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ADJUSTABLE COUNTING MEANS

3,031,622

2 Sheets-Sheet 1

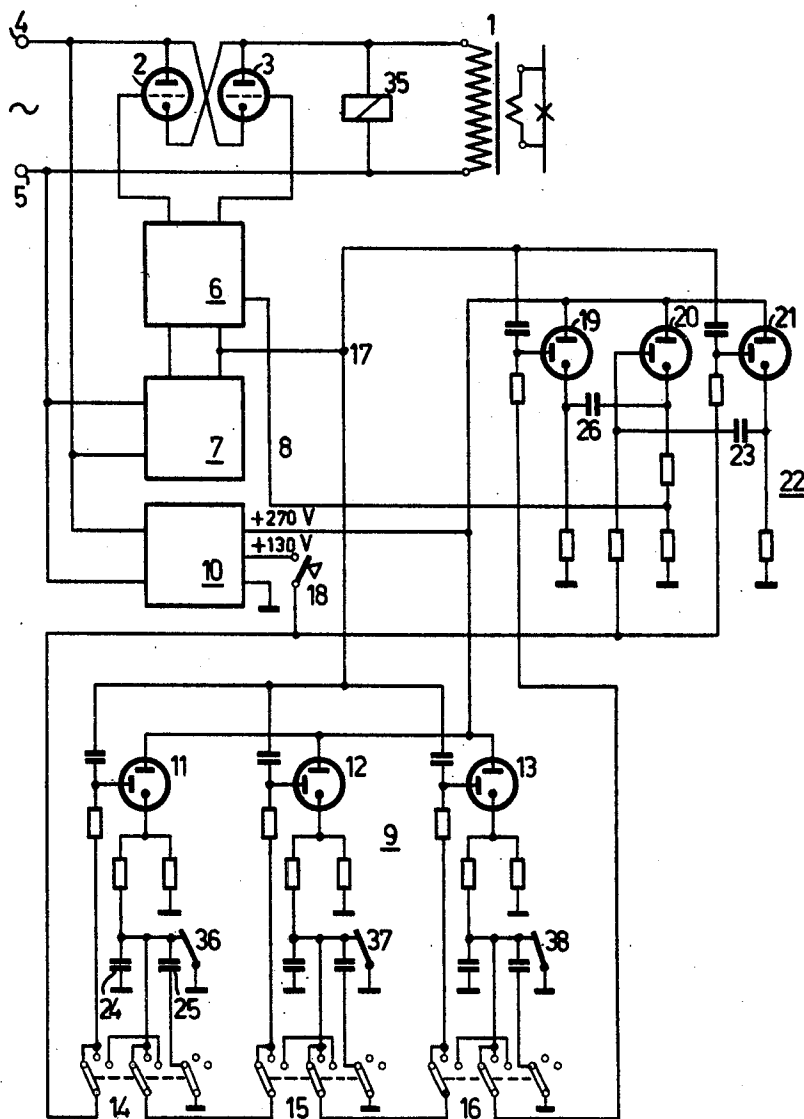


FIG.1

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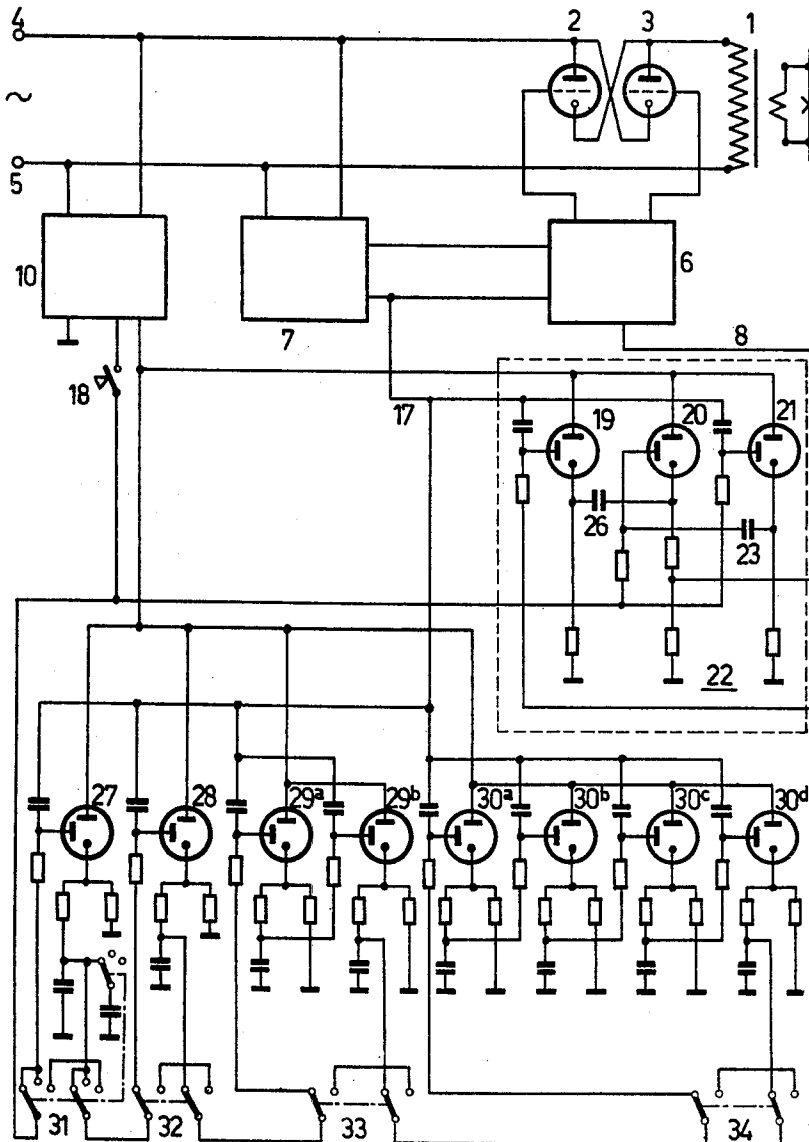


FIG.2

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TIME SWITCHING ARRANGEMENT COMPRISING SELECTIVELY ADJUSTABLE COUNTING MEANS

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2 Claims. (Cl. 328—48)

This invention relates to time switching arrangements for electronically-controlled electric devices, more particularly resistance welding tools, for determining a time interval which is adjustable according to requirements and comprises one or more cycles of a control frequency. Such time switching arrangements are known per se. They are used substantially in welding machines for controlling the switching on and off of the welding current, in which event it has been found advantageous to choose as a control frequency, the frequency of the mains from which the welding machine is operated, the time interval in each case being so proportioned as to comprise an even number of half-cycles.

Known time switching arrangements utilize one or more discharge tubes, which control relays included in the anode circuit and which become operative one after another. The discharge tubes are frequently equipped with a capacitor charging circuit, the time of charge or discharge serving to determine the time interval desired.

Since the use of relays involves inaccuracies, more particularly for comparatively short time periods, arrangements have also come to be known in which such relays are fully avoided and the whole of the time switch is built up of a plurality of discharge tubes having capacitor-resistor members coupled to them, which discharge tubes alternately become operative and thus determine the desired time interval.

