May 8, 1962 K. HEHL 3,033,949

MULTIPLE STAGE TIMING MECHANISM

Filed Aug. 3, 1959 6 Sheets-Sheet 1

Fig. 1

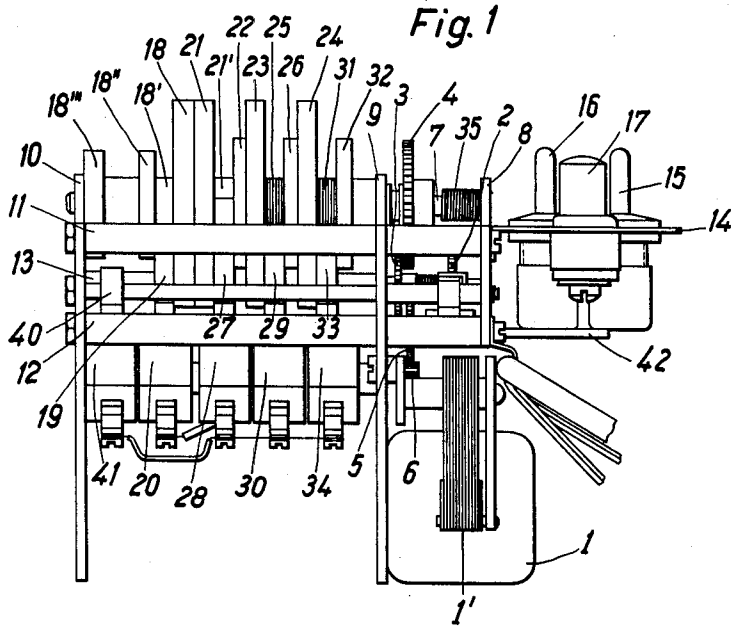
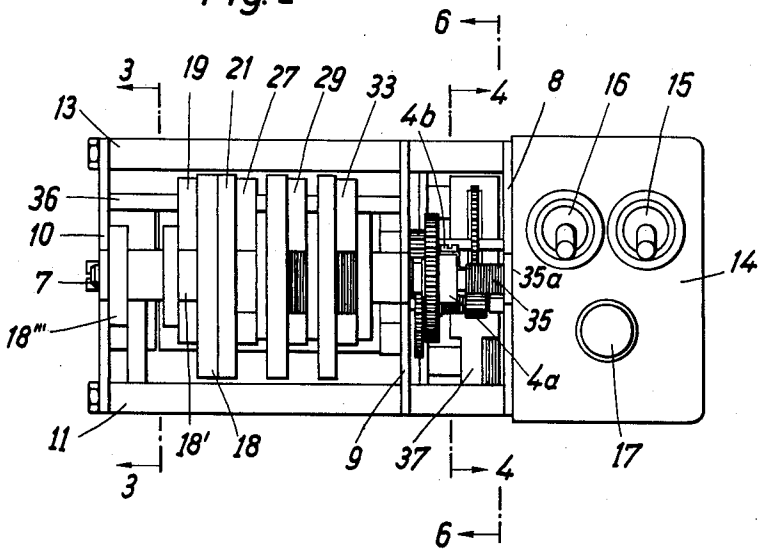


Fig. 2



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MULTIPLE STAGE TIMING MECHANISM

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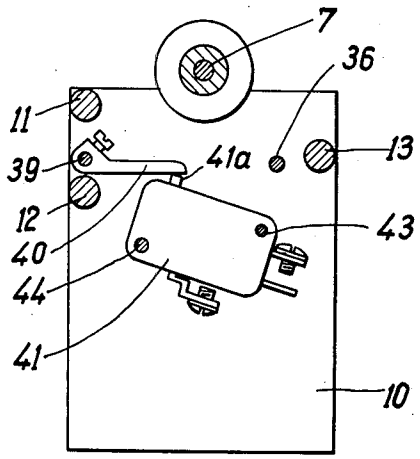


Fig. 3

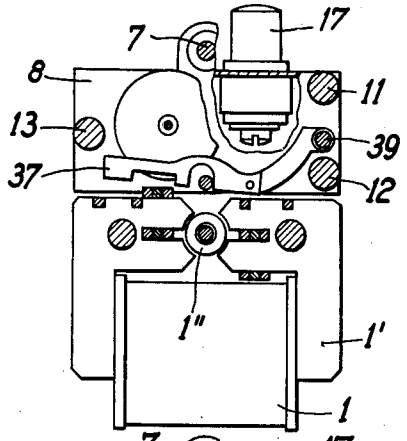


Fig. 4

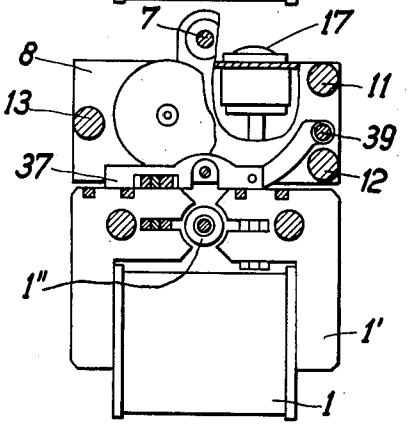


Fig. 5

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MULTIPLE STAGE TIMING MECHANISM

