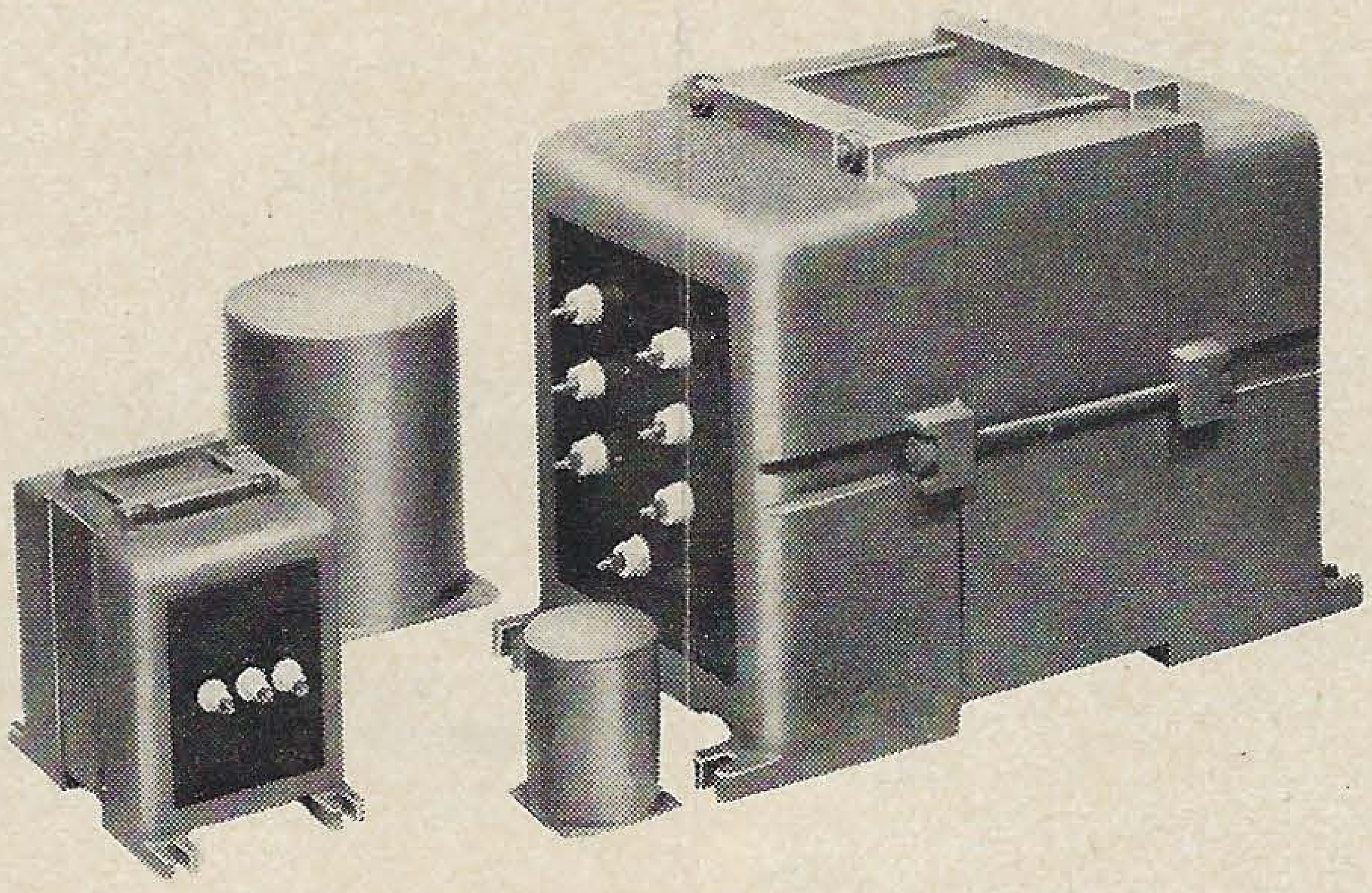
TERMINAL ARRANGEMENTS

VARIMATCH TRANSFORMERS



UNITED TRANSFORMER CORPORATION

150 VARICK STREET • NEW YORK 13, N. Y.
EXPORT DIVISION: 13 EAST 40th STREET, NEW YORK 16, N. Y. CABLES: "ARLAB"

VARIMATCH TRANSFORMERS

The ever increasing number of vacuum tubes available for audio and RF applications has increased the difficulty of obtaining transformers suitable for matching to the various correct tube loads. This is particularly an important factor in transmitter operation where a very wide range in the operating condition of the class C RF tubes is encountered. It also, however, applies equally strongly to audio tubes, as in addition to the normal operation of these tubes, the plate load varies with change in plate voltage or bias.

If a standard transformer having a limited impedance range is purchased and used for a specific purpose as the "nearest thing" available, comparatively high distortion is inevitable. As a solution to these problems, UTC has developed the Varimatch transformer, which through proper design permits a very wide range of impedance matching. Varimatch units are available for modulator service, PA service, and driver service.