In such circuits the voltage of the capacitor, which varies according to an exponential function, usually serves as a control voltage for the associated gas-discharge tubes. In order to permit more exact ignition or extinction of the tubes, it is also known in such circuits to superimpose on the variable voltage of the capacitor a pulsatory voltage which is derived from the control frequency and preferably the mains frequency. The gas-discharge tube concerned is then ignited by the pulse peak which is temporarily defined more exactly.

However, time switching arrangements of known type have the disadvantage that, despite the use of the superimposed pulse, the adjusted time interval comprises the selected number of cycles of the control frequency only if comparatively short times are concerned. For longer time intervals the slope of the voltage charging characteristic of the capacitor becomes so flat that it is no longer exactly defined which of the superimposed pulse peaks brings about the ignition of the associated gas-discharge tube.

This disadvantage is obviating in a time switching arrangement according to the invention, which is characterized in that a plurality of capacitor-resistor time circuits built up in a similar manner and adjusted to one cycle of the control frequency or a whole number of cycles thereof, together with the associated controllable discharge tubes, may be connected together in cascade so that each time after expiration of the interval determined by one time circuit, the subsequent time circuit is switched in. Consequently, in this arrangement, the longer welding times are obtained by an RC-charge in several steps, synchronisation with the control frequency, more particularly the mains, taking place after each step.

