No. 647,491. Patented Apr. 17, 1900.

E. G. HOFFMANN.

WORM GEARING.

(Application filed June 14, 1899.)

(No Model.) 5 Sheets—Sheet 1.

Fig. 1.

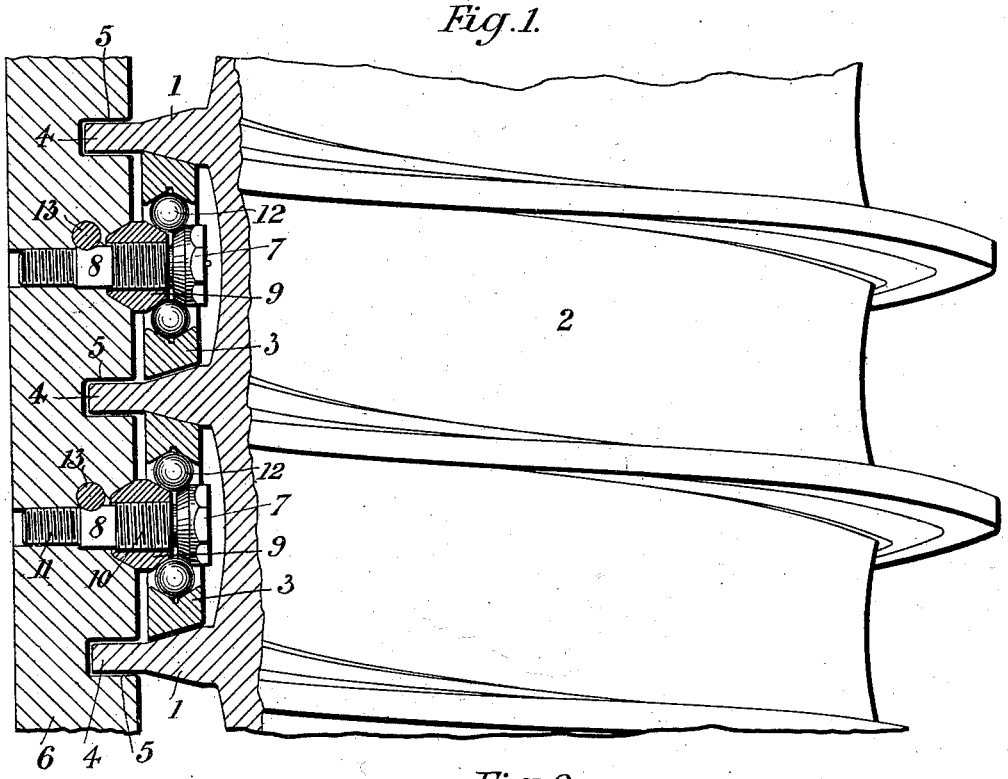
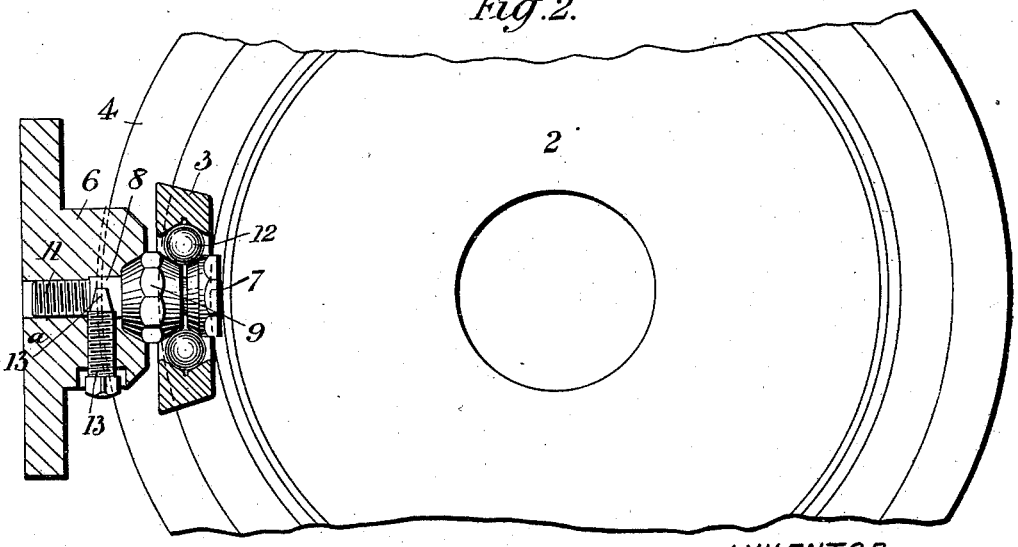



Fig. 2.

