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(54) **Switch mode transformer.**

(57) Switch mode transformer with primary winding (3) and secondary winding (4) consisting of at least one coil (8) formed by relevant metal bands which are wound, superimposed on insulating film, about a magnetic core (7). The core consists of one open, single-piece magnetic element including a first leg (9), about which is arranged said coil (8), and at least a second leg (10) connected to the first leg through a crosspiece (11) of said core which is substantially adjacent to an end face of the coil. The free ends of the legs (9, 10) are separated from one another by an air gap (12) extending at the side of the coil which is opposite to said end face of the coil.

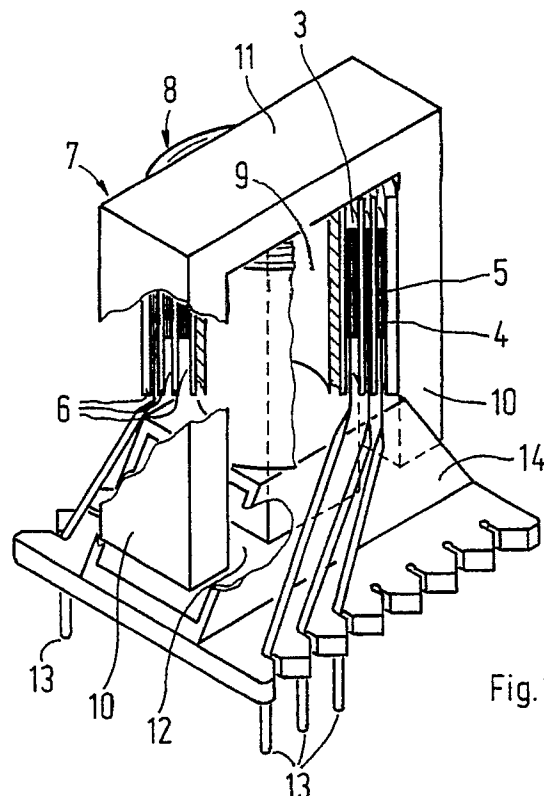


Fig.1

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SWITCH MODE TRANSFORMER

The present invention relates to a so-called SMT transformer (Switch Mode Transformer), to be used in electronic switch-mode power supply circuits for picture tubes, for instance, or the like.

Preferably, SMT transformers are arranged substantially as disclosed in US-A-3 617 854, i.e. with at least a primary winding and at least a secondary winding consisting of a coil of relevant metal bands which are wound with the interposition of an insulating film. The coil including the windings is then fitted about a leg of a ferrite core.

In contrast with the transformers which are used to handle driving signals, the core of a SMT transformer is a substantially closed core. In fact, even though such a core is sometimes incorrectly referred to as an "open" core in order to distinguish it over the complex cores including an inner core portion and an outer core cap surrounding the transformer, it actually consists of two identical E-shaped or U-shaped portions which are specularly fitted together to form a substantially closed magnetic circuit. The coil including the windings is arranged about one of the legs of the core which are defined by aligned pairs of legs of the E-shaped or U-shaped portions. Furthermore, in order to limit the undesired phenomenon of saturation, the leg of the core which is surrounded by the windings is provided with a central air gap, which however must have a short length. As it is known, in fact, during operation magnetic losses in the material of the core occur mainly in correspondence of such a gap, said losses causing eddy currents to flow in the core with the result of the whole transformer being undesirably heated up. In order to keep the consequences of such heating at a minimum, it is necessary to size the various parts of the transformer in a critical way, particularly taking care of the thermal insulation.

At any rate, the core consists of two specular portions which require particular working steps to be at first manufactured as separate parts and then assembled together with the windings, with the result of a relatively complicated and expensive manufacture of the whole transformer.

It is the main object of this invention to provide a SMT transformer which, while it has the same performances, has a particularly simple and compact construction and may be readily assembled.

Another object of this invention is to provide a SMT transformer of the kind mentioned above in which undesired heating phenomena caused by magnetic losses are kept at a minimum.

These objects are attained, according to the present invention, in a SMT transformer embodying the features recited in the appended claims.

The characteristics and advantages of the invention will be more clearly understood from the following description, given by way of non-limiting example, with reference to the attached drawings, in which:

Fig. 1 shows a cut-away perspective view of a preferred embodiment of the transformer according to the invention; and

Fig. 2 shows a side view of the core of the transformer as in Fig. 1, in which the magnetic flux lines during operation of the transformer are diagrammatically illustrated.