IMPEDANCE MATCHING

The fundamental formula for transformers applied to impedance matching service is well known to radio men. This formula states that the impedance ratio of a transformer is directly proportional to the square of the turns. Frequency is no factor in this formula, and it is therefore apparent that the impedance ratio of a transformer, particularly one of good design, will be uniform throughout the entire audio range. Fig. 1 illustrates an ideal transformer. As an example of the application of an impedance matching transformer, let us refer to Fig. 2, which illustrates a transformer of ratio 1:2 with a pure resistance of 100 ohms across terminals AA on the high side. If we were to measure

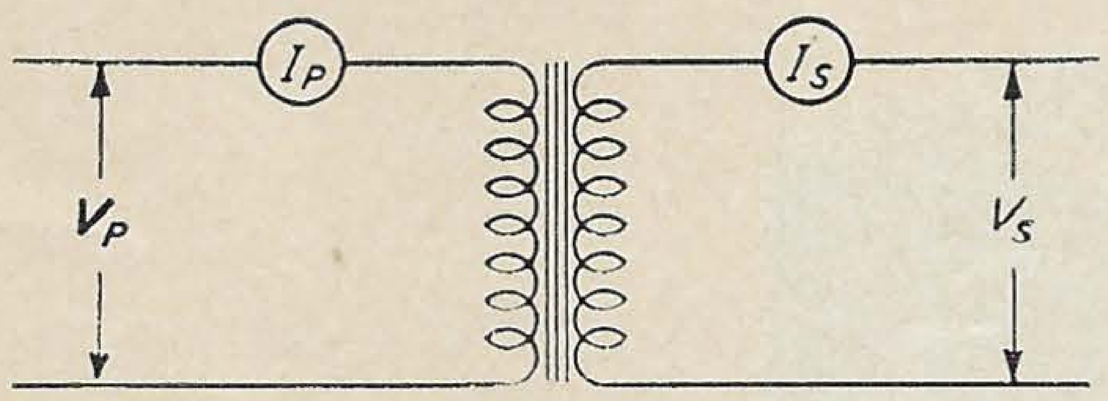


Fig. 1

the impedance of the transformer terminals BB, we would find that to all purposes the impedance would be 25 ohms, which value would remain constant throughout the entire frequency spectrum if the transformer were a perfect one. Similarly, if we were to connect a pure inductance or capacitance across the AA terminals, then terminals BB would respectively measure as a pure inductance or capacitance.

It is instructive to note therefore that if we were to tie a 2 mfd. capacitor across AA, then terminals BB would measure 8 mfds. This method is used occasionally in certain types of circuits to obtain a high capacitance where DC does not pass through the transformer. We see then that a transformer can be made to reflect any type of impedance that we choose.

Due to limitations in commercial transformers, a given unit cannot be used for a very wide range of impedance beyond a certain point. Using a transformer to obtain a given impedance ratio, but with impedance diverging considerably from that for

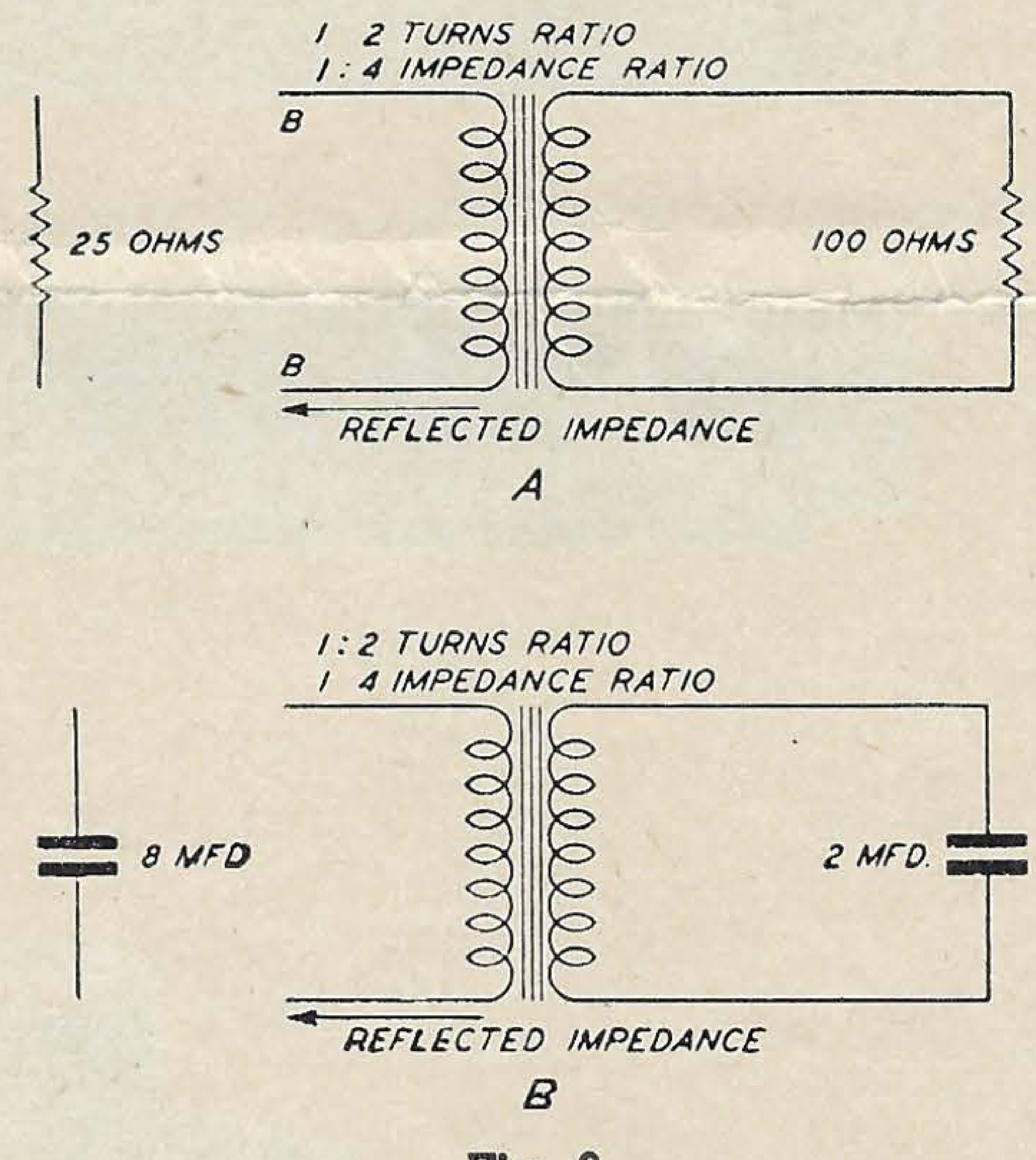
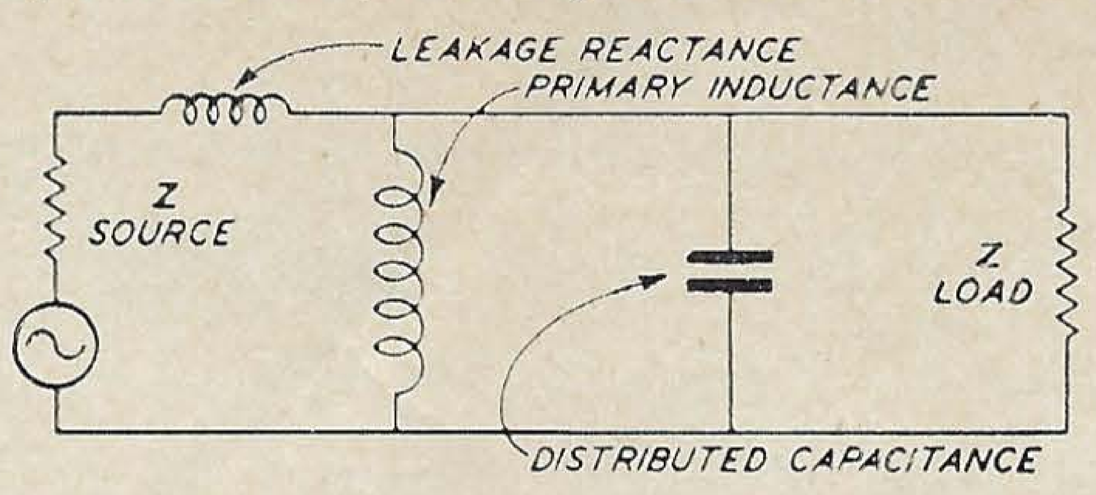


