Dec. 29, 1959 L. KULL 2,918,969

PROGRAM CLOCK

Filed Feb. 23, 1954

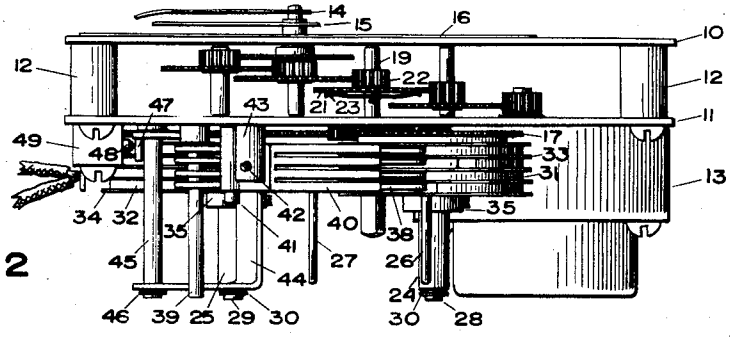


FIG. 2

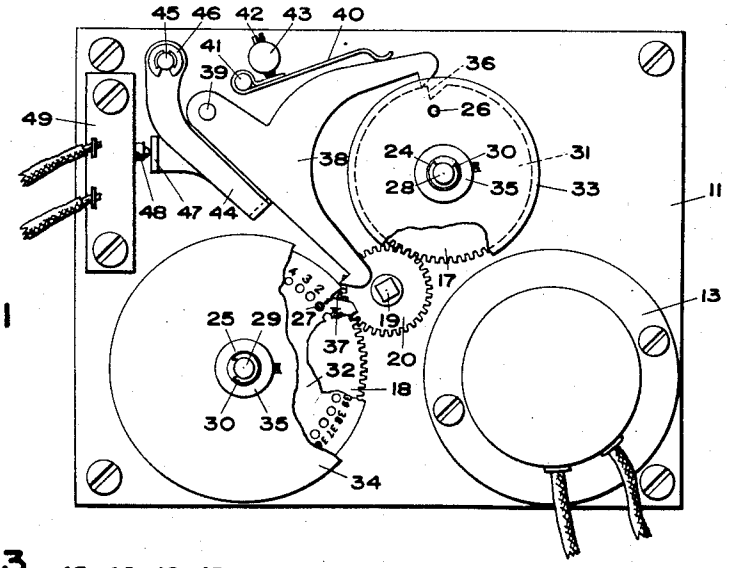
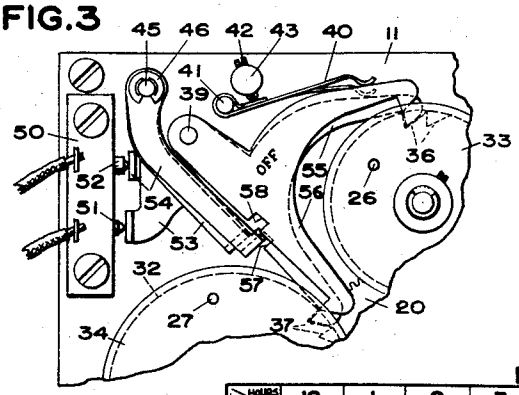


FIG. 1

FIG. 3



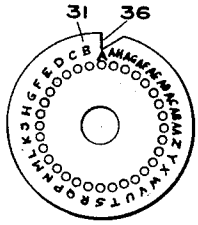


FIG. 4

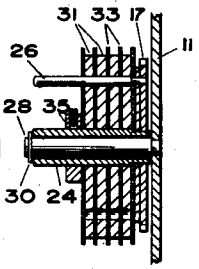


FIG. 5

FIG. 6

P.M.

