

Circuit arrangement for powering a load.

The invention relates to a circuit arrangement for powering a load from a power supply mains as defined in the preamble to the main Claim.

Non-prepublished German Patent Application P 37 22 337.2 describes a circuit arrangement for transferring electric power from an alternating voltage source
5 which is connected during given time intervals to an energy storage device for the purpose of supplying it with energy, which arrangement has a switch which is periodically activated by a control circuit for deriving the energy from an energy storage device. In this circuit arrangement high-frequency interferences produced therein are suppressed, i.e. kept away from the alternating voltage source, in that the control
10 circuit renders the switch conducting only outside the time intervals in which the alternating voltage source is connected to the energy storage device. This arrangement is particularly used in switch-mode power supplies which derive energy from an AC mains voltage thereby generating interference voltages and currents due to the switching processes of the periodically activated switch, which interference voltages and current
15 should not be introduced into the AC mains voltage. The connection or disconnection of the AC voltage source and the energy storage device is preferably effected by a rectifier stage. In the time intervals in which the rectifier stage is in the conducting state for the purpose of recharging the energy storage device, the activation of the switch is interrupted so that this switch does not introduce any interference via the conducting
20 rectifier stage into the AC voltage source, i.e. the mains.

However, interrupting the activation of the switch also interrupts the supply of energy to a load which is fed by the switch-mode power supply so that this load is periodically and not uniformly supplied with energy.

A circuit arrangement for powering a load from a mains is also known
25 from DE-OS 24 35 392, in particular Figs. 1 to 4 with the accompanying description. The circuit arrangement described therein, which is to facilitate the operation of electrical appliances, in particular radio and TV sets, still has a disproportionately high constructional cost, especially for small electrical appliances, even in the embodiment

designated as a simplified form.

It is an object of the invention to provide a circuit arrangement which with simple means ensures both a uniform power supply to the load and a reliable suppression of interferences from the load to the power supply mains and vice versa.

5 This object is achieved by means of the characteristics defined in the main Claim. The two dependent Claims represent advantageous further embodiments of the arrangement according to the invention.

According to the present art, a circuit arrangement is presented which at all times guarantees a separation between all poles of the load and the mains, which is
10 to satisfy the relevant safety requirements.

In the circuit arrangement according to the invention, however, the safety aspect is not in the foreground, but rather an even power supply combined with an effective suppression of transmitted interference between the mains and the load of as simple a construction as possible. The range of application of the circuit arrangement
15 according to the invention here is in particular that of consumer appliances, more in particular that of small domestic appliances such as, for example, shavers. Minor simplifications and improvements also play an important part economically in such mass articles of low price level.

The invention provides the possibility of suppressing interferences by
20 means of a simple circuit construction and at a uniform, uninterrupted energy supply of the load. Elaborate high-frequency filters of conventional type are not required for this purpose. Interferences originating both from the power supply mains and from the load can be suppressed with the arrangement. It is in a simple manner adaptable and usable for any power supply mains and any load construction.

25 For the required alternate connection it is advantageous that at least one of the energy storage devices is arranged in a series circuit between a first and a second switching unit. The energy storage device is preferably supplied with energy from the power supply mains via the first switching unit, while the load is supplied via the second switching unit.

30 The load is supplied with energy in a very uniform manner in that at least one of the energy storage devices is fixedly connected to the load. It is preferably supplied with energy from the series circuit(s).

A control circuit is provided for controlling at least one of the switching

units for alternately connecting at least one of the energy storage devices either to the power supply mains or to the load. This provides the possibility of operating the circuit arrangement with an arbitrary power supply mains, for example with direct currents or alternating currents of different frequencies and waveforms. Moreover, the supply of
5 power from the power supply mains to the load can be controlled by the control circuit in accordance with different requirements, for example for different types of loads.

At least one of the first switching units via which at least one of the energy storage devices can be connected to the power supply mains is adapted to rectify an AC voltage supplied by the power supply mains. To this end the relevant first
10 switching units may be formed as uncontrolled rectifiers or particularly as rectifiers controlled by the control circuit.