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Fig. 6

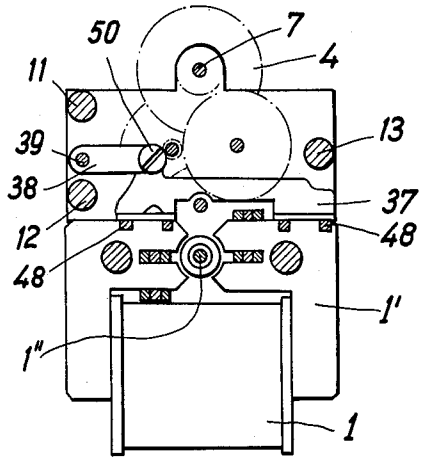


Fig. 7

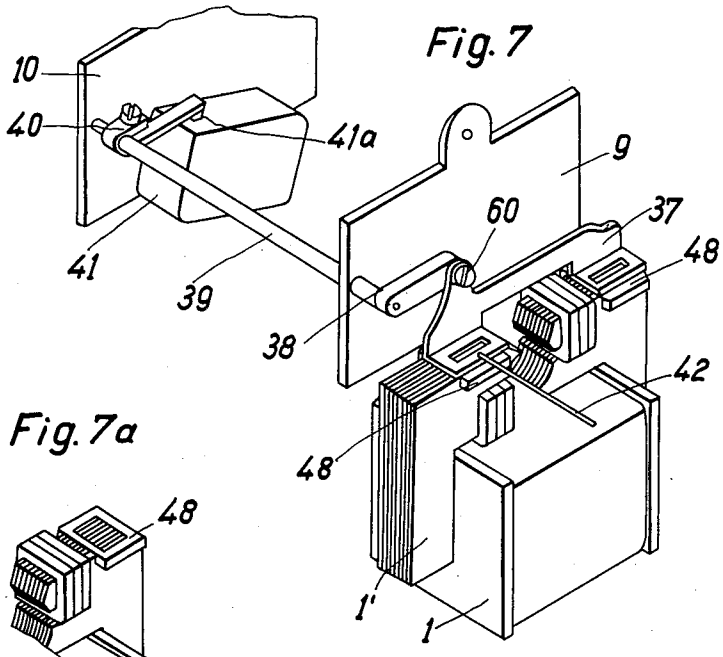


Fig. 7a

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MULTIPLE STAGE TIMING MECHANISM

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Fig. 8

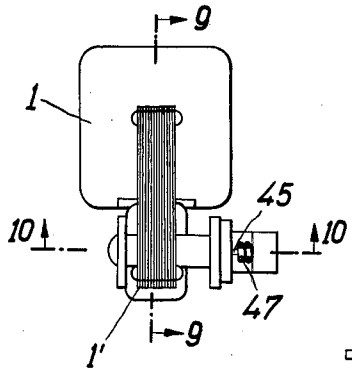


Fig. 9

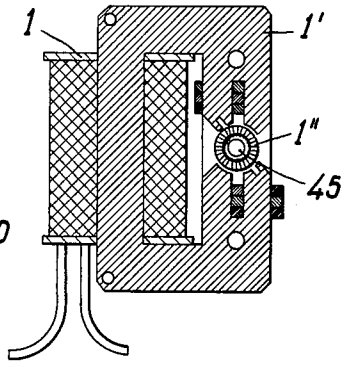


Fig. 10

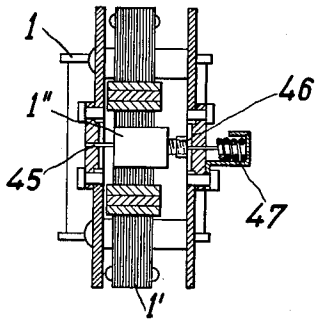


Fig. 11

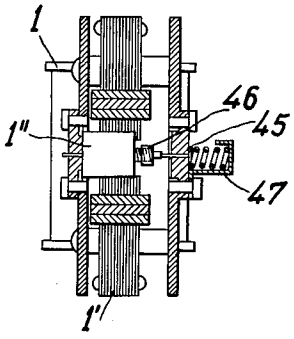
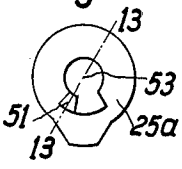


Fig. 12



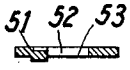


Fig. 13

Fig. 14

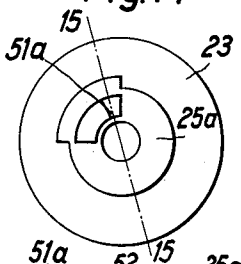


Fig. 15

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May 8, 1962 K. HEHL 3,033,949

MULTIPLE STAGE TIMING MECHANISM

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Fig. 16

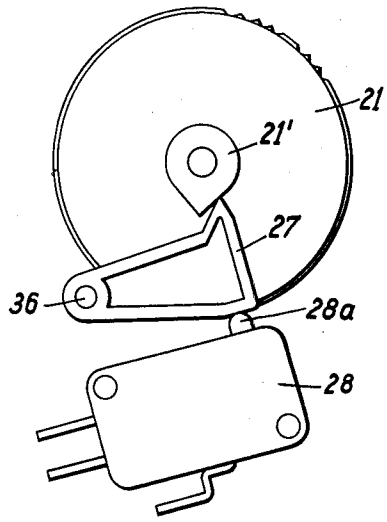


Fig. 17

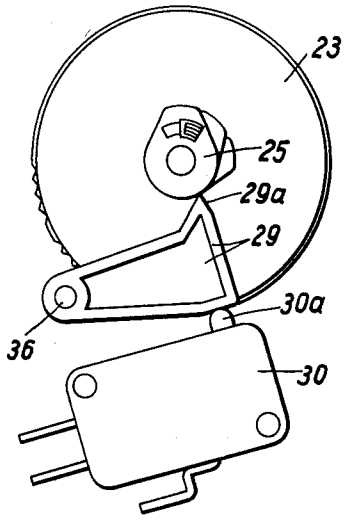


Fig. 18

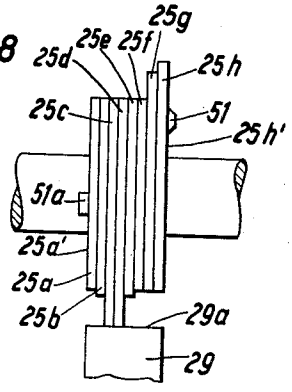


Fig. 19

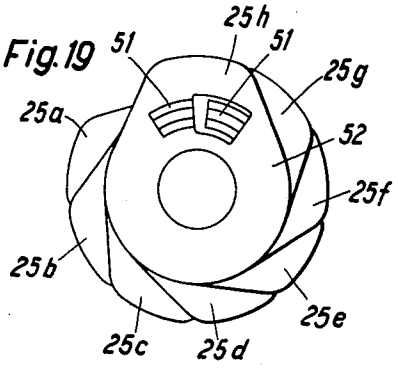
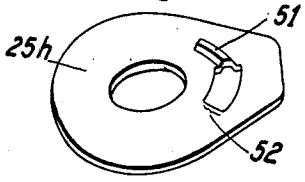


Fig. 19a



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May 8, 1962 K. HEHL 3,033,949

