Ratio : 1/3·5.
Inductance : 70/110 Henries.
Dimensions : $2\frac{1}{4}" \times 3" \times 3\frac{3}{4}"$
Weight : 1 lb. 14 ozs.
CODEWORD—AFTEE.

The FERRANTI AUDIO FREQUENCY TRANSFORMER

TYPE AF3

The FERRANTI Transformer type AF3, first made available more than 6 years ago, set a standard of uniform audio frequency amplification that has since been surpassed only by the AF5, and one other higher priced component. It was designed to provide uniform amplification throughout the musical scale, and the curve below indicates the success attained under normal operating conditions

Price 25/- Nett (in Great Britain only)

Price in Irish Free State, 29/6.

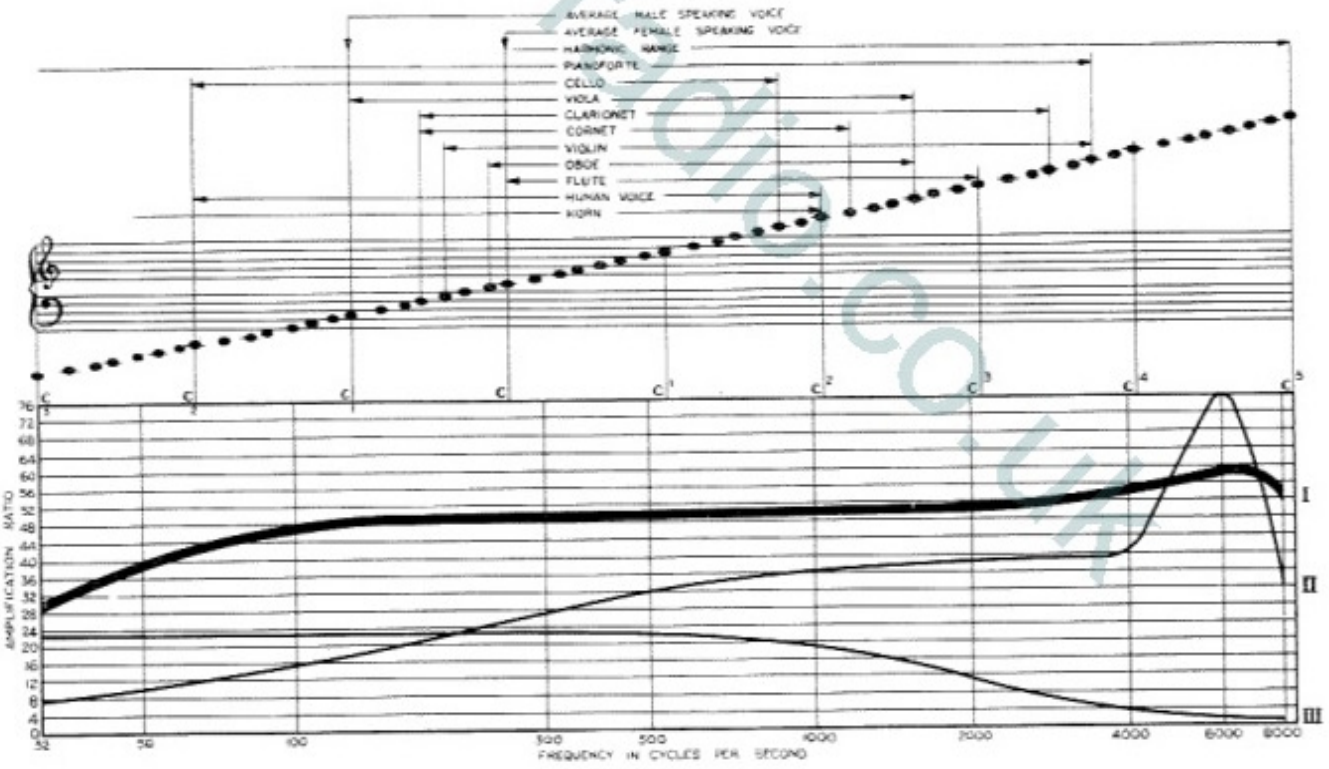


Fig. 1. D. 1037.