The first switching unit(s) is (are) exclusively controllable by the AC voltage from the power supply mains. This enables a simple rectification of this alternating voltage and also a simple transfer of power to the load via the energy storage
15 devices.

At least one of the second switching units is controllable by means of the control circuit after the first switching unit(s). The control hierarchy which is thereby determined enables a reliable functioning of the circuit arrangement in all operational cases, particularly at a fluctuating voltage in the power supply mains.

20 Preferably, at least two series circuits are arranged in parallel between the power supply mains and the load. Consequently at any moment one of the energy storage devices may be constantly connected to and supply the load, while at least one further energy storage device is connected to the power supply mains so as to be supplied with energy.

25 All described embodiments of the invention have in common that at least one blocked switching unit is always arranged between the power supply mains and the load, so that no interferences can be transferred via the connection leads which connect the power supply mains via the switching units and the energy storage devices to the load.

30 The control circuit according to the invention has at least one potential shifting stage arranged between one of the first switching units and the associated energy storage device for generating a control voltage which can be applied to the associated second switching unit via a control branch. Such an arrangement permits of

controlling the associated second switching unit in a simple manner in dependence on the operational conditions imposed on the associated first switching unit without a separate control logic with a separate current supply being required for this purpose. The control circuit according to this embodiment of the invention can therefore be
5 combined with the other components of the circuit arrangement in a very compact and inexpensive way. Moreover, its own power consumption is small.

Embodiments of the invention will now be described in more detail with reference to the accompanying drawings in which

- Fig. 1 is a block diagram,
- 10 Fig. 2 is a further block diagram,
- Fig. 3 is a more detailed representation of Fig. 1,
- Fig. 4 shows diagrams for operating the arrangement of Fig. 3,
- Fig. 5 shows a detailed embodiment,
- Figs. 6, 7 show diagrams for operating this arrangement, and
- 15 Fig. 8 shows a further embodiment.

The block diagram of Fig. 1 is the equivalent circuit diagram of a power supply mains comprising an (ideal) voltage source 1 and two mains impedances 2, 3 which are arranged in series with the voltage source 1 and constitute the internal resistance of the equivalent voltage source of the power supply mains. A junction point
20 between the mains impedances 2 and 3 is connected to ground. The mains voltage of the power supply mains is available at its terminals 4, 5.

In Fig. 1 the power supply mains 1 to 5 is connected to a first switching unit 6 to which a series circuit of a first energy storage device 7, a second switching unit 8, a second energy storage device 9 and finally the load 10 is connected. During
25 operation the first and second switching units 6 and 8 are alternately transferred to the conducting and the blocked state in such a way that only the first or the second switching unit 6 or 8 is conducting while the other switching unit is blocked. The first energy storage device 7 is thus alternately connected either to the power supply mains 1 to 5 or to the second energy storage device 9 and thus to the load 10. As a result
30 energy from the power supply mains is alternately taken up by the first energy storage device 7 and subsequently transferred to the load 10 via the second energy storage device 9. The second energy storage device 9 serves as a buffer for energy which can be applied to the load 10 during the time intervals in which the second switching unit 8

is in the blocked state. This ensures a uniform energy supply for the load 10.

On the other hand, the described manner of operation of the switching units 6, 8 ensures that there is always a separation, i.e. a high-ohmic impedance in the form of at least one blocked switching unit between the power supply mains 1 to 5 and the load 10. As a result interferences can neither get from the power supply mains 1 to 5 to the load 10 nor from the load 10 to the power supply mains 1 to 5. An interference-sensitive load 10 can thus be effectively shielded from interference voltages which may be present in the power supply mains 1 to 5; conversely, a load 10 causing interferences, for example a switch-mode power supply, can be supplied by the power supply mains 1 to 5 without interferences from the load 10 being transferred to this power supply mains.