HOURS / MIN.	12	1	2	3	4
00	A1	AE16	AA31	W1	S16
01	B2	AF17	AB32	X2	T17
02	C3	AG18	AC33	Y3	U
03	D4	AH19	AD34	Z4	
04	E5	A20	AE35	AA	
05	F6	B21	AF		
06	G7	C22			

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PROGRAM CLOCK

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12 Claims. (Cl. 161—1)

This invention relates to a program clock. More particularly it relates to a time keeping mechanism which can be conveniently pre-set to provide a substantial number of signal or output effects at selected instances in time during a given timing interval or period.

The general idea of a program clock which, for example, can be set to operate a control circuit at one minute intervals throughout a twenty-four hour period is not necessarily new. However, previous attempts have resulted in very complex and expensive mechanisms. When complexity is sacrificed, the selectivity or accuracy of the instrument decreases accordingly. It is the aim of the present invention to do away with elaborate drum mechanisms and punched tapes and the like and replace them with a simple and easily operable device.

If by way of example a clock is considered which is capable of being pre-set to close a switch or ring a bell or the like at any minute, on the minute, during a twenty-four hour interval, it is found that the clock must have one thousand four hundred and forty selectable operating points. The problem should be apparent at once. However, following the teachings of the present invention it is a simple matter to provide a clock which will cover a seven day period at one minute intervals, for example. The principle involved is susceptible of unlimited extension.

The present invention is based, in part, upon a charactertisic of rotating members operating at different speeds of rotation, which characteristic can best be explained in terms of a train of gears. If a pair of meshing gears is selected having x and y teeth, respectively, such that x and y do not have a common divisor other than "1," then a predetermined meshpoint will meet periodically, but only after a number of teeth on each gear equal to the product xy have passed through the meshpoint. A little reflection will reveal that between successive meetings of the predetermined meshpoint, that is, during a single complete cycle of the gears, each tooth on one gear will have encountered every other tooth on the other gear at the meshpoint. It can be demonstrated that if the number of teeth on each gear are increased without changing the gear ratio, and, therefore, without changing the relative speeds of rotation, the number of combinations of gear teeth encountering each other at the meshpoint will remain equal to the product xy. Since x and y obviously must each be greater than "1," it can also be demonstrated that both gears must each make more than one complete revolution during a complete cycle. This may be referred to as a "differential cycle" in order to distinguish it from conventional arrangements wherein one of the rotating members is arranged to make only one complete revolution in a given whole cycle of operation.

Now mark each gear around its periphery with a number of index marks. On the gear having nx teeth there can be placed x marks and on the gear having ny teeth there can be placed y marks where n is a positive integer. It should be obvious from the previous discussion that each index mark on one gear will encounter every other index mark on the other gear at the meshpoint during a single complete cycle of the gears. The number of combinations is equal to the product xy. From

the above it will be clear that this represents the maximum number of combinations available with the selected gear ratio or ratio of speeds of revolution.

Assuming that it is known in advance how many combinations are desired it is a relatively simple matter to work backwards and ascertain the gear ratio. If the number 1440 is chosen which is the number of minutes in a twenty-four hour period, it is known from the above that this should represent the product of the terms of the gear ratio. It has also been established that there should be no common divisor for these terms. Therefore, the number 1440 is taken and factored to ascertain its prime factors. The result is

$$2\times2\times2\times2\times2\times3\times3\times5$$

The prime factors are then separated into two groups such that all the factors having a given value are in one group. The possible groupings are:

$$2\times2\times2\times2\times2=32 \text{ and } 3\times3\times5=45$$
$$2\times2\times2\times2\times2\times3\times3=288 \text{ and } 5=5$$
$$2\times2\times2\times2\times2\times5=160 \text{ and } 3\times3=9$$

For reasons which will appear after reading the detailed description to follow, the ratio of 32:45 provides the preferred solution.

The same result can be reached if the speeds of rotation of the rotating members expressed as a fraction are chosen such that the reciprocals thereof are in the ratio of $x:y$ wherein the two terms are each greater than "1," they do not have a common divisor other than "1," and the product of the two terms is equal to the total number of combinations desired. Thus it is not necessary to limit the invention to gear driven rotating members. To cite another example, consider the number 2016 which represents the number of 5 minute intervals in a period of one week. A suitable set of speeds for the two rotating members will be found to be $\frac{1}{160}$ r.p.m. and $\frac{1}{315}$ r.p.m., respectively. The reciprocals of these speeds are in the ratio of 160:315. This ratio is reduceable to the ratio 32:63.

