United States Patent

[11] 3,592,069

[72] Inventor **Thomas Ross Welch**
P.O. Box 5339, Santa Monica, Calif. 90405
[21] Appl. No **718,453**
[22] Filed **Apr. 3, 1968**
[45] Patented **July 13, 1971**

[54] **ROLLER-RIBBON MECHANICAL MOTION APPARATUS**
28 Claims, 29 Drawing Figs.

[52] **U.S. Cl.** 74/89.2
[51] **Int. Cl.** F16h 27/02
[50] **Field of Search** 74/89.2, 108, 110, 216.53; 308/6; 200/153

[56] References Cited

UNITED STATES PATENTS

3,452,175 6/1969 Wilkes 308/6

OTHER REFERENCES

WILKES-ROLAMITE RESEARCH REPORT Sc. Rr. 67 656, Oct. 1967, Sandia Laboratories Pages 1,112,113,141,152,174,182 and 184.

Primary Examiner—William F. O'Dea
Assistant Examiner—Wesley S. Ratliff, Jr.
Attorney—Lynn H. Latta

ABSTRACT: A lever mechanism having a shiftable, frictionless fulcrum utilizing a roller-ribbon construction.

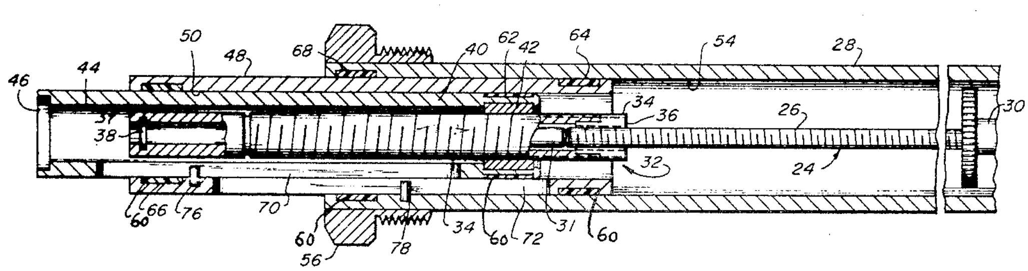


FIG. 1

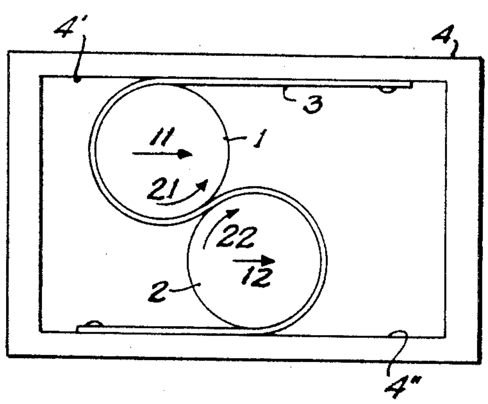
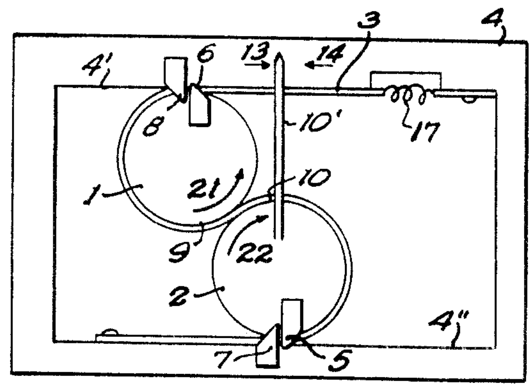


FIG. 2



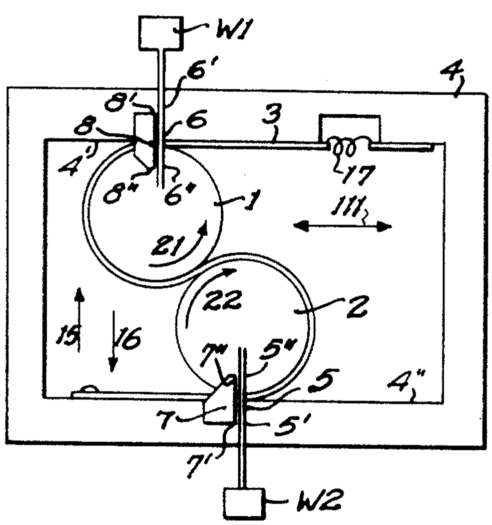


FIG. 3

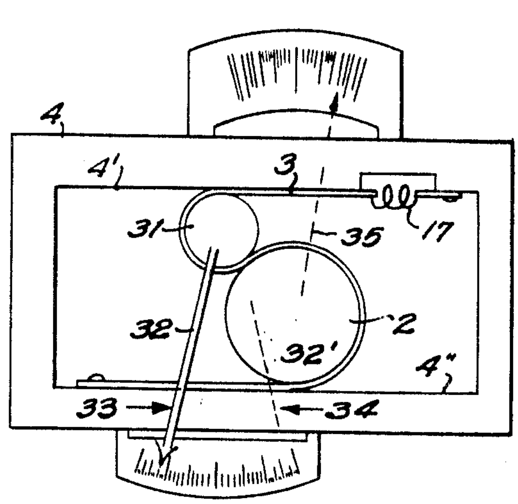


FIG. 4

INVENTOR.
THOMAS ROSS WELCH
BY Lynn H. Latta
ATTORNEY

FIG. 5

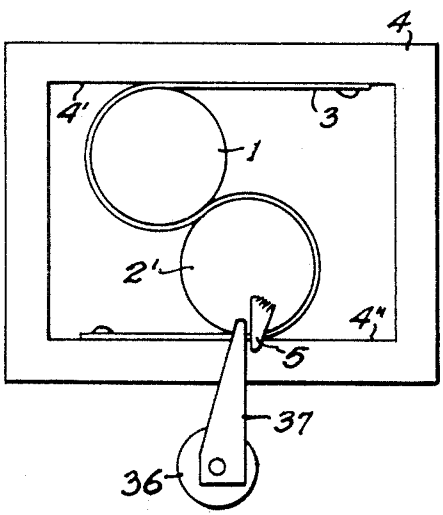
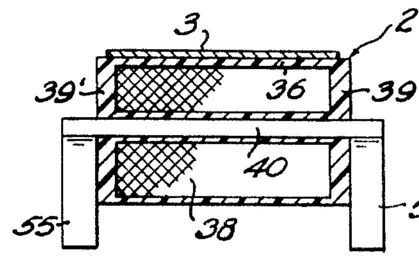


FIG. 7



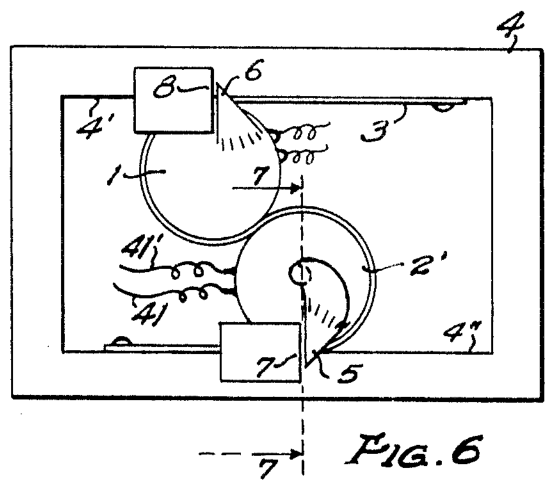


FIG. 6

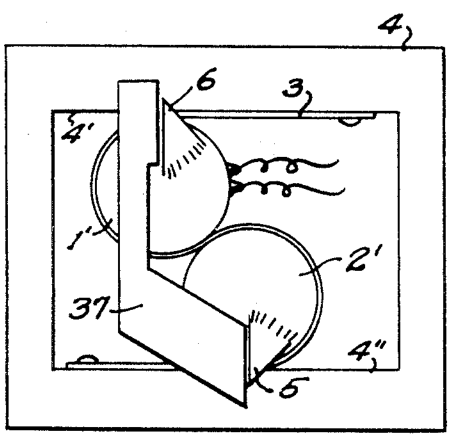


FIG. 8

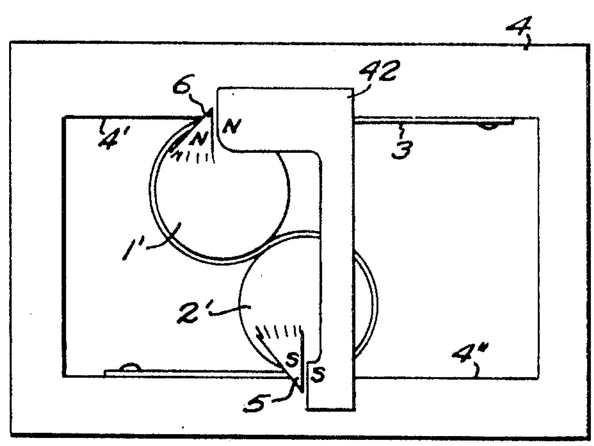


FIG. 9

INVENTOR.

