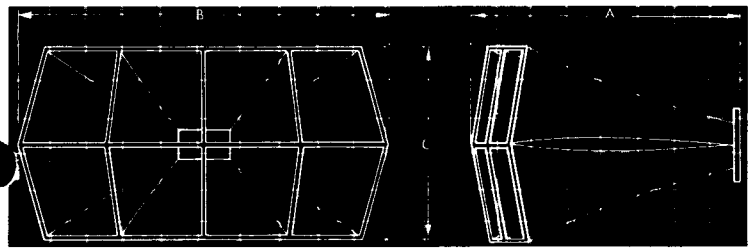


ALTEC ENGINEERING NOTES

TECHNICAL LETTER NO. 106

70 VOLT MATCHING TRANSFORMER

The Altec 70 volt transformers are provided for the many uses of distribution of power from amplifiers to loudspeakers in sound systems. The 70 volt system is an extremely practical method to adjust the power to individual speakers and incurs a minimum loss. Unlike "T" or "L" pads, these transformers do not burn up the power in resistors. Some pads also have an initial insertion loss which amounts to 3 db or more. Only the copper and core loss of transformers causes the power loss.

All calculations for their use are based on the turns or voltage ratio required, and on the fact that at its rated maximum power output the amplifier delivers 70 volts.

Given the rated impedance of the loudspeaker and the number of watts desired, the connection to an Altec 70 volt transformer can easily be made.

The loudspeaker side (secondary) of the transformer has taps which are marked in ohms (4-8-16.) The speaker should be connected to the appropriate matching impedance. The amplifier side (primary) has taps marked in watts. The 70 volt output line from the amplifier should be connected to the taps marked with the wattage nearest to that desired. A wiring diagram or connection sheet is not needed. All information is clearly marked on the transformer at a point adjacent to the terminals, and no strapping between terminals is required.

By adding up the total watts required of the various speakers, the size of the amplifier can be determined. Add 10% to this total to take care of insertion loss of the transformers.

It is often assumed that the transformer has no loss. This is not true, and it is most important to know the amount of its insertion loss.

An insertion loss of 1 db corresponds to a power loss of 21% and an insertion loss of 3 db is a power loss of 50%. Let us take an amplifier cost of $4.00 per watt at the consumer level. Then, when a 75 watt amplifier is used with matching transformers each having 1 db loss, only 79% of the power is available at the speakers, or 59 watts, and 16 watts are lost at $4.00 per watt or $64.00. When the transformer has 0.5 db loss, the cost in lost power is reduced to $33.00 or a net saving of $31.00 due to more efficient matching transformers.

Litho in USA CP-1073-2.5K

In many cases by using Altec low insertion loss transformers, the actual size of the amplifier can be smaller than one would ordinarily choose based on previous experience with inexpensive low efficiency transformers. For example, if it was estimated that 50 watts was required with ordinary matching transformers, our 35 watt amplifier and low loss transformers will deliver the required amount of power to the speakers.

In the interest of over-all installation economy, Altec has provided matching transformers with an insertion loss of approximately 0.5 db.

To illustrate the advantages of a high efficiency transformer, a comparison has been made between the Altec 8 watt and two other well known 8 watt competitive 70 volt transformers. Because 70 volt matching transformers have a relatively high primary impedance and are usually connected to a driving amplifier having a very low internal output impedance, it is rather difficult to evaluate a transformer's true effect on the performance of a system in actual service by merely measuring its frequency response. It is more desirable to examine the transformer in terms of power factor and power loss. Although a matching transformer may have substantial reactive components which we normally consider wattless components, nevertheless, these elements load the amplifier just as truly as an equivalent shunting resistance.

Figure 1 shows the losses for all frequencies on three transformers (based on VA input vs watts output)
Figure 1A - the Altec 15065 8 watt transformer
Figure 1B - a well known competitive 8 watt transformer (B)
Figure 1C - another well known competitive 8 watt transformer (C)

The dashed line in all cases represents the volt-ampere input, while the dotted line represents watts out to the speaker. The shaded area between the two lines represents the insertion loss of the transformer with respect to frequency. The solid reference line represents an ideal (zero loss) 8 watt transformer.

