

DESCRIPTION

The invention relates to a circuit arrangement in accordance with the definition of the species of claim 1.

Such a circuit arrangement is known from the article VA 1 "NO BATTERY" ANALOG QUARTZ WATCH, pages 75 to 79 in the Proceedings Volume No. 2 of the XI. International Congress for Chronometry (October 1984, Besancon), Fig. 13 there. Provided as start-up circuit arrangement, in addition to charging and discharging circuits for a capacitor of very great capacitance serving as operating store, is a small auxiliary capacitor, which is connected directly to the timepiece circuit and in parallel with the solar cell by way of a reflux blocking diode. In this way the result is supposed to be achieved that, by reason of the low time constant of the small capacitance, the timepiece starts up already after brief irradiation of the solar cell.

A very similar circuit arrangement is previously known from the unpublished older European Patent Application corresponding to EP-A2-0 194 136; with the special feature that differently adjusted voltage comparators are connected in parallel with one another, in order to set an electronic timepiece circuit into operation practically immediately with the irradiation of the solar cells, namely by reason of the charging-up of a small auxiliary capacitor, - whilst the timepiece stepping motor is controlled only when, in addition to this, also a main store has been charged and the entire timepiece circuit has been switched over to operation from the main switch.

In the case of the previously published EP-A2-0 090 330, too, a staggered operation with two power stages is provided, by an operation of higher power requirement still being carried out upon dropping of the store voltage, in order then, until there is adequate recharging of the store, to switch over into a low-power waiting state. This suggests that, even when the circuit arrangement is put into operation with the store initially still uncharged, the regular operation of all the components - irrespective of whether of slight or great power requirement - does not immediately commence. This may be non-critical for the user in the case of small appliances of the type which, like pocket calculators, react only to manual inputs, because the input can be blocked in the low-power bridging operation and the block can be signalled; however, such a staggered putting into operation is disturbing in the case of consuming appliances of a different type, such as for instance timepieces, in which the consumer, on account of apparently non-orderly putting into operation, is perplexed if the various expected operating functions (on which he has no possibilities of manual influence) do not at the same time commence from the outset in a proper manner.

A circuit arrangement similar to the one in the Congress report mentioned at the beginning hereof, thus having a small

start-up auxiliary store and a large continuous-operation store, is also known from US-A-4 434 395, there with the special feature of charging the main store up only when, and not until, there is sufficient radiation intensity of the solar cells in addition to the auxiliary start-up store. What is disadvantageous in the case of such circuit arrangements having an auxiliary start-up store is, however, more especially the price and the space requirement for the additional installation of the main store which is of considerably larger dimensions. In operating technology respects what is particular disadvantageous is, in addition to this, the fact that the auxiliary store has a very small capacitance, in order to be able to be charged up rapidly to the start-up voltage of the appliance.

From the slight capacitance it then results, however, that the operation (started after a brief period of irradiation) of the small appliance immediately already ceases again if namely e.g. the irradiation lasted only briefly or is not sufficient to maintain the charging state under load. Thus, if a consumer, for example, by switching on a room illumination has satisfied himself that his small appliance, for instance a solar timepiece, has started up, he can in no way be sure that this appliance will also, for example, run right through the remainder of a night, if after that he switches the room illumination off again.

The use of rechargeable electrochemical charge stores (accumulators or secondary elements); see US-A-4 434 395, Fig. 2; in the case of solar timepieces of the type considered here does not come into the question, since the restricted useful life of such elements, despite the buffering from the solar cell, nevertheless again from time to time requires a battery exchange by the consumer; something which in the case of a so-called batteryless solar timepiece of the present species is, however, precisely to be avoided.

It has become apparent that, to ensure the continuous operation of the solar timepiece equipped with a capacitive charge, the path also cannot readily be taken simply of increasing the store capacity once again considerably. This is because the charging time constant is thus enlarged; the rise in the voltage to a value necessary for the operation or even start-up of electrical and electromechanical circuit components thus slows down unexpectedly. The consumer namely cannot be expected, after the removal of the "batteryless" small appliance from its packaging, to wait patiently for a fairly long period of time until the operating transition into an orderly function becomes perceptible to him.

Added to this is the fact that paradoxically precisely also the increase in the capacitance of the charge store can completely prevent the orderly start-up of a small appliance; namely when it has circuit components which are distinguished by high power requirement and/or distinctly different minimum operating voltages. Then, by reason of the slow voltage rise compelled by the large capacitance, various parts e.g. of a

timepiece circuit start to function at very different points in time after commencement of the solar-cell irradiation and even perhaps as a result of their large power requirement reduce the store charge again: so that the proper acting in unison of the circuit components for the steady operation cannot occur at all or respectively even changes over into constant relaxation oscillation behaviour, without ever achieving a steady operating state.

