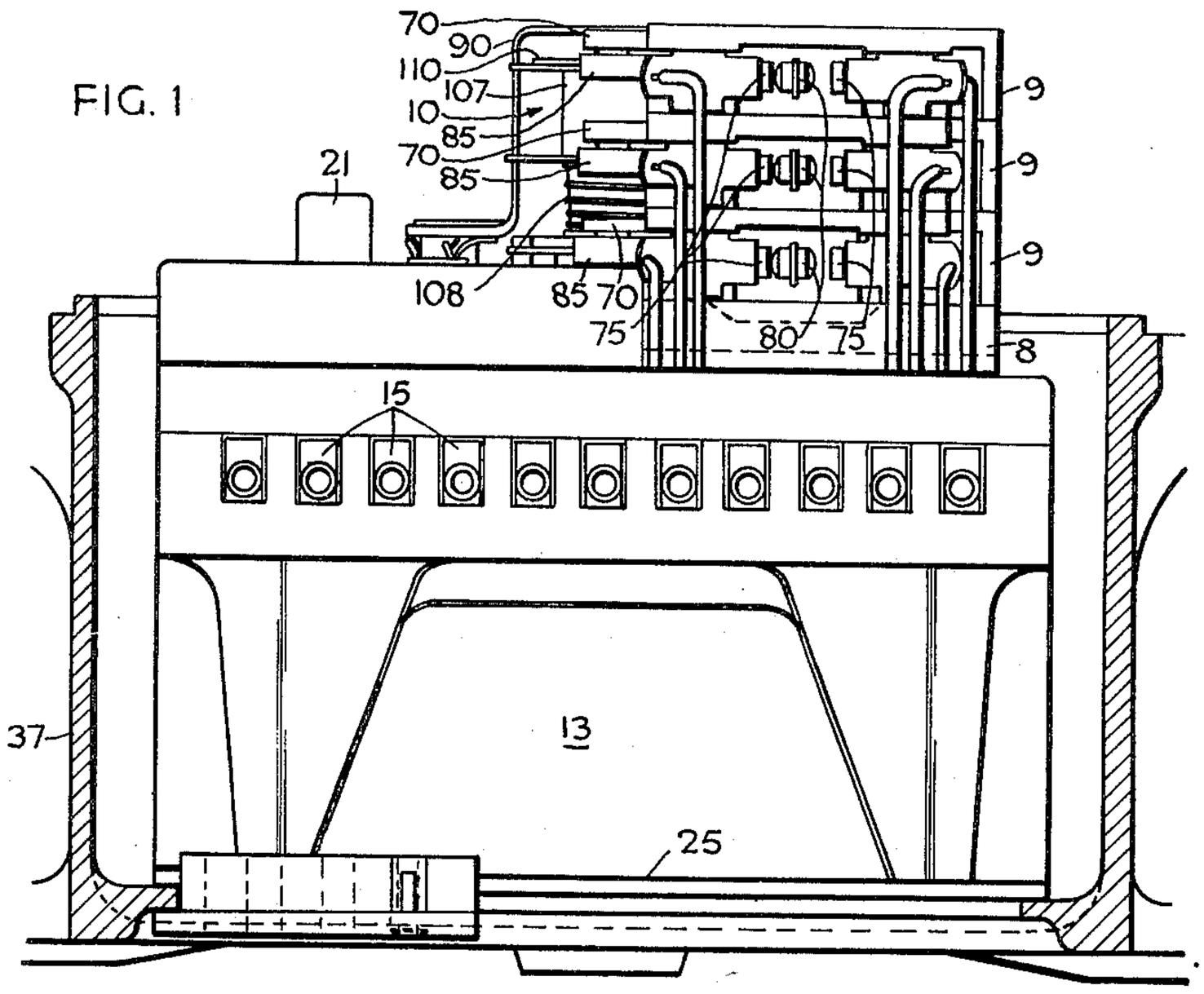
March 6, 1951 W. F. HORGAN 2,544,089

MEANS FOR OPERATING CONTROL ELEMENTS, SUCH AS ELECTRIC SWITCHES, IN A SELECTED MANNER

Filed Dec. 27, 1945

3 Sheets-Sheet 1

FIG. 1



