

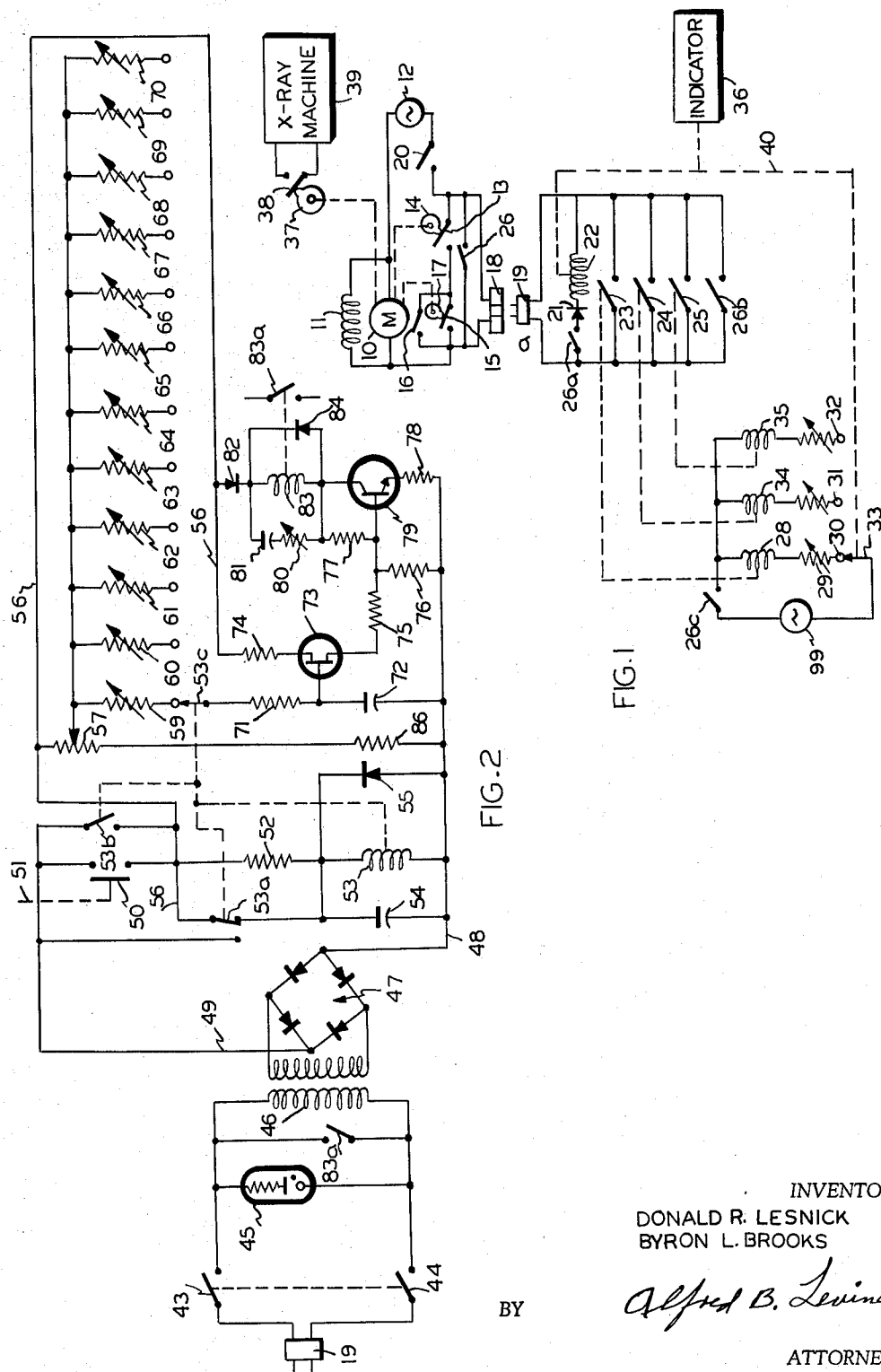
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PROGRAMMING MECHANISM FOR X-RAY SERIOGRAPH MACHINES

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3,243,591 PROGRAMMING MECHANISM FOR X-RAY SERIOGRAPH MACHINES

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This invention generally relates to improvements in automatic time programming mechanisms for many different applications and finding particular utility for use with X-ray seriograph machines, and more particularly to time programmers for cyclically operating machines for automatically controlling the machines to provide a preadjustable time interval spacing or preset delay between each cycle of operation of the machine.