Fig. 2

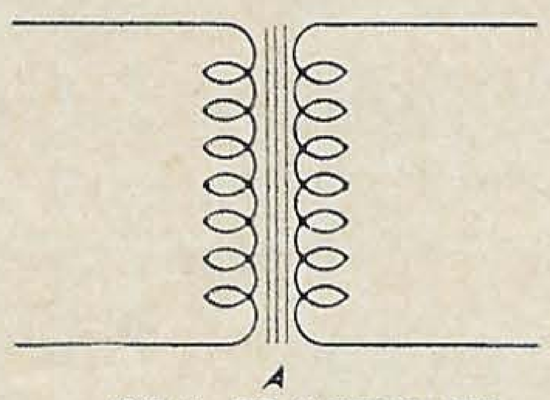
which it was originally designed, frequency discrimination and loss in power transfer will result. This can be more readily understood if we analyze the actual "T" equivalent of a transformer.

COMMERCIAL TRANSFORMER

Assuming a simple transformer, as in Fig. 3A, we find that, in addition to the power transfer characteristics of the unit, we have a primary inductance which shunts our source impedance; a leakage reactance which, in effect, operates in series with our load, and a distributed capacitance, which can be lumped to shunt the load. This simplied form is indicated in Fig. 3B. As we reduce the frequency feeding into this transformer, the impedance of the primary inductance decreases. This decrease may reach the point where some of the power, which would normally be transferred from primary to secondary, is shunted through this inductance. Similarly, as the frequency increases, the impedance of the distributed capacitances decreases and shunts some of the power, which would normally pass through the load.



SIMPLIFIED T EQUIVALENT OF COMMERCIAL TRANSFORMER



IDEAL TRANSFORMER

Fig. 3

The third element to be considered is the leakage reactance, whose impedance increases with frequency and produces a strong series loss, at the higher frequencies. The effects of primary inductance, distributed capacitance, and leakage reactance, since they are related with primary and secondary impedances, become variable, depending upon these impedances.

TRANSFORMERS FOR MODULATION SERVICE

Several factors must be remembered in coupling the modulator and final stages in a transmitter employing high level modulation. These may be enumerated as:

1. The audio output should be approximately 50% of the class C input of the RF Stage.
2. The actual audio output available for modulation is equal to the audio output of the modulator tubes minus the losses in the coupling unit.
3. The impedance ratio of any two windings on the same core is equal to the square of the turns ratio.
4. The primary impedance of a transformer depends upon the secondary load.

