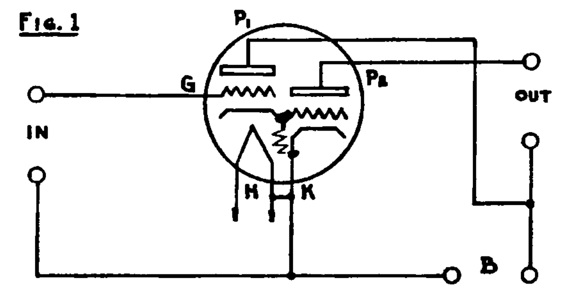
TRIADYNE 6B5

TRIAD MANUFACTURING CO., PAWTUCKET, R. I.



SINGLE TUBE CIRCUIT

FEATURING

CLASS A OPERATION

CIRCUIT SIMPLICITY

HIGHER POWER

HIGH FIDELITY

HIGH EFFICIENCY

HIGH SENSITIVITY

NO GRID CURRENT

ZERO GRID BIAS

RETARDED OVERLOAD

UNI-POTENTIAL CATHODE

FAST 6.3 VOLT HEATER

ST-14 BULB

A NEW POWER OUTPUT TUBE

The growing demand for High Fidelity fostered the development of an improved power tube. The Triadyne is the answer for a universal, efficient audio system,- one which will satisfy the requirements for small table receivers as well as the finest of consoles. Its basic operating principles are truly unique. Its circuit is the simplest ever devised. The adjacent circuit diagram is startling by the very absence of component parts. The first Triadyne is the type 6B5.

To the manufacturer of Radio and Public Address Systems, the tube simplifies his design problems. For small units, a single 6B5 will deliver up to five clean watts, and for larger units, push-pull can provide as much as twenty watts. Another remarkable fact is that it requires no driver, because its grid impedance is as high as any true Class A power tube with the result that driving tubes and their coupling transformers are eliminated, thereby affecting appreciable economy. Yet, efficiency, sensitivity, and fidelity are not compromised. The tube provides more power than any other existing tube in the same size bulb. Distortion caused by overloading is far less pronounced than with other tubes when the power rating is exceeded. Detailed information is necessary to fully appreciate these advantages.

The tube operates without bias, so that there is no need for a cathode resistor and its by-pass condenser. The cathode is simply connected directly to B - . However, this grid does not draw any current, since a grid bias is automatically developed within the tube. Thus the tube may be fed by resistance coupling. With the elimination of the bias resistor and condenser, there is no frequency discrim-