The time intervals determined by the individual time circuits are then preferably progressing according to a

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series of numbers which permits of composing arbitrary numbers of cycles of the range concerned with the least possible number of individual time circuits. The time intervals of the individual time circuits may then be progressing according to the series 1—2—3—6—9—18, the numbers of this series indicating the number of cycles or a multiple thereof comprised by the time interval determined by the individual time circuit.

It is not necessary to associate a discharge tube with each fixed time circuit, but in order to simplify the circuit arrangements, it is possible to design each time circuit so as to be commutable to at least two time intervals.

In view of the accuracy of the adjusted time interval obtainable with the novel time switching arrangement, it is preferable for the time interval determined by the resistance-capacitor connection of the individual time circuit to be at the most so long that as a result of tolerances in the data of the discharge tubes employed, which data are a measure of the determination of time, a time deviation of the duration of one cycle of the control frequency does not occur if a discharge tube is replaced by another of the same type. When using discharge tubes of the kind commercially sold, it is preferable for the time interval of the individual time circuit to be not longer than three cycles of the control frequency.

For building up time circuits having a longer time interval with equal accuracy, it is possible to proceed in such a manner that each time circuit comprises a plurality of fixedly coupled capacitor-resistor circuits and associated discharge tubes. A time switching arrangement according to the invention may then be of a design such that arbitrary time circuits which may be connected in cascade and are adjusted to one, two or three cycles may have coupled to them time circuits in which one, two or more pairs of capacitor-resistor circuits with discharge tubes, each adjusted to three cycles, are fixedly connected together in cascade.

If the time circuits are circuited so that the capacitor of the time circuit is charged for determining the time interval, the operation may be detrimentally affected in certain applications since after the charge, the discharge of these capacitors takes up a certain time. According to a further elaboration of the invention in order to avoid this loss of time, each capacitor-resistor circuit may include a commutating member which rapidly discharges the capacitor as soon as the time interval switched in has elapsed. The same commutating member may naturally also be used for rapidly charging the capacitor if the time is determined by discharge of the capacitor. Such a step is carried out only if a welding operation, insofar as the time switch is used in a resistance welding machine, is to be followed within a short time by another.

In order that the invention may readily be carried into effect, two embodiments will now be described in detail, by way of example, with reference to the accompanying drawings, in which:

FIG. 1 shows a time switching arrangement for use in a resistance welding machine, having three time circuits connected in cascade, and

FIG. 2 shows a modified time switching arrangement for the same use, having four time circuits of very high accuracy which may be connected in cascade.

The embodiments shown in the figures are represented for use with a resistance welding machine, the details of which, since they do not form a part of the invention, are shown only diagrammatically. In the figures, the welding transformer indicated by 1 is powered via two discharge tubes 2, 3 connected in anti-parallel from terminals 4, 5 of the power current mains. A control device 6 equipped with gas-discharge tubes serves to control the discharge tubes 2, 3 in a manner known per se, the

control device having supplied to it ignition voltages from a phase-shifting device 7 connected to the mains. For the control of time, the control device 6 has also supplied to it, via a lead 8, a rectangular control voltage the length of which corresponds to the welding time interval and which is provided by a time switching arrangement 9, the object of the invention. In addition, the welding installation includes an anode tension device 10 which provides the direct voltages required for the operation of the various gas-discharge tubes. In the case under consideration, this anode tension device supplies two direct voltages of different values, one of which is, for example, +270 volts and the other +130 volts with respect to earth.

The time switching arrangement shown in FIG. 1 comprises three stages, each containing a discharge tube 11, 12, 13 and an associated RC-member. Each stage permits of adjusting two different times, the stage equipped with tube 11 may in this embodiment be adjusted to times corresponding to 9 or 18, the next to 3 or 6, and the stage equipped with tube 13 to one or two cycles of the mains. Each stage may be operated either individually or with the other ones in arbitrary series-combination, whereby the individual times of the stages are added. The time switch 9 thus permits of adjusting any number of cycles between 1 and 26.