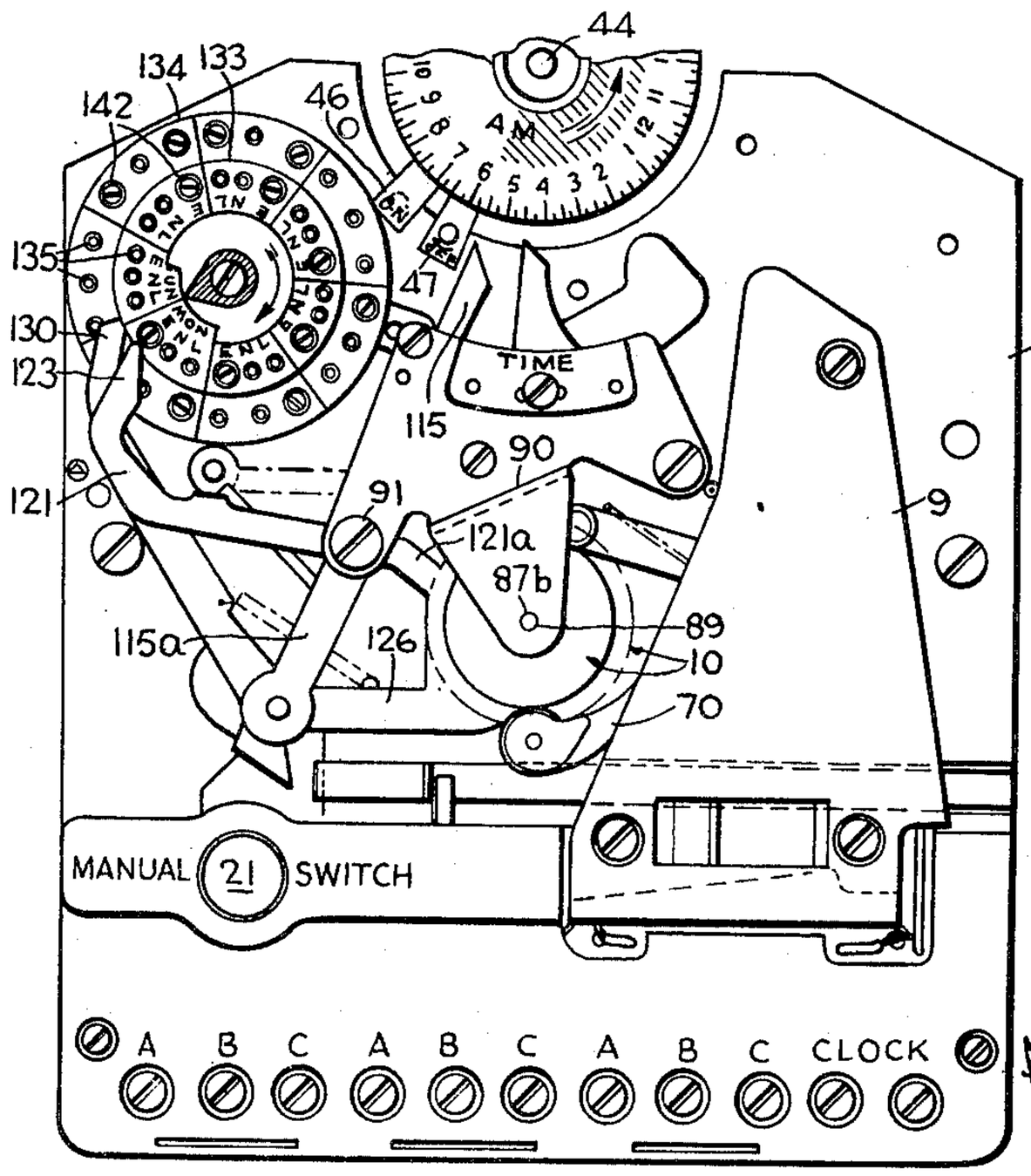


FIG. 2

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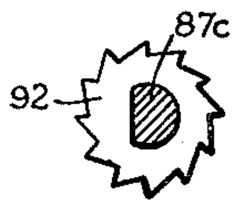

FIG.5

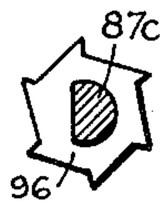

FIG.4.

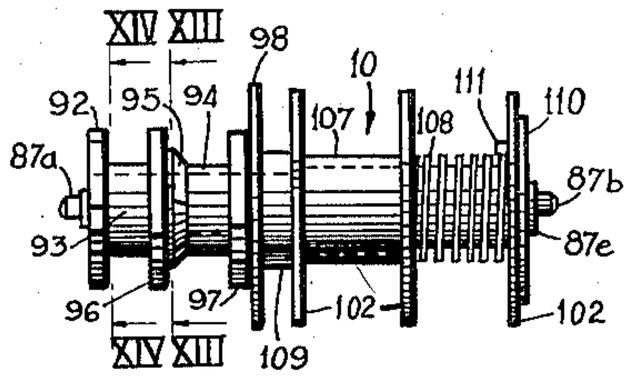

FIG.3.