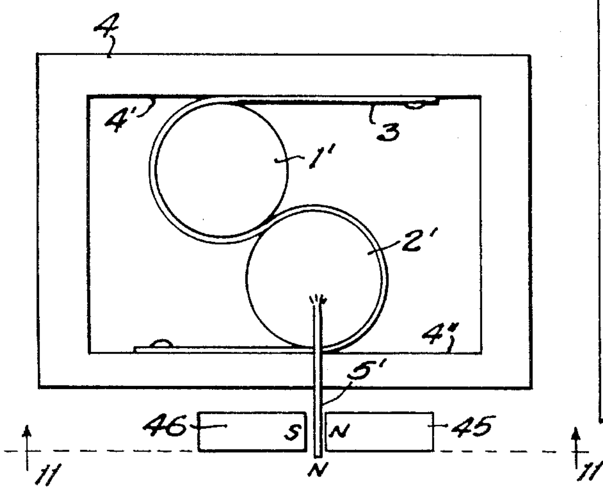
THOMAS ROSS WELCH

BY

Lynn M. Latta

-ATTORNEY-

FIG. 10



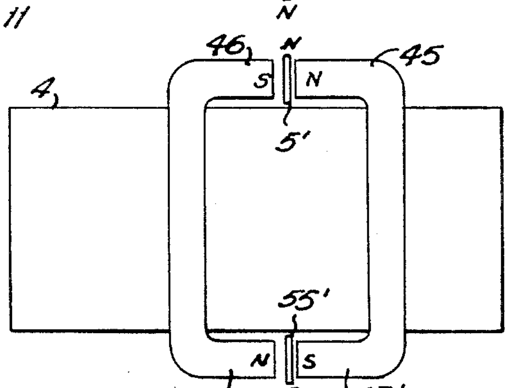


FIG. 11

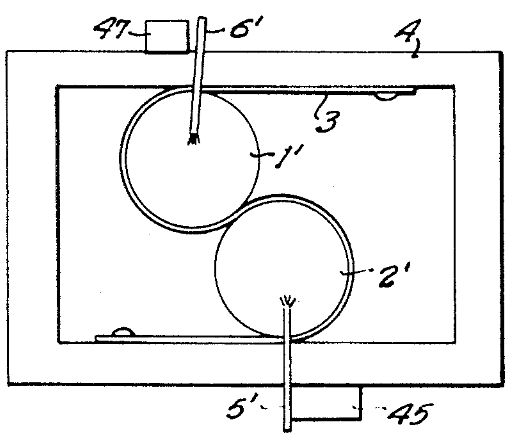
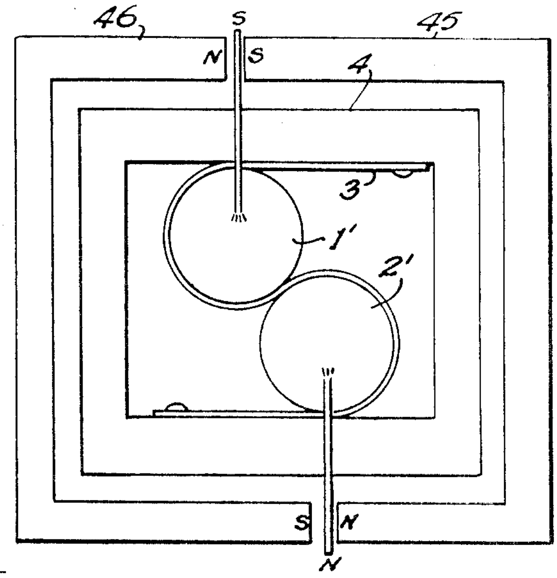