The time stages are adjusted by means of commutators 14, 15, and 16, respectively. If these three commutators occupy the positions shown in the figures, all three time stages are switched in and the time switching takes place as follows:

After the welding machine has been switched in, a positive voltage of 270 volts, is set up at the anodes of the tubes 11, 12 and 13. From the phase-shifting device 7 there are supplied not only control pulses to the discharge tubes of control device 6, but also mains-synchronous positive pulses via a lead 17 to the control electrodes of the tubes 11, 12 and 13. If, now, a welding switch 18 is closed, a positive voltage of 130 volts is set up via a commutator 14 at the control electrode of tube 11. The tube 11 is then ignited upon arrival of the next mains-synchronous pulse via the lead 17, since the sum of the on voltage set up at this electrode exceeds the ignition voltage of the tube.

In addition to the time switch 9 proper, there is provided an auxiliary circuit 22 comprising three discharge tubes 19, 20 and 21, in which the control electrodes of the tubes 19 and 21 are also connected to lead 17 and the control electrodes of the tubes 20 and 21 are connected to the direct-voltage lead which receives, via the welding switch 18, a voltage of +130 volts.

At the same time as tube 11 is ignited, the tube 21 is also ignited, since a voltage of +130 volts is set up at its control electrode upon arrival of the next mains-synchronous pulse at the lead 17. Immediately after the ignition of tube 21, the tube 20 is also ignited due to the voltage drop which occurs across cathode resistance of tube 21, which voltage drop is transferred via a capacitor 23 to the control member of tube 20. The voltage drop at the cathode resistance of tube 20 is transmitted via the lead 8 to the control device 6, thus making this device operative, so that the tubes 2 and 3 which are connected in anti-parallel become conducting. At the same time, a relay 35 connected parallel to the input of transformer 1 is energized and opens its back contacts 36, 37 and 38.

After the ignition of tube 11, the capacitors 24 and 25 which are connected parallel to this cathode are charged. The voltage which occurs across them is set up via the switches 14 and 15 at the ignition electrode of tube 12. As soon as the sum of the voltage of the capacitors and of the pulsatory voltage supplied via the lead 17 reaches the ignition voltage of tube 12, the latter is ignited. In a similar manner, after expiration of the time of charge of the capacitors connected to the cathode of tube 12, the tube 13 is ignited and then also the tube 19.

Small inaccuracies in the times of charge of the individual RC-members then remain without effect, since each subsequent stage can be ignited only upon arrival of the next pulse via the lead 17 after a minimum voltage of the capacitors has been reached.

The ignition of tube 19 provides a positive voltage pulse which is set up via capacitor 26 at the cathode of tube 20 and extinguishes it. Consequently, lead 8 comes without voltage, the control device 6 is made inoperative and the gas-discharge tubes 2 and 3 are again cut-off. The ignition of tube 19 thus causes the welding operation to be terminated. In addition, the relay 35 is de-energized, its contacts close themselves and discharge the capacitors which had been charged in each case so that the device is then immediately ready for a subsequent welding operation. If, now, the welding switch 18 is opened again, a device (not shown) ensures that all the tubes of the whole of the switching arrangement are again extinguished. The welding switch 18 can now be operated again for a new welding operation, whereby the process previously described is repeated.

If one of the switches 14, 15 or 16 is brought into its central position, a capacitor of the relevant RC-circuit is switched off and the delay in ignition of the subsequent stage reduced. If one of the switches previously mentioned is brought into the extreme right-hand position, the relevant stage is shunted and the time interval associated with it is thus zero. Each position of the switch in each of the three stages corresponds to certain time intervals, so that the full welding time may be adjusted to the value desired in each case by means of the switches 14, 15, 16. This full welding time is obtained from the sum of the time values associated with the positions of the individual switches.

Due to the stepwise charging of the capacitors in the time switching for longer welding times and the resulting intermediate synchronisation by the pulses derived from the mains voltage and supplied via the lead 17, it is thus possible to obtain considerably higher accuracies in time than would be possible with charging of the capacitors in one step.