So far the discussion has been limited to the consideration of only two rotating members. However, the principle can be extended to cover any number of members as the occasion requires. It is only necessary to choose different speeds for the rotating members expressed as a fraction such that the reciprocals thereof are in the ratio of $x:y:z: \ldots :n$ wherein all of the terms are greater than "1," no two of the terms of the ratio have a common divisor other than "1," and the product of all the terms is equal to the total number of combinations desired. If gears are employed then the above ratio represents the gear ratio as well.

Selecting as an example the number of minutes in a week (10,080) there will be found several solutions among which are 32:35:9 and 32:45:7. These relationships are preferred instead of, for example, the ratio 63:160 which is also a solution. In this case the member represented by the term 160 would have to be too large.

The invention will be better understood, however, after reading the following detailed description with reference to the accompanying drawing, in which:

Figure 1 is a vertical elevation with portions broken away, of the rear of a clock unit showing the actuator mechanism in detail and representing one embodiment of the invention;

Figure 2 is a top view of the clock unit shown in Figure 1;

Figure 3 is a fragmentary elevational view of the rear of a clock unit showing a modification of the structure of Figure 1;

Figure 4 is a detail view of an indexing member or

rotatable cam which forms a part of the invention embodied in the structures shown in Figures 1 to 3;

Figure 5 is a fragmentary detail view in section showing a portion of the actuator mechanism; and

Figure 6 represents a fragmentary portion of a typical setting chart to be used in conjunction with the mechanisms shown in Figures 1 to 5.

Referring to Figures 1 and 2 of the drawings there are shown the details of a program clock capable of being pre-set to close a switch as often as fifteen times during a twenty-four hour period. The unit comprises two rectangular frame plates **10** and **11** fastened together at their four corners and maintained in spaced parallel relationship by the spacing sleeves **12**. A suitable timekeeping mechanism in the form of an electrically operated synchronous clockmotor **13** is secured to the plate **11** and coupled through a conventional train of gears to the clock hands **14** and **15**. A clock face **16**, having appropriate indicia thereon, is secured behind the hands to the plate **10**. The hands in cooperation with the face **16** provide the usual time indicating means.

A pair of driven or spur gears **17** and **18** are secured to hubs **24** and **25**, respectively, and mounted for rotation on the posts **28** and **29**, respectively. This is best seen in Figure 5. The posts, in turn, are secured to the plate **11**. Retaining rings **30, 30** having a diameter slightly less than the diameter of the hubs are located at the ends of the posts **28** and **29** to prevent removal of the gears.

In order to interrelate the driven gears with the timekeeping mechanism a driving member in the form of a driving gear or pinion **20** is secured to the shaft **19** in mesh with the spur gears **17** and **18**. The shaft **19** is journaled in the plates **10** and **11**. In addition to the pinion **20**, two other gears, **21** and **22**, are mounted on shaft **19**. As shown, these gears are located between the plates **10** and **11** and form part of the gear train between motor **13** and the hands **14** and **15**. The gear **22** is keyed or otherwise secured to shaft **19** while gear **21** is only frictionally secured thereto by spring member **23**. The free end of shaft **19** is square-shaped to receive a setting key of suitable construction. In the alternative, a knob could be permanently secured to the end of shaft **19**. This arrangement provides the usual means for pre-setting the hands of the clock to coincide with the actual time of day.