With reference in particular to Fig. 1, the SMT transformer according to the invention comprises at least a primary winding 3 and at least a secondary winding 4 formed by relevant metal bands 5 (made of aluminium, for instance) superimposed on insulating film 6. Substantially as described in the above-mentioned US-A-3 617 854, metal bands 5 and insulating film 6 are arranged (preferably concentrically) about a portion of a magnetic core 7, for example made of ferrite, so that the primary and secondary windings form a coil 8 in which the core is inserted.

According to an aspect of the invention, and in contrast with the SMT transformers already known, the core 7 only consists of one open, single-piece magnetic element provided with a first leg 9 about which is arranged the coil 8, as well as with at least a second leg 10 which is connected to the first leg through a crosspiece 11 of the core itself, so that the core has a substantially U-shaped configuration. In the example herein described, however, the magnetic core 7 preferably includes two of the said second legs, both illustrated at 10 and provided at opposite sides of the first leg 9, so that the core 7 has a substantially E-shaped configuration. In any case, with respect to the magnetic field produced during operation by the windings 3 and 4, the free ends of each leg 10 are separated from the free end of the leg 9 by relevant air gaps 12.

As it will be more apparent hereinafter, an end face of the coil 8 is preferably disposed adjacent to the crosspiece 11 of the core 7, while the gap, or gaps 12 extend substantially at the side of the coil which is opposite to said end face.

In a per se conventional manner, the transformer also comprises a plurality of electric contact pins 13 and a shaped support frame 14 which is preferably located at the side of the coil 8 opposite to the crosspiece 11 of the magnetic core 7. The various elements may be mounted in place in the most convenient way, as the case may be.

The constructive simplicity of the SMT transformer according to this invention is apparent: the

transformer comprises only one single-piece magnetic core 7 which may have an elementary configuration and thus may be readily and quickly assembled together with the windings 3 and 4, and further requires less material to be used and also does not involve any critical step for assembling the various elements, as it would be the case of specular magnetic elements to be coupled by glueing them together with special materials.

Anyway, it will be apparent to those skilled in the art that the switch mode transformer according to the present invention is arranged in contrast with the technical prejudice that the length of the gap provided in the magnetic core must be as short as possible. It is known, in fact, that in the conventional SMT transformers the inductance values of the windings depend not only on the characteristics of the material of which the magnetic core is made, but also on the dimensions of the gap provided in the leg of the core which bears the coil formed by the windings. In particular, such inductance values are inversely proportional to the length of the gap.

Contrary to the above-mentioned technical prejudice, according to the present invention the magnetic core 7 actually is an open core, the gaps 12 having a remarkable length and the leakage flux being particularly high in correspondence of the free ends of the legs 9 and 10.

It was experimentally found, however, that the SMT transformer according to this invention can provide, under the same general dimensional conditions, performances which are at least as good as those provided by a conventional SMT transformer.

Although the phenomenon not yet is known in detail to the applicant, it was in fact experimentally found that the flux lines 15 of the magnetic field generated by the windings 3 and 4 extend substantially as illustrated in Fig. 2, with a plurality of closed paths, extending between each couple of legs 9 and 10, which are curvilinear, mutually offset and enclosed into one another. Thus, a plurality of elementary magnetic circuits are established in parallel between each couple of legs 9 and 10 of the open core 7.

More particularly, the density of the flux lines 15 has a maximum value at the base of the leg 9 (connected with the crosspiece 11) and decreases along the leg 9 to reach a minimum value in correspondence of the gaps 12.

Hence, the magnetic flux leakages occurring in correspondence of the gaps 12 have an effect which is limited thanks to the low density of the magnetic flux itself; as a consequence, as it was experimentally found, in the SMT transformer according to the invention the core heating phenomenon caused by induced currents is advantageously reduced; in practice, it is perceptible only in correspondence of the base of the leg 9 of the core

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In addition, since the windings 3 and 4 are formed using relevant metal bands - and have, therefore, an even turn-to turn coupling - each turn of the windings is subject to the whole density variation of the magnetic flux lines which are linked therewith, said density decreasing, as already stated, from the base to the free end of the leg 9.