Automatic seriograph machines as presently available are employed in conjunction with X-ray machines to successively feed X-ray films or cassettes to the machine and synchronously operate the X-ray machine with the feeding of the films for taking a series of X-rays of the patient. This time series of X-rays are employed to record the time changes of the patient's brain, heart, lungs, kidneys and the like.

Generally such automatic seriographs are selectively operable in either a continuous or intermittent mode of operation. In the continuous mode, the cassettes are automatically fed to the machine consecutively until the complete series of films are exposed, and in the intermittent mode the films or cassettes are fed individually in sequence under the control of the operator, whereby the time interval between the feeding of each cassette and the next is under the control of the operator.

In many applications, however, it is desired to automatically program the machine for a third mode of operation where the cassettes may be automatically fed to the machine, as in the continuous mode, but wherein the time interval between the feeding of each cassette may be individually preadjusted in advance without further supervision by the operator.

It is accordingly an object of the invention to provide a preadjustable automatic time programmer for automatic seriographs.

A further object is to provide such an automatic programmer wherein the time interval between the automatic feeding of each cassette in the series is individually preadjustable.

Another object is to provide such a time programmer that is compatible with existing automatic seriograph machines whereby the seriograph may be adapted for the third mode of operation as desired.

Still another object of the invention is to provide such a time programmer that may control and display the operation of the seriograph, from a remote location.

A still further object of the invention is to provide a separate time programmer device for seriographs that is detachably engageable with the seriograph whereby the seriograph machine may be employed with or without the automatic programmer and the programmer may be detachably added to existing seriograph without changes in the seriograph mechanism.

A more general object of the invention is to provide a time programming mechanism for automatically controlling a cyclically operating machine to initiate each succeeding operation after an adjustably presettable time delay following its preceding cycle of operation.

Other objects and many additional advantages will be more readily understood by those skilled in this art after a detailed consideration of the following specification taken with the accompanying drawing wherein:

FIG. 1 is an electrical schematic diagram illustrating

the electrical circuits for an existing seriograph together with one automatic programming system according to the invention, and

FIG. 2 is an electrical schematic diagram illustrating a preferred solid state automatic programmer employing the invention.

Referring to the drawings, there is shown in the upper portion of FIG. 1 the electrical controls for an automatic seriograph such as is disclosed in much greater detail in Patent 2,881,323, assigned to the same assignee; and there is shown in the lower half of this figure an automatic time programmer according to the present invention that is detachably interconnectable with the seriograph by means of an electrical connector 18 and 19 for automatically time programming its cycle of operation.

As is disclosed in much greater detail in the earlier patent, the seriograph mechanism generally comprises a drive motor 10 and a solenoid brake for the motor, which motor 10 controls both the feeding of the film cassettes to the machine and synchronously positions a series of timing cams 14, 17 and 37, that function to perform various timing functions such as energizing the X-ray machine and controlling its modes of operation. Specifically referring to this circuit, there is provided three switches 20, 13, and 15, in series with the motor 10 and with an energizing source of voltage 12. The first switch 20 is a manual power applying switch for applying energization to the seriograph motor, the second switch 15 is closed and opened once during the feeding of each cassette by means of its timing cam 17, and the third switch 13 is closed by its timing cam 14 until all cassettes have been fed through the machine and then it is opened by its cam 17.

Considering the operation of this seriograph in its intermittent mode, the initial energization of the motor to commence operations is performed by the operator closing the manual power switch 20 and then closing a foot operated microswitch 26, that as shown is connected to shunt or short circuit the initially opened cam switches 13 and 15. Closing of power switch 20 and start switch 26 applies power to the motor 10 and releases the solenoid brake 11, and as the motor commences to rotate, it rotates the cams 14 and 17 to close the series connected switches 13 and 15, respectively, to automatically continue the cycling of the motor. After beginning of the operation, the foot switch 26 may then be released by the operator and the motor 10 continues its cycle through closed switches 13 and 15.