In the twenty-four hour clock presently under discussion it is desired to provide 1440 operating points, i.e., at one minute intervals. Therefore, gears **17** and **18** are provided with 64 and 90 teeth, respectively, i.e., in the ratio of 32:45. Since these gears are required to complete one full cycle in twenty-four hours they must rotate at speeds of $\frac{1}{32}$ r.p.m. and $\frac{1}{45}$ r.p.m., respectively. This is achieved by providing pinion **20** with 32 teeth and causing it to rotate at $\frac{1}{16}$ r.p.m. As previously explained, the gears **17** and **18** could have 32 and 45 teeth, or 96 and 135 teeth, respectively, for example. The final choice is controlled by design convenience. From a practical standpoint it is desirable to arrive at a compromise between keeping the number of rotating members at a minimum and keeping the number of index points on a given member at a minimum.

In order to index or define the different combinations of positions of the spur gears **17** and **18** there are provided a plurality of indexing members **31** and **32**. Indexing member **31** is shown in detail in Figure 4. It comprises a thin disc or rotatable cam provided with operation controlling means in the form of a notch or indentation **36**. A plurality of small indexing apertures are arranged in a circle concentric with the center of the disc which is also apertured. The small indexing apertures are equally spaced around the disc and individually identified by the letters A to AH. Any other suitable indicia may also be employed. It will be noted that 32 such apertures are provided and the notch **36** is adjacent the aperture "A."

The indexing members **32** are similar to the members **31** except they are provided with 45 equally spaced apertures which are identified by the numerals 1 to 45. In this case the notches **37**, as seen in Figure 1, are adjacent the aperture "1."

One or more of the discs **31** can be located on hub **24** separated from each other by spacers **33, 33**. In order to maintain a desired indexed position of cam **31** relative to gear **17**, the latter is provided with a locating pin **26** which is arranged to receive one of the lettered apertures on the discs **31**. The locating pin effectively establishes a point of reference on the gear. The spacers **33** are disc-shaped and suitably provided with a single aperture adjacent the periphery to receive the locating pin **26**. In similar manner one or more of the discs **32** can be located on hub **25** engaging the locating pin **27** which is secured to gear **18** and separated one from the other by spacers **34**. For a reason which will be mentioned below the spacers **33** and **34** are provided with slightly larger diameters than the diameters of the respective indexing members **31** or **32**.

As best seen in Figure 5, the plurality of cams and spacers are held tightly together against the respective gears **17** or **18** by any suitable clamping means such as the collar **35** held in place by a set screw.

Considering a pair of indexing members **31** and **32** it can be appreciated that there are 1440 different combinations of letters and numbers. Since any lettered or any numbered aperture, as the case may be, can engage the corresponding locating pin there are 1440 combinations of relative positions between the cams **31** and **32**. It is arranged that each combination represents a predetermined minute during a twenty-four hour period.

As one means of determining the combination which corresponds to a particular minute there is provided a chart or tabulation, a corner of which is shown in Figure 6. The tabulation has been arbitrarily begun at 12:00 noon with that time represented by the combination "A1." The next minute, 12:01, is represented by "B2," 12:02 by "C3" and so forth until after 1440 minutes or combinations it recommences at "A1."

With the desired number of cams pre-set on the hubs **24** and **25**, it is necessary to provide means for providing the required output when the cams assume the preselected positions relative to each other. To this end there are provided a plurality of cam followers each in the form of a double-acting pawl **38** pivotally mounted on a post **39**. The latter is secured to the plate **11**. As shown in Figures 1 and 2, the pawl ends of the followers **38** are urged against the peripheries of the indexing cams **31** and **32** by means of a flat multifurcated spring **40**. The spacers **33** and **34** serve to confine the pawls to the proper cams. The non-furcated end of the spring is provided with a loop which serves to pivotally mount it on post **41** which is, in turn, fastened to plate **11**. The multifurcated end of the spring engages the separate followers **38** and is adjustable as to tension by means of a set screw **42** threadedly supported in a post **43** on plate **11**.

Means for operating an output switch in response to operation of any one of the cam followers **38** is provided in the form of an operating lever **44** pivotally mounted on the post **45**. The lever **44** is retained on the post by the retaining ring **46**. A portion **47** of the lever **44** is arranged to operate the button **48** of the microswitch **49**, the switch **49** being secured to the plate **11**. The pair of rotating members, the set of followers **38**, and the lever **44** may be thought of as an actuating mechanism for the switch **49**.

