TIMING DEVICE

Filed Jan. 2, 1948 3 Sheets-Sheet 1

Fig. 1.

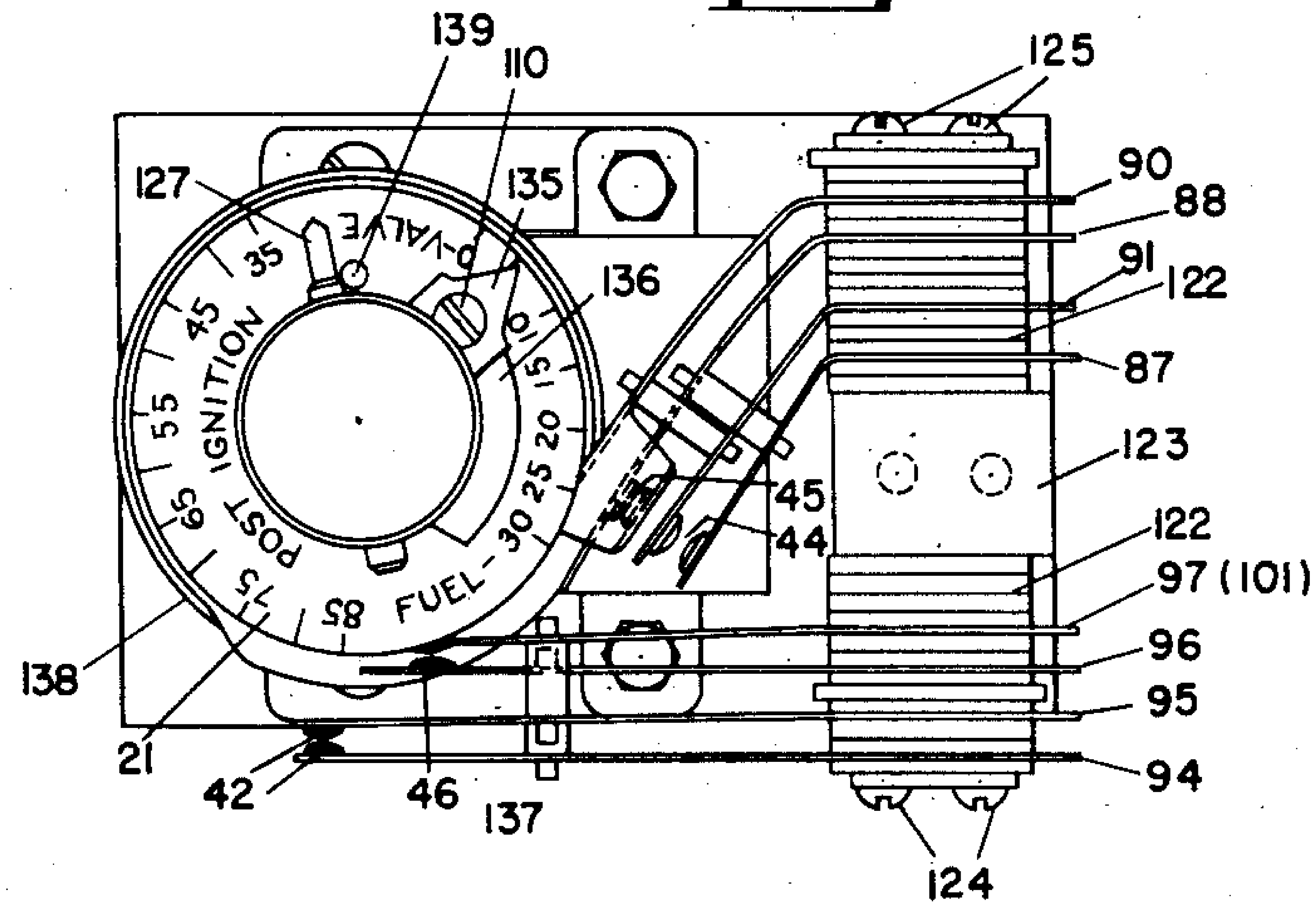


Fig. 2.