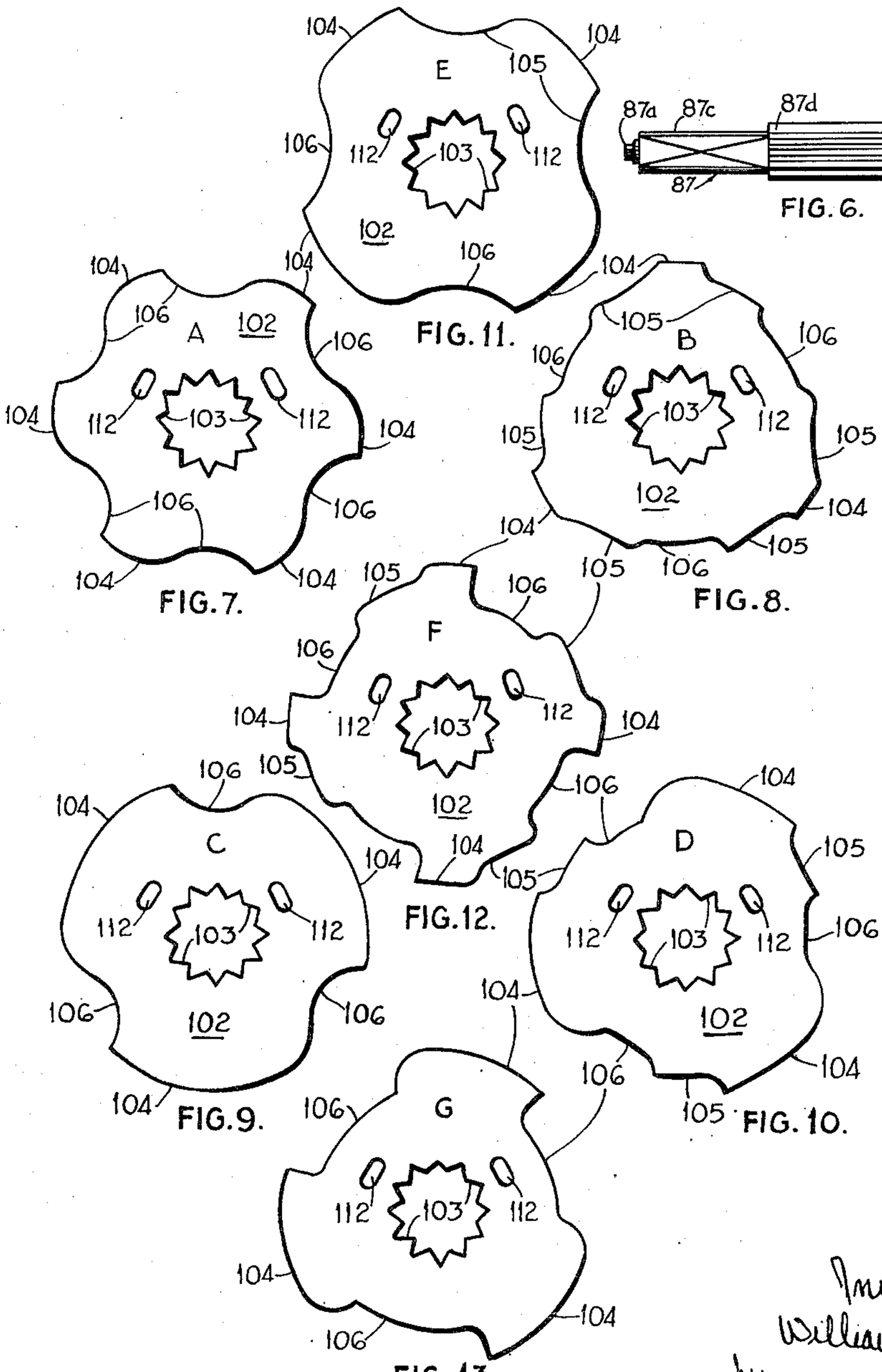

FIG.11.

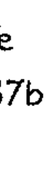

FIG.6.

FIG.8.

FIG.7.

FIG.12.

FIG.9.

FIG.10.

FIG.13.

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MEANS FOR OPERATING CONTROL ELEMENTS, SUCH AS ELECTRIC SWITCHES, IN A SELECTED MANNER