In a second embodiment, which is shown in Fig. 2 and in which components already described have identical reference numerals, a parallel circuit of two series circuits is arranged between the power supply mains 1 to 5 and the load 10, each of which series circuits comprises a first switching unit 61, 62, a first energy storage device 71, 72 and a second switching unit 81, 82, respectively. Each of these series circuits 61, 71, 81 and 62, 72, 82 is operated in the same way as the series circuit in the first switching unit 6, the first energy storage device 7 and the second switching unit 8 according to Fig. 1. Additionally, the mutual relationship with respect to time of the switching states of the switching units 61, 62, 81 and 82 in the two series circuits is such that always one of the first energy storage devices 71, 72 is connected to the power supply mains 1 to 5 and that simultaneously the other is connected to the load 10, and conversely. While one of the first energy storage devices 71, 72 takes up energy from the power supply mains 1 to 5, the other storage device of the first energy storage devices 71, 72 supplies energy to the load 10 during the same period. At the end of this period the switching units 61, 62, 81, 82 are changed over in such a way that the first energy storage device 71, 72 which has just taken up energy is connected to the load 10 for supplying energy while the other first energy storage device 71, 72 which has just supplied energy to the load 10 is now connected to the power supply mains 1 to 5 so as to take up further energy. Thus, the first energy storage devices 71 and 72 are alternately connected to the power supply mains 1 to 5 and the load 10 in a kind of push-pull operation. As a result one of the two first energy storage devices 71, 72 is connected to the load 10 at any moment which is therefore supplied with energy in

a more uniform way than by a single first energy storage device. Particularly with this arrangement an energy supply which is twice as large, i.e. a capacity which is twice as large, can be transferred from the power supply mains 1 to 5 to the load 10, as is possible in an arrangement according to Fig. 1. However, the number of components, particularly for the energy storage devices, does not increase in the same way as the amount of energy which can be supplied so that it provides a space-saving possibility for increased power supply capacity.

The parallel circuit shown can be augmented by further parallel branches with further series circuits which have a similar construction.

10 In order to achieve a smooth switching process when changing over the load 10 from one of the first energy storage devices 71, 72 to the other, a second energy storage device 9 may also be arranged between the second switching unit 81, 82 and the load 10, as is shown with a broken line in Fig. 2. However, as the time intervals to be bridged by this energy storage device are essentially shorter than in the arrangement according to Fig. 1, the second energy storage device 9 in Fig. 2 may be dimensioned to be essentially smaller, which also contributes to a simple, compact and inexpensive construction.

Fig. 3 shows as a third embodiment a more detailed circuit arrangement in accordance with the block diagram shown in Fig. 1. As above, corresponding circuit components have identical reference numerals.

20 In Fig. 3 the first switching unit 6 is constituted by a bridge rectifier (Graetz bridge). The first switching unit 6 is thus also adapted to rectify the AC voltage supplied by the voltage source 1 of the power supply mains 1 to 5. The first energy storage device 7 - a capacitor in the relevant case - is supplied with energy by the pulsatory direct voltage occurring at the DC terminals of the first switching unit 6. The second switching unit 8 is constituted by a series transistor in the connection between the first energy storage device 7 and the second energy storage device 9 - also a capacitor. The second switching unit 8 is controlled by a control circuit 11.

Fig. 3 also shows the construction of the overall load 10 as a switch-mode power supply. It comprises a switching transistor 12 which periodically connects a series circuit of a load 13 and an inductance 14 to the second energy storage device 9. A smoothing capacitor 15 is arranged parallel to the load 13 and a freewheel diode 16 is arranged parallel to the series circuit of the inductance 14 and the load 13. The switch-

mode power supply functioning as the overall load 10 is operated in conventional manner and will therefore not be further described.

The switching processes of the switching transistor 12 cause interference pulses in the overall load 10 which also reach a first switching unit 6 via the connection leads when the second switching unit 8 is conducting and these interference pulses would also be introduced into the power supply mains via the connection terminals 4 and 5 if the switching unit 6 were also conducting. The second switching unit 8 is therefore controlled by the control circuit 11 in such a way that it is only conducting during the time intervals when the first switching unit 6 is blocked.