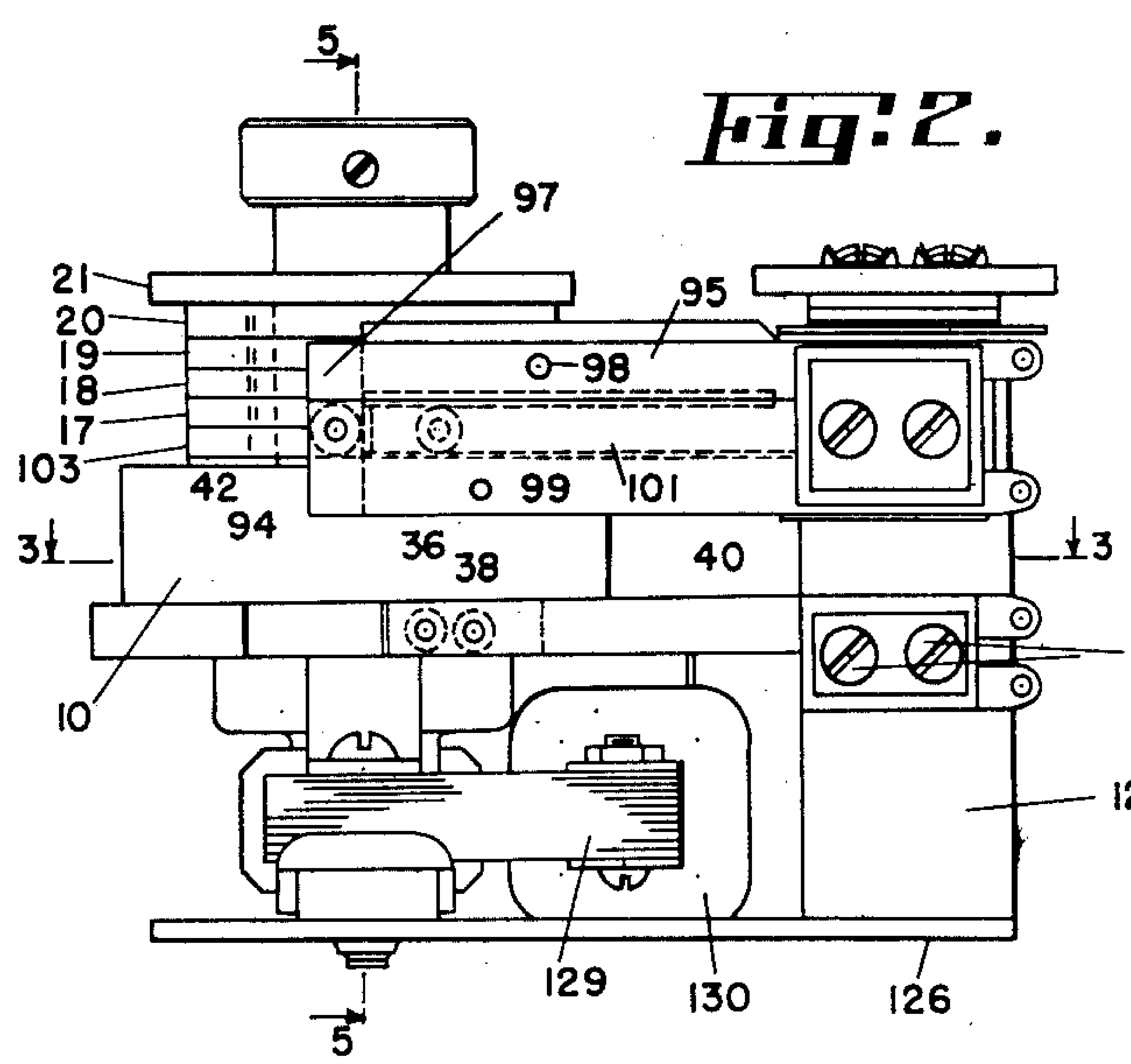
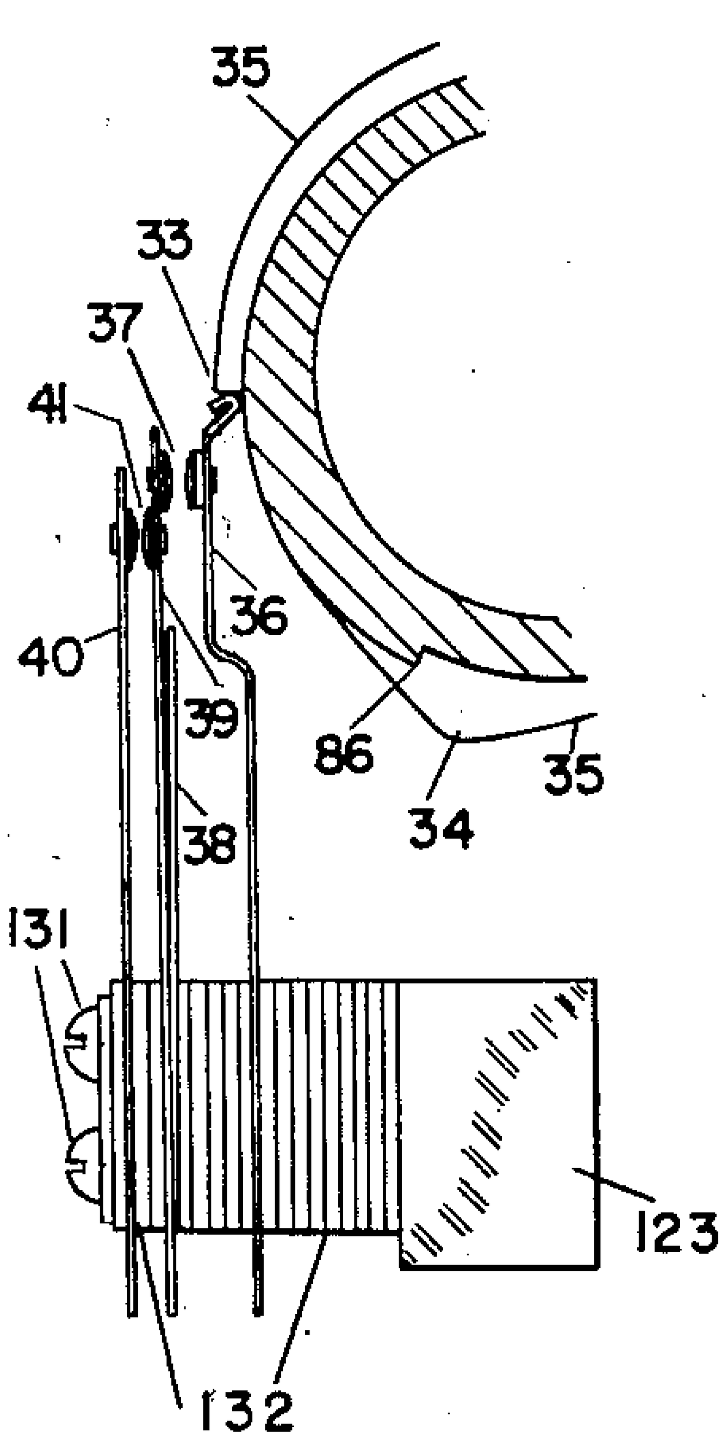


Fig. 3.



