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(54) **Pulse transformer.**

(57) The invention relates to a pulse transformer for the transformation of low voltage pulses to high voltage pulses with an extremely high step-up ratio. This is achieved by the use of a magnetic core (7) that is connected to the high voltage lead (23) and by a primary winding (8), at least partially surrounding the secondary winding (9), used to clamp the pulse transformer to an electrically conducting plate (18).

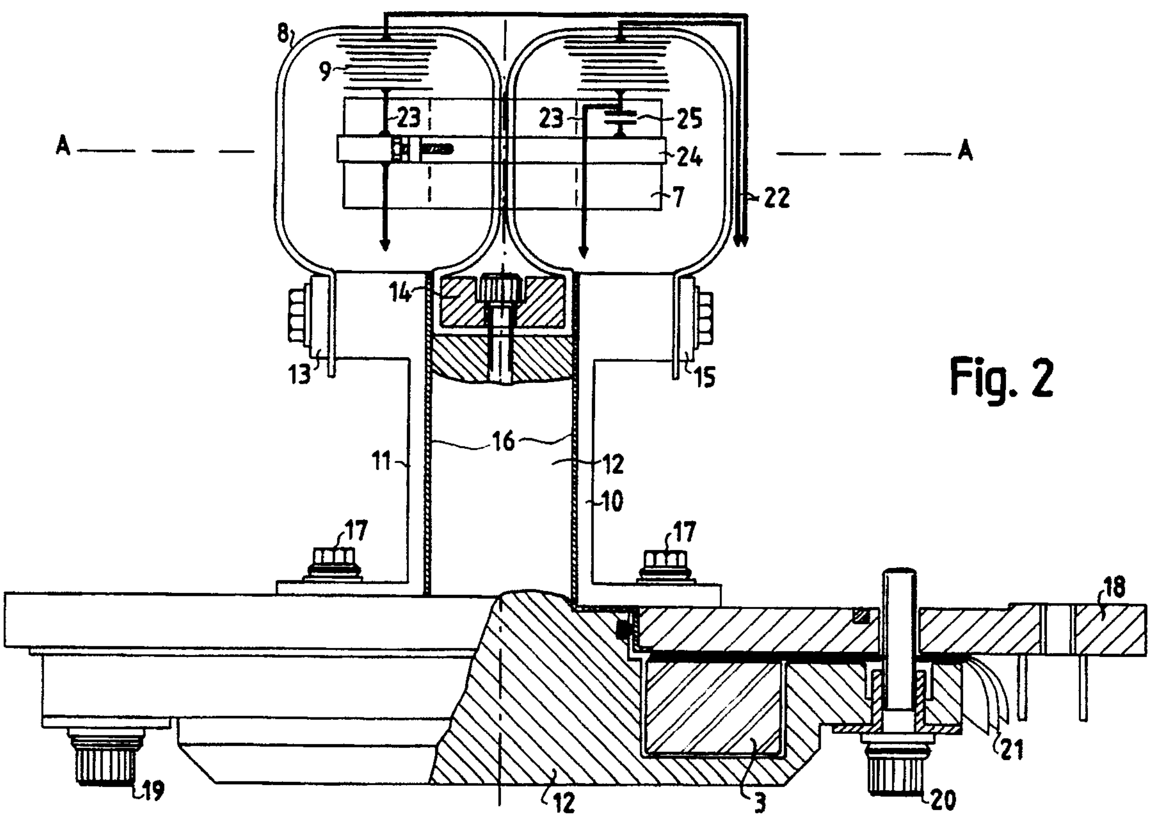

Fig. 2

EP 0 421 514 A1

The invention relates to a pulse transformer for the transformation of low-voltage pulses to high-voltage pulsesl which is equipped with a primary winding suitable for connection to a pulse transformer generating low-voltage pulses, a secondary winding provided with high-voltage terminals, and a transformer core, which is at least partly surrounded by the primary and secondary windings.

This type of pulse transformer can be used in a radar transmitter for the generation of radar transmit pulses. The transformer is then placed between a pulse forming network and a high power tube, such as a magnetron or a klystron. In that application, the transformer is required to transform voltage pulses, generated by the pulse forming network, of e.g. several hundred volts, thousands of amperes and a length in the order of microseconds, to voltage pulses of tens of kilovolts and tens of amperes. The transformed pulses are applied to the klystron or magnetron for the generation of microwave pulses.