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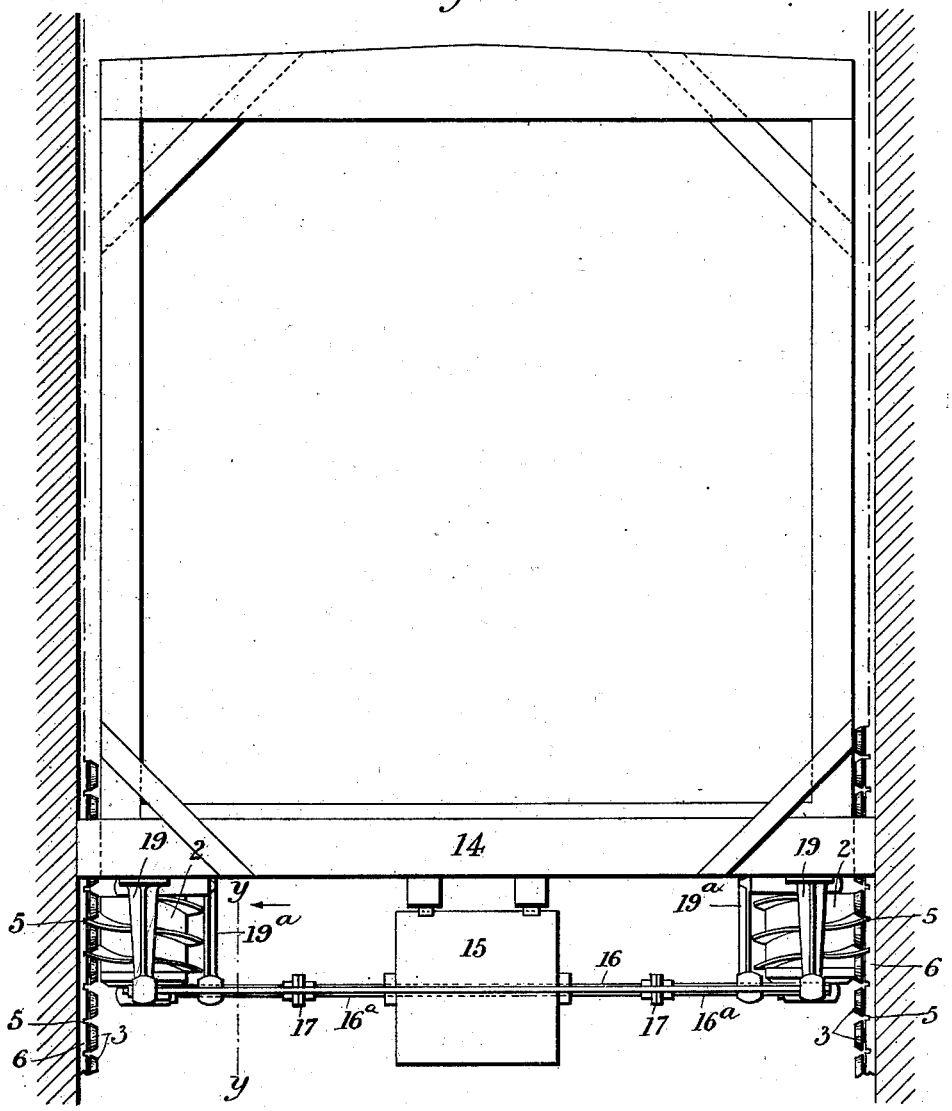
(No Model.) 5 Sheets—Sheet 2.

*Fig. 3.*

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## WORM GEARING.

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(No Model.) 5 Sheets—Sheet 3.

Fig. 5.

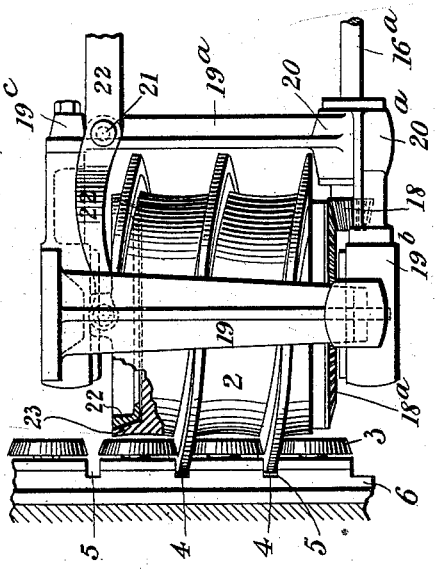



Fig. 6.