While the first factor mentioned above is commonly known and applied, the second factor is one which is frequently overlooked. A highly efficient coupling device involves considerable design and care. Some contemporary transformers recently tested in the UTC audio laboratories have shown as much as 3 DB loss. While this seems to be an insignificant amount in terms of DB, it actually means a transfer efficiency of 50%. In other words, if 100 watts were available from the modulator tubes, only 50 watts would be delivered as actual power to the class C stage. Naturally, 100% modulation could not be obtained. To reduce these losses, UTC transformer core materials are operated at conservative flux densities, the resistance of the windings is kept at a small value as compared to the matched impedance, and low leakage reactance is effected by proper interleaving of windings.

Analyzing factors 3 and 4 mentioned above, it is seen that the turns ratio of a transformer definitely limits its application. This is an important factor in modulator work as the number of combinations of modulator tubes and operating conditions available, and class C combinations possible, is almost unlimited. Standard transformers as made in the past will generally take care of only one combination of modulator and final stage, and since only a limited number of these transformers have been available, the amateur frequently found it necessary to use a transformer which was "the nearest thing" to the actual transformer required for the particular application. While a 20% mismatch caused by such an occurrence does not represent a serious loss in power, it greatly reduces the undistorted power available from a class B modulator because optimum plate load is not reflected to the tubes. The UTC Varimatch transformer eliminates this difficulty through the use of a combination of tapped windings affording an extremely wide range in impedance matching.

Fig. 4 illustrates in chart form some of the various impedance combinations available.

In many cases the specified plate to plate load impedance for the modulator tubes does not coincide with the values listed in the left hand column of the impedance chart. If such is the case, select the value nearest the specified plate to plate impedance for the tubes to be used in the modulator; then the available secondary load impedances are calculated by multiplying the values listed under secondary impedances by the ratio of the plate to plate impedance of the modulator to the value selected from the left hand column, that is

$$R_L = \frac{\text{P to P load impedance of modulator tubes}}{\text{primary impedance in left hand column}}$$

multiplied by secondary impedance listed in right hand columns.

FOR EXAMPLE: The modulator is to use 2 838's operating at 1250 V. The plate to plate load impedance of the 838's under these conditions is 11,200 ohms. The power output is 260 watts. With this AF output the DC input to the class C stage should be 520 watts. If the class C plate voltage is 2500 V the plate current will be 208 MA; giving an RF load impedance of 12,000 ohms.

The nearest primary impedance to the desired value is 12,000 ohms plate to plate and secondary taps are available to give 12,500 ohms.

Substituting in the formula

$$\text{Secondary } R_L = \frac{11{,}200}{12{,}000} \times 12{,}500$$

$= 11{,}700$ (secondary impedance)

The difference between the required 12,000 RF load impedance and the calculated available load impedance of 11,700, gives a match within 2½%.

Some typical modulator operating conditions and impedances for use with these Varimatch units are noted on the following pages.

TERMINAL ARRANGEMENT—CVM-0 to CVM-5 Inclusive

PRIMARY		SECONDARY												
P to P Imp.	P-B-B-P	Join 9 & 10 Con. to 7 & 12	Join 9 & 10 Con. to 8 & 12	Join 9 & 10 Con. to 8 & 11	Join 8 & 9 Con. to 7 & 12	Join 7 & 9 10 & 12 Con. to 7 & 10	Join 8 & 9 10 & 11 Con. to 8 & 10	Join 3 & 4 Con. to 1 & 6	Join 3 & 4 Con. to 2 & 6	Join 2 & 3 Con. to 1 & 6	Join 3 & 4 Con. to 2 & 5	Join 1 & 3 4 & 6 Con. to 1 & 4	Join 7 & 11 8 & 12 Con. to 7 & 8	Join 1 & 5 2 & 6 Con. to 1 & 2
Line to RF	500 ohms connected to 7 and 8; join 7 to 11 and 8 to 12							15000	9300	7700	5000	3700		
Line to RF	500 ohms connected to 1 and 2, join 1 to 5 and 2 to 6	16.000	11.000	8000	6800	4000	2000							
2000	2-3-4-5	8600	6350	4300	3620	2150	1070						200	
2000	1-2-5-6	15.700	11.400	7900	6550	3920	1950						350	
3000	2-3-4-5	13.000	9400	6500	5500	3240	1620						300	
3000	1-2-5-6	23.500	17.000	11.800	10.000	5900	2950						520	
3800	2-3-4-5	16.400	12.000	8200	7000	4100	2050						380	
3800	1-2-5-6	29.800	21.500	15.000	12.600	7500	3740						660	
4000	2-3-4-5	17.400	12.500	8650	7300	4300	2160						400	
4000	8-9-10-11							5500	3450	2850	1850	1380		250
5000	2-3-4-5	21.600	15.700	10.800	9150	5400	2700						500	
5000	8-9-10-11							7000	4300	3500	2300	1730		300
6000	1-3-4-6	8600	6350	4300	3620	2140	1070						200	
6000	8-9-10-11							8300	5150	4250	2750	2180		370
6600	1-3-4-6	9500	7000	4750	4000	2350	1180						220	
6600	8-9-10-11							9100	5650	4660	3000	2400		405
7000	1-3-4-6	10.000	7300	5050	4280	2500	1250						230	
7000	8-9-10-11							9700	6000	5000	3200	2400		430
8000	1-3-4-6	12.000	8400	5800	4900	2900	1440						270	
8000	8-9-10-11							11000	6900	5650	3700	2760		500
9000	1-3-4-6	13.000	9400	6500	5500	3240	1620						300	
9000	8-9-10-11							12500	7750	6300	4150	3100		550
9000	7-9-10-12							6200	3900	3200	2050	1550		275
10000	1-3-4-6	14.400	10,500	7200	6100	3600	1800						330	
10000	8-9-10-11							14000	8600	7100	4600	3450		600
10000	7-9-10-12							6900	4300	3500	2300	1740		310
12000	1-3-4-6	17.400	12.500	8700	7250	4320	2150						400	
12000	7-9-10-12							8300	5150	4250	2750	2070		370
14000	7-9-10-12							9700	6000	4900	3200	2440		430
16000	7-9-10-12							11000	6900	5600	3700	2780		500
18000	7-9-10-12							12500	7750	6300	4150	3140		550