The importance of careful rating and matching is clearly revealed. Notice that the Altec transformer (1A) permits the loudspeaker to receive the 8 watts which is expected of it. This is accomplished by adjusting the turns ratio to compensate for the insertion loss.

Figure 1B shows that competitive transformer B, instead of transmitting 8 watts to the speaker, delivers 1.5 db less or 5.7 watts.

Figure 1C shows that competitive transformer C, instead of transmitting 8 watts, delivers 3.75 db less or only 3.4 watts.

Thus, for the B and C samples, installation performance is substandard from calculated requirements because the insertion loss is high and because there is no compensation in the turns ratio.

The dashed line in competitor B and C is considerably below the zero reference line because of this improper design.

Where a distribution system is required to transmit music, the reactive component at the low frequencies becomes important. Comparing these transformers at 50 cps, it will be seen that Sample A - the Altec transformer - has an insertion loss of 0.5 db, Sample B has 2 db loss and Sample C has 3.5 db loss. These are the values that derate the amplifier output available to the speaker.

The rise in the dashed line below 100 cps represents the extra volt-ampere input required to supply the core losses and exciting current. This places a severe demand on the amplifier at these frequencies.

When matching transformers have limited low frequency response, they also have low self-inductance. In those cases where there is no low frequency cut-off at the input of the amplifier, the inadequate transformers are saturated and present a short circuit to the final stage, causing excessive tube dissipation and short life.

At the higher frequencies, it can be seen that the input volt-amperes and the output watts have drooping characteristics. Accordingly, the top frequency for which the transformer can be used with Altec's wide range loudspeakers is determined by the acceptable limit of deviation from a flat frequency response.

The Altec group of six transformers provides coverage in 3 db steps from $\frac{1}{4}$ watt to 140 watts. This is illustrated in Figure 2. Four units, each with relatively few taps, have been included in the group so as to provide, at reasonable cost, a selection of 70 volt line matching transformers of highest efficiency and widest frequency range. There is no sacrifice in the performance characteristics of the group. The connection diagrams, which are a part of the transformers, have been designed for simple, accurate, rapid planning and installation.

The 15064 transformer is the smallest in Altec's group of 70 volt line matching transformers. It has secondary impedances of 4 ohms and 8 ohms, and nominal primary wattages of 1, $\frac{1}{2}$ and $\frac{1}{4}$ when connected to a 70 volt line. (Note that while these are referred to as "primary" wattage ratings because they are associated with the primary terminals, they actually represent the powers delivered to the speakers.) The frequency response of this transformer covers the range between 60 cps and 15,000 cps within 1 db. This frequency response prevails with source impedance from 0 up to 5,000 ohms. The transformer can be mounted directly on to the 401B loudspeaker. Transformer insertion loss is .7 db* when working into nominal loads.

The 15074 transformer, while it is rated as a four watt transformer, is in reality a multi-purpose transformer. It has nominal secondary impedances of 8, 4 or 2 ohms and nominal primary wattages of 4, 2 or 1 watt when connected to a 70 volt line. Under rated conditions of operation, the frequency response is flat within plus or minus 1 db from 60 cps to 15,000 cps and the insertion loss is 1.2 db* for nominal loads. The two other optional methods of operation occur when the transformer is loaded with twice or four times its nominal impedance. Under the first optional condition, the secondary impedances are considered as 16, 8 or 4 ohms, respectively, while the corresponding powers drawn from the line become 2, 1 and $\frac{1}{2}$ watts. The second optional condition of operation prevails when the secondary impedances are considered as 32, 16 or 8 ohms, respectively, while the corresponding primary wattages become 1, $\frac{1}{2}$ and $\frac{1}{4}$ watts.

The first option operating insertion loss is .8 db* while the second option operating insertion loss is .5 db*. The two optional methods of operation are achieved with no impairment of frequency response. The 15074 transformer can be mounted directly on to the 401B loudspeaker.