In other words, this means that, whereas the specific inductance $A1$ is constant in a conventional transformer, in the SMT transformer according to the invention it changes along the leg 9 of the magnetic core 7; in particular, the specific inductance $A1$ decreases from the base to the free end of the leg 9 bearing the coil 8 formed by the windings. Therefore, bearing in mind that the inductance L of the windings of the transformer is given by the known formula: $L = N \times N \times A1$, wherein N is the number of turns of the windings, also the inductance L of the windings 3 and 4 of the SMT transformer according to the invention decreases, along the axis of the coil 8, from the crosspiece 11 of the core 7 to the free end of the leg 9.

In conclusion, in the SMT transformer according to the invention the inductance of the windings is in practice independent of the dimensions of the gap, or gaps 12, which are preferably spaced apart from the coil 8, anyway; on the contrary, the inductance depends on the height H of the wound metal bands and on the axial position of the coil 8 with respect to the leg 9 of the magnetic core. More particularly, the shorter the height H of the relevant metal bands and the closer the coil 8 to the base of the leg 9, the higher is the value of the inductance L of the windings 3 and 4. Indeed, it is a particularly surprising effect, which however was found experimentally, as already stated.

The consequent advantages are apparent; with the present invention, in particular, it is possible to provide a SMT transformer the windings 3 and/or 4 of which have an optimum inductance value while they are formed with metal bands having a reduced height and wound with a relatively low number of turns.

As a result, the SMT transformer according to the invention can be made with a remarkably compact construction, using a reduced amount of material for manufacturing the magnetic core 7 and the windings 3 and 4.

Of course, the SMT transformer described above may undergo many modifications without departing from the scope of the invention. For example, according to the desired dimensional and operational characteristics, the axial position of the coil 8 with respect to the support leg 9 of the magnetic core may be changed, or the leg 9 and/or 10 of the magnetic core may be differently shaped,

for instance with a different cross-section and/or inclination. Moreover, the various primary and secondary windings may be mutually offset axially, in a way known per se, as the case may be.

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Claims

1. Switch mode transformer comprising a primary winding and a secondary winding consisting of at least one coil formed by relevant metal bands which are wound, superimposed on insulating film, about a magnetic core, characterized in that said core (7) consists of one open, single-piece magnetic element including a first leg (9), about which is arranged said coil (8), and at least a second leg (10) connected to the first leg through a crosspiece (11) of said core which is substantially adjacent to an end face of the coil (8), the free ends of said legs (9, 10) being separated from one another by an air gap (12) extending substantially at the side of the coil which is opposite to said end face.
2. Switch mode transformer according to claim 1, characterized in that said air gap (12) is substantially spaced apart from said coil (8).

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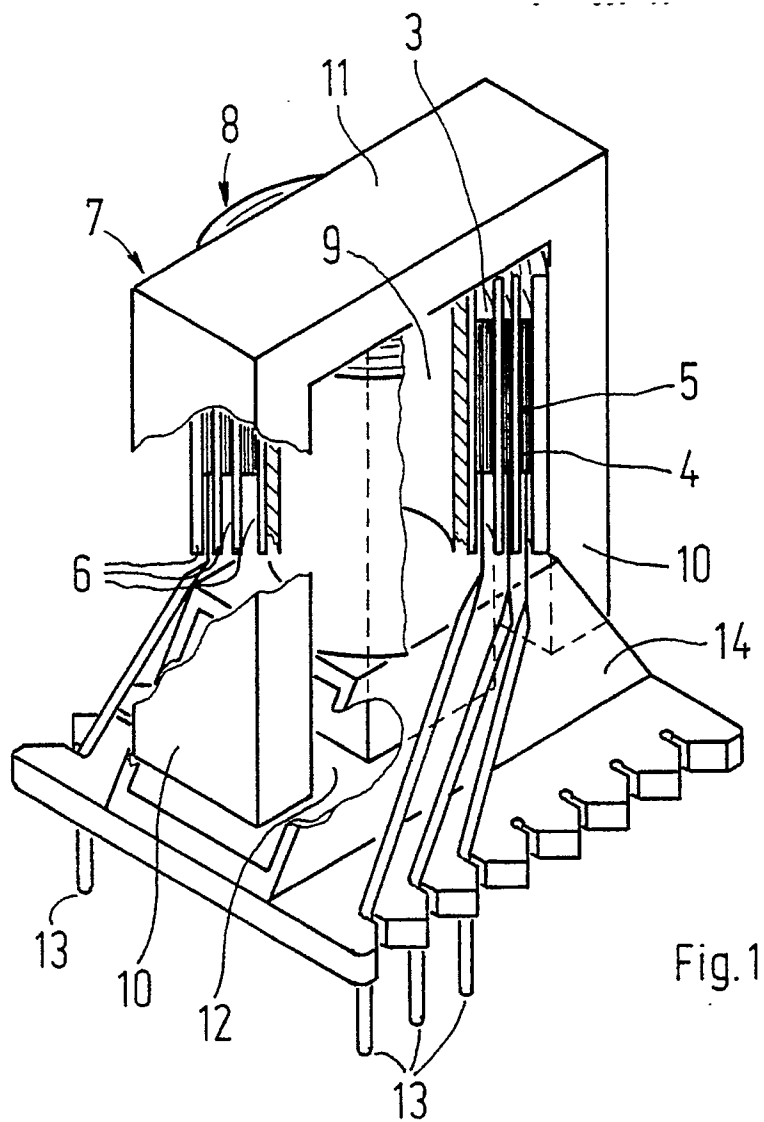