Filed Dec. 27, 1945 3 Sheets-Sheet 3

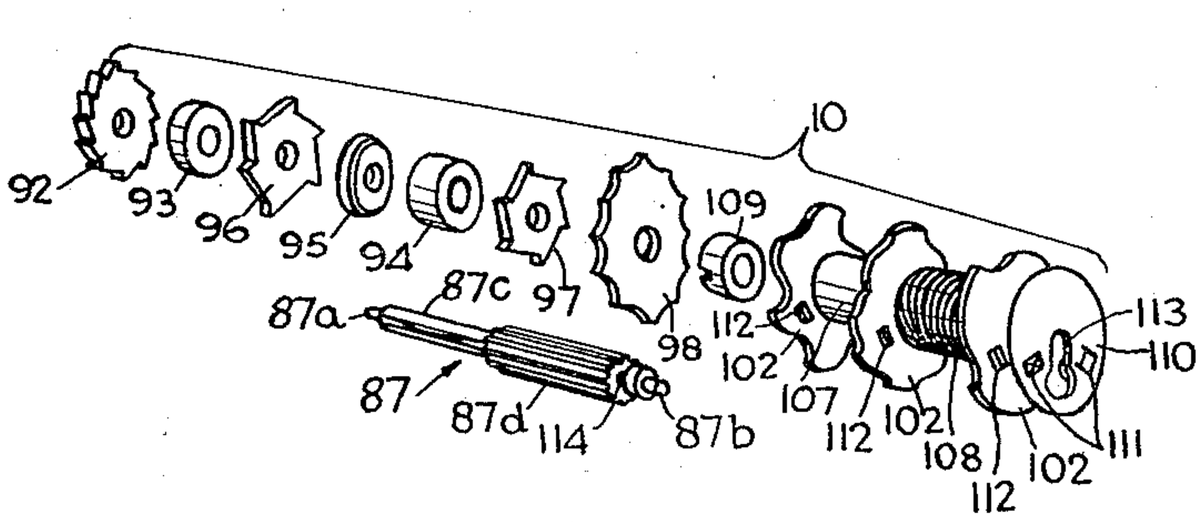

FIG. 14

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UNITED STATES PATENT OFFICE

2,544,089

MEANS FOR OPERATING CONTROL ELEMENTS, SUCH AS ELECTRIC SWITCHES, IN A SELECTED MANNER

William Francis Horgan, New Malden, England

Application December 27, 1945, Serial No. 637,418
In Great Britain January 9, 1945

11 Claims. (Cl. 287—53)

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This invention relates to means for operating control elements, such as electric switches, valves incorporated into hydraulic or fluid-pressure systems, trip mechanisms, or the like, in a selected manner, i.e. in any one of a number of possible different ways that has been chosen beforehand by appropriate setting of the operating means. More particularly, but not exclusively, the invention seeks to provide such operating means in a form that is of considerable value in connection with time switches for making them adaptable to the timed control of very varied operations of widely differing degrees of complexity.

It has previously been proposed to operate electric switches by means of a plurality of cams which are mounted on a cam-shaft in such manner that each cam may be removed from the cam-shaft and replaced in a different angular position relative thereto.

According to the main feature of the invention, means for operating control elements in a selected manner comprises in combination a cam-shaft having a plurality of axially extending splines, a series of sets of cams, each set being of a character for producing a predetermined and different sequence of operations of a control element, complementary formations on the cams for engagement with the splines and disposed in a predetermined relationship to the rises on the cams such that the rises may be positioned accurately in any one of a number of different angular positions in relation to the shaft by such engagement, a plurality of spacing elements adapted to be positioned on the cam-shaft to separate adjacent cams or to take the place of cams, as required, latching means on with each cam, and a locking element engageable with the cam-shaft and with the latching means on the cams whereby any combination of cams and spacers may be positioned in any selected position on the cam-shaft to suit the complexity of the desired operations and retained in such positions by engaging the locking element with the cam-shaft and with the latching means of the adjacent cam.

According to another feature, the cams of at least one set include a trough corresponding to one way of operating the said element and two rises corresponding to other ways of operating the element.

Preferably, at least one of the spacing elements is of an expandible construction so that it will take up any slack due to the omission of one or more cams from the number which the cam-shaft is designed to accommodate.

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It is preferred that the rotation of the cam-shaft be effected by or under the control of a timing element and, with advantage, the means according to the invention may be incorporated into a time switch comprising a timing element adapted to drive "hands" and an actuating mechanism operated, at pre-set times, by the said "hands" to cause step-wise advances of the cam-shaft. In this way a time switch may be adapted for initiating or carrying out varied operations at timed intervals, and, if the time switch be constructed in accordance with the invention described in my co-pending application No. 637,419 of even date herewith, these operations may be initiated or carried out in accordance with a predetermined programme calling for omissions of some operations or changes of the times of these or other operations within certain repeating time intervals.

In order that the nature of the invention may be clearly understood, an example of operating means according thereto will now be described in greater detail with reference to the accompanying drawings. The description will be related to a time switch incorporating the improved operating means to control electric switches but as the example of time switch selected has some features which form the subject-matter of co-pending aplications of even date herewith, these features will only be indicated generally herein.

In the drawings—

Fig. 1 is an end elevation of the time switch with part of the enclosing casing shown in section,

Fig. 2 is a plan view of the time switch,

Fig. 3 is a side elevation of operating means according to the invention as incorporated in the time switch of Figs. 1 and 2,

Fig. 4 is a section taken on the line XIII—XIII of Fig. 3,

Fig. 5 is a section taken on the line XIV—XIV of Fig. 3,

Fig. 6 is a side elevation of the cam-shaft employed,

Fig. 7 is a face view of one example of the cams that may be employed,

Figs. 8 to 13 are similar views of other examples of cams, and

Fig. 14 is an exploded perspective view of the operating means shown in Fig. 3.