FIG. 12

FIG. 13



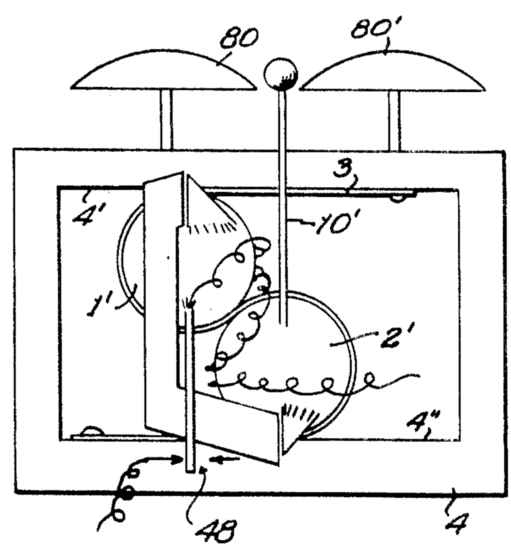


FIG. 14

INVENTOR.
THOMAS ROSS WELCH
BY

-ATTORNEY-

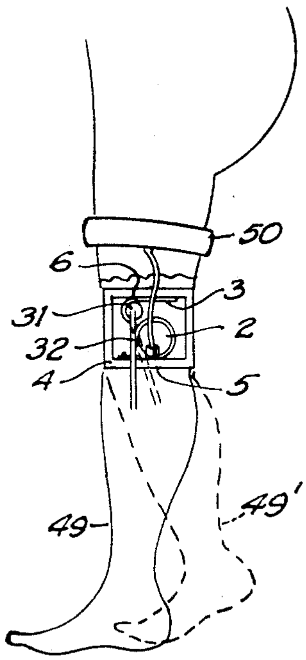


FIG. 15

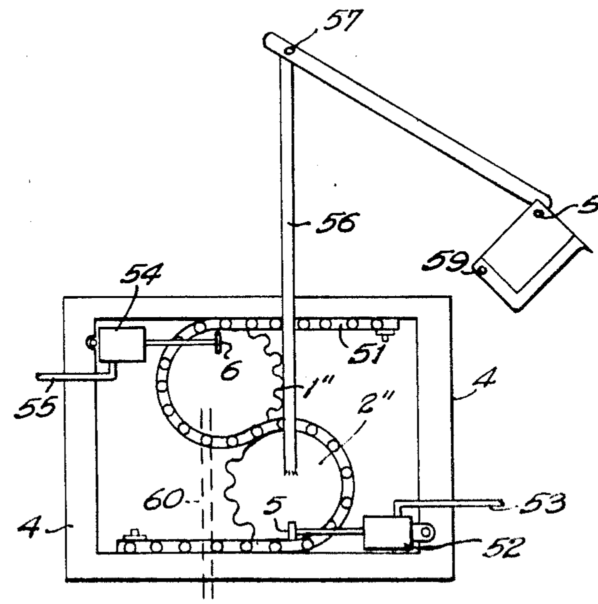


FIG. 16

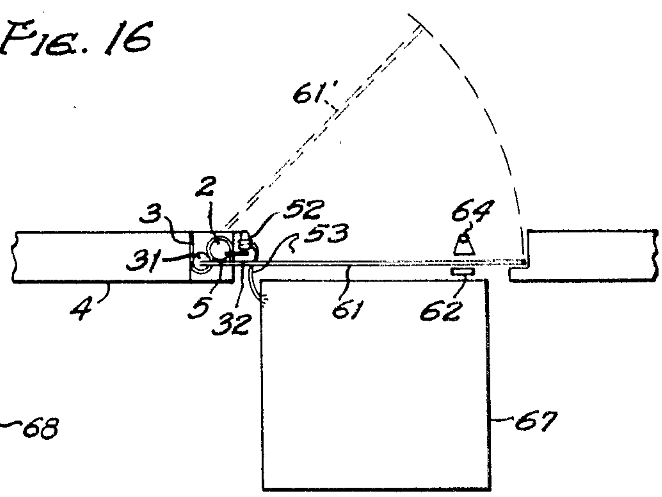


FIG. 17

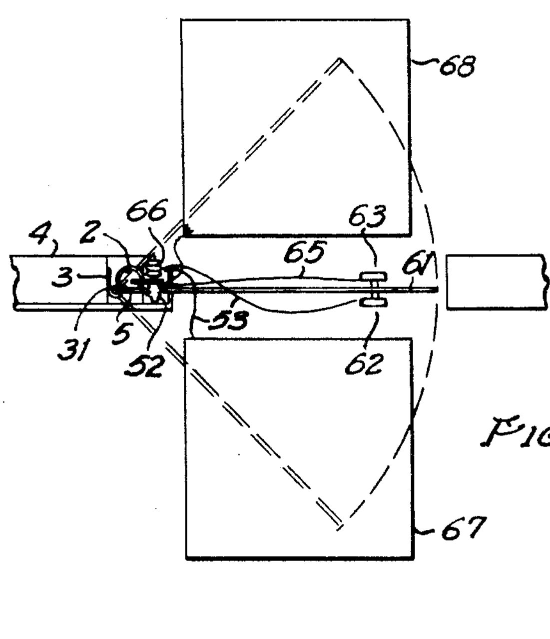


FIG. 18

INVENTOR.
THOMAS ROSS WELCH
BY
Lynn H Latta
-ATTORNEY-

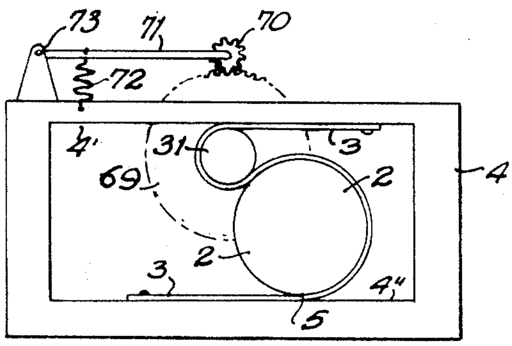
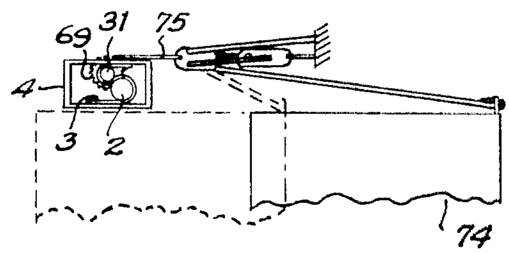


FIG. 19

FIG. 20



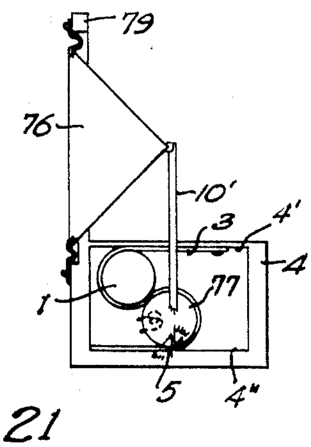


FIG. 21

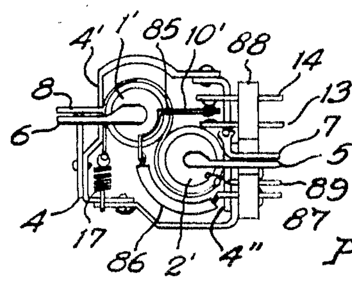
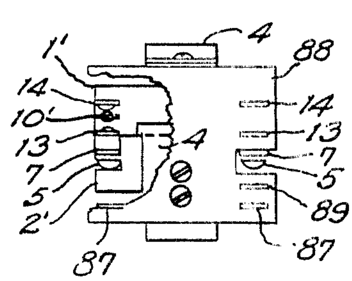


FIG. 23



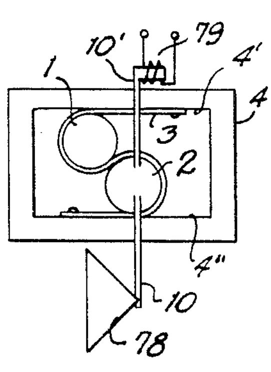


FIG. 24

FIG. 22

INVENTOR.
THOMAS ROSS WELCH
BY Lynn H. Latta
ATTORNEY

FIG. 25

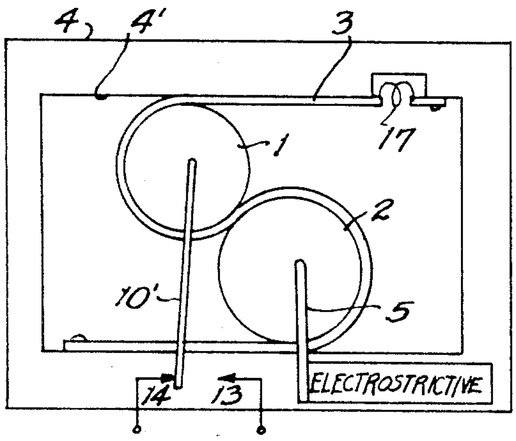


FIG. 26

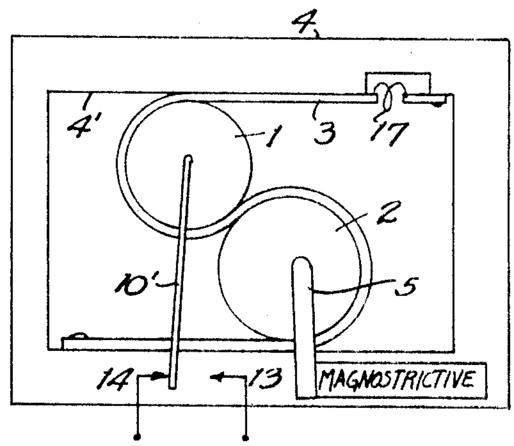


FIG. 27

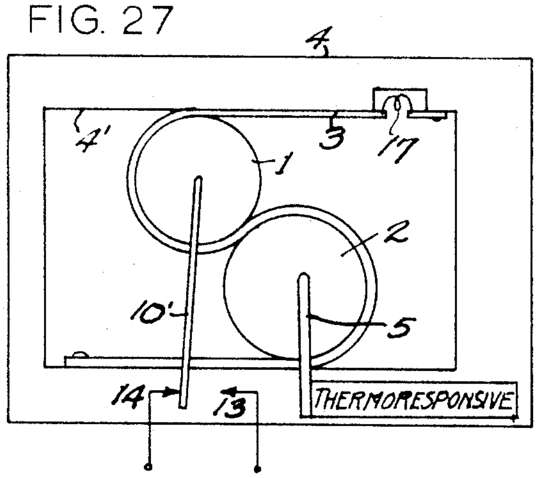


FIG. 28

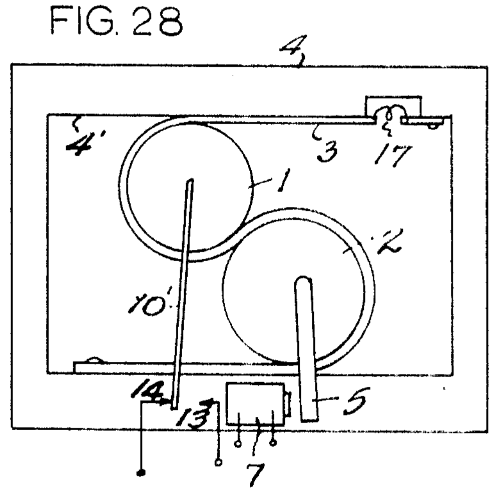
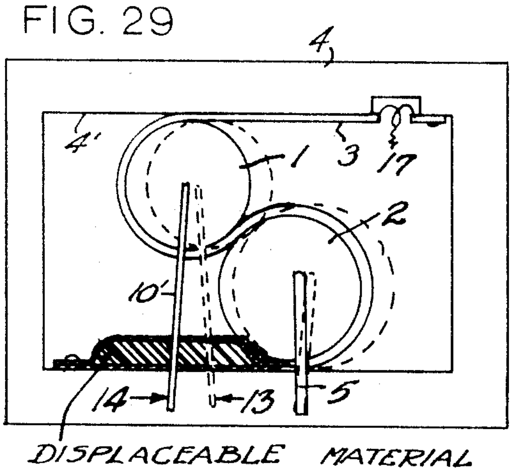


FIG. 29



INVENTOR.
T. ROSS WELCH

BY Lynn H. Latta
-ATTORNEY-

ROLLER-RIBBON MECHANICAL MOTION APPARATUS

BACKGROUND OF INVENTION

A roller-ribbon construction has heretofore been developed by Sandia Corporation of Albuquerque, New Mexico, and has been called a "Rolomite." It consists of two rollers on a continuous ribbon confined in a track.

OBJECTS OF INVENTION

The present invention has as a general object to utilize and improve upon the roller-ribbon principle so as to attain novel and advantageous results not heretofore conceived.