MULTIPLE STAGE TIMING MECHANISM

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Fig. 20

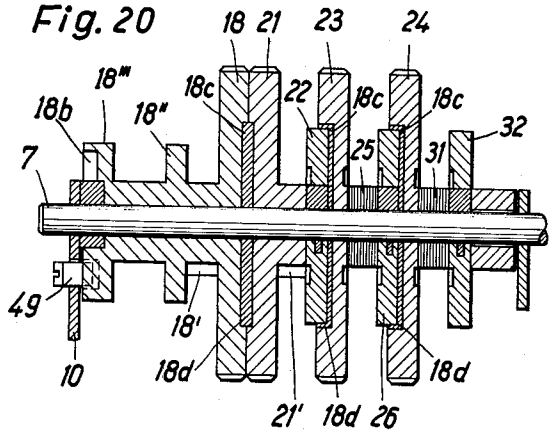


Fig. 21

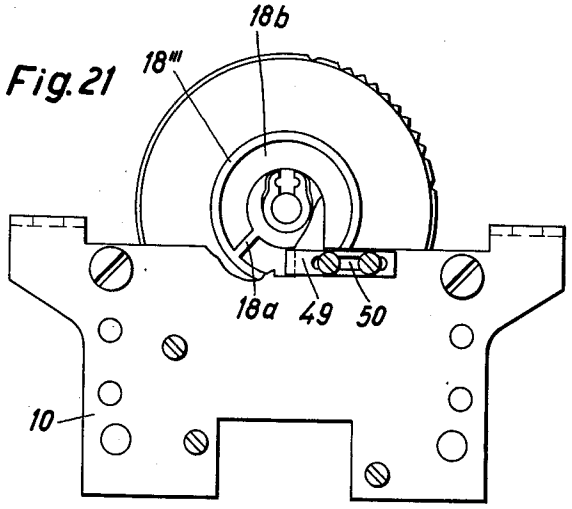
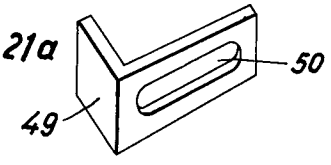


Fig. 21a



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United States Patent Office 3,033,949 Patented May 8, 1962

3,033,949

MULTIPLE STAGE TIMING MECHANISM

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Filed Aug. 3, 1959, Ser. No. 831,372
Claims priority, application Germany Nov. 5, 1958
17 Claims. (Cl. 200—38)

The present invention relates to a timing mechanism or time switch and, more particularly, to a multiple stage timing mechanism adapted for use in conjunction with a machine or device, the successful operation of which is dependent upon a series of steps at predetermined time intervals.

Although the invention will be described with reference to an injection molding machine, it is to be understood, that the timing mechanism constituting the present invention is adapted for use with other machines.

The problem with which the invention is particularly concerned is the control of the operating cycle of an injection molding machine, said cycle comprising at least three phases or stages, i.e., closure of the injection mold, injection of a thermoplastic material into the mold and the opening thereof followed by the ejection of the molded article, and the control of a continuous repetition of such cycle with very short inoperative periods therebetween. For this purpose, there is provided a simple and reliable timing mechanism by means of which the duration of the individual stages and the entire cyclic operation can be readily adjusted.

It is an important object of the present invention to provide a novel timing mechanism capable of executing a predetermined series of operations to be performed by an associated machine in a safe and reliable manner.

It is another object of the present invention to provide a novel timing mechanism wherein cam means are employed for initiating a series of operations, at least some of said cam means being adjustable to vary the time interval for successive operation of said cam means.

It is a primary object of the invention to provide a timing mechanism, the operation of which is electromagnetically controlled by means of switches operated at predetermined times by means of cams mounted on a control shaft driven by an electric motor, said control shaft being automatically decoupled from the electric motor upon termination of each machine cycle.

It is another object of this invention to provide spring means associated with the control shaft of the timing mechanism to return the control shaft to its initial position. Each of the cam units mounted on the control shaft comprises a plurality of interconnected component cam disks, one end of which is coupled to a rotatable plate and the other end is connected to a spacer disk secured to the control shaft, whereby the sequence of operation of the individual stages constituting a working cycle is controlled by a graduated disk and a rotatable wheel secured to the control shaft. One of said cams acts during the final portion of the return movement of the control shaft, resulting in closure of the motor circuit by briefly closing a switch, said last closing operation actuating a relay which, in turn, closes and retains closed the motor circuit until the same is interrupted by another cam operating another switch.

It is a further object of the present invention to provide switches which may be in the form of microswitches, for controlling electromagnets operating pneumatic or hydraulic devices of the injection molding machine at the proper times. Such control is obtained by means of the cam units mounted on the control shaft which is driven by an electric motor, said motor being automatically disengaged from the control shaft by means of a reduction gearing upon

termination of the cycle and being returned to its initial position via a return spring.

It is a still further object of the invention to provide a relay which is actuated by a microswitch with a soft-iron rocker arm attracted by the magnetic field build up in the motor stator during the brief closure of the microswitch, said rocker arm operating via a first lever, a switching shaft and a second lever to close and retain closed the microswitch until the motor circuit is interrupted by another cam-like projection operating another microswitch.

It is an additional object of the invention to provide with the timer mechanism of the invention a manually operable switch adapted to selectively change over from fully automatic to semi-automatic operation. In the last mentioned type of operation, the stages constituting a working cycle are not linked automatically and each new cycle has to be initiated by manual operation of a press button.

Still further objects and the entire scope of applicability of the present invention will become apparent from the detailed description given hereinafter; it should be understood, however, that the detailed description and specific examples, while indicating preferred embodiments of the invention are given by way of illustration only, since various changes and modifications within the spirit and scope of the invention will become apparent to those skilled in the art from this detailed description.

In the drawings:

FIGURE 1 is a side elevational view of a timing mechanism according to the present invention;

FIGURE 2 is a plan view of the mechanism shown in FIGURE 1;

FIGURE 3 is a sectional view taken along the line 3—3 of FIGURE 2 and looking in the direction of the arrows;

FIGURE 4 is a sectional view through the timing mechanism according to the invention, taken along the line 4—4 of FIGURE 2 and looking in the direction of the arrows, depicting the soft iron rocker in a position assumed when the circuit of the motor is interrupted;

FIGURE 5 is a sectional view through the timing mechanism according to the invention, taken along the line 4—4 of FIGURE 2 and looking in the direction of the arrows, showing the soft iron rocker in a position in which it is attracted by the magnetic field of a stator of the motor;

FIGURE 6 is a sectional view through the timing mechanism according to the invention, taken along the line 6—6 of FIGURE 2 and looking in the direction of the arrows;

FIGURE 7 is a perspective view of the novel mechanism, showing means for transmitting motion to an associated microswitch, said motion being produced by the soft iron rocker when attracted by the motor stator;