The operation of the embodiment described above will now be readily understood. Referring to Figure 1 it will be seen that as the clock operates and pinion **20** drives the spur gears **17** and **18** of the indexable elements, the notches **36** and **37** of the indexable means **31** and **32** will simultaneously align themselves with the

corresponding pawls of follower **38**. At this moment the follower **38** will drop into the recesses under the urging of spring **40** and cause lever **44** to pivot clockwise about post **45**. This, in turn, urges the portion **47** against button **48** to operate switch **49** and close the connected circuit which may take any well known form.

As illustrated in Figure 1, disc **32** is indexed at point "1" while disc **31** is indexed at point "A." With regard to the latter, it should be noted from Figure 4 that the notch **36** is located adjacent the aperture "A." Referring to the chart of Figure 6 it will be observed that "A1" represents 12:00 noon. Therefore the clock hands **14** and **15** should now be pointing to 12:00 o'clock noon. It follows as an obvious conclusion that the locating pins or reference points on the spur gears **17** and **18** must bear a predetermined relationship with the clock hands and thus be correlated, when the hands are properly pre-set, to the actual time of day. If the clock face covers only the conventional twelve hours, then some means will be included to indicate when the clock is operating in its a.m. phase and when it is operating in its p.m. phase. If desired, the clock face may cover the full 24 hours.

With aperture "B" of disc **31** and aperture "2" of disc **32** engaging their respective locating pins, the notches **36** and **37** will each be advanced one step in the clockwise direction from the locating pins **26** and **27**. If the gears **17** and **18** rotate in the counter-clockwise direction at the requisite speed, both notches will again engage the pawls after an interval of one minute. This agrees with Figure 6 which shows "B2" to represent 12:01 p.m. Thus the actuating mechanism comprising the controlled members **17** and **18** and the indexable cams **31** and **32** can be pre-set in a novel manner to operate at any minute within an interval of 24 hours. With fifteen sets of cams set on the clock along with fifteen followers the switch **49** will be operated fifteen times during the 24 hour period. Of course the posts **28**, **29** and **39** can be suitably extended to accommodate more than fifteen cam pairs. In such case it may be necessary to extend the captive ends of the posts through plate **11** to be staked to plate **10**.

For proper results the width of the notches **36** and **37** should be slightly less than the peripheral arc between adjacent indexing apertures. By suitable design the pawls on the follower **38** can be given an appreciable dwell period to ensure operation of the load device. A dwell of five to ten seconds is not impossible.

Theoretically a maximum of 32 disc pairs are needed on a 24 hour-1 minute interval clock in order to provide any number of operations up to 1440. This follows from the fact that disc **31** has 32 positions and disc **32** can be provided with more than one notch. For instance, if the times 12:05 p.m., 2:45 p.m., and 3:01 a.m. are considered, the combinations are "F6," "F31" and "F2" and thus only one disc pair is needed; an "F" disc and three notches in the other disc located opposite the appropriate apertures so that they will occupy positions relative to the locating pin corresponding to "2," "6" and "31." The follower **38** will drop on this disc pair three times during a 24 hour period.

In Figure 3 is shown a modification of the structure of Figure 1 with an "On-Off" microswitch **50**, having both an "On" button **51** and an "Off" button **52**. Instead of the single lever **44** of Figure 1, there are now two levers **53** and **54** pivotally mounted on post **45**. Instead of the one type of follower lever **38**, there are now two types, **55** and **56**. The difference between followers **55** and **56** and follower **38** is the provision of the cutouts or recesses **57** and **58**. In Figure 3 the "On" lever has just dropped and the "On" button **51** has been depressed. It can be seen that cutout **57** bridges the contact bar of lever **54** and thus avoids operating the latter. During the one minute interval immediately following the dropping of follower **55**, the cam faces of notches **36** and **37** raise the follower **55**. If the "Off" operation is to occur at the end of this one minute then, as shown in Figure 3, the "Off" follower **56** will drop and depress the "Off" button **52**. This restores the "On" button **51** which has been cleared by the previous raising of follower **55**.