The above curves are obtained when using the respective components under their normal working conditions, each being followed by a power valve with a non-inductive load in the anode circuit. The following are the conditions relating to each curve :—

Curve 1.—The FERRANTI AF3 Transformer following a 10,000 ohm valve having an amplification factor of 14. H.T. 100 volts. Milliamps 3·5. Grid Bias 1·5 volts Filament 4 volts.

Curve 2.—A modern Cheap Transformer used under similar conditions.

Curve 3.—Resistance Capacity using high amplification couplings.

AMPLIFICATION AND WHAT IT MEANS.

Sound is caused by rapid vibration of air particles. The pitch of a note is fixed by the frequency, i.e., the number of vibrations per second. Instrumental notes have pitch frequencies from 25 to 3,500, but actually no note is a simple vibration of one frequency, but a combination of vibrations at frequencies which have a simple relation to one another. The lowest, called the "fundamental," gives the pitch, while the others, called "harmonics," give tone or quality, and cause the sound of one instrument to differ from that of another though producing a note of the same pitch. The frequency of the harmonics may be as high as 10,000 per second, and thus musical vibrations have a frequency range from 25 to 10,000.

Above the curve on page one is shown a musical scale corresponding to rates of vibration from 32 cycles to 8,000 cycles per second.

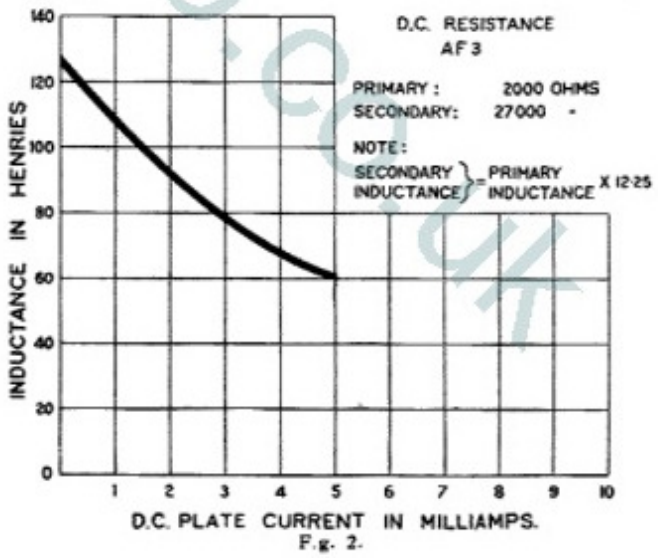
A perfect amplifier would amplify equally over the entire range.

The curve shows the amplification provided by the FERRANTI AF3 Transformer when used following a valve having a working impedance of approximately 10,000 ohms. It will be seen that the amplification is remarkably even between 100 and 8,000 cycles, the slightly rising characteristic at the higher frequencies being an advantage tending to compensate for the loss of these frequencies due to tuning, interwiring, and other stray capacities in Receivers.

At a frequency as low as 50 cycles (more than two octaves below middle C) the cut-off is only 20%, a figure better than that given by any other Transformer available at the same price.

INDUCTANCES.

A good Transformer must have a high primary inductance, this being the most important requirement. Inductance varies with signal strength and anode current. The curve, Fig. 2, shows the inductance of the AF3 under normal conditions of signal strength with various anode currents. It should be observed that the inductance of Transformers using special iron cores, such as Permalloy, falls off much more rapidly with increased anode current, and in many cases cores made of such special materials become permanently highly magnetised, thereby rendering the Transformer inefficient and the Reproduction poor.



F.g. 2.

IMPEDANCES.

Impedance depends on inductance, frequency and other factors, high primary impedance at all audio frequencies being necessary for uniform amplification. The AF3 Transformer with 2·5 milliamps flowing through its primary windings has the following primary impedances :—

At 50 cycles ... 25,000 ohms.
At 100 cycles ... 50,000 ohms.
At 500 cycles ... 410,000 ohms.

With lower milliamps the impedances are greater.