FIGURE 7*a* shows in a similar, but fragmentary, perspective view a detail which is partially obstructed in FIGURE 7;

FIGURE 8 is a side elevational view, showing the drive motor of the timing mechanism according to the invention displaced 180° with respect to FIGURE 1;

FIGURE 9 is a sectional view through the motor taken along the line 9—9 of FIGURE 8 and looking in the direction of the arrows;

FIGURE 10 is a sectional view through the same motor taken along the line 10—10 of FIGURE 8 and looking in the direction of the arrows, the parts of the motor being in a position when current is supplied to the motor;

FIGURE 11 is a sectional view through the motor taken along the line 10—10 of FIGURE 8 and looking in the direction of the arrows, the parts of the motor being in a position when no current is supplied to the motor;

FIGURE 12 shows a front view of one embodiment of one of the component disks of the composite cam unit of the timing mechanism;

FIGURE 13 is a cross section through the component disk of the cam unit illustrated in FIGURE 12 taken along the line 13—13;

FIGURE 14 illustrates the front view of a rotatable wheel of the timing mechanism according to the invention, together with a second embodiment of a component cam disk of the associated composite cam unit assembly;

FIGURE 15 is a cross section of the device shown in FIGURE 14 taken along the line 15—15.

FIGURE 16 shows in detail a timing disk and its associated teardrop cam cooperating with a cam follower and microswitch;

FIGURES 17 illustrates in detail an adjustable composite cam unit cooperating with a cam follower and microswitch;

FIGURE 18 is a fragmentary view of the control shaft and the mounting thereon of the individual cam disks constituting an adjustable composite cam unit;

FIGURE 19 shows a group of individual cam disks in fanned or spread position and the interengagement of said disks;

FIGURE 19*a* shows the interengaging means of a typical cam disk in the form of a tongue and groove;

FIGURE 20 illustrates a fragmentary sectional view of the control shaft and the mounting of the various cams and plates thereon;

FIGURE 21 is an end view of the timing mechanism shown in FIGURE 1 taken from the left-hand side and illustrating in detail the stop member for the control shaft;

FIGURE 21*a* shows in detail an adjustable angle piece employed with the stop member for the control shaft.

Referring in detail to the drawings and, more particularly, to FIGURES 1 and 2, there is illustrated a motor 1 connected by means of reduction gearing elements 2–6 to a main control shaft 7 rotatably mounted in and between spaced plates 8, 9 and 10 interconnected by bolts 11, 12 and 13. The spaced plates 8, 9 and 10 support other elements of the timer mechanism, such as microswitches 20, 28, 30, 34 and 41, said microswitches being mounted to the spaced plates 8, 9 and 10 by means of bolts 43 and 44 (FIGURE 3).

A plurality of cam followers 19, 27, 29 and 33 is pivotally mounted on a shaft 36 journalled between the plates 9 and 10. A monitor switchboard 14, comprising toggle switches 15 and 16 and a push-button 17, is fastened to the plate 8. The switch 15 is a main switch for the timer, while the switch 16 serves to select semi-automatic or full-automatic operation of said timer mechanism. The push-button 17 starts the timer when the same is set for semi-automatic operation by the selector switch 16.

The control shaft 7 carries timer control cams 18', 21', 25, 31 acting on the microswitches 20, 28, 30, 34, respectively, by means of the cam followers 19, 27, 29 and 33, respectively. The individual cams comprising the composite cam units 25 and 31 operate the respective actuating pins of the microswitches 30 and 34. The latter, by closing or interrupting certain circuits, assure the timely energization of an electromagnet associated with pneumatic or hydraulic devices for carrying out predetermined operating stages as, for example, in an injection molding machine. The unitary cam-like extensions 18' and 21', in the form of teardrop cams, see FIGURE 16, actuate the actuating pins of the microswitches 20 and 28. The latter control the sequence or cooperation of the continuously repeating cycles of the injection molding machine.

The control shaft 7, driven by an electric motor, is rotating through a maximum of 360° during a single cycle. After completion of such cycle, the control shaft 7 is returned to its initial position by means of a spring 35 upon automatic decoupling of the drive motor.

As clearly seen in FIGURE 17, the assembled composite cam unit 25 is illustrated cooperable with the intermediate member or cam follower 29 and the microswitch 30, said cam follower 29 being provided with a head 29*a* engaging the radial edge of the cam surface or profile. A similar construction is provided for the teardrop cams 18', 21' and the remaining composite cam unit 31. The thickness of the cam follower, see FIGURE 18, is dimensioned in such a manner that it is capable of scanning the profile of the cam across its entire width.

As a result of the rotation of the main control shaft 7 by means of the motor 1, the teardrop cam extensions 18' and 21', or the individual cam pieces which, when assembled, define the composite cam units 25 and 31 contact the respective engaging surfaces or head of the cam followers 19, 27, 29, 33 in a predetermined sequence which will be described in detail below. During engagement of the respective cams with their associated cam followers pivotally mounted on the shaft 36, the cam followers are forced downwardly a predetermined distance corresponding to the height of the operable cam profile. As a result of this, the actuating pins of the respective microswitches bearing against the lower edge of their corresponding cam followers are likewise forced downwardly. The actuating pins remain in this lower depressed position until the teardrop cam extensions 18' and 21' or the composite cam units 25 and 31 have passed by their respective cam followers and release the same. Upon release of the cam followers 19, 27, 29 or 33, the latter move upwardly to the initial position under the action of a spring provided for the actuating pins of the respective microswitches.

As shown in FIGURES 1 and 20, the main control shaft 7 carries a graduated disk or wheel 18 having a teardrop cam member 18' and a wider annular extension 18'' which laterally guides the cam follower 19, see FIGURE 20.

This teardrop cam 18', by means of its associated cam follower 19, controls the microswitch 20 which, if the timer mechanism is set for fully automatic operation, energizes the motor 1 provided with an iron core 1' and a rotor 1''. An annular member 18''' integral with the graduated disc 18 is provided with a recess 18*b* supporting a rib or projection 18*a*, see FIGURES 20 and 21, adapted to limit the return movement of the control shaft 7, said movement being caused by the return spring 35. The control shaft return spring 35 is secured at one end 35*a* to the plate 8, while its other end is fastened by means of suitable fasteners 4*b* to the hub 4*a* of the gear 4. The extent of said return movement of the control shaft 7 is limited by the engagement of the mentioned rib or projection 18*a* having an angular stop member 49 provided with an elongated aperture 50 for adjustable mounting on the plate 10, see FIGURE 21. Thus, the extent of the return movement of the control shaft 7 can be controlled by selectively positioning said stop member 49 relative to the rib 18*a*.