Fig. 4 shows in a few diagrams the variation with time of the processes in the circuit arrangement according to Fig. 3. In the diagram of Fig. 4a) the voltage U is plotted against time t at different points in the arrangement according to Fig. 3. The reference U_G denotes the positive rectified half waves of the rectified alternating voltage of the power supply mains 1 to 5. Each of these positive half waves recharges the first energy storage device 7 in the time interval between moments t_1 and t_2 . The voltage U_7 at the first energy storage device 7 follows the gradient U_G . The first switching unit 6, i.e. the bridge rectifier, is conducting in the time interval between t_1 and t_2 . This is diagrammatically shown in the diagram of Fig. 4c) in which the symbol "0" denotes the blocked state and the symbol "1" denotes the conducting state of the first switching unit 6. The recharge current I_L flowing from the power supply mains 1 to 5 to the first energy storage device 7 is shown in the diagram of Fig. 4d).

If the voltage U_G decreases again after the moment t_2 , the first switching unit 6 is blocked and the voltage U_7 at the first energy storage device 7 remains initially constant because the second switching unit 8 is also still blocked. This is shown in Fig. 4b) in a manner corresponding to that in Fig. 4c). The control circuit 11 keeps the second switching unit 8 in its blocked state up to a moment t_3 . The first energy storage device 7 is then separated both from the power supply mains 1 to 5 and from the second energy storage device 9 and the load 10 so that, except for leakage currents, the voltage U_7 cannot vary.

As is shown in the diagram of Fig. 4b), the second switching unit 8 is transferred from the conducting to the blocked state by the control circuit 11 at moment t_1 and consequently the first energy storage device 7 is separated from the second energy storage device 9. In the time interval between the moments t_1 and t_3 the load 10

is thus only supplied by the second energy storage device 9 so that the voltage U_9 occurring at this storage device steadily decreases from the moment t_1 , cf. Fig. 4a).

At the moment t_3 , when the second switching unit 8 is transferred to the conducting state again, the first energy storage device 7 is completely charged while the second energy storage device 9 has reached its lowest discharge state during the operation shown. By switching the second switching unit 8, a balancing process between the first and the second energy storage device 7 and 9 is initiated; energy flows from the first energy storage device 7 into the second energy storage device 9 while the voltage U_7 at the first energy storage device 7 decreases and the voltage U_9 at the second energy storage device 9 simultaneously increases. After termination of this balancing process the two voltages are identical, apart from a voltage loss at the second switching unit 8, which loss is not shown. The moment t_3 is chosen in such a way that the voltage U_7 during the balancing process does not become lower than the instantaneous value of the rectified voltage U_G , because otherwise the first switching unit 6 would again become conducting at the moment t_3 .

The load 10 is subsequently supplied from the parallel arrangement of the first and second energy storage devices 7 and 9, while the voltages U_7 and U_9 decrease to the same extent until they become equal at moment t_4 to the increasing voltage of the next half wave of the rectified voltage U_G of the power supply mains 1 to 5. At this moment t_4 , the first switching unit 6 becomes conducting again and the second switching unit 8 is transferred to the blocked state by the control circuit 11. This change is shown in Figs. 4b) and 4c). During the time when the load 10 is only supplied by the second energy storage device 9, a recharge current I_L flows again through the first switching unit 6 and the processes are repeated as from the moment t_1 .

The control circuit 11 may have different constructions. In one embodiment a voltage which is proportional to the rectified voltage U_G of the power supply mains 1 to 5 is derived by a voltage divider supplied by the power supply mains 1 to 5 via a diode and this voltage is compared with a reference voltage via a comparator. The comparator supplies a signal which is associated with a given fixed moment of each positive half-wave of the rectified voltage U_G . Moments which are shifted with respect to this moment for controlling the second switching unit 8 can be generated by correspondingly dimensioned monostable flipflops.

In a further embodiment a low-ohmic measuring resistor is arranged in the

lead to the first energy storage device 7, with which resistor the recharge current I_L and particularly its steeply rising edge is measured right after the moment t_1 . The second switching unit 8 can then be switched via monostable flipflops which determine the moment t_3 .