The valve preceding the AF3 with suitable H.T. and grid bias should not take more than 5 milliamps. Larger anode currents will not damage the Transformer but will so reduce its inductance that the value of the large amount of expensive material put into the Transformer is lost.

It should be noted that in a properly designed Amplifier it is unnecessary to employ a valve taking more than 5 milliamps before any Audio Frequency Transformer.

A ·0003 mfd bye-pass condenser is incorporated in the AF3 Transformer across the primary. Without such a condenser proper rectification cannot take place and a condenser is included to ensure that the correct capacity shall be used. It is important to note that the Transformer gives its characteristic curve under normal working conditions with this condenser in position and so avoids the cut-off in the L.F. Amplifier that occurs with all other forms of coupling when a bye-pass condenser of adequate capacity which has to be employed is used. This condenser does not affect the satisfactory functioning of the Transformer in any well-designed circuit

The curve at the bass end may be made flat by feeding the Transformer through a resistance and blocking condenser, but the complication and cost of this is usually not worth while, as for the higher price an AF5 Transformer may be obtained.

VOLUME CONTROL.

Where this is necessary it should be carried out by means of a well designed variable high resistance having a total value of 50,000 or 100,000 ohms, connected across the primary of the first Audio Frequency Transformer.

CONSTRUCTION.

The FERRANTI AF3 Transformer employs the air-spaced sectionalised windings, which are used in all FERRANTI Audio Frequency and Output Transformers. The following views of the internal structure of the AF3 Transformer give some idea of the research and precision workmanship that goes to the making of the AF3 Transformer :—

Fig. 3. The Coil Formers. W 23.

Fig. 4. The Secondary Coil. W 21.

Fig. 5. The Fixed Condenser. W 19

Internal View of Fixed Condenser

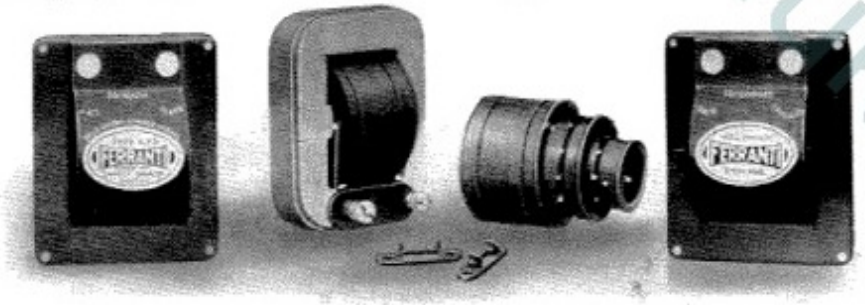


Fig. 6. Exploded View. W 25.

Fig. 7.

The transformer is provided with reversible feet and, as the views indicate, can readily be mounted in a position most suitable to the constructor.

A large amount of high-class material and labour is necessary to produce FERRANTI Audio Frequency Transformers and to secure their excellent characteristics.

Every foot of wire entering into the construction of these Transformers is tested to determine the character of its insulation. All wire falling below the standard we have set is rejected.

After winding the Coils and before assembly, they are tested twice for continuity and short circuited turns. All Transformers are submitted to eleven different tests after assembly to establish their condition and amplification ratio, in addition to a high pressure test of 1,000 volts to earth.

These Transformers are shrouded in a pressed steel case of pleasing appearance, and each terminal is clearly marked with the item in the circuit to which it must be connected.

FERRANTI LTD. have been engaged in the manufacture of Power Transformers, Electricity Meters, and other high-grade Electrical Instruments since the year 1882, and have a staff of trained research Engineers, well qualified for the development and production of apparatus of this character.