As shown in FIGURES 1 and 20, the graduated wheel or timing disk 18 is disposed adjacent a rotatable wheel member 21 provided with a teardrop cam 21'. The teardrop cam 21', by means of a cam follower 27, cooperates with a microswitch 28 which, at the end of each cycle, switches off the timer mechanism which is briefly operated. The unitary cam 21' is separated from the subsequent axially arranged rotatable disks 23 and 24 by means of a spacer member 22, said spacer member being fixedly secured to the control shaft 7. The disk members 18, 21, 23 and 24 each are provided with an annular recess 18*c* for receiving a spring member 18*d*. The wheel 23 is connected to a composite cam unit 25 comprising a plurality of individual or component disks 25*a* to 25*h*. The profile or cam surface of the composite cam unit 25 can be varied by rotating the spring biased wheel 23, since one of the individual cam disks of the composite cam unit 25 is operatively connected to the spacer disk 26 mounted on the control shaft

7, while the remaining individual cam disks are coupled to one another.

These individual or component cam disks are coupled to one another by means of tongues **51** and grooves or cutouts **52** provided on each component disk.

Figures **12** and **13** show one embodiment of a component or individual cam disk **25***a* of the assembled composite cam disk **25**. The tongue **51** is located at the end of the groove or cutout **52** which is concentric to the central axis **53**.

As shown in the embodiment of FIGURE 19, illustrating several individual cam disks coupled to one another, the tongue **51** of one individual cam disk engages the cutout **52** of the adjacent individual cam disk.

In the embodiment of FIGURE 12, the groove **52** forms part of the central annular aperture for the individual disk **25***a*, while in FIGURES 14 and 19, the groove **52** is spaced from the central aperture of the individual disk and is disposed approximately midway between said central aperture and the edge of the disk. It is, of course, possible to have the tongue and groove arrangement disposed at the periphery of the individual disk. Upon turning the wheel **23** about its horizontal axis, the respective tongues engaging the adjacent disks after a certain relative movement within the groove or cutout **52** of the adjacent individual cam disk cause rotation of the latter.

FIGURES 14 and 15 illustrate the manner in which the front face **25***a'* of the component cam disk **25***a* of the assembled composite cam disk **25** is positively connected with the respective rotatable wheel **23** by means of the tongue **51***a* receivable in a slot **23***a* provided on said wheel **23**. The rear face **25***h'* of component cam disk **25***h*, in FIGURE 18, is connected in the same manner to the spacer disk **26** fixedly secured on the main control shaft **7**.

As a result of turning the rotatably mounted wheel **23**, the first individual cam disk **25***a* coupled to said wheel **23** is initially rotated. The tongue **51** of the now revolving individual cam disk **25***a* (directed towards the right in FIGURE 18 and not visible) moves within the cutout **52** of the adjacent individual cam disk **25***b* which is initially at rest until it engages the edge of the cutout **52** of said cam disk **25***b*. As a result of this engagement, the tongue **51** of the individual cam disk **25***a* projecting into the cutout **52** of the adjacent individual cam disk **25***b* acts as a driving member. The individual cam disk **25***b*, likewise, is rotated, whereby its associated tongue **51** slides in the cutout **52** of the next adjacent individual cam disk **25***c* until the edge of this cutout is similarly engaged. By means of a chain reaction, a spreading or fanning of the individual cam disks **25***a* to **25***h*, constituting the assembled composite cam unit **25**, is obtained during rotation of the wheel **23**, see FIGURE 19. Upon termination of the fanning operation of the individual cam disk, all of the respective tongues thereof are at the edge of the respective cutouts or grooves adjacent their individual cam disks, unless the rotary movement, manually executed on the rotatable disk or wheel **23**, is terminated earlier. In the course of the described fanning of the respective individual cam disks, there is obtained a spreading of the individual cam disks with respect to one another. In FIGURE 19, the assembled composite cam unit **25** is illustrated in a position of maximum fanning, the individual or component cam disks **25***a* to **25***h* being staggered with respect to one another. Hence, the operable camming surface of the composite cam unit **25** comprises in toto the staggered individual profiles of the respective component or individual cam disks **25***a* to **25***h*.

The composite cam unit **25** cooperates via its associated cam follower **29** with the microswitch **30** controlling the opening and closing of an injection mold.

A composite cam unit assembly **31** is coupled with a rotatably mounted disk or wheel **24**, said composite cam unit **31** being similarly formed of individual or component

disks and being operatively connected via one of its individual cam disks to a fixed spacer disk **32** in a manner already described. The cam unit **31** cooperates via the cam follower **33** with the microswitch **34** to initiate and terminate the injection step.

As mentioned in the foregoing, during engagement of the cams **18'**, **21'**, **25** and **31** with their respective cam followers **19**, **27**, **29** and **33**, a downward movement of the latter takes place, said downward movement resulting in a depression of the spring-biased actuating pins of the respective micro-switches. If the assembled composite cam unit **25** engages by means of its profile or cam surface the cam follower **29** and moves the associated actuating pin **30***a* of the microswitch **30** downwardly, electromagnets are energized, due to closing of an electric circuit, said electromagnets causing closure of the injection mold. When the cam follower **29** and, accordingly, the spring-biased actuating pin **30***a* of the microswitch **30** are released after the entire cam profile has passed the cam follower **29**, opening of the injection molding mold is obtained by interruption of the previously closed electric circuit. The time interval between closing and opening of the mold is controlled by varying the geometric length of the profile of the individual cams of the cam unit **25**. This geometric length of the profile of the composite cam unit **25** is adjustable, as described above, by turning the rotatable wheel **23**.

The relation explained above between the adjustability of the geometric length of the cam profile and the control timing of the various stages of operation similarly exists in the case of the assembled composite cam **31** during engagement of the front of the cam profile and, accordingly, during the depression of the actuating pin of the microswitch **34**, the injection molding operation is initiated by energization of the electromagnets of the respectively associated hydraulic or pneumatic device. Such operation is terminated by releasing the actuating pin of the microswitch **34** when the entire operable cam profile has passed the cam follower **33**.

