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Drawing attached.

COMPLETE SPECIFICATION.

"Small calculating machine."

I, FREDERICK BERNHARD RICE, of Club Chambers, 96 Phillip Street, Sydney, in the State of New South Wales, Commonwealth of Australia, Patent Attorney, hereby declare this invention and the manner in which it is to be performed to be fully described and ascertained in and by the following statement:—

The invention relates to a small calculating machine for all four species which considerably surpasses all calculating machines of this kind hitherto known in respect of simple construction, small, pleasing shape and handiness.

The calculating machine is provided with a single stepped drum around which all the entering and totalising elements are arranged in a circle. Moreover, with this calculating machine, subtractions (divisions) can be carried out without change of direction of the stepped drum.

A calculating machine of this kind has already been suggested in the pertinent literature but has not been able to get adopted in practice because of its complicated, and yet insufficient, construction.

In order to carry out subtractions with this known calculating machine without changing the direction of rotation of the crank or of the stepped drum, the driving element for the entering elements is provided with one or two groups of movable teeth in addition to a group of fixed teeth which movable teeth require a complicated adjusting mechanism by the aid of which they are brought into the working position by hand.

This complicated arrangement of the driving element, which considerably impaired the simple construction of the small calculating machine, has been obviated by the subject of the invention. According to the invention, the stepped drum has fixed groups, of gear teeth only to wit the ordinary stepped gear teeth and

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a complementary group of gear teeth, also fixed which is arranged in such a manner that in the normal non-shifted position of the stepped drum the ordinary stepped gear teeth are brought into the operative position for addition with respect to the entering pinions and in the shifted position of the stepped drum the complementary gear teeth are operating with the entering pinions effecting a subtraction.

A further disadvantage inherent to the known small calculation machine having one stepped drum only consists in that, when such a machine has to make provision for a large number places, the stepped drum too has inavoidably a comparatively large diameter in order to allow the arrangement of an appropriate number of entering elements in a circle around it.

Accordingly there is a high transmission ratio in the drive between the stepped drum and the entering pinions in mesh with it so that when a calculation is carried out the totalising elements would also revolve at a higher angular velocity. Thereby strong resistances are set up to the drive that would prevent a light and regular operation of the calculating machine. Moreover, the high angular velocity of the totalising elements acts unfavourably on the detent devices too by means of which the totalising elements are arrested in the correct position when coming to a temporary rest.

The invention has the object of reducing the high angular velocity of the totalising elements as far as possible, and of overcoming thereby the aforesaid difficulties. According to the invention this is achieved in a simple way by interposition of reduction gearing in the transmission between each entering element and the totalising element operated thereby, and accordingly the period of action of the stepped drum on the entering pinions is prolonged, whereby the resistance to the rotation of the totalising members is distributed over a maximum length of the crank path, and whereby the angular velocity of the numeral drums is reduced. This enlarged angle of rotation of the entering pinions is moreover made use of according to the invention for an increase of the effective angle of rotation of the decade transfer pinions. For this purpose two decade transfer pinions per place are provided according to the invention which pinions have a number of teeth smaller than ten and are arranged somewhat offset relative to one another and shiftable as a total group on the spindles of the entering pinions. In this arrangement, when a decade transfer occurs, first the total group of the aforesaid two pinions is lifted by a tens transfer member acted by the next lower place of the entering mechanism so that the lower of the two pinions comes in the range of the ordinary tens transfer tooth of the stepped drum. Then the tens transfer is completed by the said tens transfer tooth, meshing with the lower of the said two pinions. Instantaneously when tens transfer is finished, the upper of the two pinions and thereby the entering spindle is locked by a locking disc connected with the stepped drum and acting on the upper pinion, meshing with it.