Specific objects of the invention are:

a. To provide a pivotless mechanical lever with mechanical advantages exceeding that of the normal lever;

b. To provide a pivotless leverage system for meter movements, bells and buzzers, vibrators, valves, artificial arms and legs, loud speakers and microphones, windshield wipers, scales, relays and oscilleograph recorders, to name a few;

c. In the case of magnetic or electromagnetic devices such as bells, buzzers and relays, to increase the power or force developed in the system by taking advantage of the magnetic power being increased by the inverse square law.

d. To place electric contacts in such a manner that their movement exceeds the normal throw of a mechanical leverage system;

e. To place one element of the lever mechanism on a portion of the lever that moves with a positive radial movement minus negative lineal movement, and so that it can be made to effectively stand still as a resultant;

f. To place one element of the leverage on a portion of the lever that moves with a positive radial movement plus a positive lineal movement so as to attain an amplified resultant movement;

g. To effect a meter movement such as to create an expanded scale in the area where the meter readings were most critical;

h. To construct vibration and shock resistant devices and components;

i. To build an improved relay by eliminating the pivot, increasing the force produced by the driving element and improving the contact efficiency by the increased contact force, contact travel and operating speed;

j. To reduce the parts in a relay by combining the coil and armature into one common part.

IN THE DRAWINGS

All FIGS. are schematic, except FIGS. 23 and 24.

FIG. 1 illustrates the basic roller-ribbon construction;

FIG. 2 shows the application of the invention to a lever arm such as a movable switch contact;

FIG. 3 shows the application of the invention to an acceleration-responsive device;

FIG. 4 shows the application of the invention to a meter;

FIG. 5 shows the application of the invention to a torque motor;

FIG. 6 shows the application of the invention to a compound torque motor;

FIG. 7 is a sectional view taken on line 7–7 of FIG. 6;

FIG. 8 shows the application of the invention to another electromagnet device;

FIG. 9 shows the application of the invention to a device embodying a permanent magnet bridging two torque motors;

FIG. 10 shows the application of the invention to a latching relay;

FIG. 11 is a plan view of the same;

FIG. 12 shows the application of the invention in another latching relay;

FIG. 13 shows the application of the invention to another electromagnetic device;

FIG. 14 shows the application of the invention to a bell;

FIG. 15 shows the application of the invention to an artificial limb;

FIG. 16 shows the application of the invention to a lever mechanism for a crane;

FIG. 17 shows the application of the invention to a door opening mechanism;

FIG. 18 shows the application of the invention to a double-swinging door

FIG. 19 shows the application of the invention to a gear train;

FIG. 20 shows the application of the invention to a sliding door opener;

FIG. 21 shows the application of the invention to a loudspeaker;

FIG. 22 shows the application of the invention to a microphone;

FIG. 23 is a side elevational view of a double-throw, double-pole relay embodying the invention;

FIG. 24 is a rear elevational view of the same, with a portion broken away.

FIG. 25 shows the application of the invention to a relay utilizing an electrostrictive element;

FIG. 26 shows the application of the invention to a relay utilizing a magnostrictive expansion element;

FIG. 27 shows the application of the invention to a relay embodying an electromagnetic expansion element;

FIG. 28 shows the application of the invention to a relay embodying a thermoresponsive expansion element; and

FIG. 29 shows a modified form of the invention embodying a core of displaceable material.

DESCRIPTION

FIG. 1 is the basic Rolomite consisting of the rollers 1 and 2, the flexible band or ribbon 3 and the frame 4. The frame 4 embodies opposed tracks 4', 4'' which in the preferred forms of the invention are parallel. Opposite ends of band 3 are anchored to the frame at diagonally opposite corners, and tail portions of the band extend from the anchorage points to looped portions of the band which are wrapped around the respective rollers in an S-configuration.

The rollers 1 and 2 have diameters the sum of which exceeds the perpendicular distance between tracks 4', 4''. Hence the oppositely looped portions of ribbon 3 have circumferential extents each greater than 180°, the rollers are therefore effectively confined in their respective loops, the areas of tangency between the loops and the tail portions of the band are snugly engaged between the rollers and the tracks, the tail portions lie in contact with the tracks, and the transition area of the band, where the two looped portions join one another in tangent relation, is snugly engaged between the rollers.

Forces on rollers, to the right, in the direction of arrows 11 and 12, will cause the roller 1 to rotate counter clockwise (arrow 21) and roller 2 to rotate clockwise (arrow 22) and the assembly to travel along the band in a right-hand direction in the frame 4 (arrow 11 and 12). Force to the left on the rollers of FIG. 1 will cause the rollers to rotate in the opposite directions, whereby the assembly will move along the band in the left hand direction in regard to frame 4.

The invention provides a method of developing greater forces and travels for such devices, as will now be described, reference being made first to FIG. 2.

I discovered that a right hand movement of the roller assembly could be achieved by applying a torqueing force to the rollers. For instance, if a clockwise torque force were applied to roller 2 the assembly would move to the right, whereas a counterclockwise force would move the assembly to the left. Opposite torques applied to roller 1 will have the same directional effects.

By applying this torque force at point 5 (e.g., a magnetic pole) on roller 2, at a point beyond where the wheel is tangent to the frame 4, as the roller turns in a clockwise rotary manner it is at the same time moving as a roller assembly in a right direction and the sum of these motions can be virtually zero motion.

In effect, at the point where the ribbon is tangent to the wheel the negative clockwise rotation is counteracted by the positive linear movement to the right, which causes point 5 on roller 2 to remain effectively stationary in relation to point 7 on the frame. Point 7 may be a magnetic pole.

If now a force, such as a magnetic force, is applied to pole 7, attracting the pole 5, (FIG. 2) the spacing between these poles 7 and 5 can be made very small, and will remain small and virtually constant while exerting a large torque force on roller 2 by reason of the added magnetic force from the inverse square law gained by the close magnetic spacing. Other force devices, such as pistons, can develop large force with small movement and thereby conserve on the volume of material used to actuate the piston.

Extending the point of application of force (e.g., at W2) beyond the radius of the roller (FIG. 3) will cause the radial travel to be greater than the linear travel and the gap between poles 5' and 7' will gradually close. If the radii of the force points are smaller than the roller radius the linear travel will

ability to withstand them

In regard to military switches and relays, the ability to withstand these G forces is important and the Rolamite, as adapted to my force system, is made also resistant to vibration, shock and acceleration forces, as follows:

Referring to FIG. 3, normally an acceleration G force applied to frame 4 in the direction of arrow 111 (to the left) would cause the roller assembly to travel to the right by inertia. By applying a mass W1 on arm 6' to roller 1 and a mass W2 on arm 5' to roller 2, when a G force is applied to the assembly to the left, in the direction of arrow 111, as roller 1 tries to turn in a counterclockwise direction in response to its inertia, to travel to the right, mass W1 tends to counteract this turning by its clockwise inertial force. Roller 2 clockwise inertial force is counteracted by the counterclockwise inertial force of mass W2. The rollers assembly is therefore maintained in place rather than accelerated by the external G forces.

The forces for all directions are as shown on the following chart 1:

Chart of Force Actions under Acceleration of G (gravity) When Counter Weight is Used

	Wheel 1 weight 1	Roller direction of travel	Wheel 2 weight 2
Operate no G forces	CCW	R	CW
Release no G forces	CW	L	CCW
G force to left tries to force any roller travel to right, results in wheels seeing torque of	CCW	-----------	CW
Opposed by force of weights applying torque of	CW	0	CCW
G force to right tries to force any travel to left results in wheels seeing torque of	CW	-----------	CCW
Opposed by force of weights applying force of	CCW	0	CW

be greater than the rotary travel and points 5'' and 7'' will gradually open.

In practical use, for instance as magnetic poles, the pole area should extend in the direction of 5' and 7' (outwardly of the roller periphery). Extending the gap in the direction of 5'' and 7'', smaller than the roller radius, can have advantages in controlling reluctance of the magnetic circuit, but normally does not contribute to the development of driving torque.

The same conditions as the above apply to roller 1 at points 6 and 8 (FIG. 2) which would also have respective points 6'—8' and 6''—8'' (FIG. 3) with 6 being the pole attached to the roller.

The condition of the rollers at points 9 for wheel 1 (FIG. 2) and 10 for wheel 2 are the opposite from the above since these points are traveling in a positive linear motion and a positive radial motion so that the movements of 10, or contact 10' from contact 13 to contact 14 is the sum of the linear and radial movements. This is also true of point 9 of wheel 1.

The positions 9 and 10 then have the advantage for the placement of actuated elements such as switch or relay contacts, or other elements that are better if they have a large travel while the positions 5 and 6 are better for the portion of the mechanism where little or virtually no travel is wanted.

Positions on the periphery from 5 or 6 move greater amounts until at the half way point between 5 and 10 or 6 and 9 the movement is radial above, except for a movement at 90° from the radial, and can be called unity movement. The movement continues to grow larger to its maximum at points 9 and 10. This change in movement is used to advantage in the meter movements as will be described.