- 5 In a modification of the examples described, the moment t_3 in the control circuit 11 may also be determined by a comparison between the measured voltages U_7 and U_9 at the energy storage devices 7, 9 and the rectified voltage U_G which is measured in the manner described. The moment t_3 is reached when the sum $U_7 + U_9$ exceeds a given multiple of the instantaneous value of the rectified voltage U_G which is
10 dependent on the proportions of the energy storage devices 7 and 9. The latter variant has the advantage that the circuit automatically compensates fluctuations of the voltage of the power supply mains 1 to 5 and of the current flowing in the load 10.

- Similarly as in conventional arrangements, the voltage U_9 at the second energy storage device 9 with which the load 10 is supplied has an essentially sawtooth-
15 shaped ripple in the circuit arrangement according to the invention. However, in the case of a predetermined maximum permissible ripple the first and second energy storage devices 7 and 9 combined are not larger than an energy storage device required for the same ripple in conventional circuit arrangements so that with reference to these components, which require relatively much space, the quantity of components is not
20 increased in the circuit arrangement according to the invention.

- Besides the embodiment of the first switching unit 6 shown as a bridge rectifier in Fig. 3 and the second switching unit 8 shown as a bipolar transistor, with the energy storage devices as capacitors, other embodiments are also possible. Instead of an uncontrolled switch, which only reacts to the difference between the voltages
25 between its input and its output, it is also possible to use controlled switches as a first switching unit, for example instead of the diodes in the bridge rectifier. Preferably, transistors are used as controlled switches. As a result the switching units can also be used at different switching frequencies than are determined by an alternating voltage transferred through the power supply mains. Particularly a plurality of switching cycles
30 of the switching units can be performed during each half wave of the rectified voltage U_G .

 Instead of the energy storage devices in the form of capacitors it is optionally possible to use accumulators. In suitably designed embodiments inductances

may also be used as energy storage devices.

Furthermore the first switching units for adapting the voltage at the power supply mains to the voltage required for supplying the load may be combined with a mains transformer, for example in the form of a switched or non-switched half-wave or
5 full-wave rectifier. Two-terminal versions instead of the one-terminal embodiment of Fig. 3 can be used for the second switching units.

For the selection of the switching frequency, particularly for the first switching units, it is to be taken into account that the switching processes performed therewith should not lead to interference signals.

10 A particular advantage of the interference suppression achieved by the circuit arrangement according to the invention is not only the interference-free operation but also the possibility, particularly in a load 10 formed as a switch-mode power supply, of dimensioning the necessary tolerance to voltage fluctuations of the required switching transistor to an essentially smaller extent than would be necessary without the
15 interference suppression according to the invention. In switch-mode power supplies in which the switching transistor is subjected to the voltage of the power supply mains without interference suppression, the tolerance to voltage fluctuations is determined while taking into account a safety margin which is often considerable for interferences, particularly so-called mains transients. This safety margin may be of the order of
20 several 100 Volts. This means that much stricter requirements must be imposed on such switching transistors. However, these requirements may be dispensed with when using the circuit arrangement according to the invention so that simpler and essentially cheaper components having a lower cut-off voltage can be used. When integrating the components of such a switch-mode power supply on a semiconductor body,
25 simplifications and lower costs are achieved through the choice of component geometry and the method of manufacture.

Fig. 5 shows a further embodiment of a control circuit 11 having a very simple and reliable design. Components already described again have the same reference numerals. In its fundamental construction the arrangement corresponds to the
30 embodiment of Fig. 3. The control circuit 11 comprises a potential shift stage comprising a series diode 17 in the connection lead between the first switching unit 6 and the first energy storage device 7 and a shunt resistor 18 which shunts the DC terminals of the first switching unit 6. At the junction point 19 between one of the DC

terminals of the switching unit 6, the series diode 17 and the shunt resistor 18, the potential shift stage 17, 18 provides a control voltage which is applied via a resistor 20 forming a control branch to the control terminal of the second switching 8 unit which is a bipolar pnp transistor in the relevant case.

