

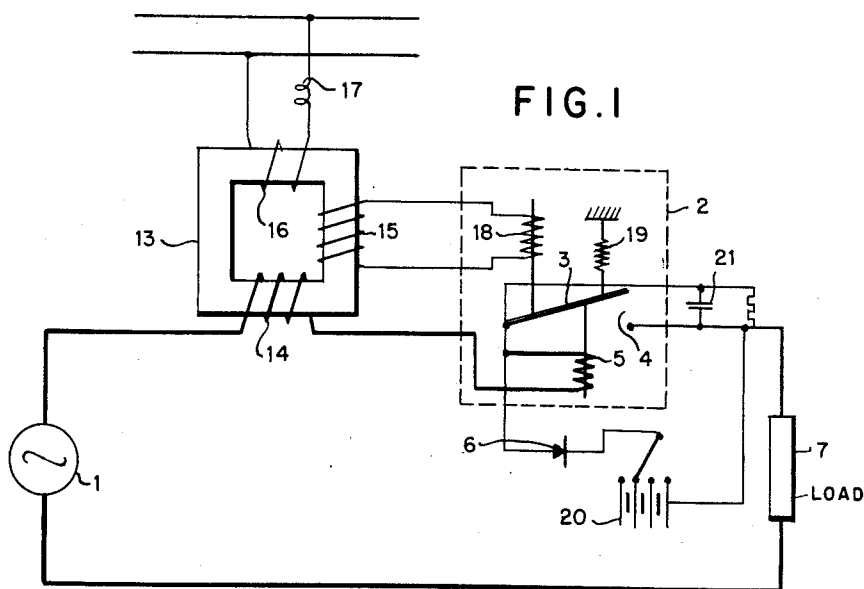
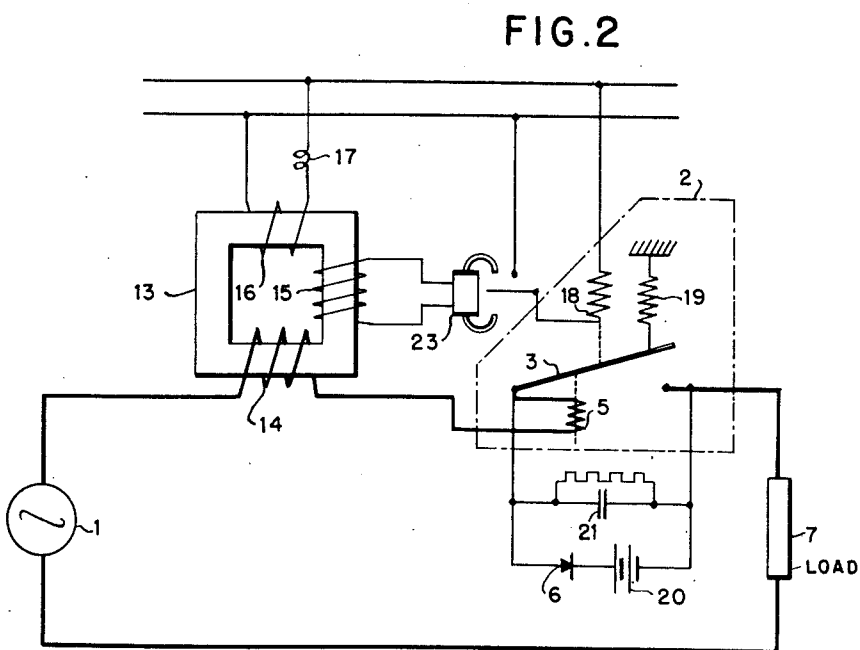
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CONVERTER WITH ELECTROMAGNETIC SWITCH

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CONVERTER WITH ELECTROMAGNETIC SWITCHES

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This invention refers to contact apparatus of the commutating or synchronous type for rectifying, inverting or frequency converting purposes. Such apparatus, hereinafter termed "converters," are usually equipped with one or several electric contacts which open and close an electric circuit in synchronism with an alternating or periodically variable current to be controlled by the contacts.

