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54 **Transformers.**

57 A high power transformer which is suitable for the generation of very high voltage pulses includes a saturable reactor which is formed integrally within it. The core of the reactor is surrounded by the primary winding of the transformer itself, so that the primary current saturates the reactor core. This permits a very compact structure and minimises stray inductance.

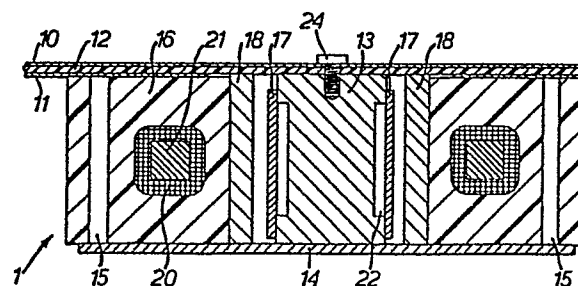


Fig.2.

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PATENT SPECIFICATIONTRANSFORMERS

This invention relates to transformers which are particularly suitable for use in pulse circuits in which a
5 high current pulse at relatively low voltage is converted into a very high voltage pulse.

A transformer of this kind can be used in a pulse circuit to provide the operating power for a high power oscillator, such as a magnetron, which forms part of a
10 radar transmitter. Such a pulse circuit is sometimes termed a radar pulse modulator. A radar transmitter can transmit pulses having a very low mark-to-space ratio; that is to say, transmitted short pulses are spaced apart in time by relatively long intervals during which echoes of the pulses
15 are returned by intercepted targets to a radar receiver. The useful range of a radar is related to the power transmitted during the short pulse periods and it is therefore very important to maximise the power of these pulses, whilst ensuring that the pulses turn on and off
20 cleanly without the generation of excessive noise. Following the turn off, or decay, of a transmitted short pulse, the receiver of the radar is enabled so that it can detect weak radar echoes. It is clearly important to ensure that the trailing edges of the transmitted short
25 pulses decay very rapidly and cleanly so that they do not mask echoes received after only a very short delay from targets at close range.

These requirements impose stringent demands on the pulse transformer itself as it may be required to convert
30 an input pulse of only a few hundred volts to an output pulse voltage of up to 30 kV or even higher, whilst handling a peak pulse power of the order of two megawatts.

The present invention seeks to provide an improved transformer which is suitable for use in a pulse circuit.

According to a first aspect of this invention, a transformer includes a primary winding and a secondary winding; and a saturable reactor which is encircled by the secondary winding, and which is arranged to magnetically couple with said primary winding, but does not so couple with the secondary winding.

According to a second aspect of this invention, a transformer includes a transformer core material shaped to constitute a closed magnetic loop; a toroidal secondary winding wound around said core material so as to magnetically couple therewith; a primary winding part of which comprises a central rigid conductor which is encircled by the core material; a saturable reactor core in the form of a hollow cylinder encircling said central rigid conductor and which is also encircled by said core material whereby the primary winding is operative to couple magnetically with the saturable reactor.

By forming the saturable reactor core within the transformer so that the primary winding also forms part of the saturable reactor, the overall inductance can be kept to a very low value.

In a high power pulse transformer, the structures can be physically very large, and the primary currents also can be large, and by combining the transformer function and the saturable reactor function into a physically integrated unit, the overall cost and weight can be reduced whilst the electrical performance is much improved.

The invention is further described by way of example with reference to the accompanying drawings in which:

Figure 1 is a simplified circuit diagram illustrating the function of the transformer and saturable reactor,

Figure 2 is a section view showing construction of the transformer incorporating the saturable reactor.

Referring to Figure 1 there is shown therein a high voltage transformer 1 which is adapted to convert a relatively low voltage pulse generated by a pulse forming network 2 into a very high voltage pulse and to make it
5 available at output terminals 3 and 4. The pulse forming network 2 consists of a distributed inductive and capacitance circuit as diagrammatically illustrated. Networks of this kind are well known and it is not thought necessary to describe it in further detail. The network 2
10 is periodically charged from a low voltage d.c. power supply present at terminals 5 and 6. When the network is fully charged, the switch 7 is closed thereby permitting the network to rapidly discharge via a saturable reactor 8 and the primary winding 9 of the transformer 1.

15 As the switch 7 is typically a solid state thyristor it can take a finite time to change from a fully non-conductive state to a fully conductive state, and if appreciable current were allowed to flow through it during this impedance transition phase a great deal of power would
20 be dissipated within the switch itself. It is to prevent this happening that the saturable reactor 8 is provided. As is well known, a saturable reactor initially behaves as an inductance and therefore controls the rate at which the build-up of discharge current can occur, but the magnetic
25 core of the saturable reactor rapidly saturates and then behaves as a very low value inductance, and exhibits a very low impedance.