Inventors

BURTON E. SHAW

PHILLIP GUIFFRIDA

By M C Metcalf

Agent

TIMING DEVICE

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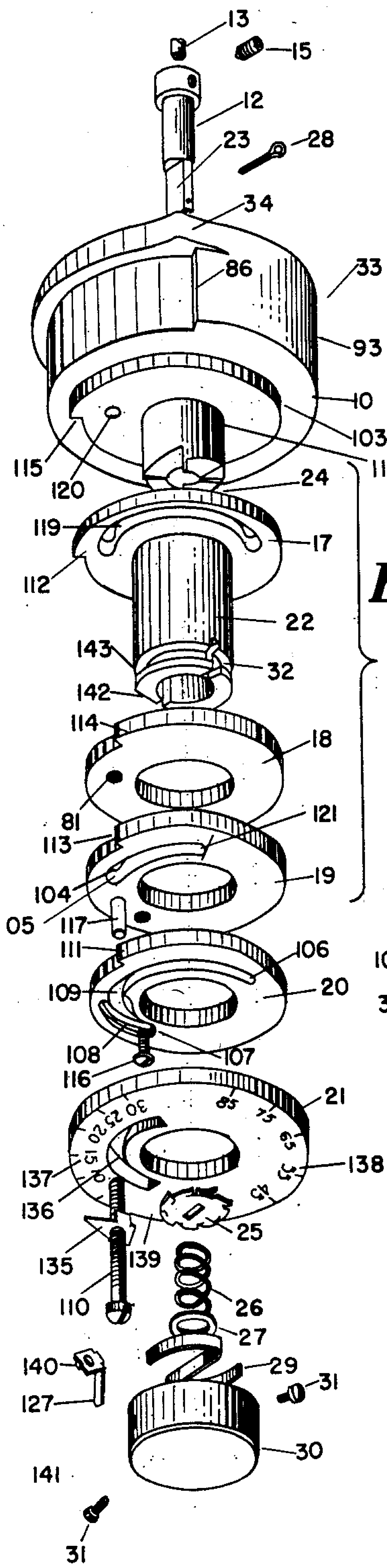


Fig. 4.

Fig. 5.

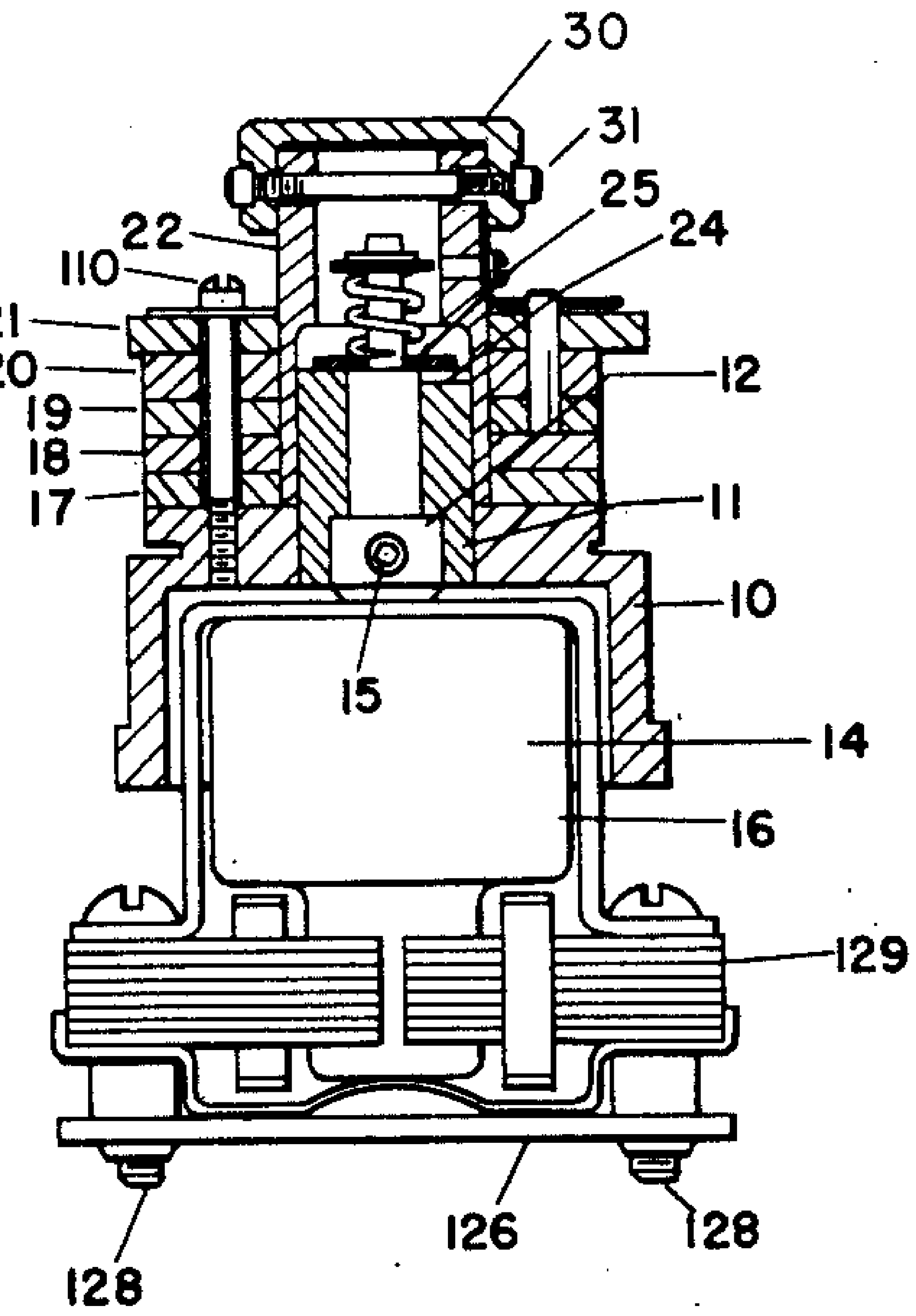
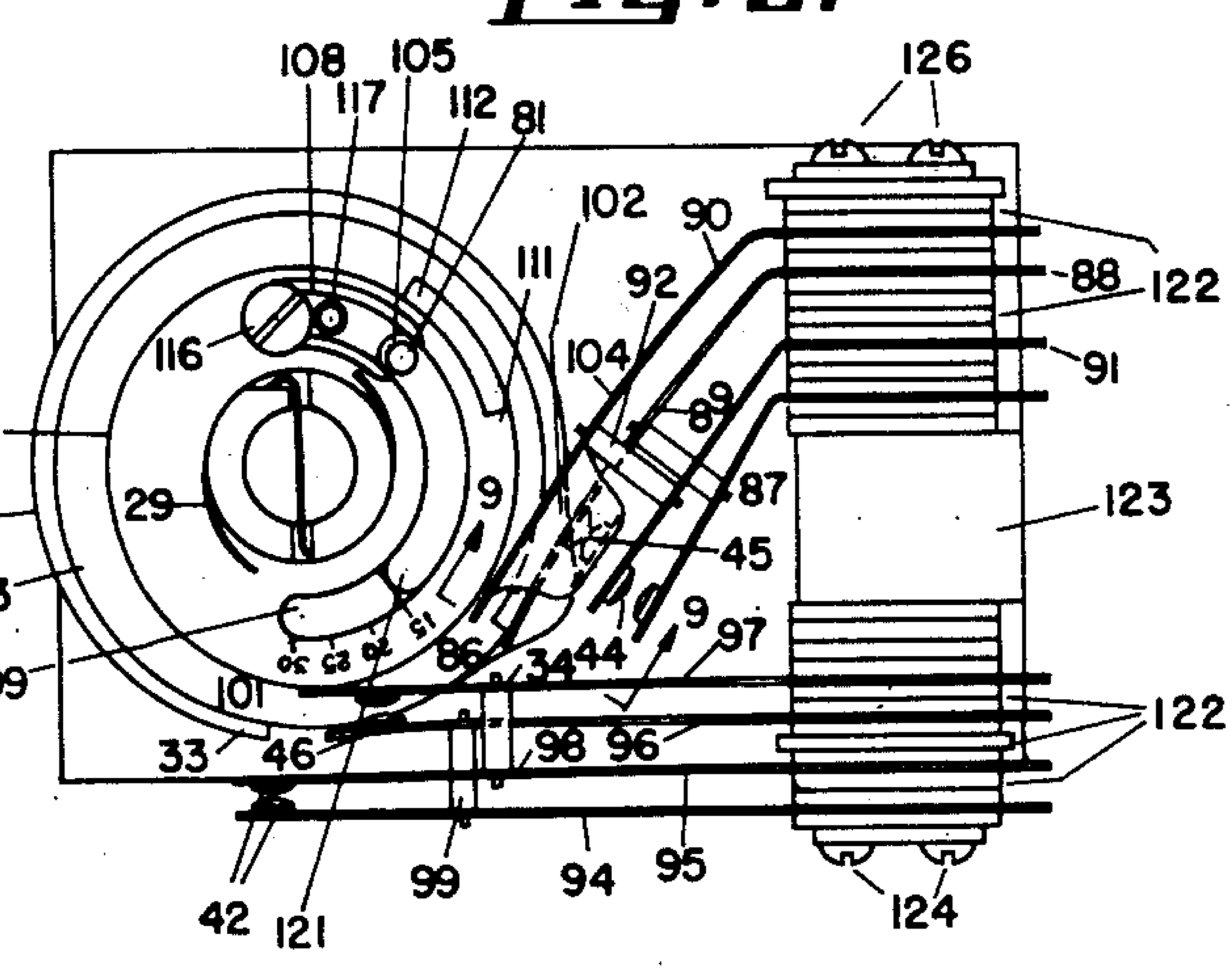