The motor 10 is connected through suitable gearing (not shown) to position the first cassette from its storage position to an exposure position beneath the X-ray machine, and at the correct time in the cycle when the cassette is properly positioned, a third cam 37 being positioned by the motor closes switch 38 to initiate the application of energization to the X-ray machine and expose the cassette.

After the correct exposure, as controlled by the X-ray equipment the rotation of the cam 17 opens the switch 15 to deenergize the motor 10 and the brake solenoid 11 applies tension to brake to stop the motor. This sequence of operations completes the exposure of the first cassette, and the seriograph remains deenergized, with the switch 15 being open, until the operator again depresses the start switch 26 to repeat the cycle of operations as described above.

In the continual mode of operation of the seriograph, a manual switch 16, in shunt with the cam switch 15, is closed, whereby after each cycle of operation, as above described, has been completed and switch 15 is opened by its cam 17, the motor 10 remains energized through switch 16 and then automatically continues to position the

next cassette in place to repeat the next cycle of operation. Since the switch 16 remains closed, the motor 10 is continuously energized to repeat its cycle of operations over and over again until all of the cassettes have been exposed. After the complete series of cycles have been completed, the timing cam 14 then opens the switch 13 to deenergize the motor 10 and terminate the functioning of the seriograph.

In this continual mode of operation, however, the feeding and exposure of each cassette occurs directly after the previous cassette has been processed and there is no manner of individually programming the cassettes in any predetermined time sequence as is desired for many medical studies. For this purpose, the time programmer of the present invention is provided for enabling the time interval between the feeding of each cassette to be individually preadjusted thereby to provide the seriograph with this added versatility.

Returning to FIG. 1 for an understanding of a time programmer according to the present invention that is compatible with the seriograph of FIG. 1, there is provided within a separate detached housing a stepping relay having an energizing winding 22 and a series of fixed contacts such as 30, 31, and 32 that are adapted to be consecutively engaged by a movable contact 33 of the relay in response to each pulsed energization of the relay winding 22. The relay winding 22 is electrically connected across the terminals of an electrical connector 19 through a diode 21, and the connector 19 is adapted to detachably engage with a mating connector 18 that is normally provided in the seriograph mechanism for the purposes of enabling remote control of the seriograph.

As shown, the terminals of the connector 18 and mating connector 19 are connected in shunt across the cam operated switches 15 and 13, whereby when the programmer connector 19 is engaged with the seriograph connector 18, the stepping relay 22 is provided in shunt with the switches 13 and 15.

In series with the stepping relay winding 22, there is provided a manually controllable start switch 26a. There is also provided in shunt with the relay 22, a series of normally open contacts 23, 24, and 25, with each being actuated by a different one of a plurality of time delay thermal relay windings 28, 34, and 35, respectively. The thermal relay windings 28, 34, and 35, are each connected in series with a separately adjustable resistor, such as resistor 29, and with each thermal relay winding and resistor being in circuit with a different one of switch contacts 30, 31, and 32, respectively, of the stepping relay. Consequently, when the stepping relay selects each of these contacts in sequence, a different thermal relay winding and its associated resistor are adapted to be energized by the leakage current across connector 19 in the same manner as is relay winding 22.

In operation, the adjustable resistor for each of the thermal relay windings is individually adjusted to preselect the current for that relay corresponding to the time delay desired, and the seriograph and programmer are then readied for operation by manually closing the power switch 20, the series start switch 26a, and the manually closable switch 26c in series with the thermal relay windings. The closing of power switch 20 and the start switch 26a directs a pulse of leakage current through the motor winding 10 and the stepping relay winding 22 which operates to advance relay contact 33 to its first position at contact 30 as shown and the leakage current is applied to thermal relay winding 28 and resistor 29. After the preselected time delay, the thermal relay 28 closes its contact 23 to short circuit the seriograph switches 15 and 13 and the relay 22 and thereby applies full energization to the motor 10. Upon being energized, the motor 10 drives the cams 14 and 17 to close the switches 13 and 15, and the seriograph drive system then proceeds to advance the first cassette (not shown) and expose the same with X-rays, and then to turn itself off after