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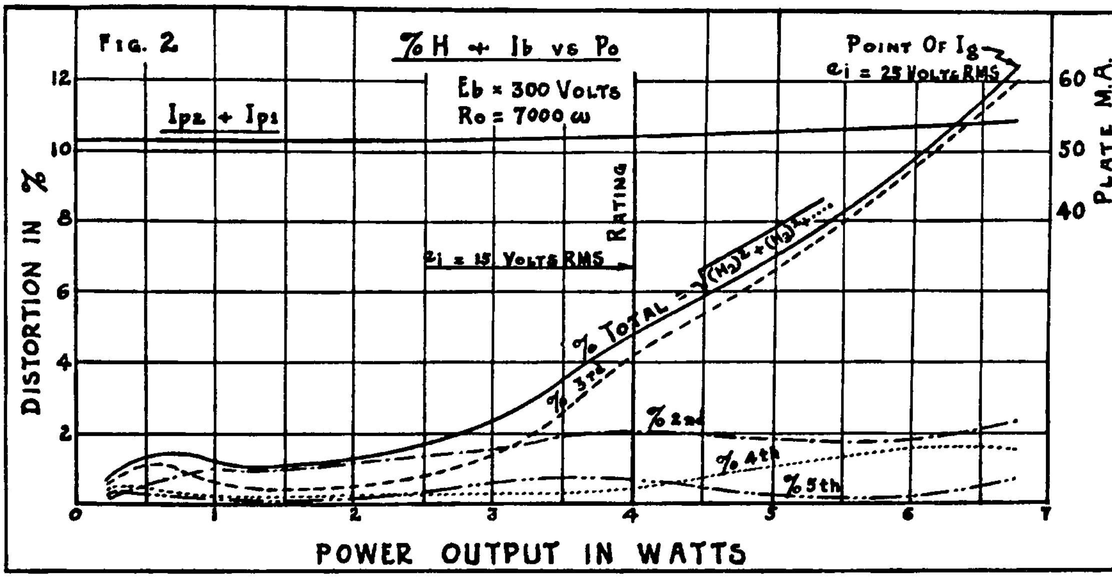
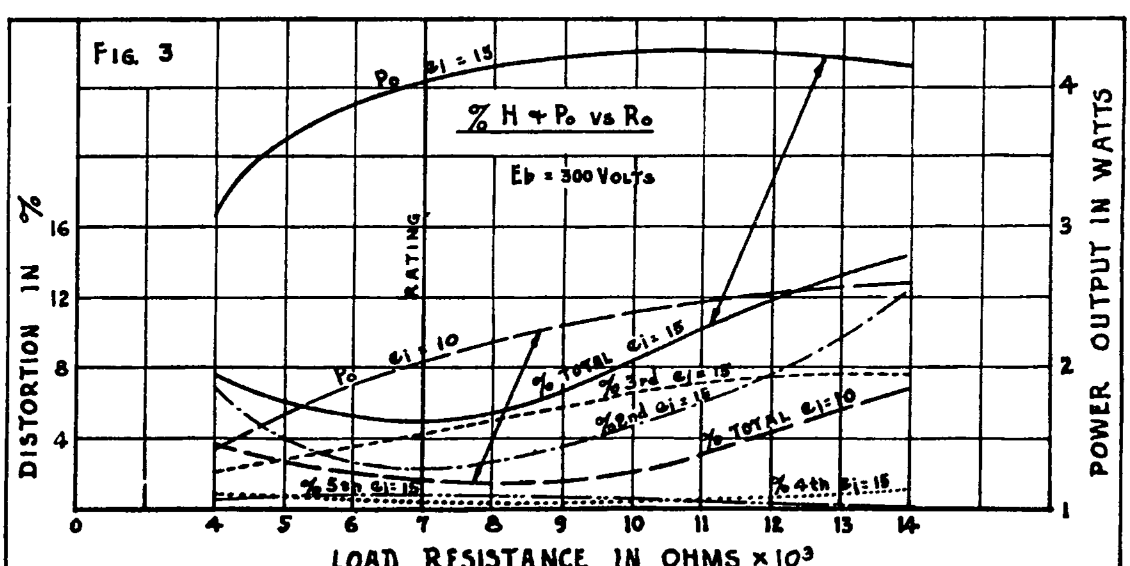
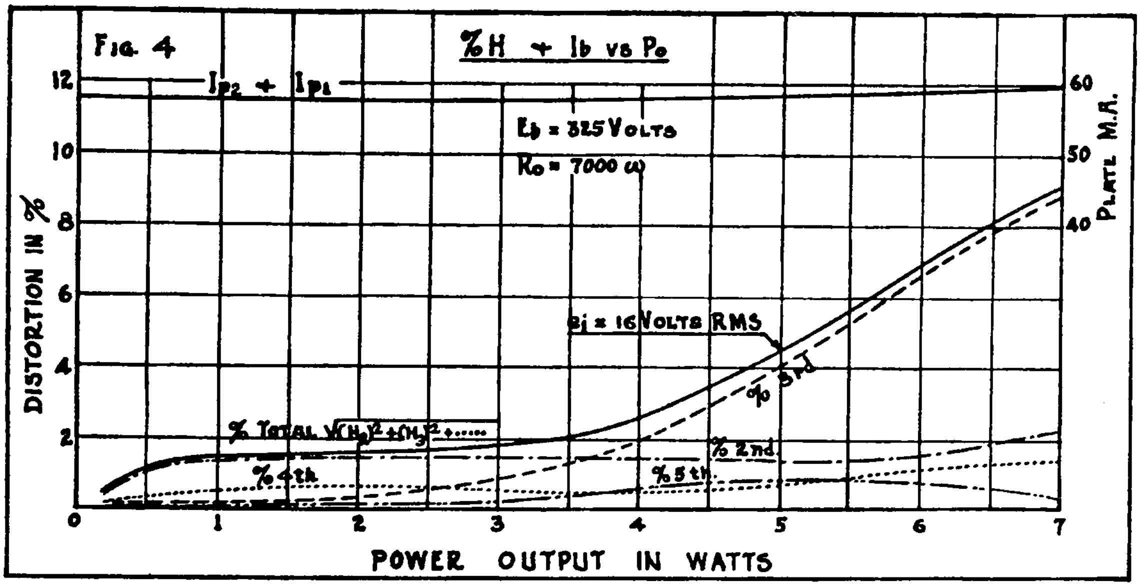


ination nor degenerative effect. Hence, the frequency characteristic is absolutely flat over the entire audio band.

The plate voltage supply for a 6B5 needs no better regulation than that of any other class A power amplifier, since this tube is operated from the center point of its plate current - grid voltage characteristic. This means that there is no appreciable increase in plate current when large signals are applied. Neither does the supply require greater filtering for a given hum output than when feeding other power tubes of equivalent sensitivity.

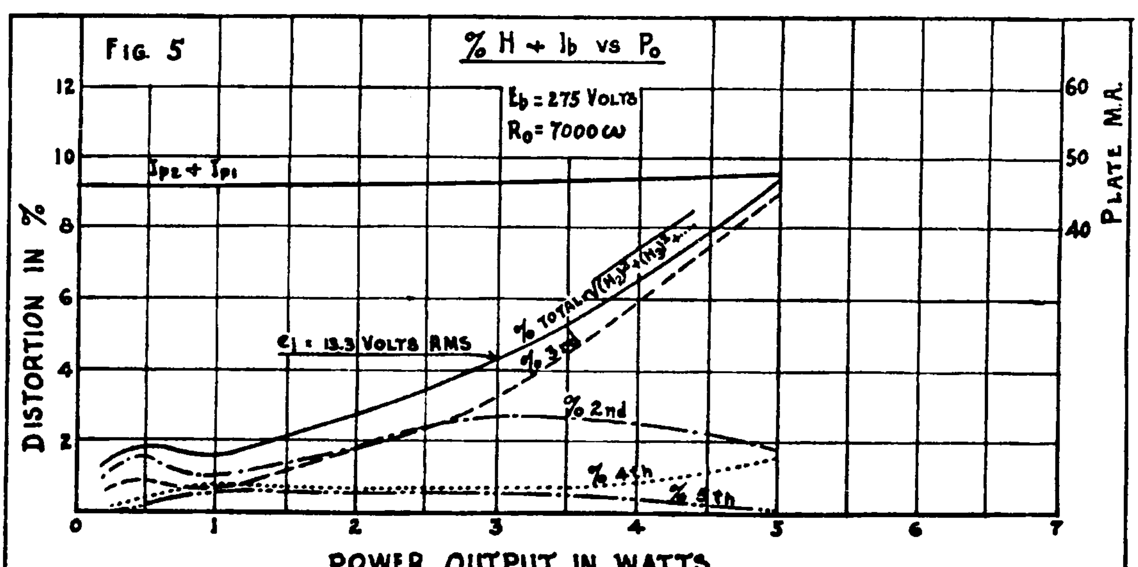
The overload characteristic is a decided improvement. The type of overload in a receiver which is decidedly objectionable occurs when the volume control is near maximum. Here peak signals produce spurts of grid current which cause unbearable squawking. Now with most output tubes, grid current flows as soon as the rating is slightly exceeded, but this is not true with the 6B5. The signal can actually increase more than 60% above the rating before the tube draws grid current. This advantage considerably retards the overload crashing. It also permits