In the example chosen the time switch comprises a top plate 1 carrying the actuating mechanism and spaced from a bottom plate 25, adapted to be secured in an enclosing casing 37, by a support 13 carrying a series of terminal block 15,

the top plate 1 or bottom plate 25, or both, serving for the attachment of a timing element (the final spindle of which is shown at 44 in Fig. 2) adapted to operate the actuating mechanism and selected from a range of such timing elements of different characters and sizes. The actuating mechanism comprising a cam assembly 10 adapted to actuate a rocking element 70 associated with each control element 9 when the assembly is rotated step-wise by either of two pawl-and-ratchet drives of similar construction (which appear superposed in Fig. 2) each including a rocking lever 115, 115*a* pivoted between its ends (at 91) and carrying on one end a pawl 126 adapted to co-operate with one of the ratchet wheels (referred to below in greater detail) when permitted by a blocking lever 121, 121*a* that is moved to an inoperative position only when an end 123 thereof is engaged by one of a series of pins 142 selectively engaged in a series of apertures 135 in an associated selector disc 133 or 134 which is adapted to be fed round by a pawl-and-ratchet drive the pawl 130 of which is mounted on the rocking lever 115, 115*a*.

On the top plate 1 is secured, in close proximity to the cam assembly 10, an insulating block 8 (Fig. 1) adapted to have secured thereon one or more control elements 9 in the form of electric switch units each having a moving contact 80 working between two spaced fixed contacts 75. The moving contact 80 is arranged normally to bear on one of these fixed contacts 75 but to be displaceable away there-from to a "central" position, in which it is out of contact with both contacts 75, or to an "extreme" position, in which it bears on the other fixed contact, upon the actuation of the associated rocking element 70 by a cam in the cam assembly 10. The switch units 9 are built up in a bank on the insulating block 8 as required, with cam-engaging rollers 85 on the rocking elements 70 axially aligned. These units 9 are described at length in my co-pending application No. 637,649, now abandoned.

The cam assembly 10 referred to constitutes the means for operating the control elements or switches 9 and in accordance with the present invention is constructed as follows.

A cam shaft 87 (Figs. 6 and 14) is rotatably mounted with its axis perpendicular to the top plate 1 and parallel with the axes of the cam-engaging rollers 85 on the rocking elements 70 of the switch units 9, the reduced diameter lower end 87*a* of the shaft 87 engaging an aperture in the top plate 1 and the reduced diameter upper end 87*b* of the shaft engaging in aperture 89 in a bracket member 90 which is supported on pillars 91 upstanding from the plate 1. The height of the bracket 90 is such as to provide accommodation for a cam shaft 87 extending at least to the level of the roller 85 of the uppermost switch unit 9 in the largest bank of such units intended to be built up on the base block 8. For ease of description, it will be assumed herein that a maximum of three such units may be banked up on the base block (as shown) but larger numbers of units may be employed provided that the cam-shaft 87 be extended to correspond and the bracket 90 be suitably modified.

The lower end 87*c* of the cam shaft 87 (see Figs. 3 and 14) has secured thereon, immediately adjacent to the top plate 1, a ratchet wheel 92 adapted to be advanced by one tooth each time that a pawl (not shown) operated manually by a test-button 21 is actuated. Adjacent to this ratchet wheel 92, but spaced therefrom (by a collar 93 and collar 94 and disc 95, respectively) as necessary to suit the disposition of the associated pawls 126 in the actuating mechanism, is a pair of further ratchet wheels 96 and 97 each arranged to be advanced by one tooth each time that the corresponding pawl 126 in the actuating mechanism is effectively operated by means of one of the "hands" 46 or 47 (Fig. 2) driven by the timing element. Since these pawls are normally operated alternately by "on" and "off" hands, their ratchet wheels 96 and 97 have their teeth angularly staggered in relation to each other by half a tooth-length and the number of teeth on each wheel is half the number of teeth on the ratchet wheel 92 which is used for effecting manual advance of the cam-shaft. In the present example, the ratchet wheel 92 has twelve teeth and the others (96 and 97) only six teeth.

Also secured on the cam-shaft part 87*c* is a positioning wheel 98 having twelve peripheral arcuate recesses and co-operating with a spring-pressed detent roller (not shown) in such manner that the cam shaft is positively positioned for each of twelve equal step-wise advances as it is rotated. All these ratchet wheels 92, 96 and 97 and the positioning wheel 98 are non-rotatably mounted on the lower end part 87*c* of the cam-shaft (which is of D-section) by means of correspondingly shaped central apertures and are suitably retained against axial movement by means (not shown) such as a radial projection at the lower end of the shaft 87 and a pin passed through a diametrical bore in the shaft at the upper end of the D-shaped part 87*c* thereof. It is to be noted that the elements described will vary with the type of actuating mechanism employed and may properly be considered to be part of this mechanism.