A series-connected time circuit is ignited, if desired, as soon as the capacitor of the preceding stage has reached a voltage of 75% of the voltage drop at the cathode resistance of this stage. The time constants of the charging members are thus so proportioned that the desired time is reached after about 1.4 time constants. The advantage is thus obtained that the subsequent time circuit is still ignited in a comparatively steep region of the charging curve of the capacitor, which is beneficial to the accuracy in time switching.

As in most circuits of this kind, an important factor is also sufficient constancy of the two direct voltages supplied by the anode tension device 10 and of the pulsatory voltage on the lead 17. It is preferable therefore to stabilize these voltages and thus make the welding times independent of variations in the mains voltage.

A more exact test of such time switching arrangements shows that, due to the unavoidable tolerances in the data of the tubes employed, certain inaccuracies in the determination of time may occur, if with tubes having the tolerances which are usual in commerce, the individual time circuit is designed for more than three cycles of the mains. This number may be improved when using either selected tubes or tubes having narrower tolerances. Another possibility of arriving at exact time values is shown in an embodiment of the circuit as represented in FIG. 2.

In this circuit, the same reference numerals are used as in FIGURE 1, insofar as identical parts are concerned. A detailed description of the similarly constructed welding tool and of the auxiliary device 22 is not necessary, so that only the different structure of the time switching arrangement proper need be dealt with hereinafter.

The time switch equipped with the tubes 27, 28, 29a and b together with 30a, b, c and d is designed so that

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time intervals up to 23 cycles of the mains can be adjusted without an error of one mains cycle occurring. The time switch is in this case built up of four stages or time circuits which may be connected in cascade with the associated switches.

The first stage equipped with the tube 27 corresponds in structure to the stages shown in FIG. 1, but may be adjusted via the associated switch 31 to zero, one or two mains cycles.

With such short times, as previously explained, no deviation occurs even if use is made of tubes of the kind commercially sold. The next stage containing the tube 28 may be adjusted via the switch 32 either to zero or to three mains cycles and thus also operates in an irreproachable manner.

The next stage comprises the two tubes 29a and 29b, each of which is adjusted to three mains cycles, the stage with the tube 29a also directly switching in the stage with the tube 29b. Consequently, it is possible via the associated switch 33 to adjust in total either the time interval zero or a time interval of 6 cycles.

The last stage equipped with the tubes 30a to 30d is of a similar structure, the time circuit of each tube comprising three cycles and automatically switching in the subsequent tube. The whole stage thus comprises twelve cycles so that the switch 34 permits of switching in time intervals of zero or twelve mains cycles.

By addition of the times of the individual stages, any arbitrary number of cycles from zero to 23 may be adjusted by means of the switches 31 to 34 without any error occurring.

It is emphatically pointed out that the auxiliary number of three mains cycles relates only to tubes having the tolerances which are usual nowadays. If better tubes are available, their number may be smaller without errors in the time intervals having to be taken into the bargain.

What is claimed is:

1. Apparatus for regulating the operating time of an electrical device, comprising means for controlling the operation of said device, input means for a source of

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periodic pulses, means for producing a signal quantity having a given duration comprising a plurality of pulse counters energized by said periodic pulses and arranged in succession, each of said counters comprising means for producing an output potential, means responsive to said output potential for actuating a succeeding counter a predetermined time interval after the actuation of the preceding counter, the time intervals of successive counters differing from each other in progressive relationship of multiples of the duration of one of said pulses, means for simultaneously initiating the operation of said controlling means and of the first of said counters, means responsive to the output potential of the last of said counters for actuating said controlling means to terminate the operation of said electrical device, each of said counters further comprising a gaseous discharge tube comprising a cathode, an anode and a control electrode, means for applying a continuous potential to said anode, means for applying a biasing potential to said control electrode, means for applying said periodic pulses to said control electrode, and timing circuit means comprising a first resistor-capacitor circuit connected to said cathode and a second resistor-capacitor circuit, and means for selectively connecting said second resistor-capacitor circuit in shunt with said first circuit.

2. Apparatus for regulating the operating time of an electrical device as claimed in claim 1, wherein said timing circuits have a timing range not longer than three cycles of said periodic pulses.

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