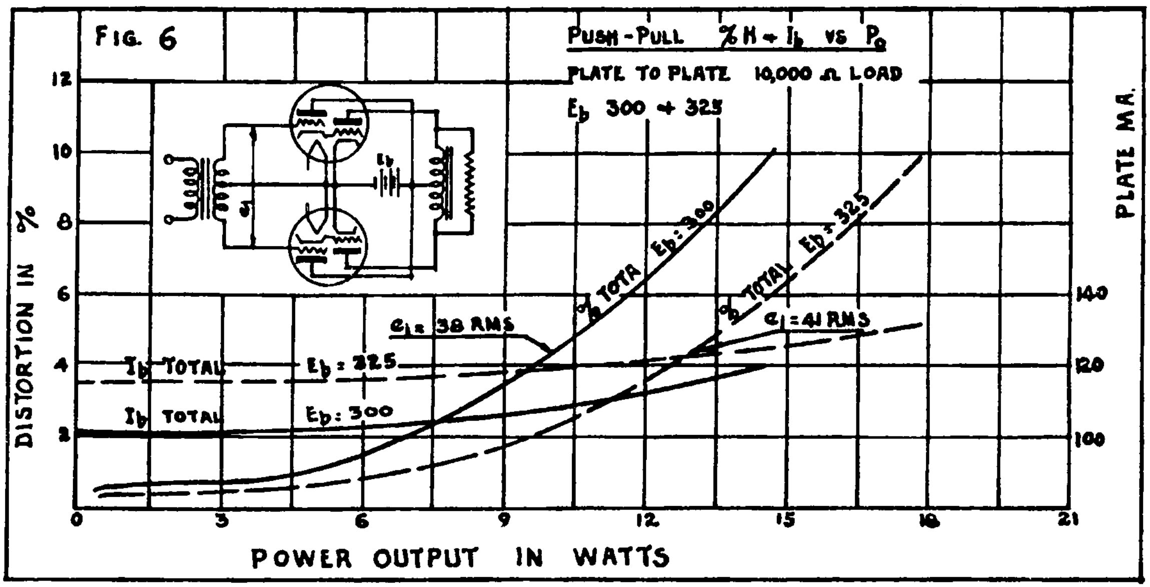




practical operation of resistance coupled push-pull. This retarded overload performance is clearly indicated in Fig. 2, - the distortion versus power output curve for 300 volt operation. Note that even when the input is increased far above the rating, considerable additional power output is available without objectionable distortion. The rated signal of only 15 volts amounts to a power sensitivity practically that of a pentode. The slight change in total plate current for full power output is also indicated.

Fig. 3 shows the power and distortion performance when the load resistance is varied over a wide range while the input signal is held constant. These curves were taken at two different signal levels. By inspection, it may be seen that the optimum load is 7000 ohms. The power does not fall off rapidly, typical of triode operation; nor does it rise, like a pentode. Therefore, a compromise is obtained between the falling triode and the increasing pentode characteristics. Hence, when the reflected speaker load is varying with the signal frequency, the high passages are not so rapidly lost nor are they objectionably exaggerated. Also the only harmonic that climbs at any appreciable rate with increasing load