The 15065 transformer is the smallest wide range transformer in Altec's group of 70 volt line matching transformers. The frequency response is flat within plus or minus 1 db from 30 cps to 15,000 cps with any impedance source from 0 up to impedance match. The transformer's secondary impedances are 16, 8 or 4 ohms while its nominal primary wattages are 8, 4 or 2 watts when connected to a 70 volt line. The insertion loss is .5 db*.

The 15075 transformer is a special purpose unit designed especially for use with voice frequency loudspeaker units such as the 730B. Secondary impedances are 16, 8 or 4 ohms and nominal primary wattages are 40, 30, 20, 10 or 5 when connected to a 70 volt line. The frequency response is flat within plus or minus 1 db from 200 cps to 10,000 cps. Source impedance may vary from 0 up to a matched condition. The insertion loss is .5 db*.

The 15066 transformer is similar in all characteristics to the 15065 except that it is larger with nominal primary wattage ratings of 32, 16 or 8 watts.

The 15067 auto transformer has extremely wide fields of application. Basically, it provides impedance ratios of 1, $\frac{1}{2}$ and $\frac{1}{4}$. Its nominal rated frequency response is from 30 cps to 15,000 cps within plus or minus 1 db. The maximum power rating is 140 watts with a maximum insertion loss of .3 db* at that power. A typical schematic is shown in Figure 3D.

This auto transformer can also be used for impedance matching between amplifiers and loudspeakers. In this service, it may be used at any power rating up to 70 volts across the entire winding. The cases illustrated in A and B of Figure 3, however, are probably the most usual applications, the impedances being 4, 8 and 16 ohms. For these cases, the power capacity is the nominal 140 watts. It may be used for either step-up or step-down matching; for example, an amplifier with a single 8 ohm output can be coupled to either a 16 ohm or 4 ohm loudspeaker (Figure 3B.)

The limiting conditions of operation for this auto transformer are 70 volts at 30 cps between terminals 1 and 4, 50 volts at 30 cps between terminals 1 and 3, and 35 volts at 30 cps between terminals 1 and 2. The other limiting condition of operation is a maximum of approximately 2.2 amperes of current through any part of the winding.

