

Feb. 13, 1940.

HANS-GÜNTHER FREYGANG

2,190,448

BROAD-BAND TRANSFORMER FOR PUSH-PULL CIRCUITS

Filed Aug. 10, 1938

Fig. 1

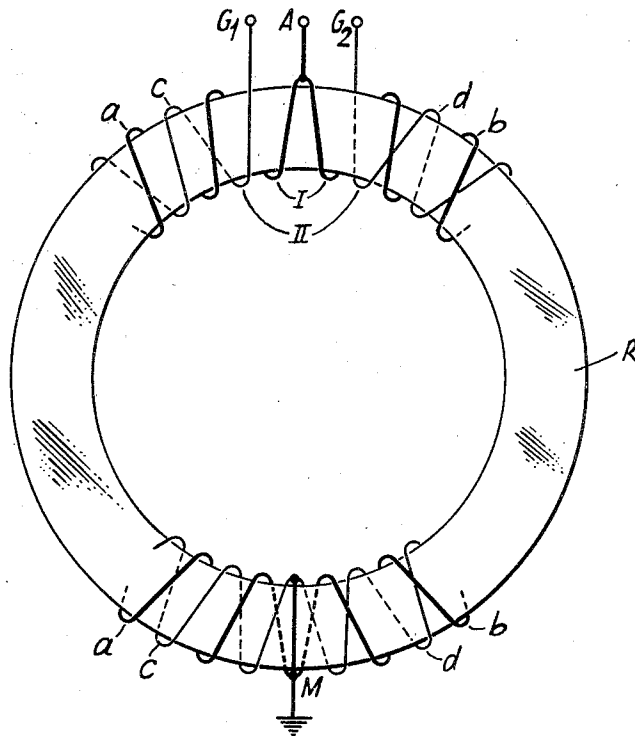
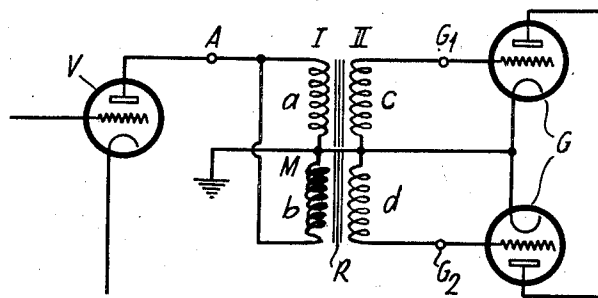


Fig. 2



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2,190,448

BROAD-BAND TRANSFORMER FOR PUSH-PULL CIRCUITS

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pany, a corporation of New York

Application August 10, 1938, Serial No. 224,203
In Germany May 11, 1937

5 Claims. (Cl. 178-44)

For radio frequency (RF) transformers designed for coupling a circuit which is symmetric in reference to a definite and fixed potential (ground) with a non-symmetric circuit, for instance, for coupling a push-pull amplifier stage with a plain amplifier input stage, a circuit organization has been suggested in the prior art in which such capacitive dissymmetries as are always present in the conventional design of transformers, and which naturally impair and prevent satisfactory operation, are avoided. This is insured by halving the two windings of the transformer thus resulting in two winding halves each, the half-windings of the symmetric circuit, as well known in the art, being wrapped in the same sense, whereas the half-windings of the unsymmetric circuit are connected in parallel relationship and wrapped in the opposite sense upon the core.

By the adoption of such a scheme it is possible to diminish the disturbing dissymmetries inherent in winding capacitances down to a residual fraction of dissymmetry which is due to routine manufacture and falls inside the tolerance limits. This residual portion of dissymmetry will become so much less apparent the lower the capacities inherently are. However, out of the usual aim and tendency to minimize inter-winding capacitance, there results this drawback in the conventional arrangements that the stray or leakage inductance between the windings becomes unduly high. The result is that invariably only a comparatively narrow frequency band can be transmitted.

Now, the invention is predicated upon the problem to create a transformer of the above kind for broad frequency bands, say, extending from 0.5 to 5 mc. of the kind particularly required for the coupling of push-pull broad-band amplifiers being symmetric to ground with an input stage which presents dissymmetry to ground.

Now, the present invention is predicated upon a proper appreciation of the fact that the chief desideratum in such a transformer is not so much to keep the capacities absolutely within small limits rather than to make them symmetrical. Hence, it is quite readily possible to raise the capacitances in favor of the stray, for, as already known, reduction of the stray is associated with a raise of the inter-winding capacitance. A limitation will be imposed only where the fall of potential across the stray inductance becomes equal to the fall of potential due to the capacitance.

Predicated upon this fact, the problem of the

invention is solved by using an annular form for the transformer core for the reduction of the stray, said core consisting of magnetic material of high permeability, upon the circumference of which for further reduction of the stray the primary and the secondary windings are uniformly wrapped.