5 The operation of the circuit arrangement according to Fig. 5 is shown in the diagrams of Figs. 6 and 7. Fig. 6a), which essentially corresponds to Fig. 4, shows some voltage waveforms in the circuit arrangement according to Fig. 5. UN denotes the pulsatory DC voltage formed by the first switching unit 6 through rectification of the AC voltage of the power supply mains 1 to 5 and made available at the DC terminals of
10 the first switching unit 6. The voltage waveform UN thus already allows for voltage shifts due to the construction of the first switching unit 6 with non-ideal rectifier elements. U7 denotes the voltage at the first energy storage device 7, U9 denotes that at the second energy storage device 9. Fig. 7 shows the voltage waveforms in greater detail in the range of the half-wave peaks of the pulsatory DC voltage UN in which the
15 switching processes of the first and second switching units 6 and 8 are carried out. The reference t again denotes the time - plotted on the abscissa.

 In the operational state of the circuit arrangement the pulsatory DC voltage UN is smaller than the voltage U7 at the first energy storage device 7 in the time interval before the moment t10. The series diode 17 is therefore blocked. The
20 pulsatory DC voltage UN which is present at the junction point 19 is applied via the resistor 20 as a control voltage to the control terminal of the second switching unit 8. As long as the difference between the pulsatory DC voltage UN and the voltage U7 at the first energy storage device 7 exceeds the forward voltage of the base-emitter diode of the second switching unit 8, the latter unit is in the conducting state so that first and
25 second energy storage devices 7 and 9 are interconnected and the same voltage is present at these storage devices. In this time interval the variation of the voltage U9 at the second energy storage device 9 thus corresponds to the variation of the voltage U7.

 If the said difference between the voltages UN and U7 becomes smaller than the forward voltage UBE of the base-emitter diode of the second switching unit 8
30 when the moment t10 is passed, this diode is transferred more and more to its blocked state as the difference decreases. The series diode 17 remains in its blocked state. As a result the connection between the first and the second energy storage device 7 and 9 is gradually broken so that the load 10 is more and more supplied only by the second

energy storage device 9. The voltage U_9 at the second energy storage device 9 therefore starts to decrease at a faster rate than in the time interval before the moment t_{10} , while the voltage U_7 at the first energy storage device 7 decreases more slowly.

At the moment t_{11} the value of the pulsatory DC voltage U_N corresponds
5 to the value of the voltage U_7 at the first energy storage device 7. At this moment the voltage which is present across the series diode 17 and hence also that which is present across the base-emitter path of the second switching unit 8 disappears. The series diode 17 is still completely blocked at the moment t_{11} while the second switching unit 8 has just reached its completely blocked state.

10 When the pulsatory DC voltage U_N further increases, the second switching unit 8 remains in its blocked state while the series diode 17 gradually changes over to the conducting state. This is achieved when the value of the pulsatory DC voltage U_N at the moment t_{12} is greater than the voltage U_7 at the first energy storage device 7 by exactly a diode forward voltage U_D of the series diode 17. The first energy
15 storage device 7 is now charged with the pulsatory DC voltage U_N via the first switching unit 6 which changes over to the conducting state simultaneously with the series diode 17; the voltage U_7 at the first energy storage device 7 therefore trails the pulsatory DC voltage U_N by the diode forward voltage U_D .

On the other hand, the load 10 is further supplied only by the second
20 energy storage device 9 so that at this storage device the voltage U_9 , with the stronger increase reached at the moment t_{11} , further decreases. As from the moment t_{12} the series diode 17 is in its saturated state.

At the moment t_{13} the pulsatory DC voltage U_N at the junction point 19 reaches its peak value and subsequently decreases again. As a result the difference
25 between the pulsatory DC voltage U_N and the voltage U_7 at the first energy storage device 7 becomes smaller again after the moment t_{13} , so that the series diode 17 is transferred from its saturated state back to its blocked state. As long as the series diode 17 is still conducting, however, the first energy storage device 7 is still further charged to a small extent so that the voltage U_7 increases still further until at the moment t_{14}
30 the pulsatory DC voltage U_N corresponds to the voltage U_7 at the first energy storage device 7 and the series diode 17 is completely blocked. The charging process of the first energy storage device 7 in this half-wave of the pulsatory direct voltage U_N is terminated thereby, while also the first switching unit 6 changes over to the blocked

state.