ADDED VALUES FOR CVM4 AND CVM5

14000	13-3-4-14	11.600	8100	5600	4720	2800	1400						260	
16000	13-3-4-14	13.200	9300	6400	5400	3200	1600						300	
18000	13-3-4-14	15.000	10.400	7200	6100	3600	1800						340	
20000	13-3-4-14	16.700	11.600	8000	6800	4000	2000						375	
22000	13-3-4-14	18.300	12.800	8800	7500	4400	2200						410	

P to P Imp.	P-B-B-P	Join 3 & 4 Con. to 13 & 14	Join 3 & 4 Con. to 1 & 14	Join 4 & 6 Con. to 13 & 14	Join 3 & 4 Con. to 13 & 5	Join 2 & 3 Con. to 13 & 14	Join 3 & 13 4 & 14 Con. to 4 & 13	Join 1 & 5 2 & 6 Con. to 1 & 2
14000	7-9-10-12	17.600	13.500	7000	9000	10.800	4400	430
16000	7-9-10-12	20.000	15.500	8000	10.300	12.400	5050	500
18000	7-9-10-12	22.400	17.400	9000	11.500	13.900	5650	550

TUBE COMBINATIONS — MAXIMUM AUDIO

CVM-0 — 15 Watts

Primary Impedance	27,000	14,000	10,000	8,000	7,000	6,000	5,000	4,000
Push Pull	38	31-33-49 46-47-2A5 59 Pent. 89 Pent. 42	6A6-19-53 49-79-89 43-19 59-71A 6B5-6F6	2A5 A Prime 42 A Prime 45-43-50 6V6 ABI		46-59 Class B 6F6 AB	6L6-250V. 2A3-6A3 6A5G	25L6 48
Single		38 49 class B 89 class B	10-41-42	59 Pent. 89 Pent.	6F6 46-42-47 49-89-31 2A5-33	31-46-59		43-59-45 71A-43-50

CVM-1 — 30 Watts

Modulator Tubes	Modulator Plate to Plate Load Imped.	Plate Volts	Bias Volts	AF Power Output	Class C DC Watts Input
2A3's AB	3000 ohms	300 V.	— 62 V.	15 W.	30 W.
2-45's AB	3200 ohms	275 V.	— 68 V.	12 W.	24 W.
6N7	10000 ohms	300 V.	0	10 W.	20 W.
6N7	5000 ohms	300 V.	0	20 W.	40 W.
46's	6000 ohms	450 V.	0	25 W.	50 W.
2-6L6's Class AB_1	6600 ohms	400 V.	— 23 V.	30 W.	60 W.

CVM-2 — 60 Watts

Modulator Tubes	Modulator Plate to Plate Load Imped.	Plate Volts	Bias Volts	AF Power Output	Class C DC Watts Input
6N7	5000 ohms	300 V.	0	20 W.	40 W.
2-46's	6000 ohms	450 V.	0	25 W.	50 W.
4-46's	3000 ohms	450 V.	0	50 W.	100 W.
2-6L6's Class AB_1	6600 ohms	400 V.	— 23 V.	30 W.	60 W.
2-6L6's AB_2	3800 ohms	400 V.	— 25 V.	60 W.	120 W.
4-6L6's AB_1	3300 ohms	400 V.	— 23 V.	60 W.	120 W.
TZ20	6100 ohms	500 V.	0	40 W.	80 W.

CVM-3 — 125 Watts

Modulator Tubes	Modulator Plate to Plate Load Imped.	Plate Volts	Bias Volts	AF Power Output	Class C DC Watts Input
4-46's	3000 ohms	450 V.	— 20 V.	50 W.	100 W.
2-6L6's AB_2	3800 ohms	400 V.	— 25 V.	60 W.	120 W.
4-6L6's AB_2	1900 ohms	400 V.	— 25 V.	120 W.	240 W.
35 T's	10000 ohms	1000 V.	— 25 V.	125 W.	250 W.
	6600 ohms	750 V.	— 35 V.	90 W.	180 W.
845's AB	4600 ohms	1000 V.	— 175 V.	75 W.	150 W.
	8800 ohms	1250 V.	— 225 V.	105 W.	210 W.
809's	5200 ohms	500 V.	0	60 W.	120 W.
809's	8400 ohms	750 V.	— 5 V.	100 W.	200 W.
TZ20	12000 ohms	800 V.	0	70 W.	140 W.
HK54	6000 ohms	750 V.	0	108 W.	216 W.