The upper end part 87*d* of the cam-shaft is formed with twelve equally spaced longitudinal splines so disposed in relation to the flat on the D-shaped part 87*c* of the shaft that the centre-line of each spline corresponds in angular disposition around the axis of the shaft to the radial face of one of the teeth of the manually-actuated ratchet wheel 92.

A set of cams 102 (Figs. 7 to 13) is provided, each having a central splined opening 103 adapted to receive the splined shaft-portion 87*d* and having cam rises and troughs located in a predetermined relationship to the centre-lines of the splines, the shapes of the cams being selected to suit the character of the movements that are to be imparted to the rocking elements 70 of the switch units 9. As will be seen from the preceding description each switch unit 9 in this example is capable of three settings, namely, moving contact 80 in "normal" position and bearing on one of the fixed contacts 75, moving contact in "central" position and out of contact with both fixed contacts 75, and moving contact in "extreme" position and bearing on the other of the fixed contacts 75. The "normal" position corresponds to the engagement of the roller 85 on the associated rocking element 70 with a "normal" rise-surface (marked 104 in Figs. 7 to 13) at a maximum distance from the centre of the appropriate cam 102, the "central" position corresponds to the engagement of this roller 85 with a "central" rise-surface (marked 105) at an intermediate distance from the cam-centre and the "extreme" position corresponds to the engagement of the roller 85 with a trough-surface (marked 106) at a minimum distance from the cam-centre. Many

forms of cam may be produced each to correspond to desired combinations of some or all of these movements in predetermined sequences but, for illustration, a typical set of seven cams will be described here. The first cam 102 (shown in Fig. 7 and marked "A") has six equally spaced "normal" rises 104 with intervening troughs 106 and when rotated through one revolution would cause the moving contact 80 of an associated switch unit 9 to move from the "normal" position to the "extreme" position and back again six times in succession. The second cam 102 (Fig. 8 and marked "B") has three equally spaced "normal" rises 104 each flanked on each side by a "central" rise 105 and three equally spaced troughs 106 each disposed between two adjacent "central" rises 105. This cam when rotated through one revolution would cause the moving contact 80 to move from the "normal" position to the "central" position, then to the "extreme" position, then back to the "central" position and finally back to the "normal" position for the cycle to repeat twice more. In each of these cams (A and B) the moving contact changes its position for each stepwise advance of the cam. The third cam 102 (Fig. 9 and marked "C") has three equally spaced "normal" rises 104 with intervening troughs 106 but each "normal" rise corresponds in length to three step-wise advances of the cam and each trough to one such advance. One revolution of this cam would cause the moving contact to dwell in the "normal" position for one quarter of the revolution then to move to the "extreme" position and back to the "normal" position for the cycle to repeat twice more. The fourth cam 102 Fig. 10 and marked "D") has three equally spaced "normal" rises 104 each corresponding in length to two step-wise advances of the cam and followed by a "central" rise 105 and a trough 106 in that order. One revolution of this cam corresponds to a thrice-repeated cycle consisting of a dwell of the moving contact 80 in the "normal" position for one sixth of the revolution, a movement thereof to the "central" position and then a movement thereof to the "extreme" position. The fifth cam 102 (Fig. 11 and marked "E") has four equally spaced "normal" rises 104 each corresponding in length to two step-wise advances of the cam and followed by a trough 106 corresponding in length to one such advance. One revolution of this cam corresponds to a four times-repeated cycle consisting of a dwell of the moving contact 80 in the "normal" position for one sixth of the revolution and a further dwell of the moving contact for one twelfth of the revolution in the "extreme" position. The sixth cam 102 (Fig. 12 and marked "F") has four equally spaced "normal" rises 104 each followed by a "central" rise 105 and a trough 106 in that order, each of the rises and troughs corresponding to one step-wise advance of the cam. One revolution of this cam corresponds to a four times-repeated cycle consisting of the movement of the contact 80 successively to the "normal" position, to the "central" position and to the "extreme" position, the contact moving from the latter back to the "normal" position during one step-wise advance of the cam. The seventh cam 102 (Fig. 13 and marked "G") has three equally spaced "normal" rises 104 each followed by a trough 106, each rise and trough being equivalent to two step-wise advances of the cam. One revolution of this cam corresponds to a thrice-repeated cycle consisting of a dwell of the moving contact 80 in the "normal" position for one sixth of the revolution and a further dwell of the moving contact for one sixth of a revolution in the "extreme" position.