Typically, the power handling capacity of the transformer is very large. Although the pulse forming
30 network can take a relatively long time to become fully charged, and therefore to store a predetermined amount of energy, its discharge will occur extremely rapidly so that the peak power transferred by the transformer is correspondingly great. Typically, the primary winding 9
35 of the transformer 1 is only a single turn although in

practice it may consist of two or more turns. The secondary winding 20 has a very large number of turns to provide the required step-up voltage. In order to obtain a rapid discharge of the pulse forming network 2 once the switch 7 has become fully conductive, it is important to minimise the inductance of the discharge path. It has proved very difficult to achieve this in a satisfactory manner. In practice, output terminal 3 is connected to a high frequency oscillator such as a magnetron, which generates bursts of oscillations during the time that the high voltage pulses are applied to it.

Referring to Figure 2, there is shown in more detail the pulse transformer which incorporates the saturable reactor as an integral part of it. This figure shows a section view taken through the central axis of the transformer. The low voltage high current discharge path is represented by the opposite conductive faces 10 and 11 of a double-sided printed circuit board 12. This board 12 is held in contact with the housing of the transformer 1. The primary winding of the transformer consists of those portions of the conductive sheets 10 and 11 which are adjacent to the transformer, a solid conductive central boss 13, a stud 24 which connects the sheet 10 to the boss 13, a conductive plate 14, and a plurality of conductive studs 15 arranged on a circle around the central boss 13 which make contact with the plate 14 and the sheet 11. The central portion of the sheet 11 is removed, so as not to contact the boss 13. Alternatively, the studs 15 may be replaced by a cylindrical shell which serves the same electrical function, but this is less satisfactory.

The secondary winding 20 of the transformer consists of very many turns of fine wire wrapped around a transformer core material 21 which is in the form of a circular ring so that the winding 20 is of a conventional toroidal nature. In practice, the core material will be mounted in a manner described in our previous UK patent application 8124320,

as it is of a relatively delicate mechanical nature. The secondary winding 20 is retained in position by embedding it in a non-conductive resin material 16.

The magnetic core of the saturable reactor 8 is
5 constituted by a thin sleeve 17 of a saturable reactor material which closely surrounds the central boss 13. It will be appreciated that it is entirely surrounded by current flowing in the primary winding in the same way that the core material 21 of the transformer is surrounded. It
10 therefore behaves as a saturable reactor in exactly the same way as the conventional series representation shown in Figure 1.

As the transformer handles very large currents, it inevitably dissipates a certain amount of heat and can
15 become fairly hot in operation. In order to transfer the heat rapidly to a suitable heat sink, an internal metal cylinder 18 is provided in contact with the resin material 16, but spaced apart from the sleeve 17. Heat can therefore be extracted via the plate 14 which can be suitably coupled
20 to an external heat sink system.

The location of the saturable reactor material in the form of the sleeve 17 makes it unnecessary to provide an additional winding of the kind usually associated with a saturable reactor. This enables the inductance of the
25 saturable reactor to be kept at an extremely low level, so that the pulse from the pulse forming network is not distorted to any significant extent. The total stray inductance of the transformer and reactor can be altered by changing the profile of the central boss 13. Thus, in
30 Figure 2, an annular recess 22 is formed in its outer surface and this has the effect of increasing the inductance as compared with an unrecessed boss of the same maximum diameter. It is not necessary that the length of the saturable reactor material sleeve 17 is less than the
35 nominal thickness of the transformer housing, as it can

project from one or both side faces thereof, if it is necessary to accommodate a large volume of the reactor material.

Claims

1. A transformer including a primary winding and a secondary winding; and a saturable reactor which is encircled by the secondary winding, and which is arranged
5 to magnetically couple with said primary winding, but does not so couple with the secondary winding.
2. A transformer including a transformer core material shaped to constitute a closed magnetic loop; a toroidal secondary winding wound around said core material so as
10 to magnetically couple therewith; a primary winding part of which comprises a central rigid conductor which is encircled by the core material; a saturable reactor core in the form of a hollow cylinder encircling said central rigid conductor and which is also encircled by said core
15 material whereby the primary winding is operative to couple magnetically with the saturable reactor.
3. A transformer as claimed in claim 2 and wherein the cylinder is in contact with the central conductor.
4. A transformer as claimed in claim 3, and wherein the
20 outer surface of the central conductor is profiled in dependence on the inductance value which the transformer is required to exhibit.
5. A transformer as claimed in claim 2, 3 and 4, and
25 wherein heat conductive means are positioned in proximity to the secondary winding so as to extract the heat therefrom.
6. A transformer as claimed in claim 5 and wherein the heat conductive means comprises a cylinder which is coaxial with said sleeve but is apaced apart therefrom.