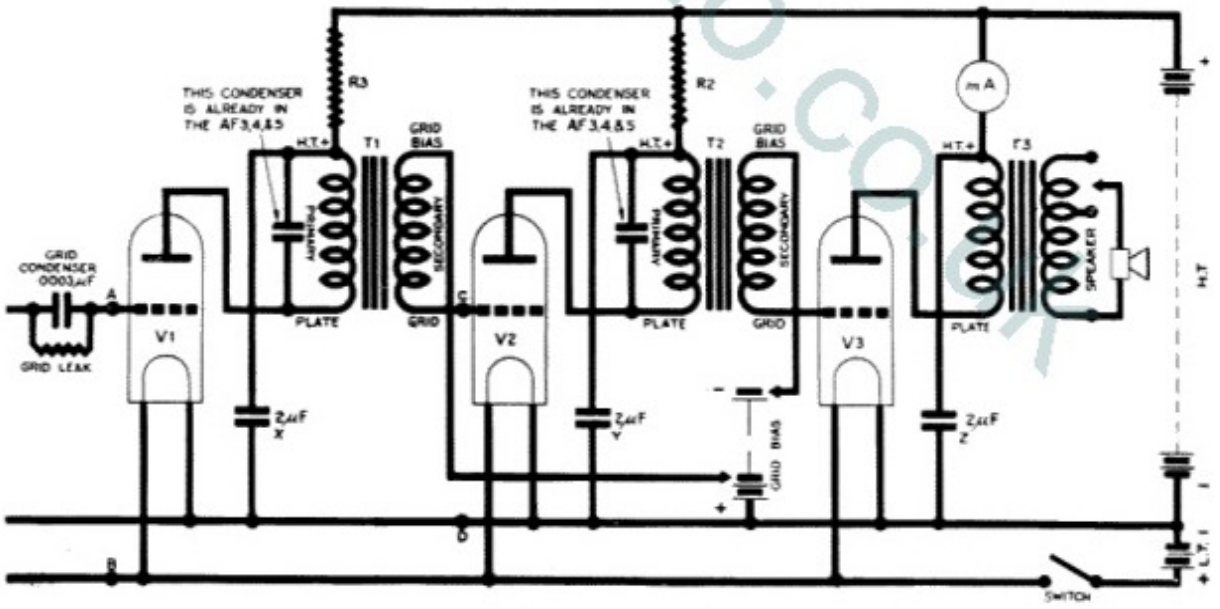


Fig. 8. D 1018. Conventional Diagram.

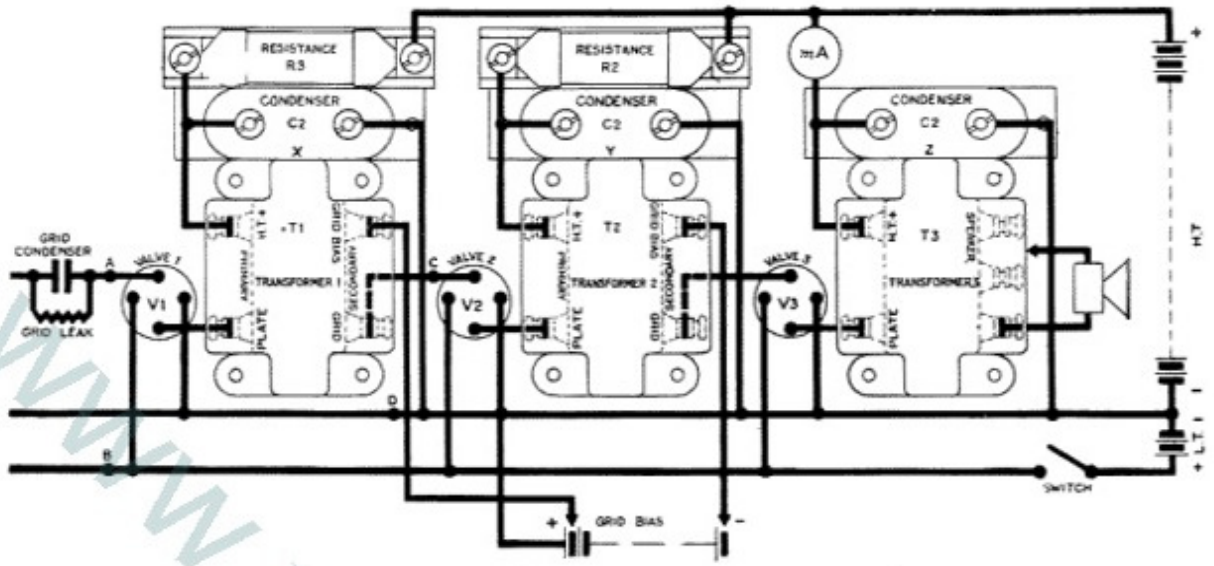


Fig. 9. D 1019. Practical Diagram (looking down on valve holder).