The graduated disk **18** is provided on its periphery with markings defining a time dial. The markings are from 0 to 60 seconds, wherein 60 seconds is the maximum duration of a single cycle. The cycle may be selected so as to be completed in a shorter or longer period of time, but in the present example, it should not exceed the time of 60 seconds.

The rotary disks or wheels **23** and **24** have markings on their circumference of colors different from the color of the time dial markings, so as to be more readily visible. The rotatable wheel **23** can be adjusted for selecting the time interval between closing and opening of the injection mold by displacing the marked rotary disk **23** with respect to the time dial of the graduated disk **18**.

A cycle of operation is terminated when the motor circuit is interrupted by the teardrop cam-like extension **21'** briefly actuating the microswitch **28**. Upon termination of each operative cycle, the control shaft **7** is returned to its initial position by the return spring **35**, whereupon a subsequent operational cycle is initiated. To initiate this subsequent cycle, the teardrop cam-like extension **18'** briefly operates the microswitch **20** during the final phase of the return movement of the control shaft **7** to reclose the motor circuit. This brief closing of the microswitch **20** results in actuation of a relay which closes and keeps closed the motor circuit for the duration of the entire cycle.

In the embodiment shown in the drawings, the relay arrangement operates as follows: the brief closing of the motor circuit by the microswitch **20** results in a magnetic field being built up in the laminated stator core **1'** of the motor **1** so that its rotor **1''** starts to rotate.

With reference to FIGURES 4, 5, 6 and 7 of the drawings, a soft iron rocker arm **37** is secured by means of a screw **60** to a link **38** carried by the switching shaft

39. The rocker arm 37 is normally disposed above the stator core 1' of the motor 1 which may be a miniature induction motor. As the magnetic field in the stator core 1' is building up, the rocker arm 37, which is spaced from the stator core 1' when no current is supplied to the motor, is attracted by the magnetized stator core 1'. Since the rocker arm 37 is rigidly secured to the switching shaft 39, a downward movement of the rocker arm 37 results in a limited clockwise rotation of the shaft 39 acting via a flexed lever 40 supported thereon on the actuating pin 41*a* of the microswitch 41. This actuating pin 41*a* then remains in contact-closing position and holds the motor circuit closed for the duration of the entire cycle. Upon completion of the cycle, the circuit is interrupted by means of the microswitch 28. Upon breakdown of the magnetic field in the stator 1', the rocker arm 37 is released, whereupon this rocker arm is lifted by the spring force of the pin 41*a* of the microswitch 41 acting against the flexed lever 40, the control shaft 39 and the link 38.

The fully automatic operation of the timer mechanism can be changed over to semi-automatic operation by a toggle switch 16, in which case the repeated cycles are not linked automatically, i.e., each new cycle has to be initiated by manual operation, that is by depressing the push button 17. The same button 17 acts mechanically on the microswitch 41 by means of an actuating rod 42, the link 38, the shaft 39 and the lever 40.

Depression of the push button 17 simultaneously returns the rocker arm 37 to its position on the stator core 1'. The field which is building up in the stator core 1' as a result of the brief operation of the microswitch 41 retains the rocker arm 37 in position on the stator core 1', so that the microswitch 41 is maintained in contact-closing position. Thus, the motor circuit remains closed until it is interrupted by the teardrop cam 21' actuating the microswitch 28 by means of its cam follower 27.

The rigid but readily adjustable connection between the rocker arm 37 and the link 38 by means of the screw 60 is important for satisfactory operation of the rocker arm 37. If the latter is to properly engage and bear against the stator core 1' without being subjected to vibration, the engaging surface of this rocker arm 37 must be absolutely plane and parallel to the adjacent engaging surface of the stator core 1'. It is extremely unlikely that the entire engaging surface of the rocker arm 37 will be absolutely parallel when the timing mechanism is originally assembled. Therefore, it is necessary to provide means for subsequent adjustment of the rocker arm, such as screw 60.

In order to assure that the main control shaft 7 rapidly returns to its initial position with very little friction upon the completion of a cycle, the motor 1 is automatically disengaged from the reduction gearing 2 to 6 when the circuit is interrupted. Since the motor 1, once it is disengaged in this way, does not oppose the force of the return spring 35 of the control shaft 7, the return time for the control shaft 7 and thus the inoperative time between the individual stages of the cycle can be considerably reduced.

The asynchronous motor is automatically disengaged as follows: When the motor is in operation, i.e., when a magnetic field is built up in the stator 1', the rotor or armature 1'', which is axially displaceable, assumes a position controlled by the center of the magnetic field in the stator core 1'. The rotor 1'' is then positioned substantially in the central plane of the stator core 1', as clearly shown in FIGURE 10, and is continuously subjected to the axial thrust of a helical compression spring 47 lodged in one of the two armature bearings. When the motor circuit is interrupted, i.e., when the stator field has collapsed or disappeared, the spring 47 moves the rotor 1'' together with its rotor shaft 45 in an axial direction towards the left, see FIGURE 11. Due to this axial displacement, a driving gear 46 mounted on the rotor shaft 45 is disengaged from the first wheel of the reduction gearing 2–6 by means of which the drive force is transmitted to the main control shaft 7.

FIGURE 11 shows the position of the rotor shaft 45 when disengaged from the reduction gearing.

FIGURES 8 and 9 illustrate further details of the drive motor which is an asynchronous miniature induction motor.

In the timer mechanism according to the present invention, the motor circuit can be maintained in closed condition for the duration of one cycle by means of a relay. In place of a conventional relay, special relay means may be employed, in which the electromagnetic field of the stator core 1' actuates an armature in the form of a soft-iron rocker arm 37 so that said arm, acting through linkage means, holds the actuating pin 41*a* of the microswitch 41 in closed position for the duration of one cycle and reopens said microswitch 41 when another cam-operated microswitch 28 interrupts the motor circuit upon completion of the cycle, whereby the stator field disappears.

Depending upon whether the timer mechanism is set for semi-automatic or for fully automatic operation, the operation in which the first brief closure of the motor circuit resulting in energization of the stator field is effected differs. In the case of semi-automatic operation, the microswitch 41 is closed manually, whereas in the case of fully automatic operation, a control cam 18' recloses the motor circuit, thereby actuating the respective pin 41*a* of the microswitch 41 to close the latter with the aid of a flexed lever 40 when the control shaft 7 is returned to its initial position by the return spring 35.