Fig. 6.



Inventors
BURTON E. SHAW
PHILLIP GUIFFRIDA
By [signature]
Agent

Fig. 7.

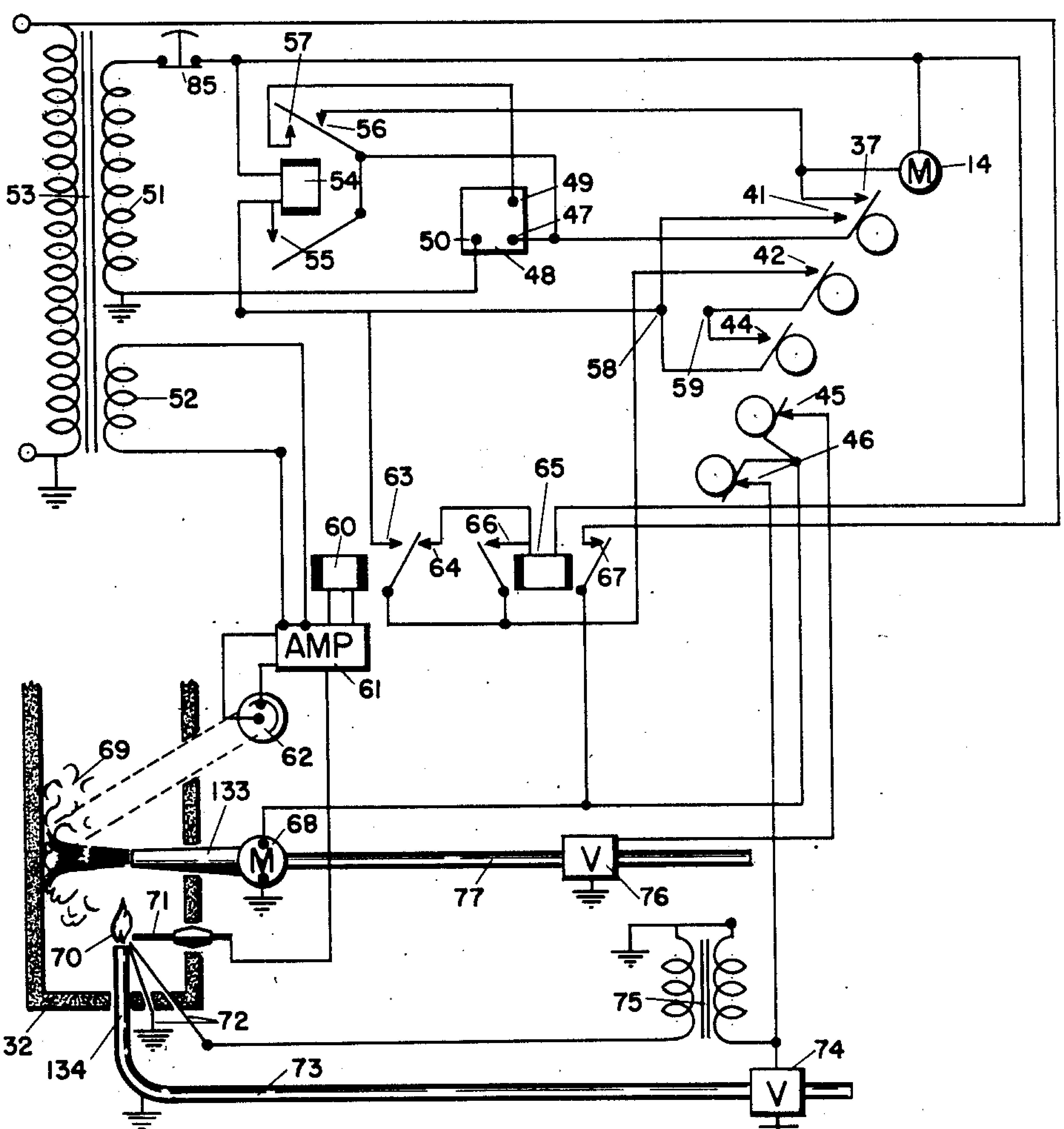


Fig. 9.