CVM-4 — 300 Watts

Modulator Tubes	Modulator Plate to Plate Load Imped.	Plate Volts	Bias Volts	AF Power Output	Class C DC Watts Input
25 T's	10000 ohms	1000 V.	— 35 V.	115 W.	230 W.
	12800 ohms	1250 V.	— 45 V.	130 W.	260 W.
	16000 ohms	1500 V.	— 60 V.	140 W.	280 W.
203 H's 203A's or 211's	6900 ohms	1000 V.	— 35 V.	200 W.	400 W.
	9000 ohms	1250 V.	— 45 V.	260 W.	520 W.
838's	7600 ohms	1000 V.	0	200 W.	400 W.
	11200 ohms	1250 V.	— 16 V.	260 W.	520 W.
805's	6700 ohms	1250 V.	0	300 W.	600 W.
HK 354's	10000 ohms	1500 V.	— 125 V.	280 W.	560 W.
HF-100's	7000 ohms	1000 V.	— 35 V.	200 W.	400 W.
	12000 ohms	1500 V.	— 52 V.	260 W.	520 W.
ZB-120's	4800 ohms	750 V.	0	150 W.	300 W.
	7000 ohms	1000 V.	0	200 W.	400 W.
	9000 ohms	1250 V.	0	245 W.	490 W.
	11000 ohms	1500 V.	— 9 V.	300 W.	600 W.
808's	13000 ohms	1250 V.	— 15 V.	190 W.	380 W.
100-TH's	5200 ohms	1000 V.	0	200 W.	400 W.
	7200 ohms	1250 V.	0	250 W.	500 W.
	9600 ohms	1500 V.	— 22 V.	300 W.	600 W.
100-TL's	5000 ohms	1000 V.	0	210 W.	420 W.
	10000 ohms	1500 V.	— 22 V.	300 W.	600 W.
811's	15000 ohms	1250 V.	0	175 W.	350 W.
811's	18000 ohms	1500 V.	— 9 V.	225 W.	450 W.
812's	15000 ohms	1250 V.	— 36 V.	175 W.	350 W.
812's	18000 ohms	1500 V.	— 46 V.	225 W.	450 W.
TZ40	9000 ohms	1000 V.	0	150 W.	300 W.
TZ40	6900 ohms	1000 V.	0	175 W.	350 W.
HK54	12500 ohms	1500 V.	— 45 V.	200 W.	400 W.

CVM-5 — 600 Watts

Modulator Tubes	Modulator Plate to Plate Load Imped.	Plate Volts	Bias Volts	AF Power Output	Class C DC Watts Input
203 H's, 203 A's or 211's	9000 ohms	1250 V.	— 45 V.	260 W.	520 W.
838's	11200 ohms	1250 V.	— 16 V.	260 W.	520 W.
805's	6700 ohms	1250 V.	0	300 W.	600 W.
	8200 ohms	1500 V.	— 16 V.	370 W.	740 W.
203H	10000 ohms	1750 V.	— 65 V.	370 W.	740 W.
	15000 ohms	2000 V.	— 75 V.	450 W.	900 W.
204A or HF 300	7800 ohms	1500 V.	— 40 V.	400 W.	800 W.
	8200 ohms	1750 V.	— 50 V.	500 W.	1 KW.
	8800 ohms	2000 V.	— 60 V.	600 W.	1200W.
	13120 ohms	2500 V.	— 85 V.	650 W.	1300W.
4-203A's	4500 ohms	1250 V.	— 45 V.	500 W.	1 KW.
4-838's	5600 ohms	1250 V.	— 16 V.	500 W.	1 KW.
4-805's	3350 ohms	1250 V.	0	600 W.	1200W.
HK 354's	15000 ohms	2000 V.	— 175 V.	370 W.	740 W.
	17500 ohms	2500 V.	— 225 V.	460 W.	920 W.
HF-100	16000 ohms	1750 V.	— 62 V.	350 W.	700 W.
HF-200	11000 ohms	2000 V.	— 92 V.	500 W.	1000W.
100-TH	16000 ohms	2000 V.	Adj.	380 W.	760 W.
	22000 ohms	2500 V.	Adj.	460 W.	920 W.
250-TH	2360 ohms	1000 V.	0	350 W.	700 W.
	3280 ohms	1250 V.	0	540 W.	1080W.
	4200 ohms	1500 V.	0	650 W.	1300W.
	6600 ohms	1500 V.	— 30 V.	500 W.	1000W.
813 Class AB_2 EC2 = 750 V.	16000 ohms	2000 V.	— 90 V.	455 W.	910 W.
	18500 ohms	2250 V.	— 90 V.	515 W.	1030W.
4-125A Class AB_2 EC2 = 350 V.	7200 ohms	1500 V.	— 41 V.	350 W.	700 W.
	13600 ohms	2000 V.	— 45 V.	350 W.	700 W.
	22200 ohms	2500 V.	— 43 V.	400 W.	800 W.
4-250A Class AB_2 EC2 = 300 V.	6250 ohms	1500 V.	— 64 V.	310 W.	620 W.
	9170 ohms	2000 V.	— 88 V.	460 W.	920 W.
	11400 ohms	2500 V.	— 90 V.	625 W.	1250W.

DRIVER VARIMATCH UNITS

Another application where impedance matching must be considered is in driver transformers for class AB and class B amplifiers. Since in a class B amplifier only one-half of the input transformer secondary functions at a time, impedance matching must be considered from the total primary to one-half of the secondary.

To make our analysis simple, let us assume that we have a perfect transformer of the correct ratio for the purpose intended. The impedance reflected into the grid circuit will be equal to the impedance ratio (total primary to ½ secondary) multiplied by the source impedance. It is desirable to keep this impedance as reflected in the grid circuit much lower than the impedance to which the grid is driven at high levels. That is, if our grid drops from infinity to 200 ohms at maximum output, the reflected impedance, which the transformer shows in the grid circuit, should preferably not exceed more than a fraction of this 200 ohms.