Such unfavourable load states immediately upon start-up of an appliance are more especially afforded when it is a matter, for example, of a radio clock; when, thus, at the start of operation an increased power requirement for the operation of the radio receiver (and of its decoding circuit for the time information received), as well as for the rapid drive of the wheel-work in the course of the entry of the timepiece hands into their reference position, accrues. Similar unfavourable operating conditions more especially immediately an appliance is put into operation are afforded if from the movement decorative elements such as ornamental pendulums, moving figures or the like which are still initially at rest have to be set in motion, especially if an electromotive transducer is provided, the high start-up current of which is reduced only after the onset, for example, of a rotor movement by the induction effects to steady operating requirement. Thus, in such cases the initially increased power requirement can cause the fact that the charging state of the store does not at all achieve steadily that voltage which is necessary for the permanent proper mode of operation of the entirety of all the circuit components; so that a free start-up out of the uncharged store situation is not guaranteed.

In recognition of these factors, the problem underlying the invention is to provide a circuit arrangement, of the type in accordance with the species, in which even in the case of circuit components having different start-up voltages, and more especially in the case of great electrical loading more especially at the start of operation, a reliable start-up into the steady mode of operation is ensured.

This problem is solved in the case of a circuit arrangement in accordance with the species in that it is designed in accordance with the characterising part of claim 1.

In accordance with this solution, by way of the threshold-value circuit a loading of the store upon commencement of operation is still temporarily prevented; so that practically the entire electrical energy supplied by the solar cell is available for the store charge-up, with the result of a rapid rise in the voltage over the operating minimum value. Only then does the threshold-value circuit free the store loading by consumers, which now, irrespective of their different minimum operating voltages which are dictated in circuit technology respects, simultaneously start to function; wherewith the proper steady acting in unison of all the circuit components is ensured even when at the

commencement of operation increased loadings occur and thereby the store voltage temporarily rises no further or even again falls somewhat.

Preferably the threshold-value circuit still does not switch off again should the switch-on voltage once be fallen below. This is because, after the commencement of operation, the power requirement is generally less; for example, by reason of the hands of a radio clock already swung into the desired position or by reason of the kinetic energy of constructional parts already set in motion. The switch-off voltage of the threshold-value circuit can thus be selected considerably lower than the switch-on voltage, whereby an interruption of operation by reason of temporary voltage declines at the store is practically prevented.

Advantageously the threshold-value circuit is not connected directly, but only functionally in series, to power consumers; thus designed as a control stage which supplies switch-on or respectively switch-off control signals to the crucial circuit parts. In this way power losses which could otherwise occur - when supplying fairly large consumers across auxiliary circuits - are avoided. It then only has to be ensured that the control circuits for such consumers initially block upon commencement of operation and connect the consumer to the supply only when the threshold-value circuit has ascertained that the switch-on voltage has been exceeded.

An upper voltage limitation behind the solar cell (see US-A-4 434 395, Fig. 1) is as far as possible avoided, in order also to be able to utilise the voltage peaks, entering quadratically into the power balance, upon the charging-up of the store. Where disadvantages for the operation of consumers (e.g. by reason of retrogressing efficiency upon fairly large voltage) would arise therefrom, these disadvantages can be simply avoided by a current limiter in front of the consumer.

Additional further developments and advantages of the invention will become apparent from the following description of a preferred example of realisation with regard to the circuit arrangement in accordance with the invention which is shown in a highly simplified manner in the drawings along with a restriction to that which is essential. The sole figure of the drawing shows, as an abstracted block wiring diagram, the operation of an electromechanical appliance from a solar cell as power source for the instance of use in the case of a clock movement.

The solar timepiece 1 shown as the small appliance has a - preferably electromechanical - clock movement 2, which is fed by way of a start-up circuit 3 from at least one solar cell 4; along with parallel connection of a charge store 5 for the bridging provision of electrical energy for periods of time in which the excitation of the solar cell 4 with radiation energy 6 is interrupted in an

environmentally-dictated manner over short to average periods of time.

The clock movement 2 has an electromechanical transducer, e.g. a stepping motor 7, which is connected by way of at least one geared coupling 8 to movement elements 9 such as hands, ornamental pendulums, figures, directional antennas, mechanical striking-work mechanisms or the like, which experience their mechanical drive from the operation of the motor 7. The motor 7 gets its operating energy by way of a control circuit 10 (for example a pole-reverser bridge circuit in the case of a single-phase-operated stepping motor) as much as possible directly from the power source in the form of the solar cell 4 (or respectively the auxiliary power source in the form of the charge store 5), in order to avoid where possible losses in electrical components connected for instance into this power path.

The control of the control circuit 10 is, for its part, effected from an operating circuit 11, in the case of which it can be a matter more especially of a crystal-stabilised, thus timekeeping, electronic timepiece circuit. Instead thereof or alternatively thereto, the control can, however, also be effected from an auxiliary circuit 12, as indicated in broken lines in the drawing; in the case thereof it is a matter more especially, for example, of a radio-clock receiver and decoder, as is described in more detail in the older application in accordance with EP-A2-0 180 155.