The extending of operating arms, such as 10' (FIG. 2) has two advantages: (1) It is a lever arm and can further increase the contact travel and (2) It can be a moment arm for a vibration, acceleration and shock-proof device as will be described.

The extending of operating arms, such as 10' (FIG. 2) has two advantages: (1) It is a lever arm and can further increase the contact travel and (2) It can be a moment arm for a vibration, acceleration and shock-proof device as will be described.

In certain applications, equipment that will withstand vibration, shock and acceleration conditions is vital and normally the Rolamite, as promulgated by Sandia, is known for its ability to respond to acceleration G forces rather than the opposite

Forces in the vertical, arrows 15 and 16 are restrained by the frame 4 and the weights W1 and W2 being on the rollers in the position as shown in FIG. 3 are not effected by these vertical forces.

These masses W1 and W2 (FIG. 3) can be the pole or lever arm structures or added weight, or both, in order to arrive at the proper weights to achieve the correct counteraction. The basic considerations for any G value to be withstood are, the weight of the rollers, counteracted by the total (pole plus lever arm) weights plus dead weight as needed for proper G value balance.

In order to develop a positional force to the roller assembly the parallelism of the tracks 4' and 4'' of frame 4 can be varied.

If the tracks 4' and 4'' were closer together on the right side of FIG. 2 as the roller assembly moved to the right, in direction of arrow 11, the rollers would be squeezed together, using more of the ribbon and therefore making the ribbon tighter, which would make the assembly want to return to the left position where the forces are less.

The resilience of the ribbon can be used in this or a spring can be in the ribbon as shown at 17 in FIG. 2.

Once the relative positions of the poles, contacts, etc. are established and especially in conditions where contacts are mounted on each roller, perforations are in the ribbon, matching projections on the rollers, in such a manner that the positions of the rollers to the other relative elements are thereafter always correct.

Where the rollers 1 and 2 come together, projections on each roller can alternate with depressions so that the projection on roller 1 can go through the ribbon perforation into the depression on roller 2 and as the assembly moves the next projection on roller 2 goes through the next perforation in the ribbon into the next depression in roller 1.

If a smaller roller 31, (FIG. 4) were used in place of roller 1, as the larger roller 2 moved a previously determined distance, such as would be the case in FIGS. 1, 2 or 3, the smaller roller 31 would radially turn much further. This greater turning could be used for even greater throw of arm 32 between contacts 33, 34.

By putting a pointer on this arm 32 a pivotless meter movement can be achieved and further, this movement can have an expanded scale, the scale being most expanded when the pointer is opposite the tangent point of the roller to the frame

By also varying the size of the roller 31 an ideal arrangement of pointer travel can be achieved, from almost zero, when the pointer and roller are tangent to the frame to maximum when they are opposite. This would give a meter where at zero values the mechanism would not come to a sudden shock stop but would gradually decelerate.

By having pointer 35 on wheel 2, FIG. 4, a meter with 2 pointers could be positioned on the relative rollers in such a manner that one pointer could be at maximum expended scale readings at one set of values, and the second pointer come to its maximum expanded scale readings at another set of values. Both pointers would not have to be on the scales at the same time as shown in FIG. 4.

Or by using different size rollers, such as FIG. 4, one pointer such as 35 can cover a large entire scale and pointer 32 will come into the maximum expanded scale (or view) at the critical meter reading position.

Combinations of pointers for meter readings and contacts for circuit closing can be made by putting meter indication on one roller and a contact or contacts for circuit closing on the other. An additional advantage of the separate rollers of possible different roller size would be that variations of contact forces and expanded reading positions could be achieved.

In a meter, as described above, the force to be measured can be applied to the tangent points 5′ or 6′, or one of the rollers can be the De Arsial type movement, in order that the force is directly applied to the rollers.

As an electrical meter or as a relay the magnetic force can be applied to the rollers in the following manners:

Coil 36 of FIG. 5 has poles 37 on opposite sides to apply magnetic force to poles 5 on opposite sides. This magnetic attraction would apply the torque force on roller 2 and cause the operation as previously described.

A more efficient system is shown in FIG. 6 where the spaces within hollow roller or rollers are used for the electromagnetic coils. Roller 2′ for instance, as shown in FIG. 7, consists of the outer shell 36 enclosing coil magnetic winding 38 with end pieces 39 and 39′ and with iron core 40 connecting magnetic poles 5 and 55. Coil connections 41 and 41′ (FIG. 6) connect the coil to the energizing circuit.

When the coil assembly is in place, as in FIG. 6 and the coil is energized the magnetic flux flows through the core 40 to the pole 5 across the gap to pole 7 which extends across the frame to meet pole 55 and complete the magnetic circuit.

If it is desired that both rollers be coils for increased power the same type of coil as shown in FIG. 7 can be used for coil 1 on which poles 6 (FIG. 2) will meet stationary poles 8 which will act in the same manner as pole 7 described above.

An additional magnetic arrangement is shown in FIG. 8 where rollers 1′ and 2′ are both magnets and poles 5 and 6 are connected in series by poles 37 (at both ends of the rollers).

These magnetic arrangements take advantage of the invention in using the increased magnetic power from the inverse square law because the poles are always close.

This invention is not limited to electromagnetic actuation but because of the small amount of movement at the points 5 and 6 is especially adapted to operation by magnostrictive and electrostrictive elements.

FIG. 9 shows an alternate magnetic method using permanent magnets 42 at each end with, for purposes of illustration only, N magnetic pole at the top of one pole 42 and S at the bottom (with the opposite polarity at pole 42 on the other side) poles 5 and 6 are facing opposite directions to meet magnet 42. When the coil of roller 1′ is energized so that pole 6 is N (the other pole 6 is S) and pole 5 is S (the other pole 5 is N) the like poles repel putting a torque on the rollers 1′ and 2′ causing them to move as previously described.

When the coils are deenergized the magnetic pull of the magnet 42 attracts the poles 5 and 6 and helps return the assembly to the first position and helps hold it there under conditions of shock, vibration and acceleration.

A latching relay can be constructed by the methods shown in FIG. 10, FIG 11 and FIG 12

The pole 5′ on magnetic roller 2′ and a like pole 55′ on the opposite end of pole 5′ are attracted by permanent magnet 45 which is N at end 45 and south at end 45′

When the coil of roller 2′ is energized with N on pole 5′ and S on 55′, magnet 45 repels the coil pole 5′ and 45′ repels 55′. This applies the clockwise torque to roller 2′ causing it to operate as previously described.

Poles 5′ and 55′ being of larger radius than the pulley 2, move the desired amount, which can be controlled by length of these poles, so that they move toward poles 46 and 46′ and are attracted toward these opposite poles. The roller is held in this position by the magnet 46, 46′ till the following:

For the returning operation, magnet 2′ is energized so that pole 5′ is south which causes 46 to repel and 45 to attract it. Pole 55′ is then north, which causes 46′ to repel 45′ to attract, and therefore the roller 2′, and the roller assembly, is rolled back and held at the original position by magnet 45.

Coil 1 can be controlled in a similar manner.

Where one coil is to control the operation one way and the second coil the other way the assembly can be as per FIG. 12.

Coil pole 5′ is repelled by magnet 45, 45′ when the coil 2′ is properly energized. This causes pole 4′ to swing away from pole 45 and pole 6′ of coil 1′ to swing toward magnet 47.

To return it coil 1′ is energized so pole 6′ and 47 are like poles which causes 47 to repel 6, applying force to roller 1′, causing it to rotate the roller assembly back to the original position where 45 again attracts and holds 5′. The description of the magnetic action on the other end of the pulleys is clear to anyone skilled in the art.

FIG. 13 shows another magnetic arrangement where both roller-coils 1′, 2′, can be energized to cause repelling from the one of the magnets 45, 46 and attracting to the other and for the return cycle the opposite effect when the magnetization of the coils is reversed.

FIG. 14 illustrates a bell consisting of rollers 1′ and 2′ and any one of the magnetic operation systems described. Lever arm 10′ being the clapper for the bells 80, 80′. The contacts 48 can make the system self actuating when DC current is used on the coils.

Leaving the clapper and bells off makes a buzzer.

Replacing the clapper with the cutting blade of a razor will make a driver for an electric razor or like instrument.

This invention can also be used for artificial arms or legs, etc. See FIG. 15.

Rollers 2 and 1 or 31 are shown with frame 4 and ribbon 3. The artificial leg 49 is attached to radius arm 32. Any small travel force, at points 5 or 6 or both will cause the leg to operate in a large swing as shown by 49′. The small movement required at point 5 or 6 can be supplied in several ways but can best be supplied by the leg muscles left in the leg stump, by a strap such as 50 connecting to 5 or 6, so that actual walking could be achieved.