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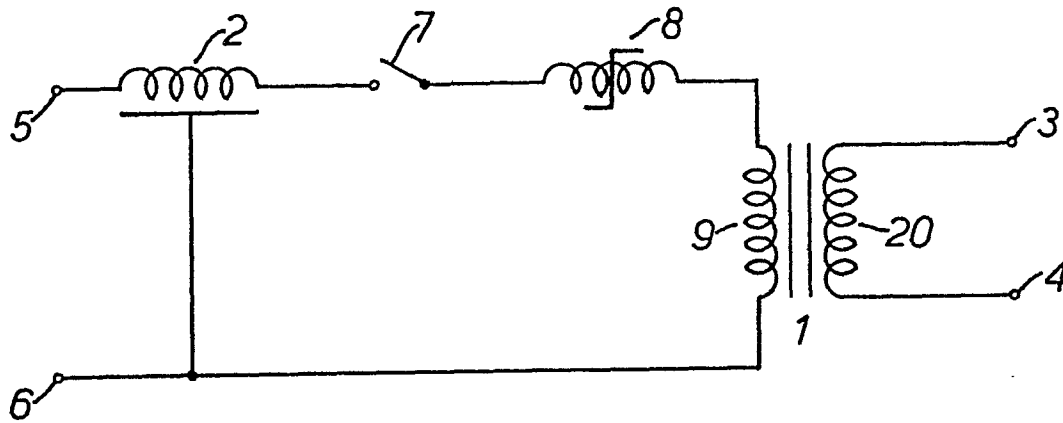


FIG.1.

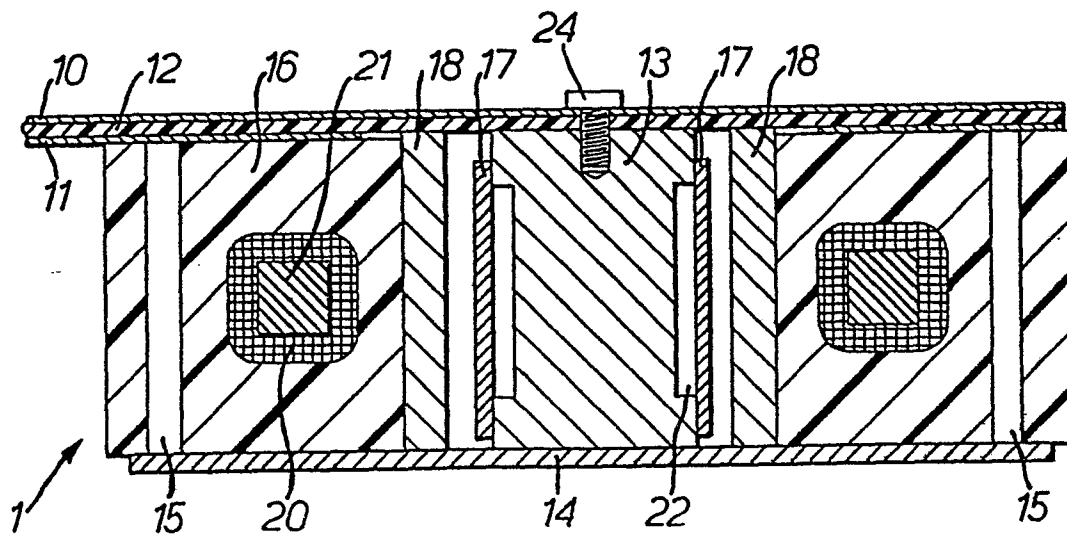


FIG.2.



DOCUMENTS CONSIDERED TO BE RELEVANT			EP 85300483.6
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 4)
Y	EP - A1 - 0 033 441 (HASLER) * Claims 1,2 *	1	H 01 F 19/08 H 01 F 17/06
A	* Page 5, line 13 - page 7, line 16; fig. 1,2 *	2	
Y	DE - B - 2 233 501 (SIEMENS) * Claims 1-3; column 2, line 65 - column 3, line 35; fig. 1 *	1	
A	GB - A - 2 103 885 (DOUGLAS) * Page 1, line 118 - page 2, line 80; fig. 1,2 *	2,4-6	
A	GB - A - 2 004 421 (AOC) * Page 3, lines 42 - 130; fig. 2,3 *	2	TECHNICAL FIELDS SEARCHED (Int. Cl. 4) H 01 F 17/00 H 01 F 19/00
The present search report has been drawn up for all claims			
Place of search VIENNA		Date of completion of the search 03-05-1985	Examiner PIRKER
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			