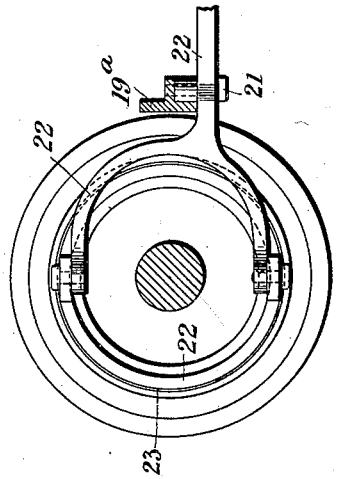
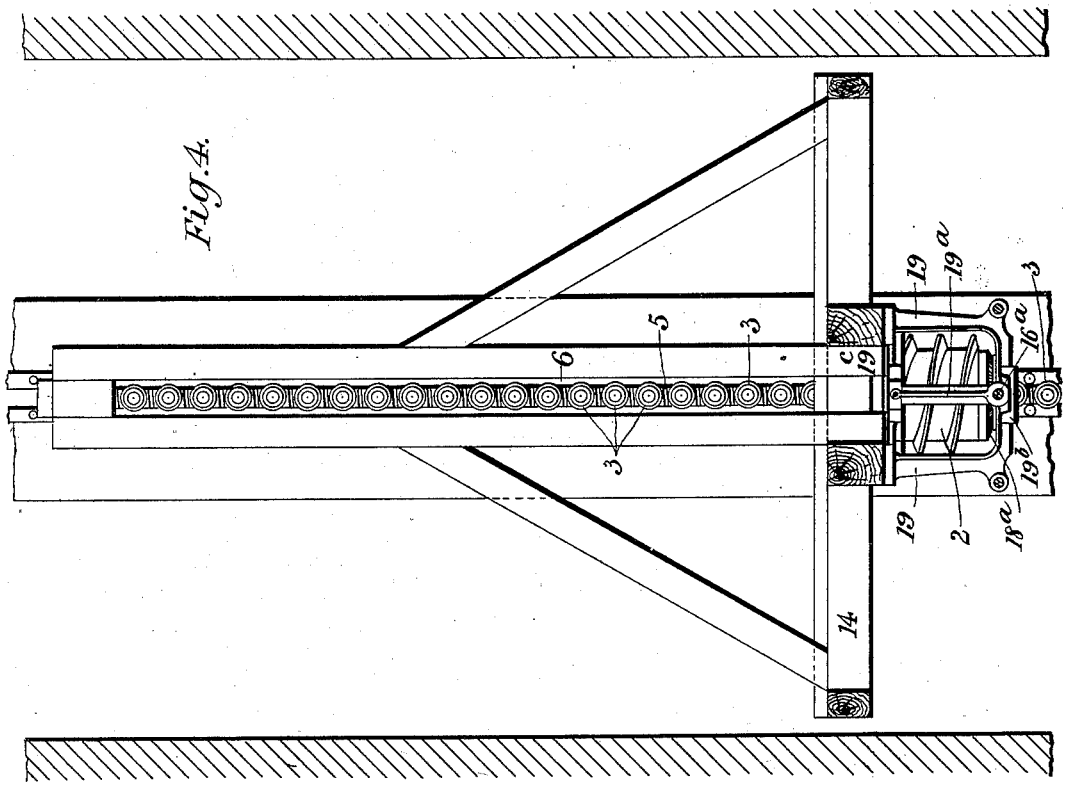



Fig. 4.

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(No Model.) 5 Sheets—Sheet 4.

Fig. 8.

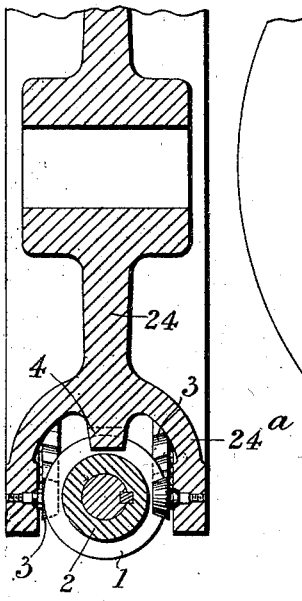



Fig. 7.