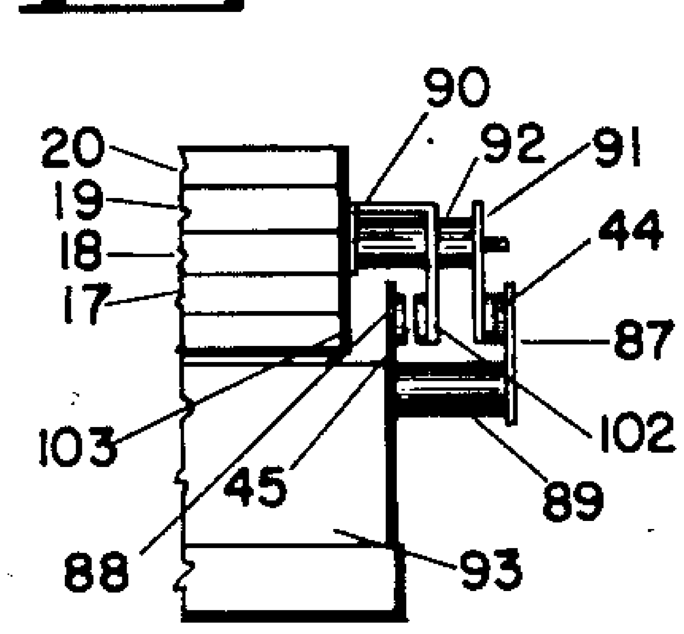
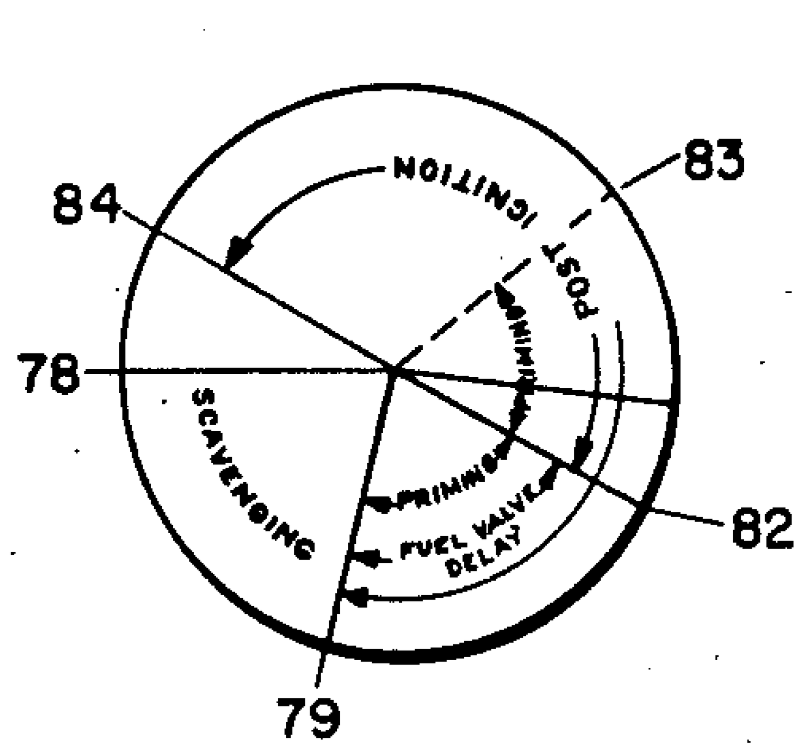


Fig. 8.



Inventors
BURTON E. SHAW
PHILLIP GUIFFRIDA
By M C Metcalf
Agent

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UNITED STATES PATENT OFFICE

2,624,812

TIMING DEVICE

Burton E. Shaw, East Boxford, and Philip Giuffrida, Lawrence, Mass., assignors to Combustion Control Corporation, Cambridge, Mass., a corporation of Massachusetts

Application January 2, 1948, Serial No. 262

5 Claims. (Cl. 200—38)

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This invention relates to furnace controls and particularly to a timing or program switch suitable for controlling the starting operations of furnaces of the full-automatic, fluid fuel-burning type.

The types of fuel burners now in common use fall into three generally recognized classifications, manual, semi-automatic, and full-automatic. The manual type of burner is both ignited and shut down by an operator. The semi-automatic type is manually ignited, but has an electrically controlled fuel supply system which is shut down by a thermostat or similar control when sufficient heat has been produced. The full-automatic type has an electrically controlled ignition system in addition to the fuel supply system, and heating periods are initiated and terminated by a thermostat, pressure switch, or similar control, without any attention from an operator under normal conditions. On full-automatic burners ignition is ordinarily accomplished by passing a high-voltage spark between electrodes in the vicinity of the fuel-admitting orifice. Burners of the large capacity, industrial type may in addition, employ a pilot burner to ignite the main burner. To insure safe and proper operation, the ignition, pilot, and main burner must be put into operation in a certain sequence and at accurately timed intervals. The optimum delay periods between starting operations depend on the capacity and construction of the burner and the type of fuel used. For example, on a typical oil burner ignited by a gas pilot, the electric ignition, pilot valve and burner motor are energized simultaneously. After an interval, generally referred to as the "fuel valve delay" or "ignition period," during which the pilot flame becomes established, the main fuel valve is opened. The pilot is left burning thereafter for an additional period, known as "post-ignition," to insure proper ignition of the main flame. The optimum fuel valve delay period for different makes and capacities of burners may vary from 5 to 30 seconds. The post-ignition period is ordinarily between 30 and 80 seconds in duration.