For bigger equipment such as cranes, diggers etc., in place of the ribbon a chain link can be used as shown by 51 in FIG. 16, rollers being replaced by sprockets. 1″, 2″.

One method of operation would be with cylinders 52 and 54 which can be operated hydraulic or pneumatic, through lines 53 and 55, or these can be electric or other types of jack screws, again with the advantage that a small movement of the force at 5 or 6 will give large movement at arms 56 or 60.

56 or 60 can directly be the arm of a crane with another Rolever at point 57 for this movable joint and another for instance at 58 for this moveable joint and another at 59 for dumping the bucket.

The arms 56 and parts 57, 58 and 59 are not shown to scale with the rest of FIG. 16.

FIG. 17 shows this invention adapted to a door for hinging and aiding in opening the door. Rollers 2 and 31 have the ribbon 3 and frame 4 as shown in general in FIG. 4.

The door 61 is mounted on lever arm 32. When pressure is applied to point 5 roller 31 moves a large amount opening door 61 to 61′.

A means of applying force on point 5 is with cylinder 52 with pressure lines 53 going to the door treadle 67 located on the floor, or to the door handles 62 and 64 located on the door, or both.

The pressure from the weight of the person on the treadle 67 creates pressure, such as fluid or air pressure in line 53 which operates cylinder 52 which puts pressure on 5 causing roller 2 to turn which turns roller 31 and lever arm 32 opens door to 61'.

When pressure is removed from treadle 67 the force on point 5 is removed and the system returns to normal.

Pressure developed on the handles, 62 or 64 by pushing, pulling or turning will also deliver a force to point 5 and open the door.

By putting the return force to the lever, beyond the closing of the door, the lever would exert a closing force to the door and a holding force to keep the door closed. With the opening aid as described above, this force could be more than would normally be possible on a conventional door. The advantage would be better control on the door and even holding it in place without a lock.

When desirable an air cylinder with a control valve could be applied to the lever to retard the closing of the door. This can be applied on the return stroke of lever arm 32 or 5 or 6.

The ribbon could be a tubing filled, on the return side, with silicone putty. In opening the lever the putty and tube expand, and when the lever goes to close the roller must displace the slow moving silicone putty, therefore the whole mechanism returns slowly.

FIG. 18 shows a top view of a double swinging door 61 where treadle 67 and handle 62 operate as described above but where treadle 68 and/or handle 63 operate line 65 to actuate cylinder 66 putting force on 5 in opposite direction than described above, and causing door to swing in the other direction.

FIG. 19 shows this invention adapted to a gear train for getting additional travel or rotation than can be had with smaller roller 31 as described above. In this case roller 2 is actuated at point 5 as described above. Roller 31 is driven which in turn drives through gear 69 to gear 70 which can be attached to another gear, pulley, drum or other device. The gear 70 floats on arm 71 which is pivoted at 73 and held against gear 69 by spring 72 since gear 69 moves in frame 4 with roller 31.

Door openers for sliding doors, 74 as shown in side view in FIG. 20, can be controlled as described for FIG. 17 and 18 except that now by using a gear train as per FIG. 19, connected by linkage 75, greater travel can be achieved to slide the door open.

FIG. 21 shows a loud speaker with cone 76 mounted on lever arm 10' the electromagnetic, electrostatic, magnostrictive or electrostrictive driven element 77 drives point 5 or 6.

FIG. 22 shows a microphone where small movement or diaphragm 78 creates large movements on lever 10' which operates a pickup device 79 for generating an output electrical signal.

In addition to the detailed descriptions above following these teachings is easy to adapt the device of FIG. 4 to a windshield wiper by putting wiper blade on lever arm 35 or 32.

Thermoelements such as bimetal strips can be used to actuate the assembly at 5 or 6 and achieve mechanical or electrical control such as at contacts 32, 33 and 34.

A scale can be made by causing pressure of the weight to actuate 5 or 6 and the pointers, as previously described for meters, to indicate the reading.

Signals, or indicators can be made by putting a flag or color panel on 10', 35 or 32 to indicate when electrical, magnetic or other forces were applied to points 5 or 6.

In speaking of forces at points 5 and 6 it is usually intended that this is on the radial line where the peripheries of the rollers are tangent to the ribbon, but in order to achieve a desired relation of stroke and force, the point of application of the force can be at other relationships, plus or minus the point of tangency.

It should also be pointed out that the mechanism can also be used in reverse where the operating lever, such as a hand brake, would be on lever arm 10' and the brake shoe would be on 5

FIG 22 may alternatively represent a mechanism wherein part 78 is a loudspeaker and torque is applied to roller 2 through lever arm 10', actuated by coil 79 in response to electrical signals applied thereto. The torque is then applied to roller 2 at its side of maximum amplitude of movement with reference to frame 4.

While the preferred form of the invention utilizes only two rollers, it is possible to utilize a larger number (e.g. four) and a larger number may be desirable for some special applications. Accordingly, the invention embraces the use of a plurality of rollers, two or more.

The ribbon may be of thin, flat, substantially nondistensible material (e.g. Mylar plastic) or it may be of tubular form with a core-chamber partially filled with displaceable material (e.g. silicon putty) in one of the tail portions of the ribbon, so related to the remainder of the mechanism as to be compressively displaced into said one tail portion by action of the associated roller in returning to a normal position from an actuated position; and to thereby exert a dampening effect in said returning action (see FIG. 29).

Instead of the opposed spaced magnetic pole-pieces for exerting torque on one of both rollers, the invention may utilize an expansible element interposed between the lever arm and a fixed abutment, torque being applied by expansion of the element, e.g. electromagnetic (FIG. 27), electrostrictive (FIG. 25), magnostrictive (FIG. 26) thermostrictive (FIG. 28), in response to fluctuations in an electric or magnetic field or temperature.

The invention further contemplates obtaining an advantage from the minimal movement of points 5 and 6 with reference to fixed points 7 and 8 (e.g. FIG. 6) in minimizing the movements of terminal conductor tails imposed thereon by rolling movements of coil-enclosing rollers (e.g. 1 and 2' of FIG. 6) or or rollers operating electrical contacts (e.g. coils 1, 2 of FIG. 2). By locating the terminal tails (e.g. of 10', FIG. 2, or of the coil in 1' or 2' of FIG. 23) close to point 5 or 6, only minimal flexing movements are imposed on the tails, and thus the likelihood of fatigue failure resulting from the flexing movements, is minimized.

FIGS. 23 and 24 illustrate a successfully operated prototype relay embodying features shown schematically in FIGS. 2, 7, 8. Armatures 5, 6 on coil-rollers 2', 1' are in spaced opposed relation to pole pieces 7, 8 carried by frame 4. A return spring 17 loads armature 6 for return movement after magnetic operation has attracted armatures 5, 6 to poles 7, 8. Armatures 5, 6 are of the double-pole type as shown in FIG. 7, i.e., armature 5 embodies the two arms 5 and 55 and the connecting shaft 40 of FIG. 7.

The relay of FIGS. 23, 24 is shown as embodying a double-throw switch, as in FIG. 2, movable contact blades 10' being normally closed on fixed contacts 13 in response to loading by a return spring 17, and movable into engagement with alternate contacts 14 upon energization of the coils embodied in rollers 1' and 2' (FIG. 8). The position of blades 10' as shown, is the energized position. Blades 10 are formed as elements of bent ribbon metal parts having respective angularly related blade and tail elements mounted in radial slots 85 in respective ends of roller 1'. Contacts are mounted on the blade elements, and conductors 86 connect the tail elements to terminal bars 87 mounted in and projecting through an insulator panel 88 carried by one end of frame 4. Fixed contacts 13, 14 embody tails similarly projecting through panel 88, and connections to the internal coils of rollers 1', 2' are provided by tails 89 likewise mounted in panel 88.

The frame 4 can be of formed plate sections having parallel track parts 4', 4'' on opposite sides of the frame.

We claim:

1. A pivotless lever mechanism comprising, in combination:
   - a frame having opposed substantially parallel tracks;
   - a flexible element having oppositely projecting tail portions attached to said frame adjacent said tracks;
   - a pair of rollers on opposite sides of said flexible element, the aggregate diameters of said rollers exceeding the

distance between said tracks;

said flexible element including loop portions each of more than 180° circumferential extent, wrapped around opposite sides of the respective rollers in an S-configuration and having a transition area of tangency between the two loops engaged between the rollers;

said tail portions extending tangently in opposite directions from the respective loops and lying against said tracks for rolling movement of the rollers and the respective tails against the respective tracks;

and a lever arm secured to one of said rollers, said arm being arranged to intersect the plane of the track engaged by the ribbon tail of said one roller at the point of tangency of said one roller and its said tail, and having a movement which is a resultant of components of circumferential swinging movement and of translational movement derived from rolling movement of said one roller along a respective track;

a movable switch contact projecting from one of said rollers past the track of the other roller; and

a fixed contact mounted on said frame in a position to be engaged by said movable contact.