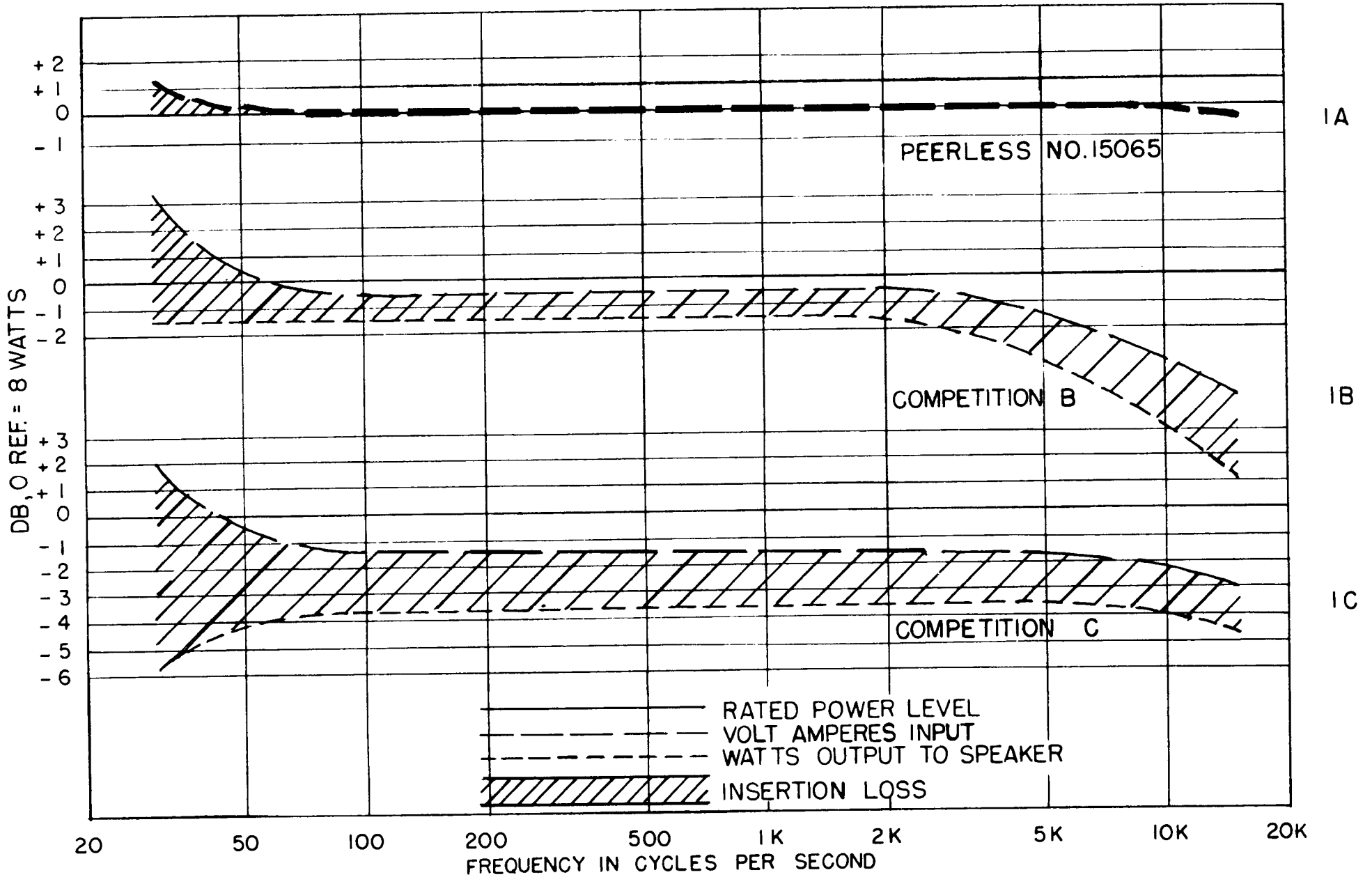
Within these ratings the transformer can be used at 75 watts to match a 70 volt line to either 32 ohms or 16 ohms or to match a 140 watt, 70 volt line to 16 ohms or 8 ohms. The open circuit reactance is sufficiently high to permit two of them to be used in parallel to handle a full 280 watt, 70 volt line (Figure 3E) or two of them in series may be used with a 280 watt, 140 volt line to match 32 or 16 ohms (Figure 3F.) Two of these auto transformers in cascade arrangement can be used to match 75 watts, 70 volts to 16 or 8 ohms (Figure 3C.) These unusual coupling combinations are possible because the actual range of frequency response for this auto transformer is much wider than its rated 30 to 15,000 cycles. Accordingly, the rated frequency response can be obtained over extremes of impedance values. While the insertion loss is less than ½ db* with the lowest recommended load impedance of 4 ohms, it may be used to match into 2 ohms or 1 ohm where circumstances will permit insertion losses of 1* or 2 db*, respectively.

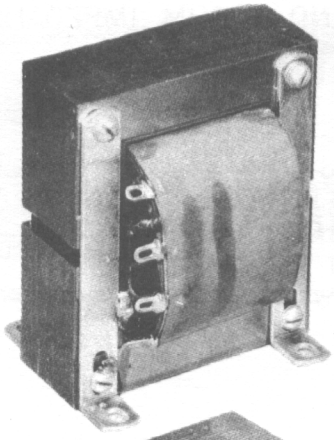
In summary, the best 70 volt matching transformer is one which has low copper loss, relatively large amount of steel, laminations being well interleaved, high self-inductance, low leakage inductance and low distributive capacitance.

