Fig. 1.

Fig. 2.

Fig. 3.

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The invention relates to a transformer, particularly a welding transformer adapted to produce a variable current, having in combination a wide range of regulation, a steep voltage-current characteristic and a substantially constant no-load voltage.

The voltage-current characteristic is of great importance for variable welding transformers. If the characteristic is steep slight variations of the current will occur as the arc voltage varies during the welding process, so that a uniform weld will be obtained.

Another important factor is the magnitude of the range of regulation that may be obtained without making any changes in the circuit used. Furthermore a substantially constant no-load voltage over the whole regulating range is of substantial importance.

It is known, in a variable welding transformer, to regulate the current by means of an adjustable magnetic shunt.

The principle of the transformer according to the invention is shown in Figure 1. 1 is the primary winding, 2 the secondary winding, and 3 the magnetic shunt. The current produced in the closed position of the magnetic shunt shown in Figure 1 will be a minimum; the current will be a maximum if the magnetic shunt is coupled as little as possible with the fixed yoke of the transformer.

Although in the latter case the voltage-current characteristic will be steep in view of the minor coupling between the primary winding 1 and the secondary winding 2, the range of regulation will be very small. Moreover, if only a narrow or practically no air gap is used in the closed position of the magnetic shunt in order to increase the range of regulation as much as possible, the no-load voltage in this position will be strongly reduced, as part of the magnetising flux will flow through the magnetic shunt, which is undesirable.

Figures 2 and 2a show other forms of known welding transformers.

In both figures the magnetic shunt 5 is provided with a winding 4 forming a portion of the secondary winding of the transformer. In Figure 2 the secondary winding comprises a portion 3 traversed by the flux in the fixed core also carrying the primary winding 1, and the portion 4 which is connected in series with the portion 3 and is traversed by the flux in the adjustable shunt core 5. In Figure 2a the same circuit is used as in Figure 2, but the secondary winding further comprises a portion 2 which is traversed by the flux in a second fixed core and is connected in series with the portions 3 and 4. As indicated in Figures 2 and 2a the transformer may be regulated by rotating the movable shunt core 5 about the axis 6 indicated in dotted lines.

In these circuits the winding 4 and the movable core 5 will constitute a choke coil the reactance of which is varied by increasing and decreasing its magnetic resistance. The reactance will be a minimum (and the current will be a maximum) when the air gap between the adjustable core 5 and the fixed yoke is as large as possible, and the reactance will be a maximum (and the current a minimum) in the closed position of the core 5 shown in the figures. However, as the magnetic circuit of a normal transformer is used for varying the magnetic resistance, the magnetising current occurring in the closed position of the core 5 will cause the reactance to depend on the winding sense of the winding 4 as compared with the winding 3. Said winding sense depends upon the rotation of the core 5 about the axis 6. In the case of an opposing winding sense the reactance will be a maximum and the current will be a minimum. With this winding sense the no-load voltage in the closed position of the core 5 will be substantially less than in the open position, which is a drawback.

If, in a circuit of this type, a steep voltage-current characteristic is desired it will be necessary, in view of the high degree of coupling between the primary winding 1 and the secondary winding portion 3 in Figure 2, or between the primary winding 1 and the secondary winding portions 2 and 3 in Figure 2a, to have a winding portion 4 of high reactance in order to produce a wide range of regulation.

There is little difference between Figures 2 and 2a. In Figure 2a the total coupling between the secondary winding and the primary winding is somewhat less than in Figure 2, as the winding portions 3 and 4 are spread over two chokes. Consequently, in this case, the range of regulation will be still further reduced.