2. A pivotless lever mechanism comprising, in combination:

a frame having opposed substantially parallel tracks;

a flexible element having oppositely projecting tail portions attached to said frame adjacent said tracks;

a pair of rollers on opposite sides of said flexible element, the aggregate diameters of said rollers exceeding the distance between said tracks;

said flexible element including loop portions each of more than 180° circumferential extent, wrapped around opposite sides of the respective rollers in an S-configuration and having a transition area of tangency between the two loops engaged between the rollers;

said tail portions extending tangently in opposite directions from the respective loops and lying against said tracks for rolling movement of the rollers and the respective tails against the respective tracks;

and a lever arm secured to one of said rollers, said arm being arranged to intersect the plane of the track engaged by the ribbon tail of said one roller at the point of tangency of said one roller and its said tail, and having a movement which is a resultant of components of circumferential swinging movement and of translational movement derived from rolling movement of said one roller along a respective track;

a second lever arm;

said lever arms being disposed at diametrically opposite positions on said one roller, on a diameter substantially perpendicular to the associated track;

and weight means on said arms for absorbing acceleration forces along the axis of said mechanism parallel to said tracks.

3. A pivotless lever mechanism comprising, in combination:

a frame having opposed substantially parallel tracks;

a flexible element having oppositely projecting tail portions attached to said frame adjacent said tracks;

a pair of rollers on opposite sides of said flexible element, the aggregate diameters of said rollers exceeding the distance between said tracks;

said flexible element including loop portions each of more than 180° circumferential extent, wrapped around opposite sides of the respective rollers in an S-configuration and having a transition area of tangency between the two loops engaged between the rollers;

said tail portions extending tangently in opposite directions from the respective loops and lying against said tracks for rolling movement of the rollers and the respective tails against the respective tracks;

and a lever arm secured to one of said rollers, said arm being arranged to intersect the plane of the track engaged by the ribbon tail of said one roller at the point of tangency of said one roller and its said tail, and having a movement which is a resultant of components of circumferential swinging movement and of translational movement derived from rolling movement of said one roller along a respective track

said lever arm embodying a magnetic pole piece, and including.

a magnetic pole piece carried by said frame in opposed relation to said first-mentioned pole piece and adapted to apply a torquing force to said one roller.

4. A lever mechanism as defined in claim 3, wherein said lever arm embodies a first magnetic pole piece projecting past the adjacent track, and

a second magnetic pole piece secured to said frame in opposed, closely-spaced relation to said first pole piece, the said resultant movement being the difference between said swinging and translational movements, thereby minimizing the change in spacing between said pole pieces incident to said movement.

5. In an assembly of rollers held between two substantially parallel tracks of a frame by a flexible ribbon, in an abutting tangential relationship to said ribbon, with portions of said ribbon looped around said rollers in opposite directions with respect to adjacent rollers, said ribbon including terminal tail portions in substantially parallel relation to said tracks, the improvement which comprises:

a lever arm anchored to one of said rollers and projecting past the track of the other roller, said lever arm having a movement which is a resultant of components of circumferential swinging movement and of translational movement derived from rolling movement of said one roller along a respective track; and

a tension spring interposed in one of said tail portions of the flexible element near one end of said frame, said tracks being lightly converging toward the other end of the frame, whereby movement of the rollers toward said other end will tension-load said spring so as to return said rollers to starting positions upon release of the force causing said movement.

6. A pivotless lever mechanism comprising, in combination:

a frame having opposed substantially parallel tracks;

a flexible element having oppositely projecting tail portions attached to said frame adjacent said tracks;

a pair of rollers on opposite sides of said flexible element, the aggregate diameters of said rollers exceeding the distance between said tracks;

said flexible element including loop portions each of more than 180° circumferential extent, wrapped around opposite sides of the respective rollers in an S-configuration and having a transition area of tangency between the two loops engaged between the rollers;

said tail portions extending tangently in opposite directions from the respective loops and lying against said tracks for rolling movement of the rollers and the respective tails against the respective tracks;

and a lever arm secured to one of said rollers, said arm being arranged to intersect the plane of the track engaged by the ribbon tail of said one roller at the point of tangency of said one roller and its said tail, and having a movement which is a resultant of components of circumferential swinging movement and of translational movement derived from rolling movement of said one roller along a respective track;

said lever arm being an armature; and a cooperating magnetic coil within said hollow roller.

7. A lever mechanism as defined in claim 6, wherein both of said rollers are hollow and including:

electromagnetic coils within said rollers;

there being two of said lever arms functioning as armatures fixed to the respective rollers;

and cooperating pole pieces on said frame in spaced, opposed relation to the respective armatures.

8. A pivotless lever mechanism comprising, in combination:

a frame having opposed substantially parallel tracks:

a flexible element having oppositely projecting tail portions attached to said frame adjacent said tracks;

a pair of rollers on opposite sides of said flexible element. the aggregate diameters of said rollers exceeding the distance between said tracks,

said flexible element including loop portions each of more than 180° circumferential extent, wrapped around opposite sides of the respective rollers in an S-configuration and having a transition area of tangency between the two loops engaged between the rollers;

said tail portions extending tangently in opposite directions from the respective loops and lying against said tracks for rolling movement of the rollers and the respective tails against the respective tracks;

and a lever arm secured to one of said rollers, said arm being arranged to intersect the plane of the track engaged by the ribbon tail of said one roller at the point of tangency of said one roller and its said tail, and having a movement which is a resultant of components of circumferential swinging movement and of translational movement derived from rolling movement of said one roller along a respective track;

there being two of said lever arms, each constituting a magnetic pole piece;

and a bridging pole piece having poles at respective ends in opposed, spaced relation to the respective lever arm pole pieces.

9. A lever mechanism as defined in claim **8**;

said lever arm pole pieces normally having the same polarity as the respective opposed poles of said bridging pole piece, so as to normally repel the same;

said rollers being hollow;

and electromagnetic coils within the respective rollers;

said coils being operative to reverse said normal polarity so as to attract said poles of said bridging pole piece when energized.

10. A pivotless lever mechanism comprising, in combination;

a frame having opposed substantially parallel tracks;

a flexible element having oppositely projecting tail portions attached to said frame adjacent said tracks;

a pair of rollers on opposite sides of said flexible element, the aggregate diameters of said rollers exceeding the distance between said tracks;

said flexible element including loop portions each of more than 180° circumferential extent, wrapped around opposite sides of the respective rollers in an S-configuration and having a transition area of tangency between the two loops engaged between the rollers;

said tail portions extending tangently in opposite directions from the respective loops and lying against said tracks for rolling movement of the rollers and the respective tracks;

and a lever arm secured to one of said rollers, said arm being arranged to intersect the plane of one of said tracks at the point of tangency of the roller and tail rolling upon said one track, and having a movement which is a resultant of components of circumferential swinging movement and of translational movement derived from rolling movement of the last-mentioned roller upon its respective track;

said lever arm is being a meter pointer;

and including a cooperating scale mounted on said frame;

said rollers being of different diameters;

and said pointer being carried and swung by the roller of smaller diameter.

11. A lever mechanism as defined in claim **10**,

there being two of said pointers and two corresponding scales;

the pointer carried by the larger roller having a swing of relatively small amplitude and its corresponding scale having a relatively wide indicator range;

and the pointer carried by the smaller roller having a swing of relatively large amplitude and its corresponding scale having a relatively narrow indicator range but with wider graduations for finer readings.

12. A pivotless lever mechanism comprising, in combination;

a frame having opposed substantially parallel tracks;

a flexible element having oppositely projecting tail portions attached to said frame adjacent said tracks;

a pair of rollers on opposite sides of said flexible element, the aggregate diameters of said rollers exceeding the distance between said tracks,

said flexible element including loop portions each of more than 180° circumferential extent, wrapped around opposite sides of the respective rollers in an S-configuration and having a transition area of tangency between the two loops engaged between the rollers;

said tail portions extending tangently in opposite directions from the respective loops and lying against said tracks for rolling movement of the rollers and the respective tails against the respective tracks;

and a lever arm secured to one of said rollers, said arm being arranged to intersect the plane of one of said tracks at the point of tangency of the roller and tail rolling upon said one track, and having a movement which is a resultant of components of circumferential swinging movement and of translational movement derived from rolling movement of the last-mentioned roller upon its respective track;

and a second lever arm secured to and projecting from one of said rollers past the track of the other roller to function as the clapper of a bell.