Spacing elements for use in conjunction with the cams 102 comprise a tubular spacer 107 (Figs. 3 and 14) of an internal diameter to fit closely over the splined portion 87*d* of the cam-shaft, a helical compression spring 108 of a similar internal diameter, and a collar 109 having a central opening to fit the said shaft-portion. The collar 109 is intended to bear upon the positioning disc 98 and to support a cam 102 in correct location to operate the rocking element 70 of the switch unit 9 nearest to the base block 8, the collar being made of appropriate axial length. This collar is not normally required to be removed. The helical spring 108 is of a length, when expanded, somewhat greater than the distance between the upper side of the cam 102 just mentioned and the lower side of another cam 102 correctly located to operate the rocking element 70 of a further switch unit 9 should one be superposed upon that nearest to the base block 8. Finally, the tubular spacer 107 is of a length equal to the distance between the upper side of this second-mentioned cam 102 and the lower side of yet another cam 102 arranged to operate the rocking element 70 of a further switch unit 9 should this be superposed upon the units 9 already mentioned. It will be understood that the spacers 107 and 108 may be transposed and both uses thereof are shown in the drawings.

In building up the cam assembly 10, the collar 109 is slipped over the splined portion 87*d* of the camshaft 87 followed by a cam 102 of the desired character. If only one switch unit 9 is present, both the spring and the tubular spacers (108 and 107) are then slipped over the shaft, the order chosen in Fig. 14 being referred to, and a locking element (described below) is engaged with the end of the latter to prevent the tubular spacer 107 from being forced off by the spring spacer 108, the latter expanding somewhat to ensure that the single cam 102 is held firmly in correct position. Should another unit 9 be subsequently added, the locking element is removed, the tubular spacer 107 withdrawn, a second cam 102 of the same or a different character is slipped over the shaft 87 and the tubular spacer and locking element replaced. Similarly, when a third switch unit 9 is added, the locking element is removed, a third cam 102, which may be either of the same character as one or both of the other two or of a different character from both, is slipped over the shaft and the locking element replaced. It will be obvious that any of these assemblies can be produced initially if the number of switch units 9 is settled at the start and further that the rollers 85 on the rocking elements 70 of the units 9 are of sufficient length to accommodate the slight difference in the disposition of the second cam 102 that is due to the omission of the third cam 102.

The locking element referred to is shown in Figs. 1, 2, 3 and 14 and comprises a disc 110, of smaller diameter than the circle tangential to the bottom parts of the troughs 106 of the cams 102, formed with a pair of pressed-out tongues 111 adapted to engage in corresponding apertures 112 formed in the cam 102 which happens to be serving as the third cam, all the cams 102 having such apertures as will be understood, and also formed with a keyhole slot 113 (Fig. 14) by means of which it may be engaged, by sliding it later-

ally, with an annular groove 114 formed circumferentially of a reduced diameter upper end portion 87b of the cam-shaft. The disc 110 is first engaged with the shaft 87 while the third cam 102, if present, is depressed somewhat against the action of the spring spacer 108 to clear the tongues 111 on the disc and this cam is then released to engage the apertures 112 therein over the tongues. If no third cam be present the tubular spacer 107 (or spring spacer 108) bears against the underside of the disc 110 and prevents lateral displacement thereof in the disengaging direction by reason of the fact that such displacement would tend to move the tongues 111 against the external surface of the respective spacer and their distance apart is less than the external diameter of the spacer.

The cams 102 may be engaged with the camshaft 87 in a plurality of different angular settings varying from each other by the distance between two adjacent splines on the shaft-part 87d so that a large number of different arrangements may be catered for with only a small range of cams. Thus it may be arranged that the moving contact 80 of one switch unit 9 is in the "normal" position while that of another unit 9 is in the "central" or "extreme" position and so on. Suitable interconnection of the fixed contacts 75 of a number of switch units 9 provides yet another means for varying the types of control operations it is possible to effect and various arrangements of the selector discs 133, 134 of the actuating mechanism of the time switch, in the manner set forth in my co-pending application No. 637,419 permitting the carrying out of a large variety of programmes of switching with a single piece of apparatus.

It is to be understood that the control elements need not be electric switches and that the invention is not limited to the specific examples of cams which have been described herein for the purpose of illustration only.

What I claim is:

1. In an assembly comprising a shaft, an abutment fixedly located on the shaft, an axially resilient combination of a selected number of elements with at least one spacer, and means whereby the said combination may be slid axially on the said shaft against the abutment with each element positively orientated angularly with respect to the shaft, the provision of readily releasable means for retaining the said element and spacer combination on the shaft comprising a locking member engageable over the shaft in an inoperative position, a retaining formation on the shaft adjacent to one end of the said combination, a cooperating formation on the locking member engageable with the said retaining formation by movement of the locking member to an operative position in a plane normal to the shaft axis, the said inter-engagement of the cooperating formations being adapted to prevent axial displacement of the locking member relative to the shaft, and latching means on the locking member adapted to engage the adjacent end of the said element and spacer combination when the locking member is in the operative position and thereby to prevent return movement of the said locking member to its inoperative position, the initial movement of the locking member to its operative position and its return to its inoperative position being permitted by a temporary axial compression of the said element and spacer combination.