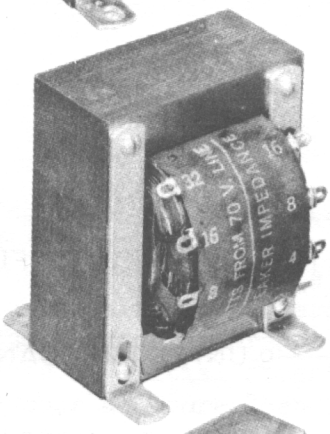
* It should be noted that the rated insertion losses of the above six transformers prevail under conditions of maximum loss. Other conditions of operation result in lower insertion losses so that no allowance beyond the published values need or should be made.

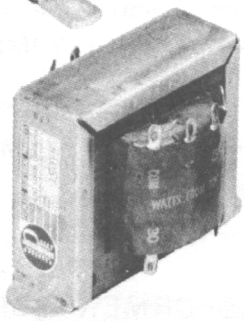
JKH:bhm

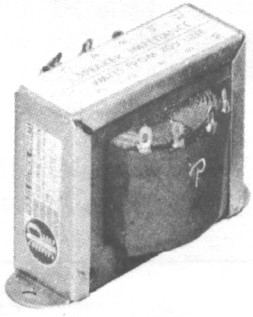
FIG. 1

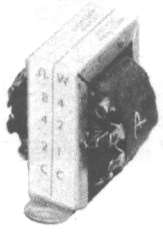

+2
+1
0
-1
+3
+2
+1
0
-1
-2
+3
+2
+1
0
-1
-2
-3
-4
-5
-6
DB, 0 REF. = 8 WATTS
PEERLESS NO. 15065
1A
COMPETITION B
1B
COMPETITION C
1C
RATED POWER LEVEL
VOLT AMPERES INPUT
WATTS OUTPUT TO SPEAKER
INSERTION LOSS
20
50
100
200
500
1K
2K
5K
10K
20K
FREQUENCY IN CYCLES PER SECOND

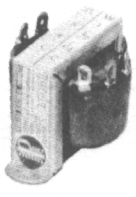




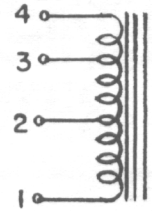




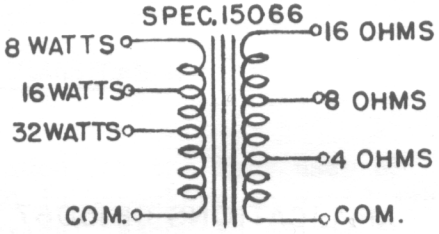




SPEC. 15067



SPEC. 15066



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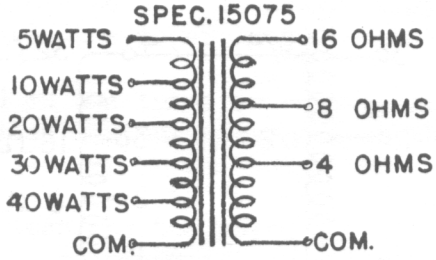

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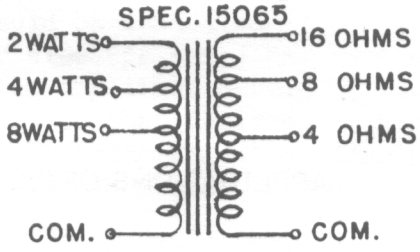

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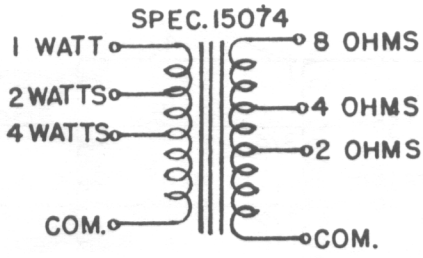