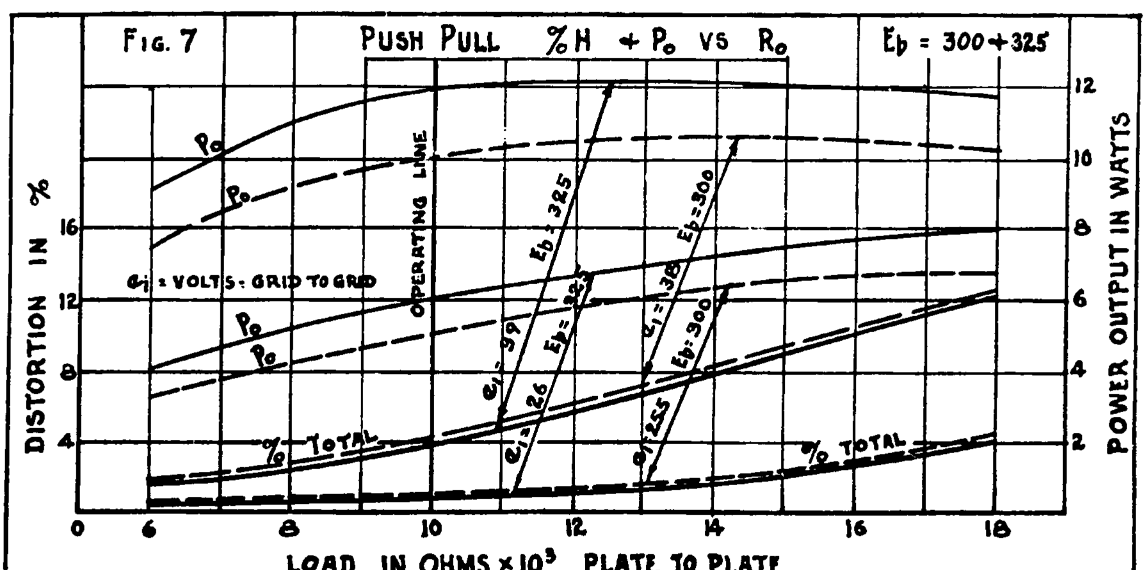


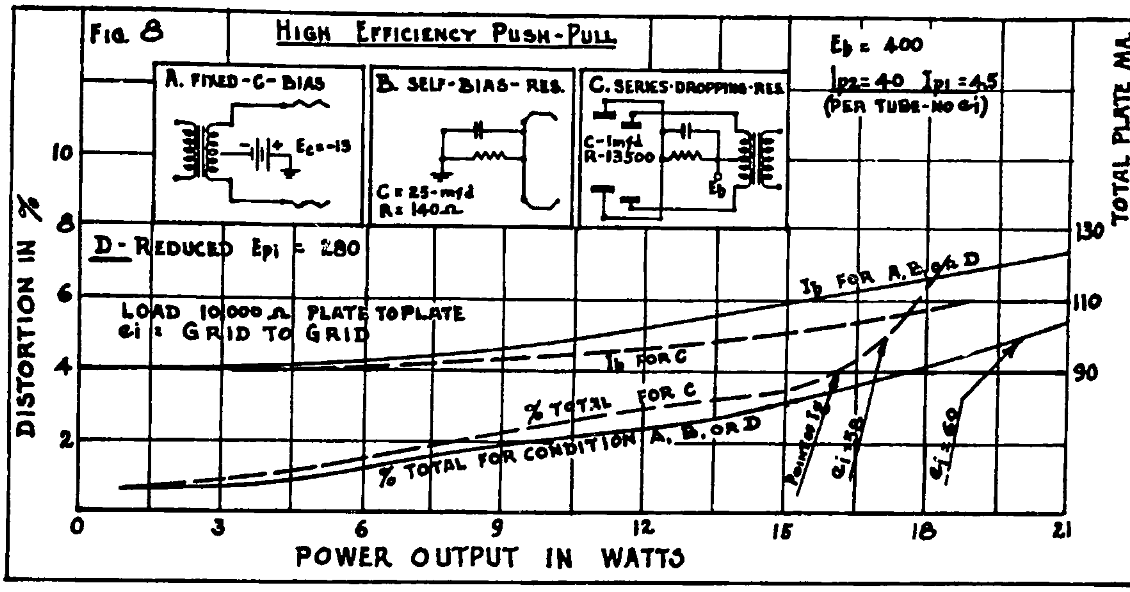


impedance is the second. These conditions aid in minimizing the transient response of the speaker. This means that overemphasis of audio peaks, occuring when the speaker resonates, will be diminished.

Performance at plate supply voltages of 325 and 275 are shown by Fig. 4 and 5 respectively. The same data as in Fig. 2 was taken with different supply voltage. 325 volt operation is the highest which may be safely recommended for ordinary operation. Its fine performance is readily appreciated when it is seen that 3.5 watts can be obtained at about 2% total distortion, 5 watts at 4.5%, and 7 watts at 9%.

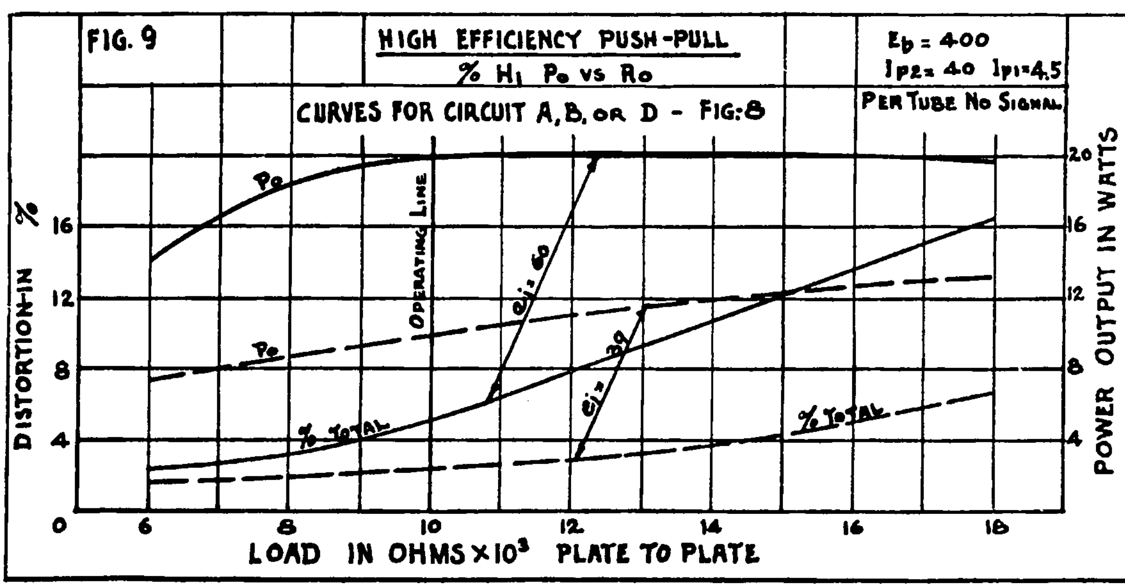
Naturally, the tubes can be used in push-pull. The simple circuit is given in Fig. 6. Again it is repeated that the grids do not take current. Thus the input transformer's secondary may be a high impedance type or resistance coupled input may be substituted for the transformer. This permits the practical employment of phase inverter circuits. The output device shown in the circuit is merely present to indicate the type of load used when taking the measurements.