completing the first cycle of operation by opening the switch 15. When the seriograph switch 15 opens, a leakage current is again directed through the motor 10 and the stepping relay winding 22 to thereby position the movable relay contact 33 to its next succeeding fixed contact 31 and enables the leakage current to energize the second thermal relay winding 34 and its series resistor. After a second preselected time interval has then expired, as controlled by the setting of the thermal relay 34 and its resistor, the thermal relay winding 34 closes its contact 24 to again short circuit the open seriograph switch 15 and again apply energization to the seriograph motor 10, thereby to commence the next cycle of operations.

In the same manner, as previously described, each of the thermal relay windings is energized in sequence and each, in turn, time delays the starting of the seriograph according to its preset time interval, such that the feeding and exposure of each cassette is adjustably time spaced from the previous cassette according to a preset time program, as is desired.

It will be noted that the programmer of the present invention does not control the internal timing of the seriograph machine during each cycle of its operation, which is under the control of a preset timing mechanism in the seriograph as disclosed in prior Patent 2,881,323. Instead, the programmer merely initiates each operation of the seriograph at a preset time delay after each previous operation has been completed. In other words, during each cycle of operation, the seriograph mechanism itself automatically exposes the cassette and then automatically shuts itself off and remains in the off position until receiving the next start command from the programmer.

In the operation of the time programmer as described above, the closing of manual switch 20 in the seriograph and manual switches 26a and 26c in the programmer conditions the programmer for automatic operation in the manner described, and a suitable counter or indicator 36 being actuated by the stepping relay 22 provides a remote indication of the number of cycles of the seriograph or the number of X-ray photographs that have been taken. If at any time during this automatic programming the monitoring operator wishes to terminate this automatic operation, it is merely necessary to open the start switch 26a in series with the stepping relay 22 or alternatively to open the manual switch 26c in series with the thermal relay windings 28, 34, and 35.

For remote manual control of the seriograph through the programmer, there is provided a manually operable switch 26b that is connected in shunt with the connector 19, and hence is adapted to short circuit the seriograph switches 13 and 15. Thus by opening switches 26a or 26c, the operator may control the seriograph remotely in an intermittent or continual manner by actuating the manual switch 26b. Furthermore, the manual switch 26b enables the operator to override the automatic operation even when the switches 26a and 26c are closed, since closing of manual switch 26b always short circuits the connector 19. Thus if the operator wishes to by-pass one or more of the time delays, it is merely necessary to close switch 26b at the end of a previous cycle and this initiates the next succeeding cycle of the seriograph independently of the time delay.

The purpose of providing the separate manual switch 26c for deenergizing the thermal relay windings is to enable use of the indicator 36 during manual control of the programmer. For example, if the switch 26a is maintained closed but the switch 26c is opened, the stepping relay 22 continues to operate in response to each cycle of operation of the seriograph since it is repetitively pulsed by leakage current each time that the seriograph switch 15 opens. As this relay 22 steps from position to position it operates the indicator 36 in the same manner as during automatic operation thereby to indicate or count the number of manually controlled cycles of the seriograph. On the other hand, the opening of switch

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26c prevents the energization of the thermal relays 28, 24, and 35 whereby the automatic stepping of the relay 22 is ineffective to control the seriograph. Thus, the operator may remotely control the operation of the seriograph by means of manual switch 26b and be provided with an indication or count of the number of exposed seriograph cassettes by means of indicator 36.

FIG. 2 illustrates a preferred solid state programmer according to the invention and employing a series of more precisely adjustable resistor-capacitor time delay circuits, instead of the thermal time delays of FIG. 1. As shown, the programmer comprises a stepping relay winding 53 having a plurality of twelve fixed contacts 59 to 70, and a movable contact 53c that is adapted to be progressively stepped or positioned to engage each of these fixed contacts consecutively each time that the relay winding 53 is pulsed. The circuit further includes a timing capacitor 72 that is adapted to be selectively connected to different adjustable resistors of each different position of the stepping relay contact to provide a series of different time delays, and a control relay 83 that is adapted to be operated after each preset time delay to actuate the seriograph to start operation.