Fig.1

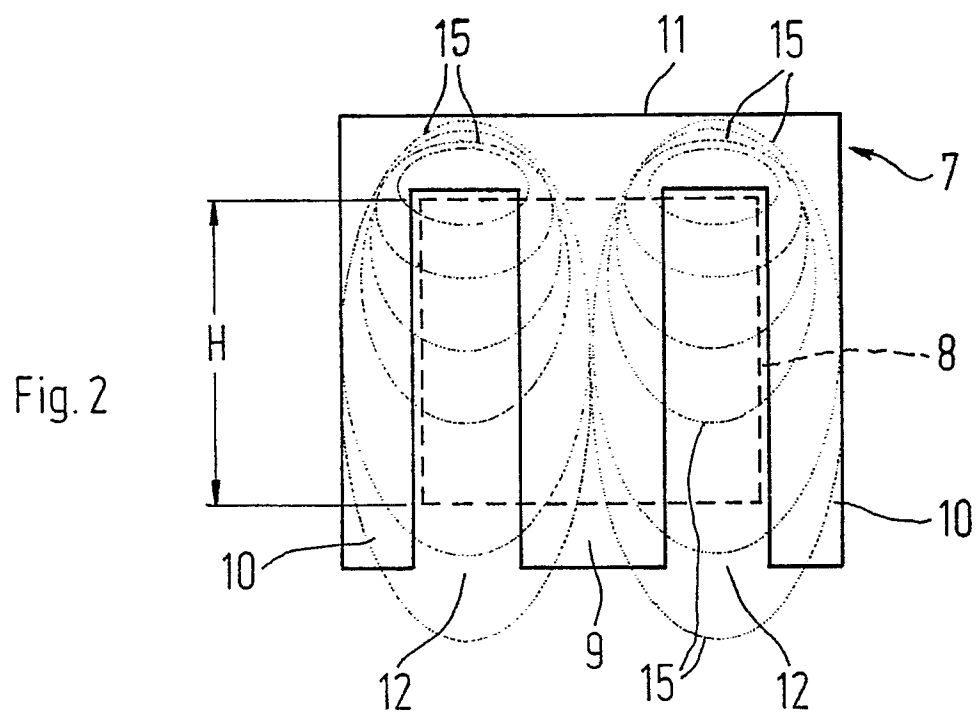


Fig. 2



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EUROPEAN SEARCH REPORT

Application Number

EP 90 11 7496

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)
Y	PATENT ABSTRACTS OF JAPAN vol. 9, no. 318 (E-366)(2041) 13 December 1985, & JP-A-60 150606 (FUJITSU K.K.) 08 August 1985, * the whole document *	1,2	H 01 F 19/08
Y	EP-A-0 126 365 (ZAMBELLI) * the whole document *	1,2	
A	US-A-1 634 923 (THULLEN) * the whole document *	1,2	
D,A	US-A-3 617 854 (COLE)		
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			H 01 F H 04 N
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of search 21 November 90	Examiner BIJN E.A.
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