The present invention relates more particularly to converters which have electromagnetically actuated contacts controlled by the current of a valve circuit that bridges the contact gap.

An object of the present invention is the provision of converters which offer technical and economical advantages due to the fact that the electromagnetic contact devices have only one main control coil through which the valve current flows when the contact is open, and which carries the total current when the contact is closed. The valve circuit functions as a means for initiating the switching-in performance and as spark extinguisher when switching off, so that in the majority of cases additional spark-extinguishing devices are no longer needed, or can at least be made much smaller.

One of the more specific objects of the invention is to provide a converter of the above-mentioned type that is suitable for regulating the rectified voltage without loss.

Another object of the invention is to devise a valve-shunted contact converter in which the contact controlling means are capable of producing an especially rapid switching operation so that the switching period, i. e. the time needed for the contact to move from one to the other position, is short enough to limit the load on the valve shunt circuit to an only small fraction, for example 5%, of the rated current. More specifically, it is an object of the invention to provide a valve-shunted converter for power current, particularly in series connection with a saturable reactor, that facilitates keeping the current at the initial moment of circuit interruption below one ampere or/and the voltage drop across the opening contact below 10 volts also at the contact opening moment. Experience has shown that under such conditions the danger of arcing is eliminated regardless of the average magnitude of the alternating current being interrupted.

Still another object of the invention, relating to contact converters with series-connected saturable commutation reactors, is to permit reducing the size and cost of these reactors for any given power rating. Whereas the reactors heretofore used for facilitating current interruption were rated for a current-flattening period of about one milli-second, the invention aims at providing a converter system which affords com-

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parable results if the reactors have a current-flattening period of only 10^{-4} seconds and less, thus considerably reducing the cost of the required reactors.

The foregoing and other objects of the invention, as well as the means provided by the invention for achieving these objects, will be apparent from the following detailed description in connection with the accompanying drawings in which Figs. 1 and 2 show two respective embodiments of converters according to the invention.

In both figures, 1 is the source of alternating current; 2 is the electromagnetic switch with switch contact 3, contact gap 4 and control coil 5. The circuit of a valve 6 extends across the contact gap 4. The converters are shown to operate as rectifiers for feeding a load 7 with rectified current from the source 1. While the illustrated examples are designed for single-phase performance, it will be understood that the invention is readily applicable to multiphase circuits by providing corresponding converting devices in each of the circuit phases. In both embodiments, the contact element 3 is biased toward the open position by a spring 19 and is moved to the closed position when the series-connected control coil 5 is sufficiently energized.

The converter illustrated in Figure 1 functions as follows:

When switch 2 is open, the alternating current from source 1 passes first through coil 5, thence through valve 6 and load 7 back to source 1. Assume that the current has just passed through the zero value and is increasing toward its maximum value, then the instantaneous current values are at first too small for energizing the coil 5 sufficiently to close contact element 3 in opposition to its opening bias. When the valve current reaches a given value, coil 5 closes the switch contact. From then on, the current passes through contact element 3. Valve 6 is short-circuited and thus relieved from current-carrying duty. This condition continues to prevail until the current has passed through its maximum and declines below a given low value at which the opening bias of contact element 3 exceeds the magnetic force of coil 5 and switches the contact element 3 to the open position. Now the current once again passes through valve 6. As the valve circuit does not include any additional inductances and resistances, this switching is instantaneous and no sparks are formed because the voltage drop at the valve remains sufficiently small. The valve 6 remains conductive until the declining current approaches the next zero passage. From then on, and during the subsequent half-cycle period, the valve 6 is effective to block a reverse current flow until the current passes again through the zero value and causes a repetition of valve-controlled switching performance.

As a result, the switching device and associated valve circuit operate as a synchronous contact rectifier.