To insure safe operation of the pilot ignited type of burner, it is necessary to prevent opening of the main fuel valve if the pilot is not burning, and for this reason, a flame failure detection device responsive to the pilot flame should be in control of the main fuel valve circuit, upon termination of the fuel valve delay period. On an oil burner ignited only by spark electrodes, however, it is necessary to hold the main fuel valve open for a short time to permit ignition. For

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this purpose, monitoring of the flame by the flame failure control must be delayed for a time after opening of the fuel valve. This interval is known as the "priming period" and runs concurrently with, but usually is shorter than, the post-ignition period.

From the foregoing discussion, it is apparent that a timing control designed for universal use in the many existing types of furnace installations must be readily adjustable to suit individual requirements. Nevertheless, to insure safe and efficient operation, once the proper delay periods for a particular burner have been determined, the settings of the control device must be accurately maintained, regardless of line voltage fluctuations and other disturbing factors normally encountered.

It is accordingly the chief object of this invention to provide a timing control of this type which is considerably more accurate and stable in its operation than controls heretofore used for the purpose. In particular, this control is designed to eliminate errors due to line voltage fluctuations. It is well-known that large fluctuations in line voltage are common in industrial installations because of the high current demands of machinery and other electrically powered industrial equipment. The performance of the warp switch type of timer, for example, may be unsatisfactory in some installations because the timed periods are dependent on the heating effect of current through a resistance coil, and therefore on the line voltage. Errors may also occur in such switches due to change in characteristics of the bimetallic leaves.

Another object is to provide a control in which the delay periods may be accurately and continuously adjusted in the field by the average factory maintenance man using only a common screw driver. This provision represents a considerable advance over the controls now in common use in which the durations of the various periods are either not adjustable at all, or adjustable only in one or two steps.

Other objects are to produce a control of this type which maintains its accuracy indefinitely, which is small and compact, but will withstand severe usage, which may be operated manually for observation and testing, and which is relatively cheap to manufacture and simple to install.

The invention comprises generally a small synchronous motor which rotates a number of cams mounted on its shaft. The cams operate spring leaves which are designed to open and close contacts in control circuits of the burner. Several of the cams may be shifted to provide adjustment of the delay periods, and a suitably calibrated dial is mounted on the face of the device. The cam assembly may be rotated by a hand knob. The motor and hand knob are connected to the cam assembly through one-way clutches to prevent turning of the cams in the wrong directions with possible resultant damage to the motor and cam contacts. The contacts are of high current capacity and are all readily accessible for cleaning. The switch here described is primarily designed for operation with a control circuit similar to that shown in the copending application of E. Craig Thomson, Serial No. 788,836, filed November 29, 1947.

In the drawings:

Fig. 1 is a front view of the device;

Fig. 2 is a side view;

Fig. 3 is a cross-section, partly broken off, taken along lines 3—3 of Fig. 2;

Fig. 4 is an exploded view of the motor shaft and cams disassembled;

Fig. 5 is a cross-section taken along lines 5—5 of Fig. 2;

Fig. 6 is a view similar to Fig. 1 with the dial, hand knob, rear contacts, and some of the mounting parts omitted;

Fig. 7 is a diagram of a typical electrical circuit employing the device;

Fig. 8 is a graph showing the various timed periods in relation to the position of the timer motor; and

Fig. 9 is a view, partly broken away, along lines 9—9 of Fig. 6.

Referring first to Figs. 1, 5, and 6, master cam 10 ordinarily machined or molded from an insulating plastic, is pressed or molded onto a metal bushing 11 which rides on shouldered shaft 12. The shaft 12 is secured by set screw 15 to the shaft 13 of synchronous motor 14. The master cam is hollow so as to fit over housing 16 of motor 14, for the purpose of reducing shaft overhang to a minimum. A second plastic cam 17 is molded onto bushing 22 which rides over bushing 11. Cams 18, 19, and 20 also made of insulating material, and dial 21 slide over bushing 22. Bushing 11 terminates in a toothed face 24 which is engaged by serrated disk 25. The disk is slotted in the center and fits over flatted end 23 of shaft 12 where it is yieldingly held in place by coil spring 26 secured by washer 27 and cotter pins 28. The motor normally turns clockwise, as observed from the face of the dial, and drives the cam through engagement of the serrations of disk 25 with the teeth of face 24. If the motor should be incorrectly connected and revolve in the opposite direction disk 25 slides over face 24 and the cam assembly is disengaged from the motor. Damage to the motor and cam contacts under such a condition is thus prevented.

Bushing 22 is grooved near its outer end to receive S-shaped leaf spring 29, as shown in Fig. 6. When knob 30 is in place, set screws 31 project into groove 32 and engage the ends of spring 29. It is apparent that with this arrangement cam 17 can be driven by the knob only in the clockwise direction when screws 31 engage the free ends of the spring 29. This one way clutch arrangement protects the device against damage in case the knob is turned in the wrong direction.

The motor and its associated field coil 130 and core 129 are secured to back plate 126 by screws 128. A base block 123, also screwed to plate 126 provides support for the contact leaf springs 94, 95, 96, 97, 87, 91, 88, and 90 which are spaced from each other by insulating spacers 122 and assembled onto the base block by means of screws 124 and 126. Further toward the rear, leaf springs 40, 38, 39, and 36 (Figs. 2 and 3) are similarly spaced apart by insulating spacers 132 and fastened to base block 123 by screws 131. Any suitable supporting frame may be used in place of plate 126 and block 123.

The synchronous motor in the example of the device here shown is so geared down that shaft 12 makes one revolution in 120 seconds, coming to rest, when the burner is in normal operation, at the point where steps 33 on cam face 35 (Figs. 3 and 6) has just cleared the end of leaf spring 36. In this position contacts 37 and 41 are open. In Fig. 6, it may be seen that the end of spring leaf 88 is approaching step 86 of cam surface 93, and contacts 45 are closed. On a few degrees turn of the motor spring leaf 88 drops off steps 86 opening contact 45. Simultaneously spring leaf 87, which is connected to leaf 88 by insulating spacer 89 (Figs. 6 and 9), springs in, closing contacts 44. As the motor continues to rotate, leaf 96 drops off the step 86 of cam surface 93 closing contacts 46. Simultaneously leaf 94, which is connected to leaf 96 by insulating spacer 99, springs in to close contacts 42 (Fig. 6). At this point, the end of leaf 36 has started up rise 34 on cam surface 35. Contacts 37 close next, and, when the top of rise 34 is reached, leaf 38 is forced back to close contacts 41. As the end of leaf 36 moves down the other side of rise 34, contacts 41 open again.