It is very simple to adjust the time intervals of the various stages. To set the time interval between closing and opening of an injection mold, it is only necessary to turn the respective rotatable disk 23, so that the assembled composite cam 25 is fanned a predetermined amount. The injection time period can be set in the same way.

The extent to which the rotatable disks 23 and 24 are turned, i.e., adjusted, and the instants at which the preset stages occur within the cycle can be determined from the graduated wheel or disk 18 mounted on the control shaft 7. Hence a phase or stage of operation can be adjusted by turning a single disk.

The timing mechanism according to the present invention can be used, for example, to control a fully automatic injection molding operation. The same mechanism can be set for semi-automatic operation in special cases, in which it is desired to manually initiate the various stages.

A copper ring 48 is suitably provided for the stator core 1' disposed at its surface of engagement with the rocker arm 37. This copper ring 48, being an annular insert, forms a square on the engagement surface of the stator core 1' adjacent the rocker arm 37. The circumference of the ring 48 abuts the contact surface of the rocker arm 37 when the latter is attracted to the stator core 1'. The copper ring 48 reduces possible vibration of the rocker arm 37, due to the A.C. current flowing in the coils of the asynchronous motor and, thereby, improves the rocker arm operation. In addition to this, the copper ring 48 increases the electromagnetic field at the rocker arm 37 and improves the pulling action on the rocker and also the release thereof when the field collapses.

In the time switch mechanism according to the invention, the control of the individual stages constituting an operating cycle of the injection molding machine is carried out in the following manner:

(*a*) *In Case of Setting the Time Switch Mechanism to Fully Automatic Operation*

Placing the time switch mechanism initially in operation by actuating the push button 17. The latter acts on

the actuating pin 41*a* of the microswitch 41 via the actuating rod 42, the link 38, the rotatable shaft 39 and the flexed lever 40. At the same time, the push button 17 acts via the actuating rod 42 in such a way, that the rocker arm 37, due to its downward movement, engages the stator core 1' of the motor 1. The circuit of the time switch mechanism is closed by depressing the actuating pin 41*a* of the microswitch 41. The rocker arm 37 is retained in its stator core-engaging position by the electromagnetic field generated in said stator core 1' of the motor 1. The rocker arm 37 thus causes the actuating pin 41*a* of the microswitch 41, due to rotational movement of the shaft 39, and the flexed lever 40 to be in depressed condition, so that the rocker arm 37 remains in said stator core-engaging position. The drive motor 1 starts to run upon closing of the circuit, i.e., the control shaft 7 starts to rotate together with all of the disks and cams secured thereto.

The composite cam unit 25, made up of numerous individual or component disks 25*a* to 25*h*, is now rotated, due to the rotation of the control shaft 7 and upon contact with its associated cam follower 29 urges said cam follower downwardly. The cam follower 29, in turn, acts on the actuating pin 30*a* of the microswitch 30 in such a manner, that this actuating pin is also moved downwardly. As a result of this, an electric circuit will be closed which causes automatic closing of the injection mold by energization of the electromagnet through the intermediary of an associated pneumatic or hydraulic device. Since the cam surface of the composite cam unit 25 extends over a certain portion of said composite cam 25, the cam follower 29 and the actuating pin 30*a* of the microswitch 30 first remain depressed. Consequently, the injection mold remains in closed position.

Similarly, the cam unit 31 comprising several component cam disks contacts its cam follower 33, due to rotation of the control shaft 7. Thus, when the cam unit 31 engages the cam follower 33, the latter is moved downwardly so as to act upon the actuating pin of the microswitch 34, i.e., move it downwardly into its contact closing position. As a result of this, the electromagnets controlling the start of the injection operation are energized. Since the profile of the cam unit 31 has a certain predetermined cam length, the cam follower 33 and the actuating pin of the microswich 34 remain in depressed condition until, in the course of rotation of the control shaft 7, the camming portions of the cam unit 31 free the cam follower 33. The injection step is lasting for the length of time, the cam follower 33 is acted upon by the cam unit 31.

When the cam profile of the individual cam disks constituting the assembled cam unit 31 passes by the cam follower 33, it releases the latter. The actuating pin of the microswitch 34 rises under the action of a return spring and moves the cam follower 33 upwardly into its initial position. As a result of this, the electric circuit through the electromagnets controlling the injection operation is interrupted and the injection step is terminated.

Similarly, the end of the cam profile of the assembled sam unit 25 passes by the cam follower 29 and releases the latter as well as the actuating pin 30*a* of the microswitch 30. This actuating pin also moves upwardly into its rest position under the action of the spring. As a result of this switching operation, the opening of the injection mold is initiated by means of the electromagnets via a respective hydraulic or pneumatic device, whereby the molded article is expelled.

The teardrop cam 21' on the rotatable wheel 21, due to rotation of the control shaft 7, contacts the cam follower 27 and moves the latter downwardly. As a result of this downward movement of the cam follower 27, the actuating pin 28*a* of the microswitch 28 is likewise moved downwardly. This causes interruption in the electric circuit of the time switch mechanism with the result, that the electromagnetic field in the stator core 1' of the motor 1 disappears. The rocker arm 37 is now released and returns to its initial position. The motor is simultaneously decoupled from the transmission gear, due to axial displacement of the armature of rotor 1'' of the motor 1, as described in the foregoing. The control shaft 7 now decoupled from the motor 1 returns relatively rapidly under the influence of the return spring 35 to its initial starting position.

During the last phase of the return movement of the control shaft 7, the teardrop cam 18' contacts the cam follower 19. Upon engagement of the teardrop cam 18' with the cam follower 19, the latter is moved downwardly, thereby forcing the actuating pin of the microswitch 20 downwardly. Consequently, the circuit of the motor 1 is reclosed and the latter starts to run, the control shaft 7 thereby being rotated to overcome the force of the return spring 35, and a new cycle is initiated. The electric circuit is retained closed by the fact that, during depression of the actuating pin by means of the teardrop cam 18' through the intermediary of the cam follower 19, the electric circuit of the motor 1 is closed, resulting in generation of the electromagnetic field in the stator core 1' of the motor 1 to cause the rocker arm 37 to assume its stator core-engaging position. The rocker arm 37, in turn, acts in its stator core-engaging position on the actuating pin 41*a* of the microswich 41 via the control shaft 39 and the lever 40. This actuating pin 41*a* remains depressed for the length of time the rocker arm 37 is in an engaging position on the stator core 1' of the motor 1. Consequently, the electric circuit through the motor 1 remains closed, although the teardrop cam 18' rapidly releases the actuating pin of the microswitch 20 due to its relatively short operating cam profile. At the end of the cycle, the electric circuit is interrupted by means of the teardrop cam 21, as mentioned in the foregoing.