The converter is equipped with current-biasing means comprising a reactance coil, and with tension regulation means comprising an auxiliary voltage source. The current-biasing reactor has a saturable iron core 13 with a main winding 14, an auxiliary winding 15 and a premagnetizing winding 16 which is excited through a coil 17 of high inductance. Switch 2 has a switching-off coil 18, which enhances the effect of switching off spring 19. A direct-current source 20 of adjustable voltage and very small internal resistance, such as a battery, is connected in the valve circuit 6 in opposition to the flow-phase voltage of source 1.

Assume that contact element 3 is in the illustrated open position and that the voltage of source 1 has just passed through the zero value and increases with the polarity needed to pass current through the valve circuit 6. At first, no such current flow occurs because of the opposing voltage of auxiliary source 20. As soon as the voltage of source 1 exceeds the countervoltage of battery 20, a current commences to flow through main control coil 5 and valve arrangement 6, as well as through the switched-in portion of battery 20. When this current reaches the critical value, coil 5 closes the contact element 3. When the intensity of the current diminishes, the premagnetization provided by coil 16 has the effect of desaturating the reactor core 13 shortly before the next current zero passage, and the magnetization of the reactor core begins to reverse. As a result, the current curve becomes flattened or stepped near its zero passages because now practically the total active voltage appears across the reactor coil 14. At the same time, a voltage is induced in coil 15 so that a current begins to pass through the switching off coil 18 with the result that switch 2 opens its contact 3 safely within the interval of the current flattening effect. Here, too, the valve circuit serves mainly to prevent sparking so that any additional spark extinguisher 21, if at all needed, may be correspondingly small. Depending upon the voltage of the auxiliary battery 20, switch 2 is closed more or less rapidly, so that the direct-current voltage on load 7 is regulated substantially without loss.

While in the above-described embodiment of Fig. 1, the voltage produced in the auxiliary winding 15 by the steep reversal of the reactor magnetization is directly applied to the circuit-opening control coil 18 of the electromagnetic switch 2, the auxiliary winding may also be connected to a very rapid relay which in turn connects the opening control coil with an auxiliary source of current. This is preferable with large size switches whose actuation requires a correspondingly large amount of power. It is also possible to employ a very rapid low-current relay which is actuated when the weak-current stage is reached and which controls the opening of the switch in a similar manner.

The converter shown in Figure 2 embodies the above-mentioned relay modification and is otherwise similar to the converter of Figure 1, the same reference numerals being used for designating similar respective elements. According to Figure 2, the voltage induced in the auxiliary reactor winding 15 is impressed upon a rapid relay 23 which in turn connects the opening control coil 18 of switch 2 to a source of current.

I claim:

1. An electric current converter, comprising a main circuit having alternating-current terminals, a contact in said circuit for opening and closing said circuit, actuating means disposed for controlling said contact in synchronism with the alternating current and having an electromagnetic control coil connected in said circuit in series with said contact, valve means connected across said contact so as to lie in series with said coil when said contact is open, and a direct-current source of adjustable voltage series-connected with said valve means and poled to oppose, during the flow phase of said valve circuit, the alternating-current voltage so as to permit the flow of valve current only when the voltage drop caused by said alternating voltage across the open contact exceeds said direct-current voltage.

2. In a converter according to claim 1, said direct-current source having an internal resistance at most about equal to that of said valve means.

3. An electric current converter, comprising an alternating-current circuit, a contact movable between opening and closing positions and series-connected in said circuit, means disposed for biasing said contact toward opening position and including a magnetic opening coil, a closing coil disposed for moving said contact to closing position and connected in said circuit in series with said contact, valve means connected across said contact for passing current through said closing coil when said contact is open and said current directed in the flow direction of said valve means, a saturable reactor for flattening the curve of the current near the current zero passages having a main coil series-connected in said circuit and having a saturable magnet core and an auxiliary winding on said core, and circuit means connecting said auxiliary winding to said opening coil for assisting the opening of said contact in response to current induced in said auxiliary winding by reversal of magnetization in said core.

4. In a converter according to claim 3, said circuit means comprising a rapid relay connected with said auxiliary winding to respond to said induced current, and auxiliary direct-current supply means, said opening coil being connected with said supply means through said relay so as to be energized from said supply means under control by said relay.

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