SPEC. 15064

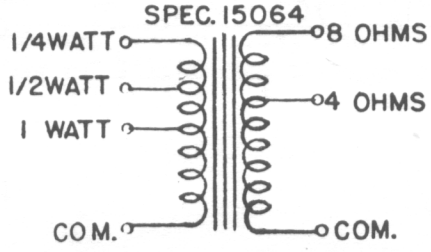
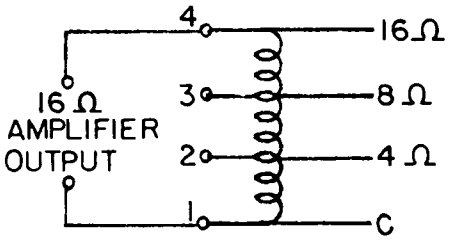
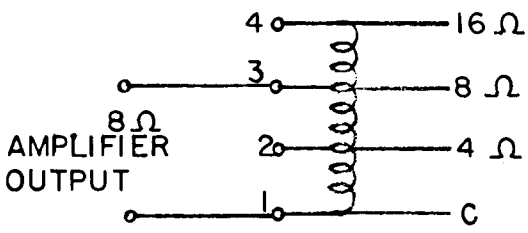


FIG. 2

APPLICATION OF 15067 TRANSFORMER ON 4, 8 AND 16 OHM IMPEDANCES

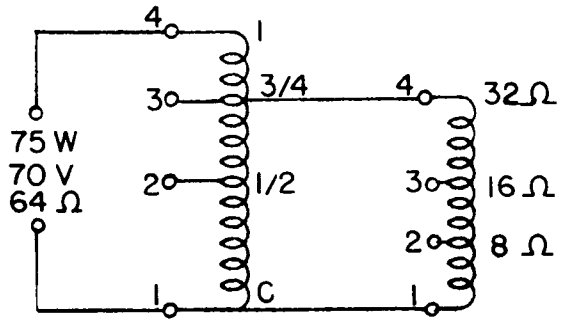


A

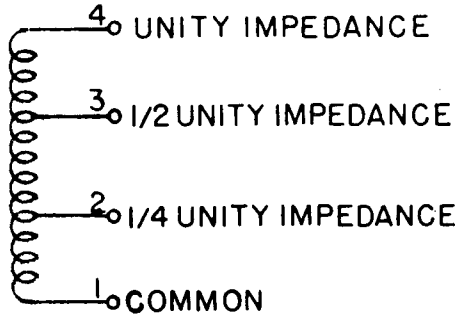


B

APPLICATIONS OF 15067 TRANSFORMER WITH 75 WATT AMPLIFIER



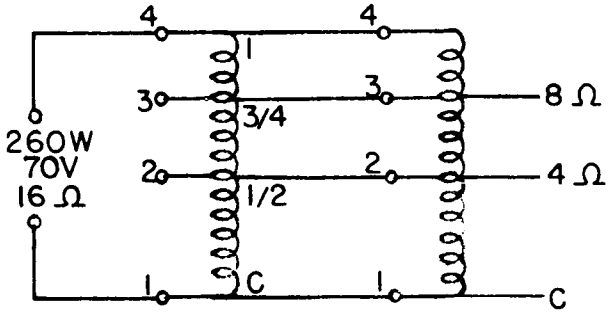
C



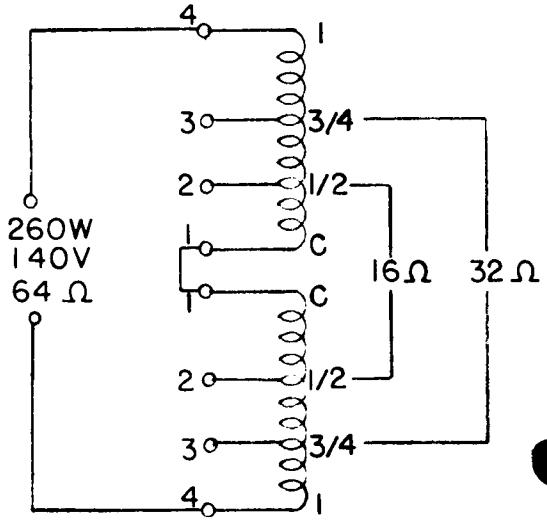
TRANSFORMER SCHEMATIC

D

APPLICATIONS OF 15067 TRANSFORMER WITH 260A AMPLIFIER



E



F

FIG.3