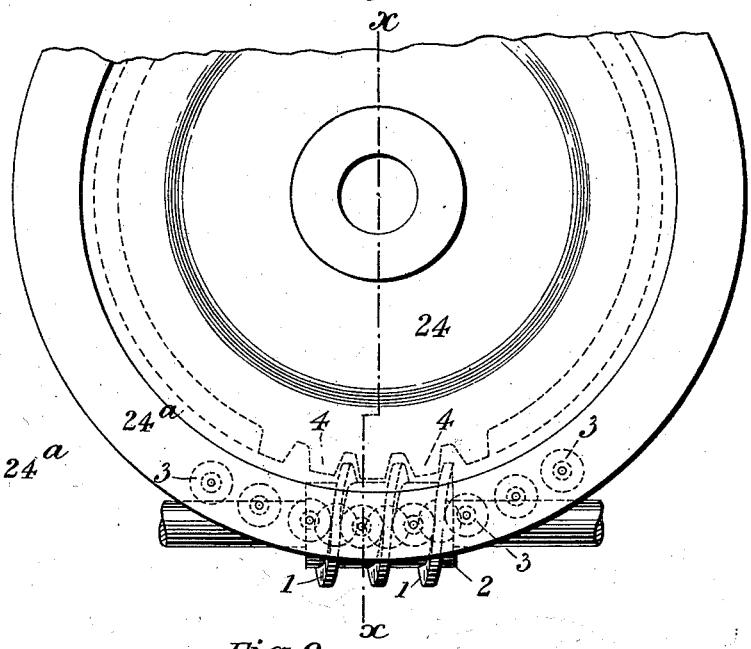
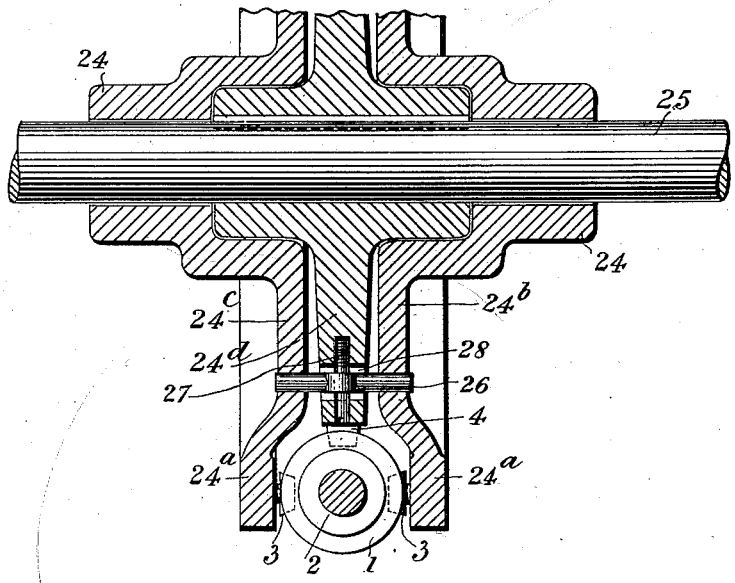



Fig. 9.

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WORM GEARING.

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(No Model.) 5 Sheets—Sheet 5.

Fig. 10.