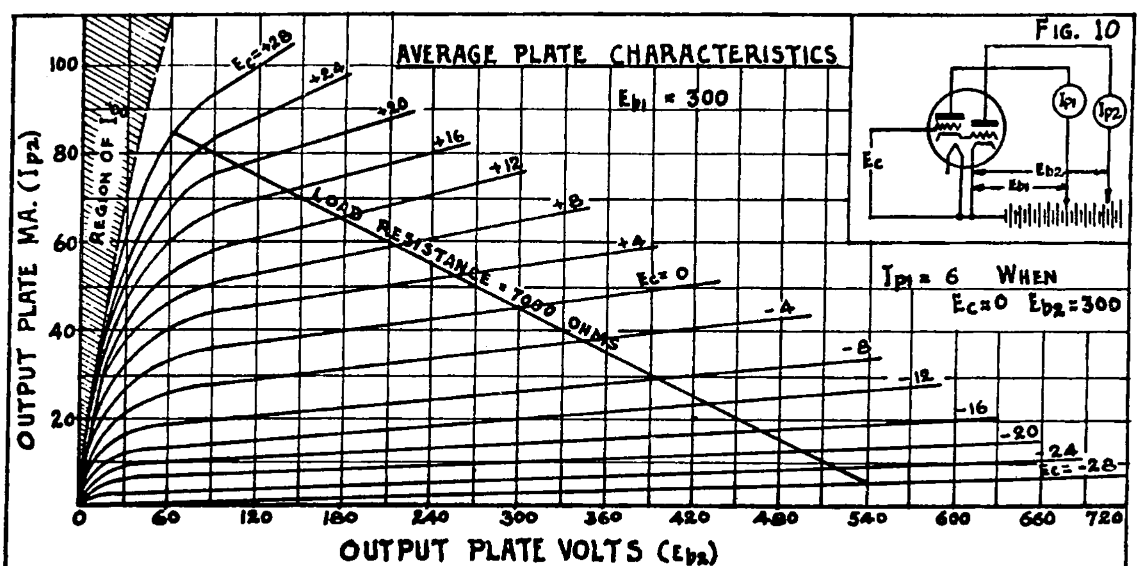
Of course, in actual operation, the usual output transformer is used. The impedance of this transformer should provide a 10,000 ohm load from plate to plate. The distortion curves are given for both 300 and 325 plate volt operation. Since the total distortion values are made up almost entirely of third harmonic, the individual harmonics have been left out purposely. Fig. 7 shows that the optimum load is 10,000 ohms. This is less than twice that recommended for single tube. Such a value can be used because of the Triadyne's harmonic distribution and the cancellation of even harmonics.

In systems where 20 watts or more are desired, the "High Efficiency Push-Pull" circuit is recommended, - Fig. 8. Here the output plates operate at 400 volts but the output plate current in each tube is held down to 40 mils at zero input signal. This amounts to 16 watts static dissipation per plate, and the dynamic plate dissipation is somewhat less. The plate heat is, therefore, no greater than when operating normally at 325 volts. Some means must be used to restrict the plate current. This can be accomplished by providing an external bias for the grid or by lowering the input plate voltage. The solid line distortion



curve of Fig. 8 shows the performance when operating under three different conditions; A, B, or D. Condition A is simply a "C" voltage in series with the center tap of the input transformer. It is represented by a battery, but naturally, it may be taken from a bleeder circuit in the power pack. Condition B supplies the same voltage by using a self-biasing resistor. The 140 ohm resistor is connected between the two cathodes and ground or B-. A by-pass condenser is necessary to surpress distortion which is introduced if an audio voltage appears across the resistor. However, since the sensitivity of the circuit is not perceptibly affected even when the by-passing is removed, the frequency characteristic is independent of the value of the condenser. A 25 mfd., condenser is all that is necessary for good quality. Condition D is for reduced input plate voltage; - that is, 280 volts. This voltage can be taken from a voltage divider on the power pack. It is interesting to note that the distortion vs power performance is the same for these three conditions. Even with the full twenty watts at 5%, the point of grid current has not yet been reached. The other distortion curve is included to show what may be expected if the input plate voltage is lowered by a series dropping resistor; - the condition C. Note that this method does not develop the power of the others. Further, increasing the capacity of the by-pass offers but little advantage. This condition is included to demonstrate what not to do. In this high efficiency system, the total plate current rises with increasing power output. However, since the total increase is only 25%, the regulation required of the power pack is even less than with other popular systems delivering equivalent power. Fig. 9 shows that a 10,000 ohm load from plate to plate is also an optimum condition for this High Efficiency circuit. When greater power is desired, the Triadynes should be used in push-pull parallel.