13. A pivotless lever mechanism comprising, in combination;

a frame having opposed substantially parallel tracks;

a flexible element having oppositely projecting tail portions attached to said frame adjacent said tracks;

a pair of rollers on opposite sides of said flexible element, the aggregate diameters of said rollers exceeding the distance between said tracks;

said flexible element including loop portions each of more than 180° circumferential extent, wrapped around opposite sides of the respective rollers in an S-configuration and having a transition area of tangency between the two loops engaged between the rollers;

said tail portions extending tangently in opposite directions from the respective loops and lying against said tracks for rolling movement of the rollers and the respective tracks;

and a lever arm secured to one of said rollers, said arm being arranged to intersect the plane of one of said tracks at the point of tangency of the roller and tail rolling upon said one track, and having a movement which is a resultant of components of circumferential swinging movement and of translational movement derived from rolling movement of the last-mentioned roller upon its respective track;

said lever arm is being connected to an artificial limb to move the same;

the frame being attached to a limb stump to which said artificial limb is articulated by means of said lever mechanism;

and including a second lever arm connected to the other roller near the point of tangency of said other roller and the flexible element and associated track;

and wherein said first-mentioned lever arm projects from the side of said one roller remote from the area of tangency of said one roller and the flexible element and associated track.

14. A lever mechanism as defined in claim **26**:

one of said rollers being smaller than the other;

said second lever is attached to a muscle of said limb stump and to the larger roller at the area of tangency between said larger roller and the flexible element and the associated track, for actuating said lever mechanism.

15. A lever mechanism as defined in claim **1**, including a second lever arm secured to said one roller and projecting past the track of the other roller, and a loudspeaker actuated by said second lever arm.

16. A pivotless lever mechanism comprising, in combination:

a frame having opposed substantially parallel tracks;

a flexible element having oppositely projecting tail portions attached to said frame adjacent said tracks;

a pair of rollers on opposite sides of said flexible element, the aggregate diameters of said rollers exceeding the distance between said tracks;

said flexible element including loop portions each of more than 180° circumferential extent, wrapped around opposite sides of the respective rollers in an S-configuration and having a transition area of tangency between the two loops engaged between the rollers;

said tail portions extending tangently in opposite directions from the respective loops and lying against said tracks for rolling movement of the rollers and the respective tails against the respective tracks;

and a lever arm secured to one of said rollers, said arm being arranged to intersect the plane of the track engaged by the ribbon tail of said one roller at the point of tangency of said one roller and its said tail, and having a movement which is a resultant of components of circumferential swinging movement, and of translational movement derived from rolling movement of said one roller along a respective track:

said lever arm is being actuated by a microphone connected to its swinging end, for transmitting torque vibrations to said one roller;

and including a second lever arm attached to the other roller and actuating an electrical signal generating device.

17. A pivotless relay mechanism comprising, in combination:

a frame having opposed substantially parallel tracks:

a flexible element having oppositely projecting tail portions attached to said frame adjacent said tracks;

a pair of rollers on opposite sides of said flexible element, the aggregate diameters of said rollers exceeding the distance between said tracks;

said flexible element including loop portions each of more than 180° circumferential extent, wrapped around opposite sides of the respective rollers in an S-configuration and having a transition area of tangency between the two loops engaged between the rollers;

said tail portions extending tangently in opposite directions from the respective loops and lying against said tracks for rolling movement of the rollers and the respective tails against the respective tracks;

and a movable switch contact arm secured to one of said rollers, said arm being arranged to intersect the plane of the track engaged by the ribbon tail of said one roller at the point of tangency of said one roller and its said tail, and having a movement which is a resultant of components of circumferential swinging movement, and of translational movement derived from rolling movement of said one roller along a respective track;

said movable switch contact projecting from the side of said one roller adjacent said transition area, whereby its resultant movement is amplified by addition of said swinging and translational movements;

and including means applying torque to the other roller at a point near the area of tangency of said other roller to said flexible element and the associated track.

18. A lever mechanism as defined in claim 17, constituting a relay including:

said torque-applying means comprising an electrostrictive element interposed between said other roller and the frame near said point of tangency;

said electrostrictive element producing movement by change in its dimension in response to fluctuations in an electrical field.

19. A lever mechanism as defined in claim 17 constituting a relay including:

said torque-applying means comprising a magnostrictive element interposed between said other roller and the frame near said point of tangency;

said magnostrictive element producing movement by change in its dimension in response to fluctuations in a magnetic field.

20. A lever mechanism as defined in claim 17, constituting a relay including:

a movable switch contact projecting from the side of said one roller adjacent said transition area, whereby its resultant movement is amplified by addition of said swinging and translational movements;

and including means applying torque to the other roller at a point near the area of tangency of said other roller to said flexible element and the associated track;

said torque-applying means comprising an electromagnetic element interposed between said other roller and the frame near said point of tangency;

said electromagnetic element producing movement by change in its dimension in response to fluctuations in an electrical field.

21. A lever mechanism as defined in claim 17, constituting a relay including:

a movable switch contact projecting from the side of said one roller adjacent said transition area, whereby its resultant movement is amplified by addition of said swinging and translational movements;

and including means applying torque to the other roller at a point near the area of tangency of said other roller to said flexible element and the associated track;

said torque-applying means comprising a thermoresponsive element interposed between said other roller and the frame near said point of tangency;

said thermoresponsive element producing movement by change in its dimension in response to fluctuations in temperature changes.

22. A lever mechanism as defined in claim 6,

said coil having terminal connections located in the area of tangency of said flexible element to said one roller and the associated track;

whereby to minimize movement of said connections imposed thereon by movement of said one roller.

23. A pivotless lever mechanism comprising, in combination:

a frame having opposed substantially parallel tracks;

a flexible element having oppositely projecting tail portions attached to said frame adjacent said tracks;

a pair of rollers on opposite sides of said flexible element, the aggregate diameters of said rollers exceeding the distance between said tracks;

said flexible element including loop portions each of more than 180° circumferential extent, wrapped around opposite sides of the respective rollers in an S-configuration and having a transition area of tangency between the two loops engaged between the rollers;

said tail portions extending tangently in opposite directions from the respective loops and lying against said tracks for rolling movement of the rollers and the respective tails against the respective tracks;

the material in said flexible element embodying a core of displaceable material in one of said tail portions, so related to the remainder of the mechanism as to be compressively displaced into said one tail portion by action of the associated roller in returning to a normal position from an actuated position, and to thereby exert a dampening effect in said returning action.

24. A pivotless lever mechanism comprising, in combination:

a frame having opposed substantially parallel tracks;

a flexible element having oppositely projecting tail portions attached to said frame adjacent said tracks;

a pair of rollers on opposite sides of said flexible element, the aggregate diameters of said rollers exceeding the distance between said tracks;

said flexible element including loop portions each of more than 180° circumferential extent, wrapped around opposite sides of the respective rollers in an S-configuration and having a transition area of tangency between the two loops engaged between the rollers;

said tail portions extending tangently in opposite directions from the respective loops and lying against said tracks for rolling movement of the rollers and the respective tracks;

and a lever arm secured to one of said rollers, said arm being arranged to intersect the plane of one of said tracks at the point of tangency of the roller and tail rolling upon said one track, and having a movement which is a resultant of components of circumferential swinging movement and of translational movement derived from rolling movement of the last-mentioned roller upon its respective track;

said rollers including sprocket teeth on their periphery;

and said ribbon having sprocket apertures receiving said teeth to provide rolling geared connections between said rollers and said ribbon.

25. A lever mechanism as defined in claim **14**, including an hydraulic actuator connected between one of said rollers and said frame to apply torque to said one roller.

26. A pivotless lever mechanism comprising, in combination:

a frame having opposed substantially parallel tracks:

a flexible element having oppositely projecting tail portions attached to said frame adjacent said tracks;

a pair of rollers on opposite sides of said flexible element, the aggregate diameters of said rollers exceeding the distance between said tracks;

said flexible element including loop portions each of more than 180° circumferential extent, wrapped around opposite sides of the respective rollers in an S-configuration and having a transition area of tangency between the two loops engaged between the rollers;

said tail portions extending tangently in opposite directions from the respective loops and lying against said tracks for rolling movement of the rollers and the respective tracks;

said rollers being of different diameters;

a door attached to the smaller roller for swinging movement about the axis thereof;

and means attached to the larger roller and operable to exert torque thereon to control said swinging movement.

27. Mechanism as defined in claim **26**, wherein said last means is operative to transmit door-opening movement to the door.

28. Mechanism is as defined in claim **26**, wherein said last means is operative to retard closing movement of the door.