It has been found when constructing the calculating machine in practice that it is unfavourable to make the entering pinions with ten teeth and to give the same as well as to the teeth of the stepped drum an ordinary flank shape in view of the given small diameter of these pinions, since the teeth would be weakened and unfavourable conditions of mesh would result. Owing to the reduction gearing it is now possible according to the invention to provide the entering pinions with less than ten teeth. Since moreover the calculating machine is conveniently built in such a manner that the sense of rotation of the entering and of the totalising elements is always the same, the teeth of the entering pinions and of the stepped drum are shaped asymmetrically according to a further development of the invention so that in spite of the small dimensions of the entering pinions the teeth thereof are in good meshing conditions with the teeth of the stepped drum.

In the drawing a small calculating machine constructed according to the invention is illustrated by way of example, to wit:—

Fig. 1 shows the calculating machine in

a longitudinal section, partly in elevation.

Fig. 2 shows a part-cross section along the line II-II of Fig. 1.

Fig. 3 shows a stepped drum with an entering pinion of the lowest place in elevation.

Fig. 4 shows a further embodiment of the stepped drum with an entering element in elevation.

Fig. 5 is a part cross-section through the gear teeth of the stepped drum with an entering element in a horizontal section.

Fig. 6 shows the decade transfer members of a place as well as further transmission members in a perspective view, and

Figs. 7 to 10 show two associated transmission elements in various positions during a transfer phase in sectional plan view.

A stepped drum 3 is fixedly arranged on a shaft 1 which journalled in the body of the machine and is adapted to be set in rotary motion by a crank 2. The stepped drum 3 has on its circumference a group of gear teeth a which act on the entering pinions 4 for the totalising mechanism c. The group of gear teeth a is composed of the toothed sector a1 arranged in echelon according to the digits 1 to 9, and of the toothed sectors a2 arranged in echelon according to the complementary digits 9 to 0, i.e. in the opposite sense. Moreover on the stepped drum according to Fig. 3 a tooth z is arranged ahead of or behind the group of teeth and in the drum according to Fig. 4 a toothed sector z1 with ten teeth is provided. The group of gear teeth a is limited to a sector of the stepped drum which in the normal position of the stepped drum lies outside the range of the entering pinions 4. The entering pinions 4 are arranged on a circle surrounding the stepped drum concentrically. They are arranged axially shiftable and are secured against rotation relative to the spindles 5. The entering pinions are individually adjustable by means of adjustment slides 6. The adjustment slides are guided on pillars 7, and are arrested each by a spring biased ball 9 engaging a rest 8 of said pillars 7 in the position corresponding to the adjusted value from 0 to 9. The adjustment slides 6 project with their handles through vertical slots 15 of the casing.

The transmission mechanism from the entering mechanism to the totalising mechanism is composed as follows:—

On the upper ends of the spindles 5 small transmission wheels 10, meshing with toothed pinions 11, are fixed. The toothed pinions 11 are rigidly connected to numeral drums 13, each of said numeral drums having a decade transfer cam 12 of known construction, and are loosely rotatable on pins 14 inserted, at right angles to the spindles 5, into radial bores of the rotatably journalled body 16 of the totalising mechanism.

The drive of the numeral drums 13 is geared down with respect to the entering pinions, for example 1:2 in the embodiment shown. For this purpose the transmission wheels 10 have five teeth each, while the toothed pinions have ten teeth.

In view of the given narrow spatial conditions, the dimensions are very small, particularly those of the transmission wheels 10 (3.4mm diameter) so that for example the use of bevel pinions, though not altogether impossible, would practically be very unfavourable. According to the invention a cog wheel gearing is provided the transmission wheels 10 being constructed as the cog wheels engaging the ordinary teeth of the pinions 11.

In the drive described, twice the angular movement of the transmission wheel 10 and accordingly also of the stepped drum 3 is required for turning a numeral drum 13 by one digit, so that the resistance to rotation of the totalising mechanism is spread over a longer path of the crank 2.