These microwave pulses must be generated at a certain repetition rate, the intervals between consecutive pulses being used by a radar receiver to collect echoes of emittted pulses. However, to enable an echo to be received immediately after the emission of a pulse, the pulses need to have steep edges.

Pulses having less steep edges may be caused by what is known as the leakage inductance of the pulse transformer. This occurs if the coupling between the primary and secondary winding of the transformer is less than optimal. Then, the electromagnetic fields generated by the primary and secondary windings are not fully coupled.

Supply leads, too, may contribute to the leakage inductance, as well as the non-conducting spacing which, to achieve the necessary insulation, is present between windings and core.

From GB-A 2.103.426 a version of this type of pulse transformer is known, which is equipped with a toroidal core around which is wound a secondary toroidal winding, the primary winding completely surrounding this secondary winding, from which it is separated by an abundance of insulation material.

A toroidal core with toroidal windings around it will keep the magnetic flux mainly contained within the core. A disadvantage is that much interspace is needed for the insulation between the primary and secondary windings, the insulation space in turn having an adverse effect on the coupling between the windings.

The pulse transformer according to the invention has for its object to provide a transformer exhibiting little leakage inductance by limiting to a large extent the spacing between the windings and between windings and core. To this end the pulse transformer is equipped with connection means between the secondary winding and the transformer core for connecting the high voltage to the transformer core, the secondary winding, for at least part of its width, being surrounded by the entire primary winding.

Since now the voltage on the transformer core closely follows the voltage on the secondary winding, little or no insulation is needed between the secondary winding and the core. This results in a better coupling and less leakage inductance.

In one embodiment of the pulse transformer featuring a primary winding in the form of a foil with conductive material, wound around a secondary winding which is also in the form of a conducting foil, the potential difference between successive layers is small.

Consequently, the required insulation space between the windings is minimal, further reducing the leakage inductance.

A further reduction of the leakage inductance is achieved in an embodiment where the transformer core is clamped, by means of the primary winding, to an electrically conducting support frame which comprises insulated parts, a current supplying part and a current draining part having a contact surface with, respectively, the conducting side of a current supplying lead and a current draining lead of the primary winding. Consequently, the space between the primary and secondary windings can be limited to a minimum and a well-defined electrical connection is obtained.

The invention will be elucidated with reference to the accompanying drawings, of which:

Fig. 1 shows a partial circuit diagram of a radar transmitter with pulse transformer;

Fig. 2 shows a schematic embodiment of a pulse transformer with support; and

Fig. 3 shows a schematic side view of the windings and core of the pulse transformer of Fig. 2 in the direction of the line A-A.

The pulse transformer according to the invention can be used in a radar transmit chain as depicted schematically in Fig. 1. A pulse generator 2, connected to power supply 1, generates pulses with a length and at a repetition rate which are suitable for radar. To this end, the pulse generator 2 comprises known pulse forming means, such as networks incorporating delay lines, and switching means using, e.g. thyristors. The generated pulses are applied in the usual way via a fast saturable coil 3 to the pulse transformer 4. The coil 3 blocks the pulses until the switching means in the pulse generator 2 have become fully conductive, to prevent power loss across the switching means.

The pulses applied to the pulse transformer 4 have characteristic pulse lengths of about 1 µs, characteristic peak voltages of about 400 v and characteristic peak currents of about 8000 A. The pulse transformer 4 transforms these low-voltage pulses to high-voltage pulses with characteristic peak voltages of 80 kV and peak currents of 40 A. The achieved transformation ratio is thus 1 : 200 in this case, which is considerably higher than customary for pulse transformers. The high-voltage pulses are subsequently applied to a radar transmitter 5, provided with a high power tube, such as a magnetron or klystron, which on the basis of the applied pulses generates microwave pulses with corresponding pulse lengths. Finally, the microwave pulses are emitted by an antenna 6.

An embodiment of the pulse transformer according to the invention, illustrated in Fig. 2, comprises a transformer core 7, primary windings 8 and secondary windings 9. The transformer core 7, for which conventional material is used, is built up from two tightly joined U-shaped parts forming a magnetic circuit, on two facing parts of which the windings 8 and 9 have been mounted. The core may also be E-shaped, however, with a primary and secondary winding wound around all three core legs, or U-shaped with a primary and secondary winding on only one leg. The principal point is that primary winding 8 should enclose the secondary winding as tightly as possible, to achieve a proper couping.