The specific structure of the clock embodying the present invention is susceptible of substantial modification to accommodate itself to various requirements of use. In the following paragraphs an attempt will be made to outline a few possibilities by way of suggestion.

In many cases a program clock is required to operate more than one circuit. In present program clocks the number of circuits is somewhat limited because there must be independent drums or disc setups for that purpose. In the present invention, however, each impulse is handled separately and independently from the others, each lever **38** may be made to operate a separate switch or contact or they might operate in groups a switch or contact using for each group a lever like **44** in Figures 1 and 2. The group levers can then be pivotally secured to the same post (e.g. **45**) and a series of switches (e.g. **49**) can be mounted on top of each other.

A weekly period program clock can be constructed using the rotating ratios as described above. However, since in many cases the signals will be the same every day but Saturday and Sunday, a calendar disc may be included driven by a 24 hour cam and arranged to switch off certain ones of the followers (e.g. **38**) and, if necessary, place into operation other followers on Saturday and Sunday.

Various types of relays may be used with the mechanism for different purposes such as a time delay relay to ring bells during a desired short time interval. An On-Off relay can be used where the first impulse of the program clock is to be used to close the circuit and the second impulse is to open the circuit. This will adapt Figure 1 to provide the same results as Figure 3.

Further modifications may be made in connection with the discs **31** and **32** and followers **38**. In the illustrated embodiment the energy to operate the switch **49** is obtained from the spring **40**. If desired, the spring can be eliminated and the motor energy used directly to operate the switch. This, however, will decrease the accuracy of the clock.

The discs **31** and **32** may be provided with pins, or notches having different shapes from those shown in the drawing. If pins are employed, the follower can be in the form of a straight lever having its midpoint coupled to the output switch. This arrangement will operate when both ends of the lever are raised simultaneously by engagement with the pins on the discs.

The discs **31** and **32** and their spacers **33** and **34** can be formed as an integral unit from a thin sheet of metal, the middle portion and the notch being pressed out. In order to locate these discs the locating pins may be eliminated and replaced by a hub provided with a key. The diameter of the hubs would also be increased. The discs **31** and **32** would then be provided with a centerhole having internal teeth for receiving the key, instead of the indexing apertures, and the identifying indicia would be appended to each internal tooth.

Numerous other modifications besides those already described will readily occur to those skilled in the art and it is therefore not intended to limit the invention to the precise embodiments shown and described but all suitable modifications and equivalents may be readily resorted to.

What I claim is:

1. A program clock having a timekeeping mechanism, means for providing an output effect, and an actuating mechanism for actuating said means for providing an out-

put effect at pre-selected instances in time during a cycle of operation within a given time interval, said cycle of operation recurring indefinitely during continuous operation of said timekeeping mechanism; said actuating mechanism comprising a plurality of independently indexable elements coupled to said timekeeping mechanism for controlled rotation at different speeds expressed as a fraction such that the reciprocals thereof are in the ratio of $x:y:z: \ldots :n$ wherein all of the terms of the ratio are greater than "1," no two of the terms of the ratio have a common divisor other than "1," and the product of all the terms is equal to the total number of pre-selectable instances within said given time interval, whereby said elements continually assume different positions relative to one another, said elements being indexable to define a plurality of said relative positions equal in number to said product, means for establishing a correlation between said indexable relative positions and the actual time of day with each indexable relative position corresponding to a different actual time within said given time interval, and means cooperating with said indexable elements and said means for providing an output effect for actuating the latter when said elements assume a pre-indexed relative position corresponding to a pre-selected time.

2. A program clock according to claim 1, wherein each of said indexable elements comprises a controlled member coupled to said timekeeping mechanism for controlled rotation, and at least one rotatable cam having means for detachably securing it to said controlled member in a given number of pre-selectable relative equi-angular positions, the number of said pre-selectable positions being equal to the term of said ratio which corresponds to the indexable element of which said cam forms a part.