The decade transfer pinion is also arranged on the spindle 5 and accordingly has also to perform twice the angular movement of a numeral drum when a decade transfer is effected. This is effected by operating the decade transfer pinion in steps, i.e. in the present case in two steps. The arrangement made for this purpose is as follows:—

The decade transfer pinions form twin pinions 17, 18 each having five teeth, rigidly connected to one another and as a total longitudinally adjustable on the

spindles 5. The five teeth of the two pinions 17, 18 are offset relative to one another half a pitch of the teeth (Figs. 7 to 10). Into a reduced neck portion 19 (Fig. 6) of each of the decade transfer pinions 17, 18 engages a fork 20, which is guided by means of a perpendicularly projecting pin 20' (Fig. 1) sliding in a stationary bearing body 21. The pin 20' is acted upon by the decade transfer cam 12 of the next lower place of the counting mechanism. The pinions 18 for the totalising mechanism are operated by a decade transfer tooth 22, and the pinions 17 by a member 23. The decade transfer tooth 22 is provided on a disc 24. The transfer pinions 17 form, in conjunction with the transfer member 23, detent devices, which arrest the spindles 5 together with their pinions 4, 18, 17, 10 and with the toothed pinions 11 after a decade transfer has been performed. For this purpose, the transfer member 23 is shaped, at its outer edge, as a circular arc and engages with this edge in the locking position into a gap between two adjacent teeth of the pinions 17. From the disc 24 an obliquely rising lug 25 is bent over which serves for restoring the decade transfer pinions 17, 18 from the transfer position. A detent disc 26 (Fig. 1) locks in a known manner the transfer pinions 17 when no decade transfer is carried out. The transfer—and detent members are rigidly connected to one another. This rigid whole is coupled to the spindle 1 and is also coupled, by means of a pin 27, with the stepped drum for rotation, but does not take part in the axial displacement of the spindle.

The transfer procedure when performing a decade transfer is as follows:—

When one of the numeral drums 13 is turned e.g. from 9 to 0, the pin 20' lying below the transfer cam 12 is pressed down by the same, and the transfer pinion 17, 18 of the next higher place is brought into the range of movement of the decade transfer tooth 22, i.e. into the position indicated in dotted lines (Fig. 6). By the transfer tooth 22 the transfer pinion 18 is then moved from the position of Fig. 7 into that of Fig. 8. The rotational movement thus performed by the transfer pinion 18 amounts to less than one fifth turn. The full fifth of a turn is then completed by the member 23, by moving the pinion 17 connected with the pinion 18 concerned from the position of Fig. 9 into the position of Fig. 10, and at the same time locking it momentarily. In the course of the subsequent rotational movement of the disc 24, the lug 25 gets below the longer prong 20" of the fork 20 and restores the latter to the normal position together with the pin 20' and with the transfer pinions 17, 18. In this position as well as in the transfer position, the transfer pinions 17, 18 are retained by a coiled spring 28 which is put around the bearing body 21 and which engages into rests 29 of the pins 20'.

In consequence of the reduction gearing described, the entering pinions 4 (Fig. 5), too, are provided with five teeth. When the calculating machine is so constructed that the stepped drum operates always in the same sense of rotation, the teeth 30 of the entering pinions 4 and of the stepped drum 3 are made with a unilateral i.e. asymmetrical flank profile (Fig. 5) so that strong teeth roots are formed.

The operation of the calculating machine for carrying out an addition is as follows:—

Any term of the addition is adjusted by means of the slides 6 on the circumference of the casing barrel, and is entered into the totalising mechanism formed by the numeral drums 13 by performing a single turn of the stepped drum 3. The term, or a sum, can be read through the display openings 31. If one and the same term is to be entered repeatedly, this is achieved by turning the stepped drum an appropriate number of times.

For performing a subtraction, the stepped drum is provided, as mentioned hereinabove, with complementary toothed arcs a2 in echelon from 9 to 0, which are arranged between the toothed arcs for the addition, of the digits 1 to 9, in the inverse echelon position, so that a toothless cross section of the drum corresponding to zero is followed by a complementary toothed arc according to Fig. 3, hav-

ing nine teeth; a cross section of the drum having one tooth is followed by a complementary toothed arc a2 having eight teeth, and so on. In order to place the complementary toothed arcs 9 to 0 for the purpose of performing a subtraction into juxtaposition with the entering pinions 4, whose entering positions are indicated on a dial or scales arranged on the circumference of the casing or are made visible through display openings, an axial displacement of the stepped drum has to be effected. This is carried out for example by means of the crank 2, either before or after the adjustment of the entering pinions 4.