Now, the invention shall be described in more detail by reference to the appended drawing.

Fig. 1 shows an exemplified embodiment of the transformer of the invention interposed between a push-pull amplifier stage presenting symmetry to ground and the input stage being inherently dissymmetric to ground. Fig. 2 shows the circuit organization of this transformer. In both figures the corresponding windings and terminals are legended by similar reference numerals and letters.

R denotes the annular core which, with a view to minimizing the eddy-currents consists of an extremely thin metal band of Nic alloy or some other high-permeability magnetic material, the different layers of the said metal tape being insulated from one another by an interposed sheet of paper. The primary winding I (shown heavy in Fig. 1), just as in the secondary winding II, are uniformly distributed over the annular circumference. The primary winding, on the one hand, is connected at point A with the plate of the input stage V, and, on the other hand, at point M which is placed diametrically opposite point A upon the annular core, it is connected with earth. The primary winding consists, as will thus be seen, of two half-windings *a* and *b* connected in parallel between the terminals A and M. However, these two half-windings are wrapped in opposite directions upon the annular core rather than in the same sense, with the result that the magnetic fluxes induced thereby in the annular core will become added and that the full inductive effect of the primary winding upon the secondary winding will be produced. The secondary winding (shown by thin lines in the drawing) which is wrapped throughout in the same direction upon the annular core consists of two half-windings *c* and *d* of like number of turns which, on the one hand, are united at the terminals G1 and G2 being directly adjacent the terminal A, with the grids of the push-pull broad-band amplifier stage G, and, on the other hand, are jointly grounded at M.

As can be readily seen from the drawing, in a construction and arrangement of a transformer as hereinbefore disclosed, both the potential of the grids G1 and G2 as well as that of the plate

A are symmetric to ground for alternating current. The use of an annular core as disclosed in the invention, and the uniform distribution of both windings thereon, as has to be noted, offers the following practical merits: In the first place, even where ultra-high frequencies are dealt with, the stray or leakage is cut down to an order of magnitude of around 1 percent; in the second place, the capacitance between the half-windings *a* and *c* is equal to that between *b* and *d*, so that the capacitive load of the ground-symmetric circuit due to the inter-turn capacitance of the transformer becomes symmetric to ground and thus harmless.

15 In the light of actual tests made on a transformer as here disclosed it has been found that compared with an air-cored transformer the capacitance is raised approximately two or three times, while the stray is cut down at a ratio of, say 1:50. Hence, it is possible only with a transformer designed as here disclosed that push-pull stages of broad-band amplifiers up to the highest frequencies can be worked satisfactorily.

What I claim is:

25 1. A wide-band transformer for coupling an unbalanced transmission line to one that is balanced, comprising a closed core member, a two-part primary winding electrically connected in parallel and wound around said core in opposite directions, one of the common terminals of said windings adapted to be connected to the unbalanced line and the other common terminal adapted to be connected to ground, a two-part secondary winding electrically connected in series and wound around said core in the same direction and between the turns of the primary windings, the common terminal of said secondary windings being grounded, and the other terminals of the latter windings being adapted to be connected to the balanced transmission line.

2. A wide-band transformer as defined in claim 1 wherein the core member is in the form of an annulus, made up of laminations, and consists of high permeability magnetic material.

3. A wide-band transformer as defined in claim 1 wherein the core member is in the form of an annulus and the terminals of the two part primary winding are disposed at diametrically opposite sides of the annular core member.

4. A wide-band transformer as defined in claim 1 wherein the core member is in the form of an annulus and the terminals of the two part primary winding are disposed at diametrically opposite sides of the annular core member, and the common grounded terminals of the secondary winding are disposed on the same side of the annular core member as the grounded terminals of the primary windings, said grounded terminals being connected together.

5. In a system for coupling a single ended circuit with a double ended circuit, comprising a transformer adapted to pass a substantially wide frequency band and having an annular core member, a pair of primary windings and a pair of secondary windings wound around said core member, one pair of said windings being wound in opposite directions and connected in parallel in said single ended circuit and the other pair of windings being wound in the same direction and connected in balanced relation in said double ended circuit, the points of zero alternating potential on both pairs of windings being electrically connected to each other and disposed on one side of the core member, and the points of high alternating potential on both pairs of windings being disposed in close proximity to each other and at the diametrically opposite side of the core member.

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CERTIFICATE OF CORRECTION.

Patent No. 2,190,448.

February 13, 1940.

HANS-GÜNTHER FREYGANG.

It is hereby certified that error appears in the above numbered patent requiring correction as follows: In the heading to the printed specification, line 8 thereof, foreign filing date, for "In Germany May 11, 1937" read --In Germany November 5, 1937--; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 10th day of December, A. D. 1940.

(Seal)

Henry Van Arsdale,
Acting Commissioner of Patents.

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