Up to the moment t_{14} , the voltage U_9 at the second energy storage device 9 also further decreases steadily because the second switching unit 8 remains blocked.

Since the pulsatory DC voltage U_N becomes smaller than the voltage U_7 at the first energy storage device 7 after the moment t_{14} , the series diode 17 remains in its blocked state while the second switching unit 8 obtains a control voltage via the resistor 20 which voltage transfers it to the conducting state. As a result the connection for supplying energy from the first energy storage device 7 to the second energy storage device 9 is established. Since the first energy storage device 7 is completely charged and the second energy storage device 9 is essentially discharged at its lowest voltage, the energy starts to flow from the first energy storage device 7 into the second energy storage device 9 so that the voltage U_7 at the first energy storage device 7 decreases while the voltage U_9 at the second energy storage device 9 begins to increase. At the moment t_{15} the difference between the pulsatory DC voltage U_N and the voltage U_7 at the first energy storage device 7 reaches a value at which the second switching unit 8 has changed completely to the conducting active state of the bipolar transistor constituting this unit. From this moment, the variation of the voltage U_7 follows that of the pulsatory DC voltage U_N which controls the second switching unit 8 via the junction point 19 and the resistor 20. Simultaneously with the above-described controlled discharge of the first energy storage device 7, the second energy storage device 9 is charged with the energy supplied by the storage device 7. The reversal of the charge of the energy storage devices 7 and 9 is determined by the increase of the falling edge of the pulsatory DC voltage U_N . If the charge were reversed more slowly, i.e. if the voltage U_7 decreased more slowly, the second switching unit 8 would become saturated which would result in the reversal of the charge being accelerated. Conversely, in the case of a too fast discharge the difference between the pulsatory DC voltage U_N and the voltage U_7 would become too small so that the second switching unit 8 would immediately be brought more strongly towards its blocked state. As a result the reversal of the charge would be slowed down.

At the moment t_{16} the voltages U_7 and U_9 at the energy storage devices 7 and 9 are balanced; the process of reversing the charge is terminated. When the pulsatory DC voltage U_N is further decreased, and as was hitherto the case, the voltage U_7 at the first energy storage device 7 no longer follows the forward voltage of the

base-emitter path of the second switching unit 8 over a distance U_{BE} . Rather, the common decrease of the voltages U_7 and U_9 is only determined by the energy flow into the load 10. With a decreasing pulsatory DC voltage U_N , the difference with voltage U_7 becomes larger so that the second switching unit 8 is driven into its saturated and hence conducting state via the resistor 20. This state subsequently remains unchanged until the next half-wave of the pulsatory DC voltage U_N for which the processes described for the period from moment t_{10} onwards are repeated correspondingly.

The described voltage variations and values also ensure that the series diode 17 continuously remains in its blocked state and that accordingly the first switching unit 6 is in its blocked state.

The diagrams of Figs. 6b) and c) show in a simplified form and in a manner corresponding to Figs. 4b) and c) the states of the first and second switching units 6 and 8 in dependence on the time t . Before the moment t_{11} the first switching unit 6 is in the blocked state designated as "0" in the diagram according to Fig. 6c) while the second switching unit 8 is in the conducting-saturated state designated by "1". At the moment t_{11} these states are changed; before that moment the second switching unit 8 has changed over to the blocked state in conformity with a transfer to the state "0" in the diagram of Fig. 6b) which transfer is shown in a simplified form as a perpendicular edge. After the moment t_{11} the first switching unit 6 assumes the conducting state. At the moment t_{14} the first switching unit 6 changes back to the blocked state while the second switching unit 8 is changed over to the active state "a" of the bipolar transistor constituting this unit and remains in this state until the moment t_{16} . The active state "a" is shown as a conducting intermediate state in Fig. 6b). At the moment t_{16} the second switching unit 8 assumes the conducting, saturated state "1" while the first switching unit 6 is further in its blocked state "0". These processes are repeated in a corresponding manner in the subsequent half-wave of the pulsatory DC voltage U_N .