When step 111 of cam 20 reaches the end of leaf 90, which is connected to leaf 91 by insulating spacer 92, contacts 45 close and contacts 44 open. The position of cam 20 with respect to cam 10 is adjustable within the limits 121 and 105 of slot 104 of cam 19 in a manner and for a purpose to be described later. In the position shown in Fig. 6, the opening of contacts 44 and closing of contacts 45 occur substantially simultaneously with the closing of contacts 41.

As seen in Fig. 2, leaf 97 rides over cams 18, 19, and 20. When step 111 of cam 20 reaches the end of leaf 97, this leaf and leaf 95 which is connected to it through insulating spacer 98, drop in, opening contacts 42.

After further rotation of the motor, leaf spring 101, which rides over the surface of cams 17 and 103 (Figs. 2 and 6) drops off step 112 of cam 17, opening contacts 46. At this stage contacts 45 and 37 are closed, and contacts 41, 42, 44, and 46 open. The motor continues to rotate the cam assembly until a revolution is completed and leaf 36 drops off step 33, opening contacts 37. Spring leaf 39 acts as a stop for leaf 38 and insures a sharp break of contacts 37.

Fig. 7 shows an example of a complete burner control system which is described in more detail in copending application, Serial No. 788,836, filed November 29, 1947, by E. Craig Thomson. In Fig. 7 the cams are schematically indicated but contact points corresponding to the contacts of Figs. 1, 2, 3 and 6 are correspondingly numbered. A combustion chamber, generally indicated as 132, has mounted therein a main burner 133, producing a main flame 69 and a pilot burner 134 producing pilot flame 70. Fuel to the main flame is supplied through blower 68 and fuel line 77 controlled in a well-known manner by a solenoid valve 76. Fuel to the pilot is supplied through fuel line 73 controlled by solenoid valve 74. The pilot is ignited by spark electrodes 72 which are excited by ignition transformer 75. A flame failure detection device, here illustrated as responsive either to a photocell 62 or to a flame electrode 71, energizes relay 60, closing contact 63 and opening contact 64, when either the pilot or the main flame is burning. On cooling, contact first 47, then contact 49, engages contact 50 and with rising temperature, the operation is reversed. The device for initiating heating cycles is here represented as a conventional three wire thermostat 48 having contacts 47, 49 and 50. The system also includes a power relay 65 controlling normally open contacts and an auxiliary relay 54, controlling normally open contacts 55 and 57, and normally closed contact 56. The closing of contacts 50 and 49 establishes a circuit from secondary 51 through 50, 47, 56 to timer motor 14, and the motor starts to revolve.

As previously described contact 45 opens soon after the start of the timing cycle. This contact is in the circuit of the main fuel valve. Since the circuit is at this time broken at 67, the opening of 45 has no effect, but this arrangement permits location of step 36 on cam 10 to serve the double purpose of opening contact 45 and at a later point in the cycle closing contacts 42 and 46. Contact 44 closes at the same time that contact 45 opens. After 42 and 46 are closed contact 37 closes, shunting out 56 so as to establish a holding circuit for motor 14. Contact 41 then closes. Up to this time none of the operating circuits of the burner have been energized and the burner has remained shut down. The delay between the starting of timer motor and the closing of contact 41 is known as the scavenging period and insures the dissipation of unburned gases in the combustion chamber before the ignition is turned on.

The closing of contact 41 initiates the "starting cycle" by completing the energizing circuits of relay 54, through 58, 41, 47, and 50 to secondary 51, and of relay 65, through 64, 42, 44, 58, 41, 47, and 59 to secondary 51. Relay 54 closes holding contact 55, which shunts contact 41 and thermostat holding contact 57, which shunts 49 to 47, so as to hold relay 54 energized until 47 separates from 50, and opens contact 56. Relay 65 closes its holding contact 66 and main contact 67, which completes the circuits to the burner motor 68, pilot valve 74, and ignition transformer 75. Under normal conditions the burner motor starts to run and the pilot ignites. Soon afterward the flame failure safeguard 61, in response to the detection of flame by electrode 71, energizes relay 60 closing contact 63, which shunts contact 42 and 44. Since contact 63 is in the circuit of the main fuel valve 76, it is apparent that the pilot flame must be established in order for the main fuel valve to be opened. Contact 41 opens again after a few seconds, but relays 54 and 65 are now held in through contact 55. After a certain delay, which may be varied by the setting of cams 19 and 20, contact 45 closes. Under normal conditions, with contact 63 closed, the closing of contact 45 completes the circuit to main fuel valve 76. The main valve then opens and the main flame ignites shortly thereafter. Contact 44 opens simultaneously with the closing of 45. As the circuit is here shown, the energizing circuit relay 65 is then dependent on contact 63, that is, the flame failure device is in control of the system and if the flame should be extinguished, relay 60 would become deenergized opening contact 63 and causing main relay 65 to drop out and shut down the burner. On certain types of burners, for example, those consuming oil or pulverized coal, it may be desirable to allow for a certain delay known as the "priming period" between the opening of the main fuel valve and monitoring of the flame. In this case, a jumper is connected across terminals 58 and 59, and contact 63 is then shunted by contact 42 for a certain period after the opening of 44. This period is adjusted by the setting of cam 20 in a manner to be described later. At the end of the priming period, contact 42 opens. Later in the cycle contact 46 opens, shutting off the pilot and ignition. The interval between the closing of 41 and opening of 46 is designated the "ignition period" and varies in length according to the setting of cam 17. The burner is then in normal running condition, with only the main flame burning. The timer motor continues to revolve until leaf 36 drops off step 33 breaking contact 37 and leaving the cam assembly in the starting position with all the timer contacts open except contacts 45, which hold in the main fuel valve circuit.