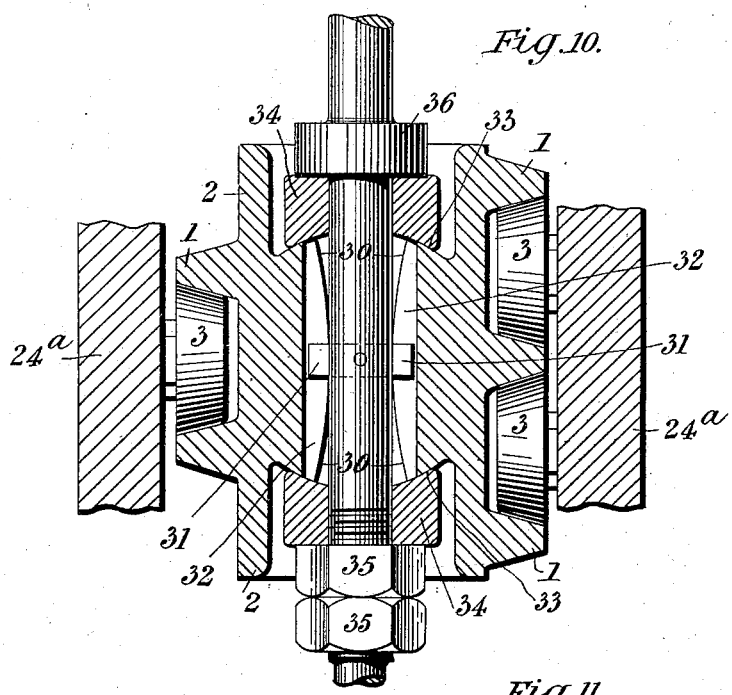
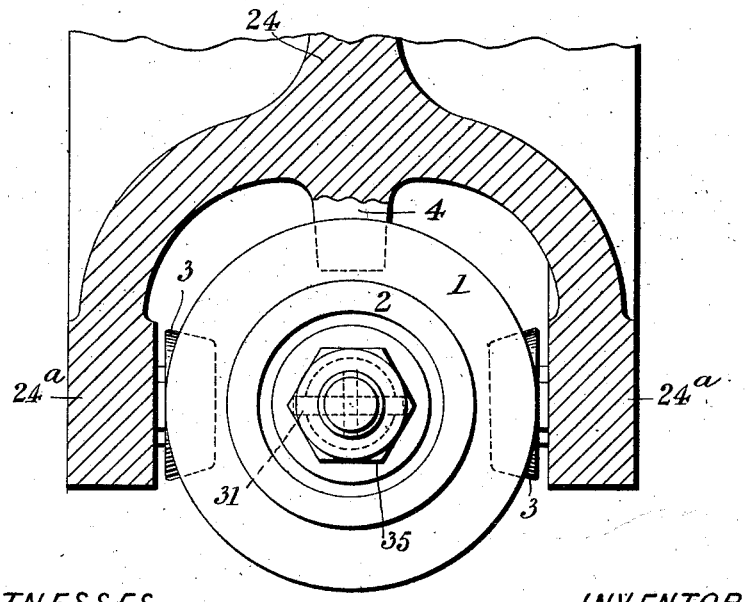



Fig. 11.

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# UNITED STATES PATENT OFFICE.

ERNST GUSTAV HOFFMANN, OF CHELMSFORD, ENGLAND,

## WORM-GEARING.

SPECIFICATION forming part of Letters Patent No. 647,491, dated April 17, 1900.

Application filed June 14, 1899. Serial No. 720,474. (No model.)

*To all whom it may concern:*

Be it known that I, ERNST GUSTAV HOFFMANN, a subject of His Majesty the German Emperor, residing at Chelmsford, in the county of Essex, England, have invented a certain new and useful Improvement in Worm-Gearing, of which the following is a specification.

My invention relates to certain improvements in and connected with worm-gearing, the object of the same being to produce a practical worm-gearing adapted by reason of its easy running, absence of friction, and its great safety for various mechanical purposes, such as for elevator-work, where the use of a rack and worm is even safer than a hydraulic ram, by reason of the whole gearing being self locking or holding in any position, so long, of course, as the worm does not exceed a certain amount of incline.

According to one form of my invention the worm may be of any usual or convenient form, though the actual tooth is of a construction hereinafter described; but in place of employing teeth on the worm-wheel, or, it may be, the rack as an equivalent thereof, I insert studs on the periphery of the wheel, either in line with the radius or in line with the axis of the wheel, or on the face of the rack, and upon each of said studs a ring-shaped roller having the outline of the tooth it substitutes revolves on a ball-bearing of a special construction. In the case of an elevator such racks would be preferably fixed to the sides of the well and the worm or worms to the car-platform or to some suitable part of the car, which would also carry a suitable motor, preferably electric, with shafting and gearing connecting it to the worm or worms to rotate same, and thus move the car positively up or down, the arrangement enabling the gearing to be self-locking and permitting the car to be counterbalanced to the extent desired.

I also employ various other details in carrying out my invention, which form an important feature of same and which will be claimed as part of same.

In the accompanying drawings I illustrate various forms of my invention and the manner of carrying it into effect.