In order to be able to effect the axial displacement of the stepped drum by means of the crank, the stepped drum is fixedly connected to the spindle 1 by means of a pin 32. In the positions for addition and for subtraction the stepped drum is secured against axial displacement by a detent device not shown in the drawing. When in the totalising mechanism for example the digit 3 is contained, and from this the digit 3 is to be subtracted, the entering pinion 4 of the place desired is adjusted to "3", and thereupon the stepped drum 3 is brought into the position for subtraction as indicated in Figs. 3 and 4 of the drawing in chain-dotted lines. In this position of the stepped drum the entering pinion is in juxtaposition to the complementary toothed arc, which has six teeth, of the stepped drum, so that upon rotation of the latter the entering pinion and the numeral drum 13 coupled therewith is turned six teeth in the sense of addition. Thereby and owing to the decade transfer going right through as described hereinafter, the digit 3 is eliminated from the totalising mechanism, and the numeral roll concerned is set to zero.

Although the mathematical principles of the complementary subtraction can be assumed to be well known, attention may be drawn again to the fact, that the digit of each decade is to be supplemented to 9, except that of the first (lowest) decadic place which is to be supplemented to 10, whereby the aforesaid decade transfer, is initiated which goes right through. Accordingly a device is provided according to the invention which effects this supplementing to 10 automatically. For this purpose, on the stepped drum shown in Fig. 3 an additional tooth is arranged outside the range of the groups of teeth described so far, in such a manner that it appears in the cross section of the drum as a tenth tooth marked "z" of the toothed arc. For this tooth z, on the spindle 5 of the lowest place, a gear wheel 33 (Fig. 3) is so arranged that it comes into mesh with the tooth z exclusively after the lifting of the stepped drum, but remains out of mesh otherwise. By this arrangement it will be achieved, that in the lowest place the actual complementary number is always increased by one, i.e. that the number as entered originally is supplemented not to 9 but to 10, as required.

The same effect is achieved also by means of the embodiment of the stepped drum as illustrated in Fig. 4. The stepped drum 3 has ten teeth z1 instead of an additional tooth z, into the range of which the entering pinions 4 never can get, since their uppermost position corresponds to the zero-range of the stepped drum, which lies below these ten teeth. On the spindle 5 of the lowest place of the machine, an entering pinion with two sets of teeth 4', 4" is arranged, which are spaced so far from one another, that the upper set of teeth 4" meshes with the toothed arc a1, provided for addition, of the next lower place of the stepped drum, while the lower set of teeth 4' is in juxtaposition to that toothed arc of the stepped drum, which corresponds to the value to be read off on the mark on the scale or dial.

In Fig. 4 the entering pinion 4', 4" is for example set to 3; it is accordingly turned three teeth by means of its lower set of teeth 4' while two teeth only of the stepped drum pass through the upper set of teeth 4". When now the stepped drum is raised the width of a tooth into the subtraction position for carrying out a subtraction, the entering pinion 4' gets into the range of that complementary toothed arc a2 which has six teeth i.e. the number of teeth supplementing the digit 3 to the number 9, whereas the set

of teeth 4" is in juxtaposition to the next higher complementary toothed arc a2 which has seven teeth. The entering pinion is consequently turned by means of the set of teeth 4" not six, but seven teeth, i.e. actually the number which supplements the digit 3 to the number 10. The additional ten teeth z1, which by the way could be replaced by the tooth marked z by itself, analogously effect a correct turning in case zero has to be subtracted from the lowest place.

According to Fig. 1 the stepped drum is driven by the crank 2. However, it is possible without difficulty to drive the casing barrel round the stepped drum instead of driving the latter, so that the entering pinions 4 are moved in a circular path round the stepped drum, when a calculation process is carried out. The drive can be effected by hand or by a motor.