CONNECTION AND OPERATION.

Having produced a Transformer of such superior characteristics we desire to ensure that it is properly used. The two diagrams (Figs. 8 and 9) each showing a detector and two stages of audio frequency amplification, are identical in principle, the first being a conventional theoretical diagram and the second a modified plan showing the outline of the Transformers, Valves, and Condensers, etc.

No attempt is made to compare the relative merits of various types of Receivers as regards the arrangement of the high or radio frequency portion, but in any Receiver the low or audio frequency portion in which audio frequency amplification occurs may be considered as a separate section and may be represented as shown in these diagrams.

The diagrams are intended to show the arrangement of the audio frequency side of a good Receiver, the connections preceding the detector valve vary according to different conditions. It is, however, a general rule to connect the grid of the detector through the grid leak to the L.T. battery at a point 2 volts positive.

An electrical vibration applied across " AB," the grid circuit of the valve " V1" is passed on greatly magnified by this valve and the Transformer " T1 " to " CD," the grid circuit of the valve " V2 " and the ratio of this magnification is called "Amplification Ratio." By means of sensitive laboratory apparatus the amplification ratio of the type AF3 Transformer has been accurately measured and the results are shown by the curve, Fig. 1, on page 1.

The following points should be observed if the best results are to be obtained :—

1. The output valve, or valves, only should be of the power or super-power type. Power valves should not be used in other positions, as they are unnecessary.

2. The anode current taken by the valve preceding the AF3 Transformer should not take more than 5 milliamps. The most satisfactory method of determining the consumption of various valves is by means of a FERRANTI Radio Meter or a FERRANTI Valve Tester

3. Adequate high tension voltage must be used, as without this the valves overload easily, causing the Speaker to give out a rattling noise on powerful passages. Not less than 120 volts, preferably more, should be used on the output valve with about 60 volts on the first valve, and 100 volts on the second where 3 valves are used.

4. WITHOUT GRID BIAS THE BEST TRANSFORMER IS NO BETTER THAN THE WORST. The correct amount of grid bias as specified by the Valve Makers, or, as set out in FERRANTI publications, must be used to obtain the best reproduction.

   In general, the first L.F. valve will need 1½/3 volts grid bias, and the output valve, if of the small power type, will need 9 volts grid bias, whilst if of the super-power type may need anything from 15 to 50 volts grid bias, according to type.

5. BACK COUPLING, or Audio Frequency regeneration, sometimes gives rise to serious distortion in Radio Receivers. This distortion is due to a small portion of the signal from the output valve feeding back to the preceding valves and being re-amplified until the whole circuit becomes unstable and oscillates. This low frequency oscillation appears usually as a high-pitched whistle, or in the form of a popping noise known as "motorboating."

   Back coupling has a greater tendency to occur at the bass frequencies, and therefore if components are used which amplify these properly, precautions should be taken to see that back coupling does not occur. Back coupling can be prevented by careful layout of components keeping the output of the Receiver well away from the input and by the use of the Anode Feed Resistance System, connections of which are indicated in the preceding diagrams.

6. REASONS FOR THE SUPERIOR PERFORMANCE OF FERRANTI TRANSFORMERS :—

   (a) Ample core section with practically no air gap.

   (b) The use in the core of first-grade Transformer steel, the suitability of which has been proved over a number of years.

   (c) The avoidance of the use of special materials in the core, such as Permalloy, with the attendant possibility of permanent high magnetisation resulting in reduced efficiency and poor reproduction.

   (d) High primary inductance under normal operating conditions 70/110 henries at the voltages and conditions usual in Radio Receivers.

   (e) Great sub-division of windings and special design to reduce self-capacity and eddy current losses.

   (f) Manufacturing precision and multiple tests ensuring the unfailing excellence of the finished product.

FERRANTI ELECTRIC LIMITED, TORONTO, ONTARIO, CANADA.

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