It is further evident from the foregoing that in the arrangement according to Fig. 5 the time intervals in which the switching units 6 and 8 assume their conducting or blocked states are always separated from each other, i.e. they cannot overlap because of the special generation of the control voltage for the second switching unit 8. Thus, a high-ohmic separation between the power supply mains 1 to 5 and the load 10 is always ensured.

In order to obtain transmission of interference which is as small as possible via the resistor 20, this resistor is dimensioned as high-ohmic as possible. Therefore, a current amplification as high as possible is aimed for in the transistor constituting the second switching unit 8 in order that the control current via the resistor
5 20 can be chosen as small as possible in the case of a predetermined current for the transfer of energy from the first energy storage device 7 to the second energy storage device 9.

Fig. 8 shows a modification of the embodiment according to Fig. 5 in which the second switching unit 8 is in the form of a combination of a pnp transistor
10 and an npn transistor for increasing the current amplification. To obtain the ratios between the voltages when controlling this version of the second switching unit 8, a series circuit of two series diodes 171, 172 replaces the series diode 17. Moreover, a discharge diode 21 is arranged parallel to the resistor 20 in the control branch, which
15 switching unit 8.

The circuit arrangements according to Figs. 5 and 8 have a very simple construction; particularly, the control circuits 11 in these arrangements do not require any separate logic circuits and no separate associated energy supplies. The interference suppression achieved with these circuit arrangements is very good because particularly
20 fluctuations of the voltage at the power supply mains 1 to 5 and fluctuations of the energy being taken up by the load 10 are automatically compensated. The operation of the interference suppression is also ensured in the case of a variation with respect to time of the voltage at the power supply mains and hence the pulsatory DC voltage UN. Due to the small number of required components the circuit arrangement can be
25 constructed in a simple manner and at low cost also for larger energy flows to be transferred, and in particular it can be integrated on a semiconductor body.

Claims:

1. A circuit arrangement for powering a load (10) from a power supply mains (1 to 5), comprising at least two energy storage devices (7,9) of which at least one is arranged in a series circuit between at least one first (6 or 61,62) and at least one second (8 or 81,82) switching unit and can be alternately connected to the load (10) or
5 to the power supply mains (1 to 5) and of which at least a further one (9) is fixedly connected to the load, and comprising a control circuit (11) for controlling at least one (8) of the switching units for the alternate connection of at least one (7) of the energy storage devices either to the power supply mains (1 to 5) or to the load (10), while at least one of the first switching units (6 or 61,62), through which at least one of the
10 energy storage devices (7 or 71,72) can be connected to the power supply mains (1 to 5), is constructed so as to rectify an AC voltage supplied by the power supply mains (1 to 5) and is controllable exclusively by means of the AC voltage from the power supply mains (1 to 5), at least one of the second switching units (8 or 81,82) being controllable by the control circuit (11) after the first switching unit(s) (6 or 61,62),
15 characterized in that the control circuit (11) comprises at least one potential shift stage (17,18) which comprises a diode and is arranged between one of the first switching units (6) and the lead to the associated energy storage device (7) for the generation of a control voltage which can be applied to the associated second switching unit (8) through a control branch (20).
- 20 2. A circuit arrangement as claimed in Claim 1, characterized in that at least two series circuits (61, 71, 81 and 62, 72, 82) are arranged in parallel between the power supply mains (1 to 5) and the load (10).
3. A circuit arrangement as claimed in Claim 1 or 2, characterized in that
25 the potential shift stage comprises a series diode (17) in the connecting line between the first switching unit (6) and the first energy storage device (7), as well as a parallel resistor (18) which shunts DC connection terminals of the first switching unit (6).