Nothing is changed in the principle of construction of the machine, if the toothed arcs a1, a2 provided for addition or as complementary gears, respectively, are arranged in groups separated from one another, on the stepped drum, and if the entering pinions 4 are made adjustable over both ranges.

Finally it may be mentioned, that the changeover of the machine from addition to subtraction or vice versa may be effected by the simultaneous displacement of the entering elements, if desired. In this case the stepped drum 3 is axially immovable, whereas the pillars 7 together with the adjustment slides 6 and the entering pinions 4 are axially adjustable. In order to displace the pillars 7 simultaneously, they are for example guided on the one hand, shiftably in the longitudinal direction in a bearing body 21, and with their other ends in a shoe having the shape of a circular arc which is movable in the casing parallel to the pillars, and which can be raised and lowered by means of a lever or of an eccentric. The axial movement performed thereby corresponds to the length through which in the embodiment described hereinabove the stepped drum was displaced when switching over to a different species of calculation.

Having now fully described and ascertained my said invention and the manner in which it is to be performed, I declare that what I claim is:—

1. A calculating machine having a single stepped drum, surrounded by entering pinions, and having a device for performing subtractions without change of sense of rotation of the stepped drum, wherein in addition to the ordinary stepped group of gear teeth a complementary group of gear teeth is fixedly arranged and wherein, by axial displacement of the said stepped drum or of the entering elements, alternatively the ordinary stepped group of gear teeth or the complementary group of gear teeth gets into operative position with respect to the entering pinions.

2. A calculating machine according to claim 1 wherein the complementary toothed arcs are interspersed between the toothed arcs provided for additions at equal axial intervals on the circumference of the drum, whereby the toothed arc provided for additions associated to a certain mark on the adjustment scale for the entering pinions and the associated complementary toothed arc lie immediately adjacent to one another.

3. A calculating machine according to claim 1 wherein the stepped drum has in the range of the complementary toothed arcs a tenth tooth co-ordinated to the arc "zero" provided for additions, which upon performing an axial relative movement between the entering pinions and the stepped drum moves into the range of movement of a pinion which is arranged on the spindle of the entering pinion associated with the lowest place.

4. A calculating machine according to claim 1 wherein the additional pinion of the lowest place is fixedly connected to the shiftable entering pinion associated to this place, at a distance equal to that of two numerically consecutive toothed arcs in such a manner that always both sets of teeth of the said two pinions come into mesh with two numerically consecutive toothed arcs of the stepped drum, whereby, when adjusting the stepped drum for additions, the set of teeth of

the said associated pinion, and, when adjusting the stepped drum to subtractions, the set of teeth of the entering pinion determines the amount of rotation of the spindle of the entering pinions and/or of the numeral drum.

5. A calculating machine according to claim 1 wherein reduction gearing is inserted into the drive between the entering pinions and the numeral drums, so that the phase of action of the stepped drum on the entering pinions is prolonged, whereby the resistance to turning of the totalising elements is spread out over a maximum path of the crank and whereby the angular velocity of the numeral drums is reduced.

6. A calculating machine according to claim 5 wherein the decade transfer pinions are turned to the extent of the angular turning of the entering spindles as enlarged by the reduction gearing.

7. A calculating machine according to claim 6, wherein each decade transfer pinion is constructed as a twin pinion having two sets of teeth off-set relative to one another, of which one set receives a partial transfer movement by the ordinary transfer tooth, while a further transfer member acts on the second set of teeth, and teminates the decade transfer.

8. A calculating machine according to claim 6 or to claim 7, wherein the transfer member is constructed as a detent segment whereby after the termination of the transfer movement of the second transfer pinion the latter is locked, and consequently all other transfer—and totalising elements, too, are locked.

9. A calculating machine according to claim 5, wherein for the reduction of the gearing between the entering pinion and the numeral drum, which is journalled at an angle thereto, one of the two transmission pinions is constructed as a kind of cog wheel.