The relationship of the various periods in the starting cycle can be best understood by reference to Fig. 8. Line 78 indicates the starting position. Line 79 indicates the closing of contact 41, which ends the scavenging period. The fuel valve delay or ignition period which begins with the closing of 41 (line 79) may vary from zero seconds (line 79) to line 82, representing in this example approximately 30 seconds. The priming period starts with the end of the fuel valve delay, somewhere between lines 79 and 82, and may vary from zero to a line approximately 90° from the starting point, representing approximately thirty seconds. In the switch here shown by way of example, the zero priming period is achieved by omitting the jumper across terminals 58 and 59 as previously described. The opening of contact 42, which determines the priming period may be adjusted to give between 15 and 30 seconds delay. The post ignition period starts from the end of the fuel valve delay period, between lines 79 and 82, and may be adjusted from zero to 85 seconds for zero fuel valve delay, and from zero to 55 seconds for the maximum fuel valve delay of 30 seconds.

The priming period setting is intended to be made by the manufacturer of the control or one especially familiar with the operation of the control system. The device is accordingly purposely designed so that removal of the dial is required.

Referring to Figs. 4 and 6, cam 20 is secured to cam 19 by screw 116 which runs through slot 109 into tapped hole 118 and cam 19 and the head of which rests in groove 108 in cam 20. If the screw is loosened, cam 20 may be rotated with respect to cam 19 within the limits of groove 108. The setting shown in Fig. 6 allows leaf 97 to drop off steps 111 and 113, which coincide opening contact 42 and thereby terminating the priming period, fifteen seconds after leaf 90 drops off step 113 closing fuel valve contacts 45. If cam 20 is rotated counterclockwise, step 111 is moved so as to lag behind steps 113. Leaf 97 which extends over both cams is thus held out longer, during the revolution of the cam assembly, delaying the opening of contact 42, while leaf 90 which extends only over cam 19, continues to drop out at the same point in the cycle. The priming period, according to the arrangement here shown, may be extended up to thirty seconds.

The fuel valve delay and post ignition periods are intended to be set at the furnace installation by a maintenance man of ordinary skill. Referring to Figs. 4 and 5, dial 21 is provided with a "fuel valve" scale 137, and a "post ignition" scale 138. A pointer 135 rides in slot 136 next to the fuel valve scale. This pointer and the dial are secured by screw 110 which extends through slots 109, 104, and 119 in cams 20, 19, and 22 and hole 81 in cam 18, and engages threaded hole 120 in cam 10. The dial is fixed to cam 19 by pin 117 which extends through slot 109 in cam 20 into hole 139 in the dial. When screw 110 is loosened, the dial and cams 19 and 20 may be rotated independently of cam 10 so that step 113 may be positioned to give a delay in the doing of contacts 45 up to 30 seconds after the closing of 41 by rise 34 of cam face 35 engaging leaf 36. The scale 137 is calibrated so that the position of pointer 135 indicates the length of this delay period. Since a zero fuel valve delay is ordinarily not desirable, pointer 135 is so designed as to limit the minimum setting in slot 136 to about 5 seconds. For special conditions, however, the pointer may be removed, so as to extend the adjustment range to zero.

The fuel valve adjustment is made with the cam assembly in the starting position. With the dial and fuel valve pointer held in place, cam 17 may be rotated by the knob 30. Cam 17 controls leaf 101, and the position of step 112 determines the delay in closing contacts 46 which shut off the ignition system of the burner. Pointer 127 is held in slot 143 by tab 140 and secured in place by screw 141 which enters flat 142 of bushing 22.

Since scale 138 moves with scale 137, the position of pointers 127, indicates the period between the closing of fuel valve contacts 45 and the opening of ignition contacts 46. Scale 138 therefore directly indicates the post ignition period. After the settings are made, screw 110 is tightened so that the whole cam assembly moves together.

From the foregoing description, it will be clear that the switch herein disclosed is designed to regulate the starting operations of a furnace system with a high degree of accuracy and reliability. The timing operation is entirely independent of line voltage fluctuations and wear or fatigue of the switch parts, being dependent only on line frequency which is considerably more stable than line voltage. The effect of frequency variations is further made negligible by the gearing down of the timer motor. The construction of the cams and spring leaves insures positive contact action and permits the use of heavy duty contacts wherever desired. The range and simplicity of adjustments makes the device adaptable for use in a wide variety of burner installations.

It will be further noted that the arrangement of several of the contacts so as to operate in pairs, and the cooperating arrangement of the cam surfaces permits all the necessary timing operations to be accomplished with a minimum of working parts.

Since certain changes may be made in the above-described article and different embodiments of the invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative only and not in a limiting sense.

What is claimed is:

1. A program switch comprising: a synchronous motor having a drive shaft flatted toward its outer end, a master cam secured to a bushing which is mounted on said motor shaft, said bushing terminating in a toothed face; a slotted disk mounted on the flatted part of said shaft and having a serrated edge adapted to engage said toothed face; a retaining spring for holding said disk in yielding contact with said face; a second cam secured to a second bushing which is mounted freely on said first-named bushing; a groove near, and a slot across, the end of said second bushing; an S-shaped leaf spring lying in said groove and slot; a handle having inner projections for engaging the ends of said spring to drive said second cam; a pointer fixed to said second bushing; a dial freely mounted on said second bushing and carrying a scale over which said pointer rides; a circumferentially slotted cam fixed to said dial; a slot in said dial coinciding with the slot in said last-named cam; a second pointer riding in said dial slot and a second scale on said dial cooperating with said second pointer; a screw extending through said second pointer and the slots in said dial and last-named cam into a tapped hole in said master cam for the purpose of securing all of said cams together; and a plurality of spring leaf contacts adapted to be operated by said cams.

2. A program switch according to claim 1 wherein said contacts comprise several pairs of leaf springs, the first leaf of each pair acting as a cam follower and the second leaf being substantially rigidly spaced away from the first.

3. A program switch according to claim 2 having a second circumferentially slotted cam adjustably secured to the first-named slotted cam, one of said cam followers riding only on said first-named slotted cam and another of said cam followers riding on both said slotted cams.

4. A program switch according to claim 1 having a second circumferentially slotted cam adjustably secured to the first-named slotted cam.

5. A program switch according to claim 1 wherein said master cam is recessed to receive said motor.

BURTON E. SHAW.
PHILIP GIUFFRIDA.

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