3. A program clock according to claim 2, wherein each of said indexable elements comprises the same number of said cams, and wherein said means cooperating with said indexable elements comprise a set of cam followers equal in number to the number of cams included in a single indexable element, each cam follower being constructed to simultaneously engage one cam in each of said indexable elements, each cam in a particular indexable element being engaged by a different cam follower, whereby operation of a cam follower is predicated upon said indexable elements simultaneously attaining predetermined positions relative thereto.

4. A program clock according to claim 3, wherein said means for providing an output effect comprises means responsive to operation of any one of said cam followers for controlling an electrical switch device.

5. A program clock according to claim 3, wherein said means for providing an output effect comprises first and second electrical switch means, means responsive to operation of any one of some of said cam followers for controlling said first electrical switch means, and means responsive to operation of any one of the remainder of said cam followers for controlling said second electrical switch means.

6. A program clock according to claim 1, wherein there are two of said indexable elements and the reciprocals of their speeds of rotation are in the ratio of 32:45.

7. A program clock according to claim 1, wherein there are two of said indexable elements and the reciprocals of their speeds of rotation are in the ratio of 32:63.

8. A program clock according to claim 1, wherein there are three of said indexable elements and the reciprocals of their speeds of rotation are in the ratio of 32:35:9.

9. A program clock according to claim 1, wherein there are three of said indexable elements and the reciprocals of their speeds of rotation are in the ratio of 32:45:7.

10. A program clock having time indicating means, a timekeeping mechanism coupled thereto for driving said indicating means so as to manifest the actual time of day when properly pre-set, means for pre-setting said indicating means, means for providing an output effect, and an actuating mechanism for actuating said means for providing an output effect at pre-selected instances in time within a given time interval; said actuating mechanism comprising a plurality of independently indexable elements coupled to said time indicating means for controlled rotation in time therewith, said elements being coupled to be rotated at different speeds expressed as a fraction such that the reciprocals thereof are in the ratio of $x:y:z: \ldots :n$ wherein all of the terms of the ratio are greater than "1," no two of the terms of the ratio have a common divisor other than "1," and the product of all the terms is equal to the total number of pre-selectable instances within said given time interval, whereby said elements continually assume different positions relative to one another, said elements being indexable to define a plurality of said relative positions equal in number to said product and each relative position corresponding to a different time within said given time interval, and means cooperating with said indexable elements and said means for providing an output effect for actuating the latter when said elements assume a relationship which has been pre-indexed with reference to said preset indicating means to correspond to a pre-selected time.

11. A program clock having a timekeeping mechanism, means for providing an output effect, and an actuating mechanism for actuating said means for providing an output effect at pre-selected instances in time within a given time interval; said actuating mechanism comprising a gear train having a driving gear operatively associated with said timekeeping mechanism, and a pair of cooperating driven gears having a gear ratio of $x:y$ wherein both x and y are greater than "1" and the product of x and y is equal to the total number of pre-selectable instances within said given time interval, whereby said driven gears continually assume different operative positions relative to one another, means for establishing a correlation between said different operative positions and the actual time of day, indexable means coupled to said driven gears for defining a plurality of said operative positions equal in number to said product, and means cooperating with said indexable means and with said means for providing an output effect for actuating the latter when said driven gears assume a pre-indexed operative position corresponding to a preselected time.

12. A program clock according to claim 11, wherein said indexable means comprise at least one rotatable cam for each driven gear having means for securing it to the corresponding driven gear in a given number of selectable relative equi-angular positions, the number of said selectable positions being equal to said x or said y depending upon whether the driven gear to which it is secured has nx or ny teeth, respectively, where n is a positive integer, and wherein said means cooperating with said indexable means comprise at least one cam follower operatively associated with a cam in each indexable means for actuating said means for providing an output effect when said cams assume predetermined positions relative to said cam follower.

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