In the embodiment of FIG. 2, as in FIG. 1, it is intended that the programmer be enclosed within a separate housing from the seriograph and be detachably interconnected thereto by means of an electrical connector 19, similar to that shown in FIG. 1, to enable either a direct or remote control of the seriograph, as is desired.

Referring to FIG. 2, the connector 19 applies the programmer circuit in shunt with the seriograph switches 15 and 13 in the same manner as is shown in FIG. 1. In series with each line from the connector 19 are provided manually operated switches 43 and 44, respectively, that are preferably ganged together as shown, and across the connector 19 is provided an indicator 45 to display when the programmer circuit is being energized. The input lines from the connector 19 are directed to a transformer 46 feeding a full wave rectifier including four bridge connected diodes 47, to provide full wave rectification of the alternating current energy 12 from the seriograph, to provide a direct current source for energizing the programmer circuit.

In operation, the seriograph manual switch 20 is initially operated (FIG. 1) to energize the seriograph, and then the manual switches 43 and 44 are then actuated to apply energization to the programmer, which is rectified by the diode bridge to provide a direct current across lines 48 and 49. To commence operation, a start switch 50 is then manually and momentarily depressed to energize the stepping relay winding 53 through an initially closed contact 53a of the relay 53. Energization of relay winding 53 actuates the holding contact 53a to short circuit the start switch 50 and thereby continuously applies the rectified direct current to the relay winding 53 to maintain it in an energized condition. Additionally, the start pulse energizing the stepping relay winding 53 advances its movable contact 53c to engage the first fixed contact 59.

The closing of the start button 50 and operation of the holding contact 53a, also applies direct current voltage to line 56 whereby a direct charging current then flows over line 56 and through a potentiometer 57 and through variable resistor 59 and fixed resistor 71 to charge the timing capacitor 72. After an initial short time interval as is controlled by the resistor 59, the voltage on capacitor 72 increases sufficiently to trigger a unijunction transistor 73 into conduction, and energizing current flows over line 56 and through resistor 74 and the unijunction transistor 73 to the resistors 75 and 76. A resulting voltage drop across resistor 76 biases the transistor 79 into conduction and enables a direct current flow from line 56 and through a diode 82 and the control relay 83.

The control relay 83 has contacts 83a being connected in shunt across the terminals of the electrical connector

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19, and the closing of these contacts short circuits these terminals and applies current to the motor 10 (shown in FIG. 1). This commences the first cycle of operation of the seriograph.

The closing of contacts 83a also short circuits the primary winding of the transformer 46 leading to the rectifier thereby to deenergize the stepping relay winding.

The relay winding 83 is not immediately deenergized since there is provided in shunt with this relay winding a time delay circuit including a capacitor 81 and a resistor 80 which more gradually discharges through the relay winding. A variable resistor 80 is included to adjust for tolerance variations of the capacitor 81 enabling the relay winding 83 to remain energized for a short interval until after the seriograph motor 10 has commenced its operation and has closed the cam operated switches 13 and 15. Thereafter the relay 83 is deenergized to open its contacts 83a.

This energization of the seriograph motor 10 then commences the first cycle of seriograph operation, including the feeding and exposure of the first cassette, and when this is completed, the cam 17 opens the switch 15 as previously described to terminate the first cycle of the operation of the seriograph.

The opening of switch 15 again applies a leakage current through the connector 19 to the programmer, which is again rectified and applied to energize the stepping relay winding 53, thereby to advance its movable contact 53c to its next fixed contact 60. Again in the same manner as previously described, the capacitor 72 is charged according to the preset time constant of the next resistor 60 and capacitor 72 whereby after the second preset time delay has expired, the control relay 83 is again operated to close its contacts 83a and thereby energize the seriograph motor 10 to start its next cycle of operations.

