 5 is a similar view of a modification of the force take-off device designed to decrease friction; Fig. 6 is a section on line 6—6 of Fig. 5; Fig. 7 is a view of another force take-off device; Fig. 8 is a section on line 8—8 of Fig. 7; Fig. 9 is a section through still another form of take-off device; and Fig. 10 is a diagrammatic view illustrating an application of the force amplifier in which the pen arm of a sensing device is used to control a valve.

The frame of the device is in two parts, a back frame 1 having vertical side walls 2 and 3 and a front frame 4 having vertical side walls 5 and 6. At the lower part of the side walls 2 and 3 are fixed bars 7 and 8, the front ends of which project past the lower ends of the side walls 5 and 6. Pivots 9 and 10 connect the front ends of the bars 7 and 8 to the lower ends of the side walls 5 and 6. Tension springs 11 and 12 urge the upper ends of the side walls 5 and 6 toward the side walls 2 and 3.

Journalled between the side walls 5 and 6 is a cylindrical roll 13 having a shaft extension 14 by means of which it may be driven. The roll 13 is urged by the springs 11 and 12 toward a roll 15 journalled between the side walls 2 and 3. Between the bite of the rolls is a ring 16. The ring need be of no particular cross section and is ordinarily of rectangular cross section so as to have inner and outer flat surfaces in contact respectively with the rolls 13 and 15. The flat surfaces distribute the load and prevent local indenting of the surfaces of the rolls. The ring should be of such cross section that it is self-supporting to the extent that a line intersecting and perpendicular to the axis of the rolls will be parallel to a plane which is perpendicular to the axis of the ring, when the ring is supported solely by the spring loaded rolls. In other words, the gripping pressure exerted on the ring causes it to assume a position in which its axis is in a plane parallel to the axis of the roll. The desired ring design would be such that this self-suporting feature

allows forces to be exerted equally in either direction. If one of the rolls 13, 15 were not of constant diameter, then the shape of the ring must be such that theoretically only point contact is made between the ring and that member, in order to achieve precision from the device. When the ring makes contact at multiple points along the axis of the rolls, that surface of the ring must generate a true cylinder to prevent a tendency for the ring to try to "walk" and create its own force against an external control element.

At the center of the ring is an external control element in the form of a vertical yoke 17 guided between spaced bars 18 and 19 extending between the side walls 2 and 3 and parallel to the axes of the rolls 13 and 15. The upper end 20 of the yoke has provisions for connection to a control device for moving the yoke back and forth between the bars 18 and 19. The yoke has depending arms 21 and 22 straddling the ring 16. The arms 21 and 22 in conjunction with the guide rods 18 and 19 hold the axis of the ring 16 in a plane parallel to the axes of the rolls 13 and 15 but permit tilting of the axis of the ring in that plane. In practice, there will be substantially no clearance between the arms and the ring so the yoke can accurately position the ring. At the center of the arms 21 and 22 is fixed a block 23 carrying trunnions 24 journalled in a support 25 fixed to a rod 26 slidably carried in the side walls 2 and 3 on an axis parallel to the axes of the rolls 13 and 15.

When the yoke 17 is in a vertical position, the axis of the ring 16 is parallel to the axes of the rolls 13 and 15 and the plane of the ring 16 is perpendicular to the roll axes. In this position of the yoke, the ring remains in a fixed position and tracks in fixed circular paths on the surfaces of the rolls 13 and 15. This is a stable position of the ring in that there is no tendency for the ring to move from that position. When the yoke 17 is tilted in either direction, the ring is steered so that it now tends to follow a path inclined to the axes of the rolls 13 and 15. For stability, the rolls should turn in a direction to pull the half of the ring on which the control force is exerted toward the bite of the rolls. In the structure illustrated the control exterted by the upper end 20 of the yoke is on the upper half of the ring, which is always moving toward the bite of the rolls. Since the ring is frictionally gripped between the bite of the rolls, when the ring is tilted it will roll along the bite of the rolls, generating helices on the surface of the rolls, the pitch of the helices varying with the tilt of the ring. The action is like that of a variable pitch screw. The force which the ring can create or resist parallel to the bite of the rolls is dependent upon the pressure with which the rolls 13 and 15 are urged together and the coefficient of friction between the rolls and the ring. The power available (rate of doing work or rate at which the force can act through a distance) is dependent upon the roll pressures, the coefficient of friction, the roll speed, and the tilt of the ring.

Theoretically the side force or thrust from the ring along the bite of the rolls could be taken off from any point along the line lying in the plane of the ring and perpendicularly intersecting the axis of the rolls without introducing a tilting force to the ring such as, for example, through the sliding rod 26 fixed to the support 25 for the yoke 17. However, if force is taken off at this point, there will be a force tending to twist the axis of the ring out of a plane parallel to the axes of the rolls and special provisions will have to be taken to prevent this twisting. The preferred location for thrust take-off is from between the bite of the rolls 13 and 15 or, in other words, at the point at which the components of force on the ring originate. A thrust take-off at this point will avoid couples tending to twist the axis of the ring.