In the drawings, Figure 1 is a section of a part of a worm and rack, the worm being partly in elevation. Fig. 2 is a sectional plan through the rack and one of the roller-studs shown in Fig. 1, the worm being viewed in plan. Fig. 3 is a front elevation of an elevator-platform and part of a well, showing my invention applied thereto, the side walls of the well being in section. Fig. 4 is a side elevation of Fig. 3, partly in section, on line *y y* of said figure, looking in the direction of the arrow. Fig. 5 is an elevation, on a larger scale than Figs. 3 and 4, of the rack-worm and a part of certain appliances connected thereto. Fig. 6 is a plan of the worm shown in Fig. 5. Fig. 7 is a modification, being a side elevation of a worm-wheel engaging with a worm. Fig. 8 is a cross-section through line *x x*, Fig. 7. Fig. 9 is a similar view to Fig. 8, but showing a modification of the worm-wheel. Fig. 10 is a plan view, partly in section, of a modified arrangement over that shown in Figs. 7 and 8, in which the worm is allowed a play or movement; and Fig. 11 is an end view of same.

The gearing may consist of the ordinary form of worm; but I prefer to use the special form shown most clearly in Figs. 1 and 5, where it will be seen that the ordinary beveled faces 1 1 of the tooth of the worm 2, which engages in the present case with the rollers 3, are provided with a prolongation 4, which enters into the angularly-arranged grooves 5 on the rack bar or base 6—that is to say, the tooth is so extended diametrically that it enters the solid part of the rack. These grooves or slots, however, have a margin of space on both sides of the tooth, so that the latter is not actually in contact with the rack, the object of this extension or prolongation of the tooth being to provide a safety device whereof the tooth may actually engage with a solid rack in the event of one of the rollers breaking, although normally the tooth is out of contact with this portion of the rack. This forms a safety device of considerable value where much depends upon the worm, as in the case where same is used in elevator-work.

The faces of the worm-teeth are flat, but of such an angle with the rollers as if the two were bevel-wheels, the two angles meeting in the axis of the worm, this construction en-

abling flat, and therefore increased, contact surfaces to be employed.

The rollers 3, as will be understood, replace the usual teeth of the rack, each roller being ring-shaped and having the outline of the tooth it substitutes. The ring or roller 3 is mounted on a ball-bearing of the kind known as a "single-row four-track bearing." The head 7 of the stud 8, which holds the roller, is conical on its under side and forms a part of the ball-bearing cone, and adjoining it is a movable double cone 9, fitting on the stud by a screw-thread 10, having, for instance, twenty-four threads per inch, while the end of the stud is also provided with a screw-thread 11, which (with twenty-four threads on the first) preferably has only twenty threads per inch, this latter screwing into the rack body or base 6. Between the outer face of the cone 9 and the cone-face of the head 7 is situated a row of balls 12, which bear on the double-coned face forming the interior of the ring or roller 3. The head 7 of the stud projects from the outer face of the ring and is suitably shaped to enable it to be held by a wrench or tool, so that the stud may be screwed into the rack. The inner face of the cone 9 seats in a correspondingly-shaped recess in the rack-base 6. It will be seen that in this way the stud may be screwed onto the base 6 from the outside; but in the operation of an elevator service, for instance, it will be appreciated that unless some device were provided to secure the stud the concussions would have a tendency to loosen it.

The device which I employ is the above-described arrangement of the two threads, which are non-corresponding in their pitch, together with, if desired, a locking device. With such threads when screwing the stud into the rack it will be obvious that the twenty-threads-per-inch portion will pull the stud into the rack faster than the twenty-four-threads-per-inch portion will allow it to pass through the cone 9, which is seated in the rack-base, so that a slight straining is set up through the difference between the two small threads, with the result that a very gradual tightening of the parts is produced, the operation being practically the same as if a screw having one hundred and twenty threads per inch were employed, without the disadvantages which such a fine thread as the latter would have. As a matter of practice it may be said that with this construction of twenty-four and twenty threads per inch, respectively, one complete turn of the stud can be given to same after the parts have just begun to tighten, and this one complete turn shows to what extent the members have been strained and jammed together. The incline of the threads being thus small, no danger exists of the stud being loosened by concussions when the above method is employed. To furthermore secure the stud, I employ a set-screw 13, which passes through from the side of the rack-base 6 and is provided with a conical end $13^a$, which bears tangentially against the plain portion of the stud 8 and jams the latter after it has been tightened up.