2. Readily releasable means as claimed in claim 1, in which the locking member is formed with an opening having opposed edges which are more widely spaced over one part of their length than they are over another part of their length, the more widely spaced edge-parts permitting the shaft to pass endwise between them but the less widely spaced edge-parts not permitting such passage of the shaft, and the shaft is formed with a reduced portion of lesser diameter which will pass between the said less widely spaced edge-parts, the engagement of the locking member over the shaft in the inoperative position being effected by passing the shaft endwise between the more widely spaced edge-parts until the reduced portion of the shaft is opposite the said edge-parts and the displacement of the locking member to its operative position causing the less widely spaced edge-parts to embrace the reduced portion of the shaft.

3. Readily releasable means as claimed in claim 1, in which the latching means on the locking member comprises a number of projections so disposed that the movement of the said member from the operative to the inoperative position, and vice versa, causes each projection to pass through a location normally occupied by a solid portion of the element and spacer combination.

4. Readily releasable means as claimed in claim 1, in which the latching means on the locking member is adapted to engage an end of the element and spacer combination which is constituted by an element, and the said element has a formation adapted to cooperate with the said latching means to prevent return movement of the locking member from its operative position.

5. Readily releasable means as claimed in claim 4, in which the latching means comprises a number of projections and the co-operating formation on the element comprises at least a like number of recesses.

6. Readily releasable means as claimed in claim 1, in which the latching means on the locking member is adapted to engage an end of the element and spacer combination which is constituted by a spacer, and the said spacer is of such dimensions that it will cooperate with the said latching means to prevent return movement of the locking member from its operative position.

7. Readily releasable means as claimed in claim 6, in which the latching means comprises projections spaced apart in a direction transverse to the direction of movement of the locking member by a distance less than the dimension of the spacer in the corresponding transverse direction.

8. In an assembly comprising a shaft, an abutment fixedly located on the shaft, an axially resilient combination of a selected number of elements with at least one spacer, and means whereby the said combination may be slid axially on the said shaft against the abutment with each element positively orientated angularly with respect to the shaft, the provision of readily releasable means for retaining the said element and spacer combination on the shaft comprising a locking member engageable over the shaft in an inoperative position by means of a keyhole slot formed in the said member to exhibit a wide end capable of passing over the shaft in the axial direction thereof and a narrow end incapable of passing over the shaft in the said direction, a neck formation on the shaft adjacent to one end of the said combination and having a diameter such that it may be embraced by the narrow end of the said keyhole slot upon movement of the locking member to an operative position in a

plane normal to the shaft axis, and latching means formed on the locking member to extend normal to the plane of movement thereof and towards the said end of the element and spacer combination, the said latching means being displaced through a location normally occupied by a solid portion of the said end of the element and spacer combination as the locking member is moved from its one position to the other and such movement only being possible when the said combination is compressed axially to remove the said solid portion out of the said location.

9. In an assembly as claimed in claim 8, the provision of latching means comprising projections spaced apart in a direction transverse to the direction of movement of the locking member by a distance less than the dimension of the spacer in the corresponding transverse direction, and the provision in each of the elements capable of embodiment into the element and spacer combination of spaced recesses capable of receiving the said projections when the locking element is disposed in its operative position adjacent to an element of such a combination.

10. In an assembly comprising a shaft, an abutment fixedly located on the shaft, an axially resilient combination of a selected number of elements with at least one spacer, and means whereby the said combination may be slid axially on the said shaft against the abutment with each element positively orientated angularly with respect to the shaft, the provision of readily releasable means for retaining the said element and spacer combination on the shaft comprising a locking member engageable with the shaft by motion relative thereto in a predetermined direction, and latching means for preventing reverse motion of the locking member relative to the shaft, which latching means is rendered operative by axial expansion of the said element and spacer combination.

11. In an assembly comprising a shaft, an abutment fixedly located on the shaft, an axially resilient combination of a selected number of elements with at least one spacer, and means whereby the said combination may be slid axially on the said shaft against the abutment with each element positively orientated angularly with respect to the shaft, a locking member for releasably retaining the said element and spacer combination on the shaft and co-operating parts formed on the said member and the said combination, respectively, to inter-engage for maintaining the locking member in the operative position, the said parts being adapted to be held in inter-engagement by axial pressure provided by the resilience of the said combination.

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