10. A calculating machine according to any one of the claims 5 to 9 having transfer— and totalising elements working always in the same sense of rotation wherein the entering pinions are provided with less than ten teeth, and wherein these teeth as well as those of the stepped drum are made asymmetrical, whereby teeth roots of maximum strength are formed.

11. A calulating machine according to any one of the claims 1 to 10, wherein all of the transfer pinions are automatically retained in both operational positions by means of a single coiled spring which engages into detent rests of the transfer elements of the transfer pinions from the side.

12. A calculating machine according to any one of the claims 1 to 11, wherein the adjustment slides are automatically arrested by spring-loaded balls dropping into detent rests in the positions adjusted.

13. A calculating machine as claimed in claim 1, substantially as described with reference to Figs. 1 to 3 and 5 to 10 of the accompanying drawings.

14. A calculating machine as claimed in claim 1, substantially as described with reference to Figs. 1, 2 and 4 to 10 of the accompanying drawings.

Dated this 15th day of May, A.D. 1951.

F. B. RICE.

Witness—J. Waller.

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Fig. 1

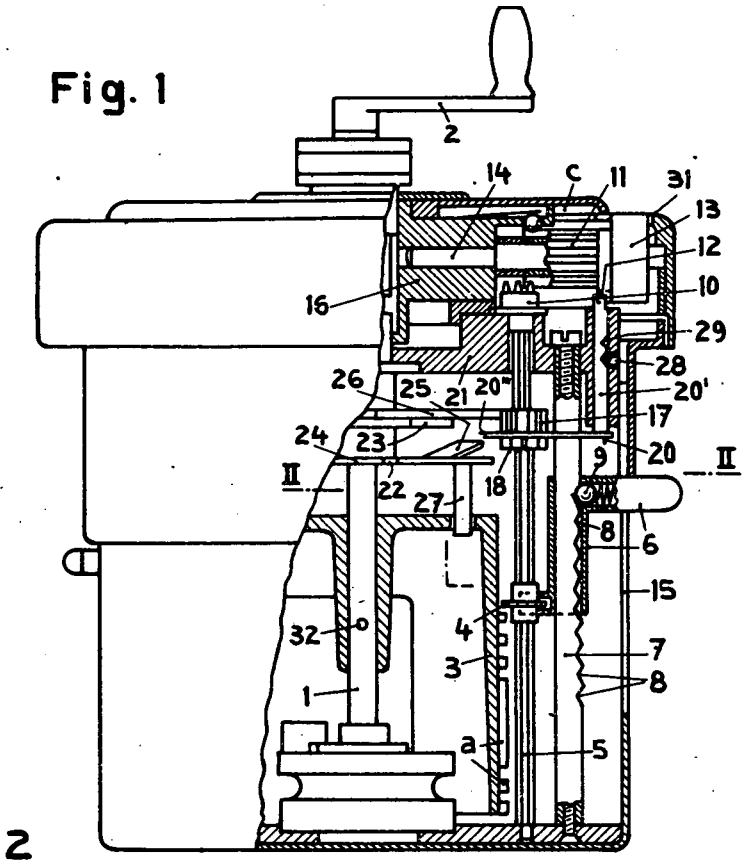

Fig.2

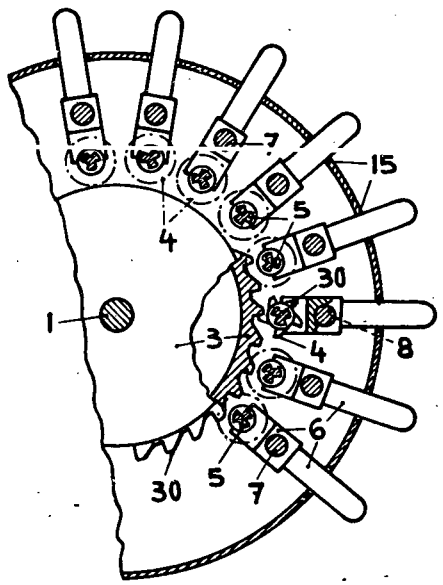

Fig. 3

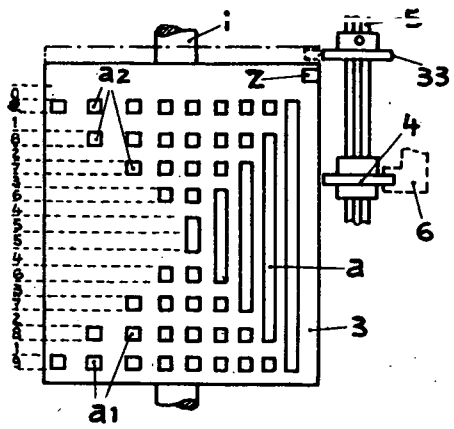

Fig. 4

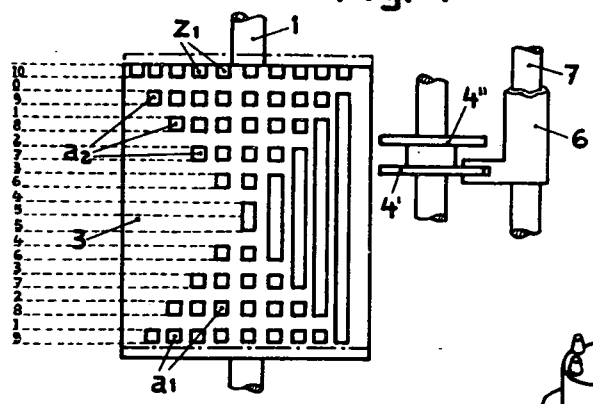

Fig. 5

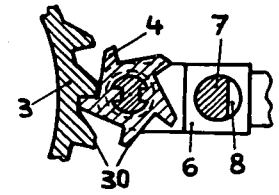

Fig. 6

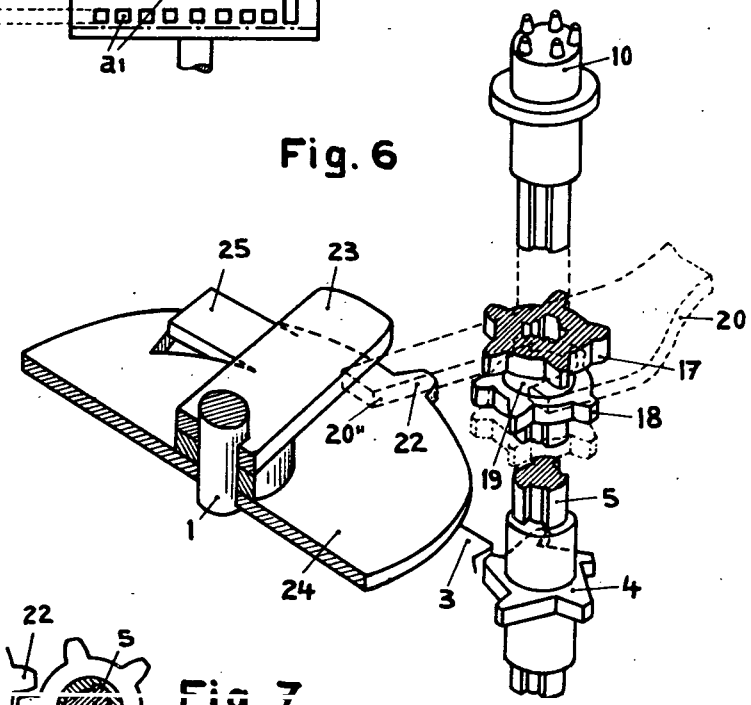

Fig. 7

Fig.8

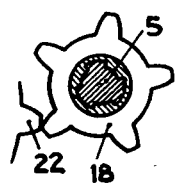

Fig.9

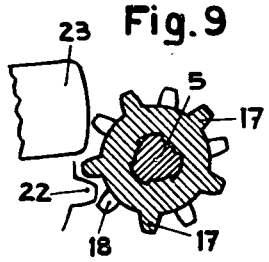

Fig. 10