Thus in the same manner as previously described, the programmer stepping relay winding 53 is energized after each cycle of operation of the seriograph has been completed, and it functions to selectively insert the next time delay in the circuit. After this next preset time delay has expired, the seriograph motor 10 is again energized by the closing of contact 83a to commence the next cycle of operation of the seriograph. Since each of the resistors 59 to 70, inclusive, in the programmer circuit area are individually adjustable, the individual time delays provided by the programmer are individually preadjustable, and the operator may initially preset any desired series of time delays in the automatic feeding of the cassettes.

For enabling the operator to determine the number of cassettes or films that have been exposed at any time, there is also provided a suitable counter or indicator 36 (FIG. 1) that is preferably incorporated in the separate programmer housing. This enables the operator to employ the programmer at some distance remotely from the seriograph and to visually monitor its operations. The counter or indicator 36 may be mechanical, electrical, or electronic in nature, and of types well known in the art adapted to be suitably coupled to the stepping relay mechanism (22 in FIG. 1; 53 in FIG. 2) thereby to indicate each different position of the stepping relay and therefore each different number of operations of the seriograph.

If the operator should at any time desire to terminate the operation of the automatic programmer, it is merely necessary to manually open the switch 26a in the embodiment of FIG. 1, or the switches 43 and 44 in the embodiment of FIG. 2, both of which electrically disconnect the programmer from the seriograph mechanism.

Although but limited preferred embodiments of the invention have been illustrated and described, it is believed evident that many changes may be made by those skilled in the art without departing from the spirit and scope of this invention. Accordingly, this invention

should be considered as being limited only by the following claims appended hereto.

What is claimed is:

1. In an automatic time programmer for seriographs, a plurality of individually adjustable time delay means, a switching means for initiating each operation of the seriograph, control means responsive to each completion of operation of the seriograph to select a different one of said time delay means, and means responsive to the selected time delay means for actuating said switching means after the time delay imposed by said selected time delay means,
2. In an automatic seriograph having a motor drive and a control switch for deenergizing the seriograph after the completion of each X-ray cycle,
 - a compatible time programmer detachably interconnectable with the seriograph for initiating each succeeding cycle of operation of the seriograph upon the expiration of a preselectable time delay after the preceding cycle of operation has been completed,
 - said time programmer including a detachable electrical connector interconnecting said programmer in shunt with the control switch of the seriograph,
 - a programmer switch means connectable by said electrical connector in shunt with said control switch,
 - a time delay means having a plurality of preadjustable time delay settings,
 - and means responsive to the actuation of said seriograph control switch at the completion of each seriograph operation and being controlled by said time delay means for actuating said programmer switch means after a preselectable time delay to initiate the next succeeding operation of the seriograph.
3. In an automatic time programmer for seriographs, a plurality of individually adjustable delay means, a switch means for initiating each succeeding operation of the seriograph, a commutator means responsive to the completion of each operation of the seriograph to select a different one of said time delay means, and means responsive to the selected time delay means to actuate said switch means after the time delay established by said selected time delay means.
4. In the automatic time programmer of claim 3, said time delay means including a presettable thermal time delay relay for actuating said switch means.
5. In the automatic time programmer of claim 3, said time delay means including a resistor and capacitor time delay circuit.
6. In the automatic time programmer of claim 3, said commutator comprising a stepping relay having a relay winding, a plurality of fixed contacts, and a movable contact consecutively actuated by the winding to traverse the fixed contacts,
 - and each of said plurality of preadjustable time delay means being connected to a different fixed contact.
7. In an automatic time programmer for seriographs, a plurality of individually adjustable time delay means, a commutator for consecutively selecting each time delay means in sequence, detachable electrical connector means for interconnecting said commutator with the seriograph to receive energization after each cycle of operation of the seriograph has been completed, switch means being detachably interconnected with said seriograph by said connector, for initiating each succeeding operation of said seriograph, a manually operable switch in series circuit between said seriograph and programmer, said switch means being consecutively energized by the time delay means.
8. A solid state time programmer for cyclically operating seriographs comprising:
 - a plurality of independently adjustable resistors,