The usual family of plate characteristics are given in Figure 10. These are particularly interesting for they show the region wherein grid current flows and that high positive voltages may be put on the grid without swinging into this region. The average characteristics for the 6B5 follow:-



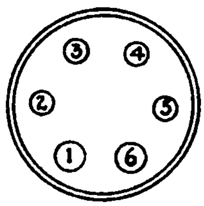
PHYSICAL DIMENSIONS

Max. Length	4-11/16"
Max. Diameter	1-13/16"
Bulb	ST-14
Base	Medium 6-Pin

6B5 AVERAGE ELECTRICAL CHARACTERISTICS

Heater *	Coated Uni-potential Cathode	
Voltage	6.3	a-c or d-c volts
Current	0.8	amperes

BASE CONNECTIONS



Bottom View of Base

Pin 1-Heater
Pin 2-Output Plate (p_2)
Pin 3-Input Plate (p_1)
Pin 4-Input Grid
Pin 5-Cathode
Pin 6-Heater

AMPLIFIER RATINGS (CLASS A)

Output Plate (p_2)	300	volts
Input Plate (p_1)	300	volts
Grid Bias	0	volts
Output Plate Current	45	m.a.
Input Plate Current	6.0	m.a.
Amplification Factor	58	
Plate Resistance	24,100	ohms
Mutual Conductance	2,400	micromhos
SINGLE TUBE		
Load Resistance	7,000	ohms
** Power Output	4.0	watts
Input volts for rated power	15	r.m.s.
PUSH-PULL		
Load Resistance (plate to plate)	10,000	ohms
** Power Output	10	watts
Input Volts for rated power (grid to grid)	38	r.m.s.

HIGH EFFICIENCY PUSH-PULL

Plate Supply	400	volts
Fixed Grid Bias	-13	volts
Or, Self-Bias Resistor (shunted by 25 mfd.)	140	ohms
Or, Reduction of input plate voltage to	280	volts
Static P_2 Current (per tube)	40	m.a.
Static P_1 Current (per tube)	4.5	m.a.
Load Resistance (plate to plate)	10,000	ohms
** Power Output	20	watts
Input Volts for rated power (grid to grid)	60	r.m.s.

** 5% total harmonic distortion.

If a grid coupling resistor is used, its maximum value should not exceed 0.5 megohm.

* The potential difference between heater and cathode should not exceed 50 volts and in no case should the heater be left floating.

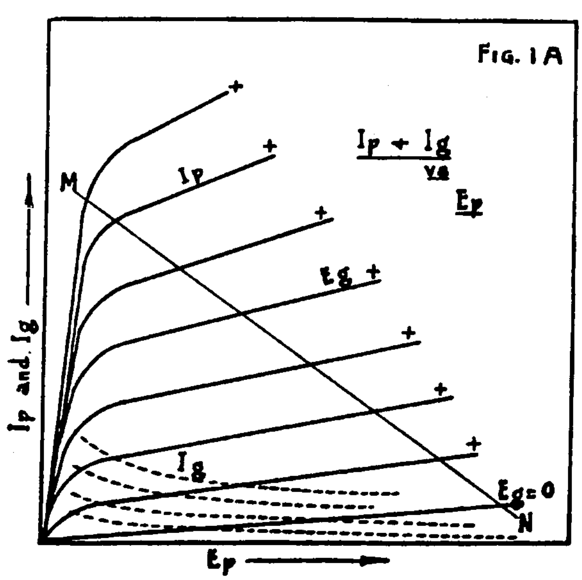
From the foregoing, it is evident that existing receivers may be easily adapted to make use of the Triadyne's advantages. High fidelity triode, Class A-B, and Class B systems may be greatly simplified and, in most cases, the performance will be improved. In quality auto sets, the tube will also find a place. As a replacement tube, the service man will find many sockets where the Triadyne may fit. Sets using a Type 42 pentode will easily accommodate a 6B5 by simply eliminating the grid bias. Such a substitution is especially effective because the sensitivity and speaker load is almost identical for both tubes. The slightly higher current drain of the new tube will have no affect on the operation of most sets. A fundamental explanation of the tube's internal operation has so far been avoided in order not to burden the reader who might not be interested in such a discussion. For those who are interested, the explanation follows.

FUNDAMENTAL EXPLANATION

The basic principles of the tube's operation are simple but due to its newness an explanation would be somewhat confusing if this discussion were started by describing the finished product rather than the logical sequence in the development process.

In the first place, what is the purpose? An attempt to obtain high power, efficiency, good sensitivity, low distortion and all of this at low cost. Pentodes and Class B systems fail to meet some of these requirements. Class A triodes are unsatisfactory due to low plate efficiency and low sensitivity. Their low plate efficiency, the ratio of audio power to d-c plate power, is due to the relatively high plate voltage that is necessary to obtain an appreciable plate current swing which must be restricted to the negative portion of the Ip vs Eg characteristic.