To this end the primary winding 8, which in this case is in the form of a foil, is clamped through connections 13, 14, 15 to a support frame consisting of three parts 10, 11 and 12. The parts 10, 11 and 12 of the support frame are made from electrically conducting material, the part 12 being electrically insulated from the parts 10 and 11 by an insulating layer 16. Part 12 makes electrical contact with a part of the electrically conducting side of the primary winding 8, which part is clamped by the connection 14. The side of the primary winding 8 adjoining the transformer core 7 is not provided with an insulating layer.

The parts 10 and 11 make electrical contact with the leads of the primary winding 8 which are clamped by the connections 13 and 15. The parts 10 and 11 are subsequently connected electrically, through connections 17, to a conducting plate 18. The part 12 protrudes through an opening of the plate 18, and is clamped on the opposite side of it through connections 19 and 20. Between the part 12 and the plate 18 a foil 21 is inserted, with two conductive sides which are separated by an insulation layer. The foil 21 is connected to the pulse generator 2 via the saturable coil 3. The primary current path then runs via the side of the foil 21 which makes contact with the part 12, the part 12 proper, the primary winding 8, the parts 10 and 11, the plate 18 and the side of the foil 21 which makes contact with plate 18. Between the plate 18 and part 12 there is further the coil 3.

The primary winding 8 is preferably a foil with on one side a conducting layer. The advantage is that the potential differences between the layers remain limited to, in this case, 400 V per layer. Consequently little space is needed for inter-layer insulation and the arrangement can be quite compact, which has a favourable effect on the leakage inductance and the coupling. The parts of the secondary winding 9 which are nearest to the primary winding 8 and those which are nearest to the transformer core 7 are provided with low-voltage leads 22 and high-voltage leads 23, respectively, such that they are externally connectable. The high-voltage leads 23 are electrically linked to the transformer core 7 through a core-surrounding clamping ring 24. The secondary winding 9 is wound on a coil former (not shown in the figure), which freely surrounds the transformer core 7. One of the high-voltage leads 23 is connected to the core 7 by way of an AC coupling in the form of capacitor 25, which forms a low impedance to the generated pulses but, conversely, a high one to a low-frequency AC voltage, applied in the customary manner across the secondary winding 9, to power the filament of a high power tube, when connected.

It should be noted that there are different ways in which the core 7 can be electrically linked with the secondary winding. In an alternative embodiment, for instance, part of the secondary winding 9 is wound directly on the core 7, no coil former being used in this case.

In yet another embodiment, the secondary winding 9 may take the form of a wire winding, but then more space will be needed for insulation.

Fig. 3 is a side view of the pulse transformer according to the line A-A in Fig. 2. The low-voltage leads 22 are kept as far as possible removed from the transformer core 7. The ratio between the width of the primary winding 8 and the width of the secondary winding 9 determines the transformer characteristics to a considerable extent. Preferably, the secondary winding 9 is made wider than the primary winding 8.

Claims

1. Pulse transformer for the transformation of low-voltage pulses to high-voltage pulses, which transformer is provided with a primary winding suitable for connection to a pulse generator generating low-voltage pulses, a secondary winding provided with high-voltage terminals, a transformer core which is at least partly surrounded by the primary and secondary windings, and connection means between the secondary winding and the transformer core for connecting the high voltage to the transformer

core, the secondary winding, for at least part of its width, being surrounded by the entire primary winding.

2. Pulse transformer according to claim 1, wherein said connection means is provided with a flexible conductor between the transformer core and a high-voltage terminal.

3. Pulse transformer according to claim 1, wherein said connection means comprise part of the secondary winding which is in contact with the transformer core.

4. Pulse transformer according to one of the claims 1 to 3, wherein the primary winding takes the form of a conducting foil, wound around a secondary winding, also in the form of a conducting foil.

5. Pulse transformer according to one of the foregoing claims, wherein said transformer core comprises two butt-jointed U-shaped core parts, and two facing core pieces of the transformer core are each surrounded by a primary and a secondary winding, the primary and secondary winding, respectively, of one core piece being connected to the primary and secondary winding, respectively, of the other core piece.

6. Pulse transformer according to claim 4 or 5, wherein the transformer core is clamped, by means of the primary winding, to an electrically conducting support frame which comprises insulated parts, a current supplying part and a current draining part having a contact surface with, respectively, the conducting side of a current supplying lead and a current draining lead of the primary winding.