One structure for thrust take-off is illustrated in Fig. 4 and comprises upper and lower rods 27 and 28 slidably carried between the side walls 2 and 3. Fixed to the upper rod 27 is a block 29 and fixed to the lower rod 28 is a block 30, both being clear of the rolls 13 and 15. Extending between the blocks 29 and 30 is a plate or member 31 thinner than the radial thickness of the ring so that it extends between the bite of the rolls 13 and 15 without contacting either roll. At the center of the member 31 and in the plane of the bite of the rolls is a point 32 which contacts the ring 16 and receives thrust from it when the thrust is to the left as viewed in Fig. 4. A spring 33 arranged between the side wall 2 and the block 29 urges the point 32 against the ring 29 and keeps it in contact with the ring when the ring is moving to the right as viewed in Fig. 4. From one aspect, the parts 27–32 inclusive constitute a carriage which receives thrust from the ring 16 through the point 32. With this construction, there will be a continual sliding friction load between the ring and the point 32.

In order to minimize the friction, the construction shown in Figs. 5 and 6 can be used where there is at the point of contact with the ring 16 a ball bearing 34 mounted on a shaft 35 extending between arms 36 at the forward end of the plate 31. With this construction, it may be necessary to slightly thicken the ring 16 in order to allow space for the ball bearing 34 between the bite of the rolls 13 and 15. The ball bearing take-off decreases the friction load.

Another construction for decreasing the friction at the thrust take-off is shown in Figs. 7 and 8 where the thrust receiving carriage consists of a support 37 fixed to the upper and lower slide rods 27 and 28. The support 37 serves as the outer raceway of a ball bearing. The inner raceway 38 of the ball bearing has a clearance slot 39 for the ring 16 so that the ring is gripped between the bite of the rolls 13 in the same manner as the previously described constructions. There are two pairs of rollers 40 which make antifriction contact with the edges of the ring. With the construction of Figs. 7 and 8, the ring can tilt in any direction with a minimum of restraint because the ring is guided in the inner raceway 38 of a ball bearing. The take-off thrust either to the right or to the left as viewed in Fig. 7 is through a pair of rolls 40, one above and one below the bite of the rolls 13 and 15. The construction of Figs. 7 and 8 has the advantage that the spring 33 may be eliminated since the thrust can be taken off either to the right or to the left.

The fragmentary view of Fig. 9 shows another way of decreasing the friction in the thrust take-off. It is intended to fit directly in the construction of Figs. 1 to 4 inclusive where the thrust take-off is through the point 32 on the plate 31. In the construction of Fig. 9, the ring 16*a* is the center race of a ball bearing having outer races 41 and 42 which are stationary. The outer race 41 bears directly on the point 32 and, therefore, transmits the thrust without the sliding friction loss present in Fig. 4.

Fig. 10 diagrammatically illustrates an application of the force multiplier. In this application a sensitive element 43, for example, a temperature measuring device, moves a pen arm 44 in accordance with the temperature. Obviously the accuracy of the sensitive element would be impaired if substantial resistance were offered to the movement of the pen arm 44. The pen arm 44 is coupled to the upper end 20 of the yoke 17 and tilts the yoke as the temperature changes. The force required to tilt the yoke is multiplied and appears in the slide rods 27 and 28 as a force sufficient to actuate the valve 45.

What is claimed as new is:

1. A force amplifier comprising a pair of pressure rolls journalled on axes parallel to each other and having a bite therebetween and provisions for exerting pressure between the rolls at the bite, means for driving one of the rolls, a ring gripped between the bite of the rolls and driven thereby and encircling one of the rolls with its axis of rotaion in a plane parallel to and spaced from the bite of the rolls, said ring being of cross section which is substantially self-supporting when gripped between the rolls, means guiding the ring for bodily movement along a path parallel to the bite of the rolls, said guiding means being capable of tilting the ring to and from a position perpendicular to the axis of the rolls at any position along the axis of the rolls, provisions for connecting said guiding means to an external positioning means or element, and a thrust take-off transmitting thrust from the ring.

2. The device of claim 1 in which the thrust take-off comprises a carriage guided for movement along a path parallel to the bite of the rolls and having a part between the bite of the rolls in thrust receiving relation to the ring.

3. The device of claim 2 in which the part in thrust receiving relation to the ring comprises a race of an anti friction bearing.

4. The device of claim 2 in which the part in thrust receiving relation to the ring comprises the inner race of an anti friction bearing rotatable on an axis extending through said plane and perpendicular to the bite of the rolls, said race having a slot receiving the section of the ring passing through the bite of the rolls.

5. A force amplifier comprising a pair of pressure rolls journalled on axes parallel to each other and having a bite therebetween and provisions for exerting pressure between the rolls at the bite, means for driving one of the rolls, a ring gripped between the bite of the rolls and driven thereby and encircling one of the rolls with its axis of rotation in a plane parallel to and spaced from the bite of the rolls, said ring being of cross section which is substantially self-supporting when gripped between the rolls, a carriage guided for movement along a path parallel to the bite of the rolls, a part between the bite of the rolls journalled in the carriage on an axis perpendicular to the axes of the rolls and extending through the bite of the rolls, and bearing means on said part engaging the ring.

6. A force amplifier comprising a pair of rotatable pressure members at least one of which is a cylinder, journalled on axes lying in the same plane and having a bite therebetween and provisions for exerting pressure between the members at the bite and each member having a surface disposed parallel to the surface of the other member in a plane common to the axes about which said members are rotatable, means for driving one of the members, a ring gripped between the bite of the members and driven thereby and encircling one of the members with its axis of rotation in a plane parallel to and spaced from the bite of the members, said ring being of cross section which is substantially self-supporting when gripped between the members, means guiding the ring for bodily movement along a path parallel to the bite of the members, said guiding means being capable of tilting the ring to and from a position perpendicular to the axis of the members at any position along the axis of the members, provisions for connecting said guiding means to an external positioning means or element, and a thrust take-off transmitting thrust from the ring.

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