The invention provides a variable welding transformer, having a steep voltage-current characteristic combined with both a wide range of regulation and a substantially constant no-load voltage. In a circuit having a first portion of the secondary winding which is traversed by the flux in a fixed core also carrying the primary winding, a second portion of the secondary winding which is connected in series with the first portion and is traversed by the flux in an adjustable shunt core, and a third portion of the sec-

3 Claims. (Cl. 323—44)

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ondary winding which is traversed by the flux in a fixed core, this result is produced by connecting said third portion in parallel with the series connection of said first and second portions. The winding of the circuit according to the invention is that as a result of this parallel connection the volume of the transformer may be substantially reduced without affecting the properties required for a good welding transformer.

The invention will be explained by means of Figure 3 in which the same references occur as in the other figures.

The winding 1 is the primary winding 1. The secondary winding comprises the portion 2 connected in parallel with the series connection of the portions 3 and 4. The portion 2 is a fixed winding coupled with the primary winding 1. The winding 3 is also coupled with the primary winding 1.

It would appear that the function of the winding 4 in Figure 3 is the same as that of the corresponding winding in either Figure 2 or Figure 2a. This however is not the case. The two functions are the same only when the adjustable core 5 carrying the winding 4 is adjusted in such a manner with respect to the fixed core 6 that the magnetic lines of the circuit in the fixed yoke do not have any or any substantial reactive influence on the adjustable core 5. This will be the case for instance if the core 5 is removed as far as possible from its closed position.

In the closed or substantially closed position of the core 5 the reactance of the winding 4, as contrasted with that of the corresponding winding in Figure 2 or 2a, will depend upon the flux in the fixed yoke and the adjustable core produced by the strong field repelling action which will occur when the winding portion 2 is being loaded. In the case of equal winding senses said reactance will be much higher than in Figure 2 or 2a, whereas for opposing winding senses the reactance will be even less than in the position of the core 5 of maximum air gap.

In the case of opposing winding senses the different flux values in the core 5 produced by the magnetising current and the current flowing from the winding portion 3 through the winding portion 4 to the junction with the winding portion 2 will have the same direction. In the case of equal winding senses said flux values will be opposing and consequently the shunting action of the core 5 for the winding portion 2 will disappear. Thus it will be clear that the maximum and minimum values of the resulting reactance produced by the parallel connection will be far apart, which means that a wide range of regulation is obtained.

The voltage current characteristic of the transformer according to the invention is as a whole substantially independent of the number of turns of the winding portion 4. Said number of turns will merely influence the reduction of current in the closed position of the core 5 with opposing winding sense of the winding portion 4, and the increase of current in the closed position of the core 5 with assisting winding sense.

Consequently, in the case of a maximum range of regulation, the greater part of the current will be supplied by the winding portion 2, so that this winding will be mainly responsible for the voltage-current characteristic obtained.

The no-load voltage will not submit substantial variations in the different positions of the adjustable core 5, as in view of the parallel connection of the winding portions 2 and 3 the winding portion 4 will substantially compensate any voltage difference that might tend to develop between the winding portions 2 and 5 as a result of the leakage flux in the core 5.

The current may be taken from the winding 2 either directly or by means of a transformer.

What I claim is:

1. A variable current transformer comprising a core having a main core section, a fixed shunt section and a movable shunt section, a primary winding on said main core section, and a secondary winding comprising three parts mounted respectively on said three core sections, the parts of said secondary winding mounted on said main and movable core sections being connected in series with each other and in parallel with the part of said secondary winding mounted on said fixed shunt section.

2. A variable current transformer according to claim 1, in which the winding sense of the two series connected parts of the secondary winding is mutually reversible, so that in combination with the parallel connected part of the secondary winding a wide range of regulation is obtained.

3. A variable current transformer having a stationary core member comprising two parallel core legs, a movable shunt core member, a primary winding and a first secondary winding portion disposed on one of said parallel core legs, a second secondary winding portion connected in series with the first secondary winding portion and disposed on the movable shunt core member, and a third secondary winding portion disposed on the other of said parallel core legs and connected in parallel with the series connection of the first and second secondary winding portions.

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The following references are of record in the file of this patent:

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