If the solar timepiece 1 is to be put into operation for the first time, the store 5 is still not charged. Electrical charging brought about by the radiation energy 6 leads by way of the supply leads 13 on account of the large capacitance of the directly connected store 5 to an exponential rise in the voltage U over the time t , as shown in the drawing in the case of the circuit 14 lying in parallel with the capacitive store 5. The response voltages of the different consumers (electronic circuits and electromechanical components) connected to the supply leads 13 are, in the same way as their respective power requirement, relatively different; with the result that, at different points in time during the rise of the voltage U , different consumers become effective and can then at least delay the rise in the voltage U , perhaps prevent same as a result of the increase in the energy requirement and can even cancel same again. From this it results that consumers which have the highest response voltage for their orderly mode of operation or respectively the greatest start-up power requirement, perhaps do not achieve a regular operating state at all, and thus a stable mode of operation of the solar timepiece as a whole can then never be achieved.

In order to overcome these start-up problems, thus in order irrespective of the very different response and operating behaviour of the individual electrical components even without initial charging of the store to be able to put the timepiece 1 into service immediately from the irradiation of its solar cells 4, subsequently connected to its

failure-bridging charge store 5 is a threshold-value circuit 14, preferably - on account of the said problems of the voltage drop in power circuits - connected in parallel. This allows the operation of consumers only when a switch-on voltage on the supply leads 13, thus above store 5, is at least achieved; so that a rise, stagnating after that, in the charging voltage U does not immediately again lead to the cessation of the operation which has just started up. Preferably the threshold-value circuit 14 is even equipped with a switch-off hysteresis, thus with a switch-off response voltage 0 which lies under the potential of the switch-on voltage I; whereby it is ensured that even a certain decline in the supply voltage U still does not again lead to the interruption of the operation which has just now started. Provision can also be made - as taken into account in the drawing by a multiplicity of control leads 15 for consumers or groups of consumers which are very different with respect to their electrical operating behaviour to interrogate different switch-on or switch-off voltages I/O within the threshold-value circuit 14 and to release these consumers accordingly with control signals 16 appearing independently of one another and naturally functionally harmonised with one another) or respectively to block same again.

In any case, as a result of the control signals 16 supplied by the threshold-value circuit 14 it is ensured that the supply leads 13 can be loaded only when the charging voltage U of the store 5 is sufficient for orderly operation commencement and adequately permanently stable operation, because the switch-on voltage 1 is already exceeded and a switch-off voltage 0 is still not again fallen below is - with the desired result that a relaxation oscillation operation of the electrical consumers upon the onset of fairly large power requirement and thus a prevention of properly commencing operation of the appliance as a whole is reliably avoided. The control circuit 10, which is switched off at commencement of operation, thus controls e.g. the motor 7 only after the switch-on voltage 1 is achieved.

Since the function of the threshold-value circuit 14 does not need a voltage limiter between the solar cell 4 and the bridging store 5, it is advantageous to the extent that the full voltage obtained from the radiation energy 6, which enters quadratically into the energy balance, is available for the operation of the consumers (circuits and other, for example electromechanical components). On the other hand, it is advantageous to provide a current limitation circuit 17 in series with such consumers, the mode of operation of which depends strongly upon the energy content of the control signals; as in the case of a stepping motor 7, the stepping torque of which both in the case of smaller and in the case of larger motor-impulse voltages drops severely. Since too small voltages are avoided by the prescription of the switch-off voltage 0, the circuit 17 for optimising the motor operation does not need to be designed as a power constant, but only for the current limitation upon the motor control; which is realisable with low circuit technology expenditure

by a component having a constant current characteristic (for example realised by a transistor).



CLAIMS

1. A circuit arrangement with voltage comparator and a capacitive charge store (5) fed by solar cells for the start-up of a small electrical appliance having a high start-up power requirement, more especially of a solar timepiece (1) having a start-up circuit (3) for the operation of its clock movement (2), characterised in that provided as voltage comparator is a threshold-value circuit (14) which can still temporarily prevent the start-up of the small electrical appliance so long as the capacitive charge store (5) is not charged upon from the solar cells (4) to a switch-on voltage (I) lying above a minimum operating value.
2. A circuit arrangement according to claim 1, characterised in that the threshold-value circuit (14) still cannot interrupt the already commenced operation of the small appliance again even when the output voltage of the charge store (5) temporarily falls below the switch-on voltage (I), without however falling below a switch-off voltage (0) lying therebelow.
3. A circuit arrangement according to claim 1 or 2, characterised in that the threshold-value circuit (14) can by way of control leads (15) switch-on consuming devices which are connected in parallel with the threshold-value circuit (14) to the charge store (5).
4. A circuit arrangement according to one of the preceding claims, characterised in that the threshold-value circuit (14) controls by way of a current-limitation circuit (17) a control circuit (10) for an electromechanical transducer (7).
5. A circuit arrangement according to claim 4, characterised in that the threshold-value circuit (14) controls by way of a current-limitation circuit (17) an electromechanical transducer (7) which is designed for the drive of auxiliary mechanisms - such as a rapid-motion drive of radio-clock hands and/or a drive of ornamental pendulums, which typically have immediately after commencement of operation a higher electrical power requirement than during the predominant period of time of their steady operation following on the start-up.