It would seem, therefore, that one possibility of obtaining high efficiency would be to design a triode operating without a negative grid field, that is, a tube which will have only a positive Ip-Eg characteristic so that the same plate current swings can be obtained at a much lower plate voltage. This can be accomplished by increasing the mu of the tube so that very little current is present when the grid is at zero potential. This will also provide high sensitivity. Such a tube would have plate characteristics similar to those in Fig. 1A. Particularly, note that the curves are for zero and positive values of grid voltage. Now, of course, a positive grid draws current so that the grid action of swinging the plate current is no longer a simple field voltage relation. Consequently, power is required in the grid circuit to swing the plate current. A few grid current curves are also shown in Fig. 1A. Ip vs Eg and Ig vs Eg curves may be plotted from these characteristics by the usual method of representing an optimum plate load resistance by the load line, MN. The result is shown in Fig. 2A.



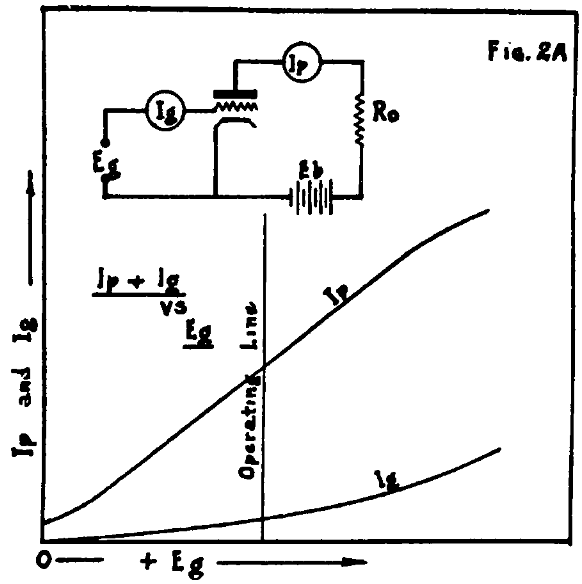


Fig. 2A

It is at once apparent that over a considerable portion, there is good linearity of plate current as a function of grid voltage, but grid current versus grid voltage is something far different. This grid current curvature means that the grid impedance of this tube is not a constant value. Further, the design limitations of such plate characteristics necessitate a relatively low average grid impedance.

Now in order to have low distortion, a voltage must be impressed on this grid by some method which will be little affected by this varying impedance. The usual method of supplying grid power by a driver stage and a coupling transformer is unsatisfactory due to high distortion as well as high cost.

This problem is answered by direct coupling of driver to output tube. A driver, whose plate impedance would be low enough to match the average grid impedance load, will not be considered since such a design is impractical, chiefly because it would necessitate excessive physical proportions. Consequently, a step-down ratio must be used.

First then, suppose an ordinary triode is working into a load much lower than its plate impedance, but instead of this load being in its usual location; that is, between plate and B+; the plate is tied directly to B+ and the load is placed between cathode and ground. This load will be represented by a resistor, and of course, the d-c drop across this resistor, when no signal is on the grid, produces a negative bias similar to usual self-biasing. The question is - how would the voltage developed across this resistor vary with respect to input volts? This is graphically shown in Fig. 3A, curve A-B. Fair linearity is present. This is much better than should ordinarily be expected when it is realized that the resistance value used was approximately one fifth the plate impedance of the triode. This is explained by the fact that the circuit is degenerative, as the developed voltage appears as part of the input circuit and both voltages are in phase with respect to ground. In other words, the voltage appearing directly across the grid to cathode at any instant is always equal to the input voltage minus the voltage across the resistor. The greater distortion that would be present if the circuit were not degenerative is indicated by the curvature of C-D, Fig. 3A, which represents the performance when the input signal is impressed between grid and cathode.

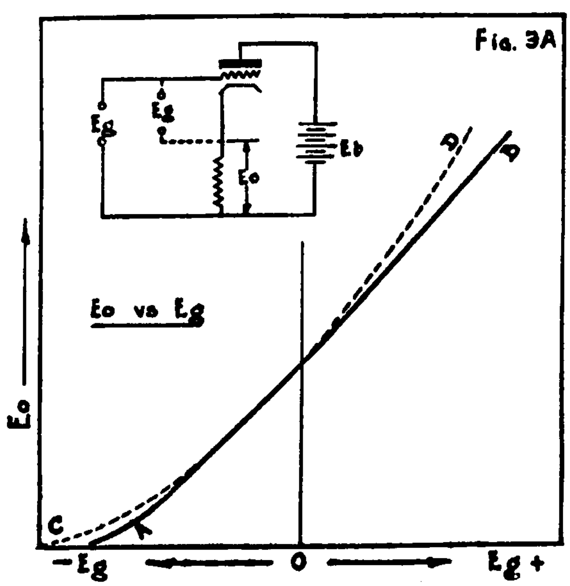
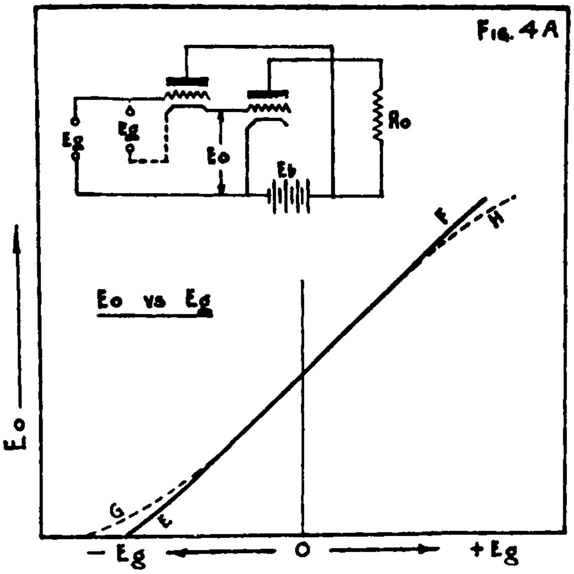