As an example, let us take the case of an amplifier using type 46 tubes, operating in class B. If we check back to a typical transformer for these tubes, we find a ratio, total primary to ½ secondary, of 3.2. Since this is the voltage ratio, it must be squared to obtain the impedance ratio, which we find to be 10. If we use a 46 driver, the source impedance would be 2380 ohms. Dividing 2380 by 10, we obtain a reflected impedance in the grid circuit of 238 ohms. **The lower we can make this impedance, the further we can drive our output tubes with low grid distortion.**

While it is possible to obtain a lower grid impedance by increasing the step down ratio of our transformer, this cannot be carried too far, as a definite amount of grid driving voltage is necessary. It is also possible to obtain the same effect by using the same transformer and changing our driver tube. Let us assume that we use the same transformer with a 2A3 tube. Since the plate impedance of this tube is approximately 800 ohms and the impedance ratio of our transformer is 10, the reflected impedance in the grid circuit would be only 80 ohms. This is much less than that obtained with the 46 driver.

The use of pentodes and other high mu tubes has been frequently recommended for class B driver service. An analysis of the above paragraphs will immediately show the fallacy of this. A typical mistake in this respect is the recommendation of the 6L6 tube as a driver for high power class B systems. Since the plate resistance of this tube is 24,000 ohms, it is readily seen that the reflected impedance will be 30 times as great as that obtainable with a 2A3 tube having 800 ohms resistance. The very high impedance which the 6L6 would reflect into the grid circuit of our class B tubes would limit their power appreciably; in some cases to less than half that obtainable by using the 2A3 tube.

The UTC Varimatch driver transformers are tapped to afford various impedance ratios so that optimum operation can be obtained for a given combination of driver and output tubes.

VARIMATCH UNITS FOR PUBLIC ADDRESS SERVICE

Tubes used in PA equipment have increased considerably in number during the past few years. It is only natural that PA amplifiers be changed over to new tubes such as the beam power tubes as they become available. To eliminate obsolescence and also for use on special PA equipment, where universal matching is essential, the UTC PA Varimatch transformers have been designed. These units have secondary impedances for voice coils and lines and have a tapped primary arrangement covering many impedance combinations.

PA VARIMATCH TRANSFORMERS

UTC PA Varimatch transformers are designed with universal tapped primaries which will match practically any PA output tubes. The available connections for the CVP 1, 2, 3, 4 and 5 are as follows:

Pri. Impedance	Join	Connect to
14,000 ohms	3 to 4; 6 to 7	1-5-9 (P-B-P)
10,000 ohms	2 to 4; 6 to 8	1-5-9 (P-B-P)
8,000 ohms	———	4-5-6 (P-B-P)
7,000 ohms	1 to 4	2-6 (P-B)
6,000 ohms	1 to 4; 6 to 9	2-5-8 (P-B-P)
5,000 ohms	2 to 4; 6 to 8	3-5-7 (P-B-P)
3,000 ohms	1 to 4; 6 to 9	3-5-7 (P-B-P)

Sec. Load	Connect to	Sec. Load	Connect to
500 ohms	10 & 12	8 ohms	A & C
200 ohms	10 & 11	5 ohms	B & D
50 ohms	11 & 12	3 ohms	A & B
16 ohms	A & D	1.5 ohms	C & D

Typical tube combinations that are taken care of by these primary impedances are:

14,000 ohms—Pushpull 47's, 2A5's, 42's, and other similar pentodes
10,000 ohms—Pushpull 59 triodes, 71A's, 6B5's, 6F6 pentodes, and Class B 6A6, 19, 53, 49, 79, 89
8,000 ohms—Pushpull 250's, 245's, 43's, 2A5 triodes, 42 triodes, etc.
7,000 ohms—Single 2A5 pentode, 42 pentode, 31 triode, 33 pentode, 47 pentode, 89 pentode
6,000 ohms—Class B pushpull 46's, 59's, 6F6's fixed bias, 6L6's AB_1, single 31, 46, 59 pentode
5,000 ohms—Pushpull self bias 2A3's, 6A3's, 6L6's at 250 volts 46's at 300 volts
3,000 ohms—Pushpull fixed bias 2A3's, 6A3's

Impedances differing somewhat from the impedances noted above can be accommodated by the primary winding. A corresponding change is obtained in the secondary output impedance. In other words, if pushpull 6L6's were used at the 400 volt operating condition, the matching impedance is 6600 ohms. The 6000 ohm connections would be used for this application with the result that all secondary impedances would be increased 10%. In other words, the 5 ohm connection would be 5.5 ohms; the 200 ohm connection, 220 ohms, etc. In a similar manner, the secondary impedances can be changed up to 30% from the normal value with a corresponding change in the primary impedance. For example, if a 6 ohm voice coil were connected across the 5 ohm taps, then the primary impedance shown would be multiplied by 6. In other words, the 5000 ohm plate

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5

to plate connection would become 6000 ohms.

LINE VARIMATCH TRANSFORMERS

UTC Line Varimatch Transformers are designed to match voice coil impedances to a 500 ohm line, where the speakers are located at some distance from the audio amplifier. The voice coil impedances available on these units range from .1 to 30 ohms, so that any speaker or group of speakers can be matched (see chart). Where speakers are to be connected in groups to one transformer, it is always preferable that parallel connection be used to eliminate the possibility of multiple resonance. It is also important to remember that if two speakers of different impedances are connected in parallel, the lower impedance speaker will develop greater power. If connected in series, the higher impedance speaker will develop greater power.