(*b*) *In Case of Semi-Automatic Operation of the Time Switch Mechanism*

The sequence of the initiated stages of operation constituting a working cycle corresponds to that in the fully automatic operation with the exception that the electric circuit for the motor remains interrupted upon completion of a cycle which, during the fully automatic operation of the time switch mechanism, is closed by the teardrop cam 18' in the very last phase of the return movement of the control shaft 7 by means of the microswitch 20. The initiation of each new cycle is caused by depressing the pushbutton 17, as previously described.

I claim:

1. A timing mechanism adapted to control performance of a series of operations in a predetermined sequence constituting a work cycle in a machine, comprising a rotatable control shaft, drive means operatively connected to said rotatable control shaft to impart rotational movement thereto, cam means supported by said rotatable control shaft including adjustable cam means, said adjustable cam means consisting of a group of individual juxtapositioned axially disposed disks including means for interengaging adjacent disks in such a manner that rotation of one disk about its axis imparts rotational movement to successive disks to spread said disks in a fan-like manner to thus selectively change the profile of said adjustable cam means, said cam means being adapted to actuate a group of operable members associated with said series of operations to initiate performance of a work cycle in said machine.

2. A timing mechanism according to claim 1, including a plurality of cam followers disposed adjacent said cam means, each of said cam followers being cooperable with and acted upon by said cam means at prescribed instants of time during rotation of said rotatable control shaft.

3. A timing mechanism adapted to control performance of a series of operations in a predetermined se-

quence constituting a work cycle in a machine comprising, a rotatable control shaft, drive means operatively connected to said rotatable control shaft to impart rotational movement thereto, cam means supported by said rotatable control shaft including adjustable cam means, said adjustable cam means consisting of a group of individual juxtapositioned axially disposed disks provided with tongue and groove means, the tongue means of said disks being engageable with the groove means of its adjacent disk to interlock said individual disks to define a composite adjustable cam unit, whereby rotation of one disk about its axis imparts rotational movement to successive disks to spread the latter to change the profile of said adjustable cam means, a plurality of cam followers disposed adjacent said cam means, each of said cam followers being cooperable with and acted upon by said cam means at prescribed instants of time during rotation of said rotatable control shaft, said cam followers being adapted to actuate a group of operable members associated with said series of operations to initiate performance of a work cycle in said machine.

4. A timing mechanism according to claim 2, including means operatively connected to said cam means for selectively altering the time in which said adjustable cam means act upon their respective cam followers, thereby changing the time sequence of said series of operations.

5. A timing mechanism according to claim 4, said means comprising a plurality of disk members, at least one of said members being provided with markings and serving as a fixed reference point, the remaining disks being rotatable relative to said marked disk to vary the camming action of their associated cam means.

6. A timing mechanism according to claim 3, wherein said tongue and groove means are integral with said individual disks.

7. A timing mechanism according to claim 6, wherein said tongue and groove means are disposed substantially midway between the central axis of said individual disks and its peripheral edge.

8. The combination with a machine performing a series of predetermined operations constituting a work cycle, said series of predetermined operations being controlled electromagnetically by means of switches of a timing mechanism comprising a rotatable control shaft, electric motor means including stator and rotor means operating in an electric circuit and in registry with said rotatable control shaft to impart rotational movement thereto, cam means supported by said rotatable control shaft, a plurality of cam followers disposed adjacent said cam means, each of said cam followers being cooperable with and acted upon by said cam means at prescribed instants of time during rotation of said rotatable control shaft to actuate said switches in a predetermined sequence, and rocker means disposed adjacent said stator means and in registry with said switch means which closes said electric circuit for the duration of a work cycle, said rotatable control shaft being provided with spring means for returning said shaft into its initial position upon deenergization of said electric circuit, one of said cam means being in registry with said electric circuit to briefly reclose the latter during the last phase of the return movement of said rotatable control shaft to thus build up a magnetic field in said stator means, said rocker means being pulled toward said stator by said magnetic field to thereby actuate said work cycle switch so that said timing mechanism automatically executes a series of successive work cycles, whereby initially said electric circuit is closed for the duration of said work cycle by one of said switches, the machine operation then being executed by other of said switches, and deenergization of said electric circuit for said motor means being achieved by another of said switches.

9. The combination according to claim 8, wherein said timing mechanism is provided with a monitor board having switching elements, one of said switching elements preventing brief closure of said electric circuit for said motor means by said one cam means, whereby each successive work cycle is manually initiated by actuating another of said switching elements.

10. The combination according to claim 8, wherein said rotor means is provided with a spring member decoupling said electric motor means from said rotatable control shaft when said electric circuit is deenergized and said magnetic field of said stator collapses.

11. The combination according to claim 9, wherein one of said switching elements of said monitor is in registry with said rocker means to advance the latter in the direction of said stator means, whereby manually closing said work cycle switch.

12. The combination according to claim 8, wherein some of said cam means consist of a group of individual adjacently arranged coaxial disks provided with means for interlocking said disks with one another to define a composite cam unit.

13. The combination according to claim 12, wherein said interlocking means are tongue and groove members integral with said respective individual disks, said tongue member of one disk engaging said groove member of an adjacent disk and being slidably disposed in said groove member, whereby said individual disks may be rotated relative to one another to form a different cam surface.

14. An adjustable cam comprising a plurality of individual adjacently disposed rotatable coaxially arranged disks having an aperture adapted to receive a supporting shaft, the periphery of said individual disks being provided with a cam surface, each of said disks having adjacently disposed tongue and groove means, said tongue means of one disk engaging said groove means of its adjacent disk to interlock said respective individual disks to one another to define a composite cam unit, said tongue means being slidably arranged in said adjacent groove means, whereby rotation of one of said individual disks causes successive rotation of the remaining disks to spread the latter to form a different cam surface arrangement.

15. An adjustable cam according to claim 14, wherein said groove means extends into said aperture.

16. An adjustable cam according to claim 14, wherein said tongue and groove means are spaced from said aperture and are disposed approximately midway between said aperture and the periphery of said disk.

17. An adjustable cam according to claim 14, wherein said tongue and groove means are located adjacent the periphery of said disk.

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