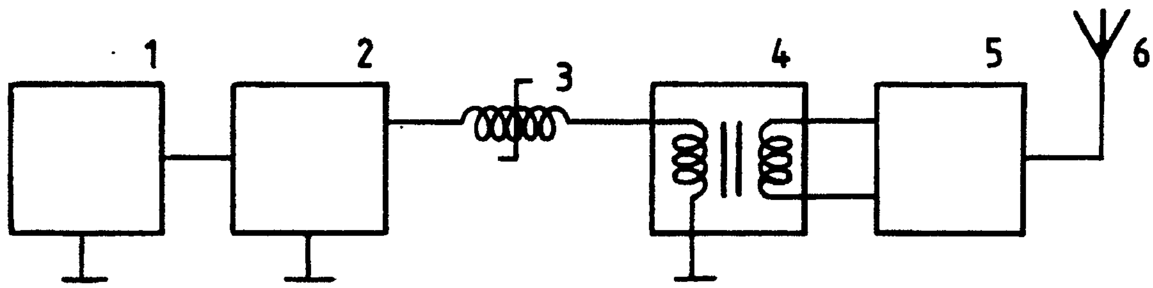

Fig. 1

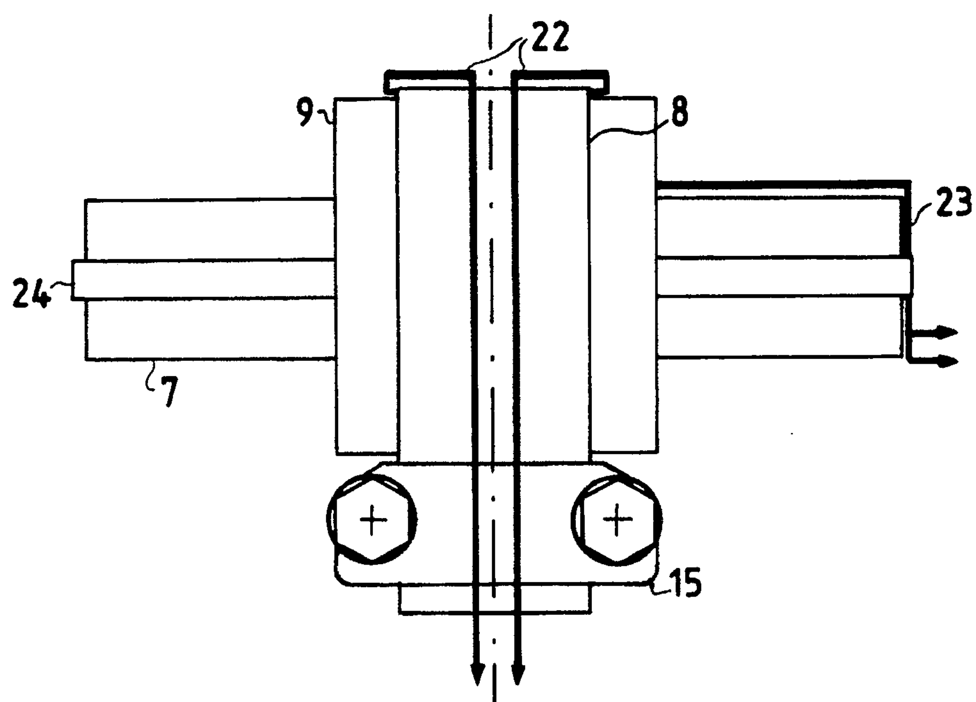

Fig. 3

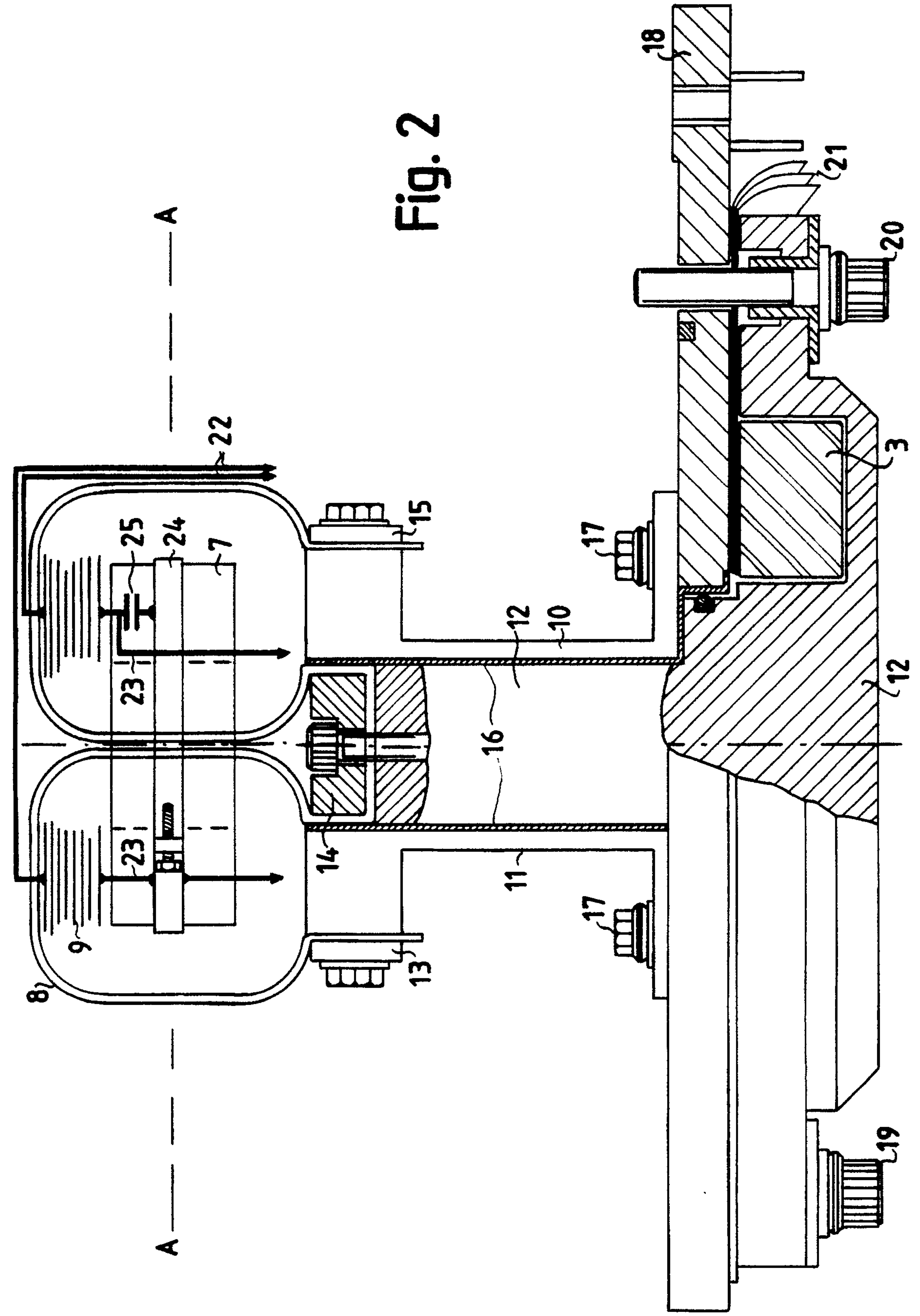

Fig. 2

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EUROPEAN SEARCH REPORT

Application Number

EP 90 20 2532

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	GB-A-7 669 46 (PHILIPS ELECTRICAL INDUSTRIES LIMITED) * page 2, lines 1 - 40 * - - -	1-3	H 01 F 27/36 H 01 F 19/08
A	US-A-3 617 854 (RAYTHEON COMPANY) * column 4, lines 30 - 47 * - - -	4	
A	US-A-2 998 583 (W.G.WORCESTER) * column 5, line 48 - column 6, line 30 * - - -	4,5	
D,A	EP-A-0 072 151 (THE MARCONI COMPANY LIMITED) * page 6, line 37 - page 7, line 20 * - - -	6	
A	DE-A-3 534 006 (SIEMENS AKTIENGESELLSCHAFT) - - -		
A	NL-A-7 405 428 (BENTELER-WERKE AKTIENGESELL-SCHAFT WERK NEUHAUS) - - -		
A	GB-A-2 044 74 (VEIFA-WERKE AKTIENGESELLSCHAFT) - - - - -		

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

H 01 F

The present search report has been drawn up for all claims

Place of search	Date of completion of search	Examiner
The Hague	02 January 91	VANHULLE R.

CATEGORY OF CITED DOCUMENTS

X: particularly relevant if taken alone
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