In applying the foregoing arrangement of parts to an elevator, as shown in Figs. 3 to 6, I preferably employ two of the worms 2 and place them beneath the platform 14, driving them by means of an electric motor 15 through a shaft 16 and couplings 17, the shaft $16^a$ on the other side of said couplings driving through bevel-wheels 18 $18^a$, Fig. 5, the worms 2. Each worm is carried on suitable bearings in a bracket 19, consisting of a top part, a bottom part $19^b$, and two vertical connecting-bars, said brackets having a third connecting-bar $19^a$, which is bolted at $19^c$ to the upper part of the bracket 19 at the top and carries the upper half 20 of the bearing for shaft $16^a$. The lower half $20^a$ of the bearing is formed as part of the bottom $19^b$. By releasing the bolt $19^c$ the bar $19^a$ can be removed, together with the upper part 20 of the bearing, so that after undoing the coupling 17 the part $16^a$ of the shaft, with the bevel-wheel 18, can be removed, whereby the worm 2 can be reached for repair or removal. To the bar $19^a$ is pivoted at 21 lever 22, the yoke-shaped end of which pivotally carries a cone-shaped ring or disk 23, which fits into a correspondingly-shaped recess $23^a$ in the upper part of the worm 2, one of such coned parts bearing a leather or other suitable facing. The lever 22 may be operated in some suitable and well-known way from the car and as will be seen may act on the coned part 23 to cause it to act as a clutch or brake or holding device for the worm, in which manner the worm proper becomes the means for stopping the car, the arrangement being preferable to applying a brake direct to the motor-shaft, as the worm is in direct and positive engagement with the rack.

The above-described arrangement of gearing, being absolutely self-locking, permits the car to be counterbalanced to any extent desired, because the car can neither go up nor down, but can only move in the direction in which the worms drive it as said worms wind their way either up or down the rack.

When the worm is used in connection with a worm-wheel, it is preferable to mount the studs, with their rollers, on the side of the periphery of the wheel or at right angles to such periphery, as the arrangement affords greater facility for carrying the construction into effect. The advantage of this ball-bearing and gearing is also very great when it becomes necessary to drive the worm instead of the worm-wheel. Such gearing is frequently used where high speed is required, but no great power is to be transmitted except that wanted to create the speed. As at present constructed such gears require the worm to have a very rapid incline in order to make them work at all satisfactorily, whereas the angle of the

worm-thread can be much reduced when the present arrangement is employed in consequence of the friction between the worm and the worm-wheel teeth, which in this instance are the rollers, being reduced to mere rolling friction as against a rubbing one in the ordinary construction.

In the construction shown in Figs. 7 and 8 the ball-bearing rollers 3 are carried on the opposite side of a yoke-shaped portion $24^a$ of the worm-wheel 24—that is to say, on the inside of such part $24^a$—and opposed to each other, this double construction enabling the dimensions of the ball-bearing rollers forming the worm-wheel teeth, and naturally the diameter of the worm, to be considerably reduced. The extension or safety teeth 4 in this case I prefer to form on the worm-wheel 24, between the parts $24^a$, the teeth passing between the teeth 1 of the worm 2, but not engaging with same unless through the breakage of some of the rollers. The teeth 4, however, may be formed on the teeth 1 in the same way as previously described and enter grooves in the parts $24^a$ between the rollers in the same way.

It is desirable where the rollers are duplicated, as in the above instance, that necessarily the rollers on both sides should be in gear with the worm, which might not be the case if the divisioning of the wheel in the setting of the rollers is at all faulty. To obviate this, I employ the arrangement shown in Fig. 9, where it will be seen that the worm-wheel 24 is divided into two parts $24^b$ and $24^c$, which are loose upon their shaft 25, so that they are compensating, the play enabling the worm to bear equally on a roller on each side. The two parts $24^b$ and $24^c$ drive, through a number of pins 26, a wheel $24^d$, placed between the two parts $24^b$ and $24^c$ and fixed to the shaft 25, such pins 26 being pivotally hung on studs 27 in slots 28, which studs are formed in this instance as screws passing from the periphery of the wheel $24^d$ through the slots. In this way the pins, while serving to drive wheel $24^d$, can yet rock sufficiently to enable the compensating movement to take place between the parts $24^b$ $24^c$, or when the worm-wheel is arranged substantially as shown in Figs. 7 and 8—that is to say, is a fixture—the worm may be allowed to be slightly movable laterally as between the two sets of rollers, so that should those on one side press heavily against the worm the latter will yield sidewardly, and thus insure an equal pressure on both sides. To accomplish this, various constructions could be used. For instance, the worm might be mounted on a shaft in a kind of ball-and-socket joint or on a slide which moves sidewardly, in which event of course the worm would require to be attached to its shaft by a suitable coupling.