- a capacitor,
- a commutator for selectively and consecutively connecting each of said resistors to said capacitor to provide a consecutive series of preadjustable time delay circuits,
- a switching means,
- a solid state discharge circuit for said capacitor and controlling the actuation of said switching means,
- a detachable electrical connector for interconnecting said switching means with the seriograph whereby each actuation of said switching means initiates a succeeding cycle of operation of the seriograph,
- said commutator being interconnected with said seriograph through said detachable connector and being energized in response to completion of each preceding operation of the seriograph to selectively connect the next succeeding adjustable resistor to said capacitor.
9. A remotely controlled time programmer for automatic seriographs having a control switch that is closed when the seriograph is engaged in a cycle of operation and is open when the seriograph has completed its cycle of operation,
 - a detachable electrical connector for making connection to said seriograph in shunt with said control switch and an elongated electrical conductor for remote electrical energization by and to said connector,
 - a commutator connected for energization by said conductor,
 - a plurality of individually adjustable time delay means consecutively selected by said commutator,
 - programmer switching means electrically connected in shunt with said control switch through said elongated conductor and electrical connector and being actuated in response to the time delay means selected by said commutator,
 - whereby said seriograph is automatically time programmed for consecutively variable time delayed operations responsively to the individual adjustments of said time delay means.
10. In the remote programmer of claim 9, said time delay means comprising resistor-capacitor networks,
 - a unijunction transistor connected to discharge a capacitor of the time delay means,
 - a transistor energized by the operation of the unijunction transistor,
 - a relay energized by said transistor,
 - and said relay actuating said programmer switch means.
11. In the remote programmer of claim 9, said commutator comprising a stepping relay having a winding, a plurality of fixed contacts, and a movable contact consecutively positioned to engage said fixed contacts responsively to each succeeding energization of the stepping relay winding, said relay winding being interconnected in shunt with the control switch of said seriograph thereby to receive energization and step the relay contacts after each opening of the seriograph control switch.
12. In an automatic time programmer for a cyclically operating machine for adjustably time delaying each succeeding cycle of operation of the machine from the preceding cycle of operation,
 - time delay means for providing a plurality of individually adjustable time delays,
 - a commutator means for consecutively selecting each different time delay,
 - conductor means interconnecting the commutator to receive energization in response to each completion of a cycle of said machine,
 - control switch means associated with said conductor means and being actuatable to initiate each succeeding operation of said machine,
 - and means for successively actuating said control switch means responsively to the time delay selected by said commutator,

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13. In a programmer for seriographs having a control switch that is closed during each operation of the seriograph and automatically opened after each operation thereof has been completed,

a remote detecting means for sensing each opening of the seriograph control switch and providing an indication of the total number thereof, and a remote switching means that is actuable to short circuit the seriograph control switch thereby to initiate each succeeding operation thereof.

14. In an automatic programmer for seriographs, elongated conductor means for detachable interconnection in shunt with a pair of power controlling terminals in the seriograph,

commutator means interconnected with said conductors and remotely detecting the presence of power across said seriograph terminals,

an indicator controlled by said commutator for indicating the number of energizations thereof,

time delay means providing a plurality of separately adjustable time delays that are consecutively selected by said commutator means responsively to each detection of power across said terminals,

automatically controlled programmer switching means for short circuiting said elongated conductor means after a time delay controlled by the adjustable time delay selected by the commutator means,

a manually controlled programmer switching means for short circuiting said elongated conductor means,

and manually controlled means for selectively disabling the automatically controlled programmer switching means.

15. An automatic programmer for cyclically operating machines having a pair of terminals that are in short cir-

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cuit condition during operation of the machine and in open circuit condition when the machine is not operating, a plurality of individually adjustable time delay means, detecting means for sensing each open circuited condition of the machine and consecutively selecting a different one of the time delay means in response thereto,

automatic switching means controlled by said selected time delay means for short circuiting said terminals after the time delay imposed by said selected time delay means,

and an indicator means controlled by said detecting means for indicating the number of open circuited conditions sensed by said detecting means.

16. In the programmer of claim 15, said programmer additionally including a manually controllable switch means for short circuiting said terminals.

17. In the programmer of claim 16, said programmer additionally including means for selectively disabling said automatic switching means.

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