The effective impedance of a group of speakers connected to one transformer can be calculated in the following manner:

For speakers in series, add all the impedances. For example, the effective impedance of a 2 ohm and two 4 ohm speakers in series is $2 + 4 + 4 = 10$ ohms.

For identical speakers in parallel, divide the impedance of one speaker by the number of speakers used. In other words three 15 ohm speakers in parallel would have an effective impedance of $\frac{15}{3} = 5$ ohms.

For two different speakers in parallel, divide the product of their impedances by the sum of their impedances. That is, the impedance of a 4 and 12 ohm speaker in parallel would be $\frac{4 \times 12}{4 + 12} = 3$ ohms.

For a number of different speakers in parallel, add the reciprocals of the individual impedances and then take the reciprocal of this sum. If three speakers having impedances of 2, 4 and 8 ohms were connected in parallel the impedance would be $\frac{1}{1/2 + 1/4 + 1/8} = \frac{1}{.875} = 1.1$ ohms.

PARALLELING LINE VARIMATCH UNITS

If the individual speakers or groups of speakers are located at some distance from each other, separate Line Varimatch transformers must be used. The 500 ohm output of these units can then be connected in parallel to the amplifier. A single speaker, four speakers in series parallel, or nine speakers in three series—three parallel groups, will effect a direct 500 ohm impedance for matching to the amplifier. For other combinations, the 500 ohm outputs of the LVM units should be connected in parallel and then matched to the amplifier by using the correct tap on a Line Varimatch Autoformer unit. The autotransformer is tapped at 500, 250, 167, 125, 100, 83, 71, 62, 55, and 50 ohms for from 1 to ten 500 ohm lines in parallel respectively.

LINE VARIMATCH IMPEDANCE COMBINATIONS

CVL 1-2-3

Connect Voice Coil to	join	also join	Voice Coil Impedance with 500 ohms connected to A&B	Voice Coil Impedance with 500 ohms connected to B&C*	Voice Coil Impedance with 500 ohms connected to A&C
2 and 3	2 to 6	3 to 7	.4	2.5	.62
1 and 2	1 to 7	2 to 8	1.	6.25	.2
3 and 5	3 to 4	5 to 6	1.25	8.	1.25
1 and 3	1 to 6	3 to 8	2.5	16.	1.5
2 and 5	2 to 4	5 to 7	3.	20.	2.
1 and 8	2 to 7		4.	25.	2.25
1 and 6	2 to 4		4.5	28.	2.5
3 and 6	4 to 5		5.	31.	3.3
1 and 8	2 to 6		6.6	40.	3.8
1 and 5	1 to 4	5 to 8	7.5	47.	4.
2 and 6	4 to 5		8.	50.	5.
1 and 8	3 to 6		10.	63.	5.5
2 and 8	3 to 4		11.	69.	6.
2 and 7	4 to 5		12.	75.	7.
1 and 8	2 to 4		14.		7.5
1 and 6	4 to 5		15.		9.
1 and 8	5 to 6		18.		10.
2 and 8	4 to 5		20.		15.
1 and 8	4 to 5		30.		.5

CVL 10-11-12

Connect 500 ohm line to 1 & 10

Impedance	Connect to
50 ohms	1 & 2
62 ohms	1 & 3
71 ohms	1 & 4
83 ohms	1 & 5
100 ohms	1 & 6
125 ohms	1 & 7
167 ohms	1 & 8
250 ohms	1 & 9

* This connection gives a low frequency loss which is frequently desirable in PA work to eliminate the overloading of loud speakers with low frequency.

DRIVER TRANSFORMERS

Type No.	Primary Connections	Typical Driver Tubes	Secondary Connections	Turns Ratio Primary to ½ Sec.
CG-51AX	P-B	45, 2A3 6F6, 6L6, 6N7	G-F-F-G G'-F-F-G'	2.8:1 3.1:1
CG-53AX	P-B-P	45's, 2A3's 6L6's	G-F-F-G G'-F-F-G'	2:1 3:1
CG-59AX	500 Ohms — Connect to 1 & 5 Join 3 & 4		G-F-F-G	1:1
	200 Ohms — Connect to 2 & 5 Join 3 & 4		"	1:1.5
	50 Ohms — Connect to 4 & 5 Join 1 & 4, 2 & 5		"	1:3
	500 Ohms — Connect to 1 & 5 Join 3 & 4		G'-F-F-G'	1.4:1
	200 Ohms — Connect to 2 & 5 Join 3 & 4		"	1:1
	50 Ohms — Connect to 4 & 5 Join 1 & 4, 2 & 5		"	1:2
CG-238AX	P-B-P P'-B-P' P-B-P P'-B-P'	Push-Pull Parallel 45, 2A3 6L6	G-F-F-G G-F-F-G G'-F-F-G' G'-F-F-G'	2:1 1.55:1 3:1 2.5:1
CG-512	500 Ohms — Connect to 1 & 5 Join 3 & 4		G-F-F-G	1:2.5
	200 Ohms — Connect to 2 & 5 Join 3 & 4		"	1:3.8
	50 Ohms — Connect to 4 & 5 Join 1 & 4, 2 & 5		"	1:7.5