One arrangement which has been found suitable is shown in Figs. 10 and 11. In this the worm-wheel 2 is provided with an opening through same, formed with outwardly-flaring mouths at each end, as shown at 30, the curvature through the hole being that of the segment of a circle which touches the shaft only at the central point. The worm is capable of revolving with the shaft through a key 31, secured to the shaft and engaging in slots 32, the arrangement enabling the worm to be drawn off the shaft. The worm is provided, further, with a central boss portion, the ends 33 of which are struck on the curve of a circle and which correspond with abutments 34 34, having similar curved faces, one of these abutments being held against the boss portion of the worm by means of nuts 35, engaging with a screwed portion of the shaft, which forces the other abutment against a fixed collar 36. When the pressure of the nuts is properly adjusted, the worm will be able to rock slightly on the ball-and-socket joint which is thus formed and so may adjust itself to inequalities of the other member.

What I claim is—

1. In a worm-gearing and in combination with the worm forming one member, a revoluble ring forming part of the other member, a double cone-face on the inside of the ring, a stud for carrying the ring provided with a head having a cone-face, a second adjustable cone-face carried by the stud, and antifriction-balls between the cone-faces of the stud and ring.

2. In a worm-gearing, the combination with a roller forming a part of one member thereof, a stud for holding same having separate threaded portions of a different pitch, a base into which one threaded portion screws, and a threaded part carried by the base into which the second threaded portion screws whereby a straining or jamming is set up between the two parts as the stud is screwed in.

3. In a worm-gearing and in combination, a revoluble roller forming a part of one member, a threaded stud for carrying same, a base forming a further part of the same member, into which the stud is screwed, a further threaded portion on the stud, the threads of which are of a different pitch to the first threads, an adjustable part carried by such further threaded portion and adapted to seat on the base whereby when the stud is screwed into the base a straining and jamming is set up between the part seating on the base and the threaded portion screwing into the latter.

4. In a worm-gearing, and in combination, a revoluble ring forming a part of one member, a threaded stud for carrying same, a cone-shaped head on the stud, a base forming a further part of said member into which the stud is screwed, a further threaded portion on the stud the threads of which are of a different pitch to the first threads, an adjustable cone-shaped part carried by the latter threaded portion and adapted to seat on the base, and antifriction-balls carried between this coned part, the coned head, and the ring, the difference between the pitch of the threads causing a straining and jamming between the

part seated on the base and the threaded portion screwing into the latter when the stud is screwed in.

5. In a worm-gearing, the combination with a roller forming a part of one member thereof, a stud for holding same, having separate threaded portions of a different pitch, a base into which the threaded portion screws, a threaded part carried by the base into which the second portion screws, whereby a straining and jamming is set up between the two parts as the stud is screwed in, and a set-screw having a conical head screwing into the base and adapted to engage tangentially with the stud.

6. In a worm-gearing, the combination with a worm forming one member thereof, of rollers forming a part of the other member thereof, and means carried by one of the members, and adapted to engage with the other member, in the event of the rollers giving way.

7. In a worm-gearing, and in combination a worm forming one member thereof, having a tooth provided with a prolongation, and a base forming a part of the other member thereof, provided with grooves with which said prolongation can engage in the case of a breakage of a part forming the rest of the member.

8. In a worm-gearing, the combination with rollers forming one member thereof, a base for carrying same, and grooves on such base between said rollers, of a worm forming the other member, the tooth of said worm being prolonged to engage with said grooves in the event of the rollers giving way.

9. In a worm-gearing, a worm forming one of the members of same, a worm-wheel forming the other member of same, two sets of antifriction-rollers oppositely arranged with which the worm engages, means for carrying the rollers, and means for equalizing the pressure on the rollers on both sides of the worm.

In testimony whereof I have hereunto set my hand in the presence of two subscribing witnesses.

ERNST GUSTAV HOFFMANN.

Witnesses:
PHILIP M. JUSTICE,
ALLEN PARRY JONES.