Fig. 3A

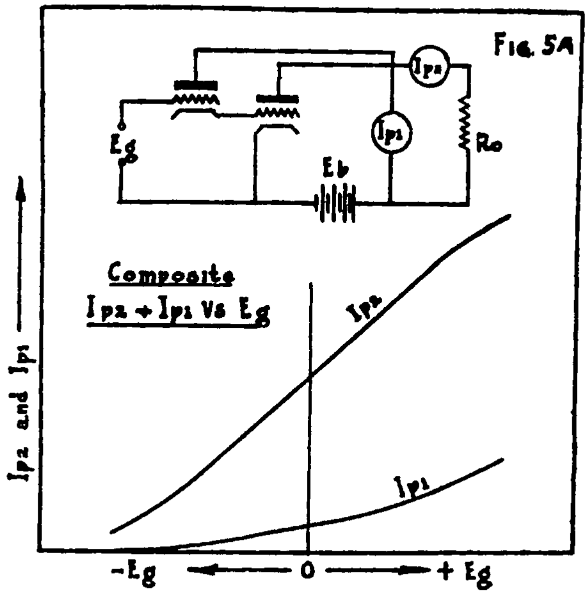


The bias voltage necessary to duplicate the plate current when Eg equals zero has been purposely omitted from the circuit drawing for the sake of simplicity. Incidentally, the input voltage scale was made one third that for the curve A-B, as then the slope of the two curves more nearly coincide which makes it easier to compare curvature. By introducing degeneration, then, it is possible to operate into a low impedance with much less distortion.

This fact suggests the possibility of using a triode for driving where its load will be between cathode and ground. Suppose the grid-cathode impedance of the output tube previously described is substituted for the resistor, as shown in Fig. 4 A. Then the voltage drop across this impedance becomes the negative bias for the grid of the input section in the same manner as when the resistor load was used, and correspondingly, it becomes the positive bias for the output grid. Also this bias establishes the operating point for the Ip vs Eg characteristic of the output section. In designing, the desired positive bias is determined by selecting the midpoint of the Ip vs Eg curve, Fig. 2A. At this voltage, the value of grid current is determined, and the driver is simply designed so that at a negative bias equal to the selected positive bias, the driver's plate current will equal the output grid current. So much for the static current-voltage relationship.

The question now arises, how will the voltage appearing across the grid-cathode impedance vary with respect to the voltage on the driver? Curve E-F, Fig. 4A, shows the performance. The linearity is excellent. The curve G-H is included to show the relation without degeneration, and again, the greater curvature is plainly evident. Note that both curves are considerably straighter than those when a resistor load was used, Fig. 3A. This statement certainly needs clarifying because the grid-cathode impedance is not a simple fixed value as was the resistor. It is actually a varying load, for the grid current does not vary lineally with applied voltage as previously shown by the Ig curve, Fig. 2A. The reason why this changing load has an advantageous effect can be explained as follows. When a triode works into a step-down load its Ip vs Eg characteristic has pronounced curvature. Thus the plate impedance is not a linear function of the input signal. If the load impedance could be made to vary such that it maintained a constant ratio with the plate impedance throughout the signal excursion, the output voltage would become an exact replica of the input signal. In this system, the grid impedance of the output section provides a load which varies in the required manner. Also, this circuit's phase relation is such that both the plate impedance of the driver and the grid cathode impedance of the output section varies in the same direction, - that is, in sympathy with each other. Consequently, a nearly constant ratio is maintained throughout the signal excursion.

So it has been shown that the output section's plate current versus grid voltage relation is linear. Further, it has been shown that a driver can be made to produce voltage across the grid impedance of the output section which will be linear with respect to its input voltage. Thus the composite relation of out-



put plate current to input volts should likewise be linear. This is precisely the final result, see the Ip2 curve, Fig. 5A.

This curve also indicates that a signal applied to the input grid will produce equal negative and positive peaks of Ip2. Therefore, this sytem's power supply regulation is no different from that required for a Class A triode.

The unequal peak currents of the driver, as represented by the Ip1 curve Fig. 5A, are of such low magnitude that their effect can be neglected.

It should be clearly understood that no power is required in the driver grid circuit. Power developed by the entire linear portion of the Ip2 curve is realized long before the input grid is swung far enough to draw current;- that is, becomes positive with respect to its cathode. This unique grid overload characteristic functions as follows. When Eg (the signal input voltage) is zero, Eo (the voltage across input cathode and ground) is the static bias of the tube. At positive values of Eg, Eo rises beyond the established bias at a rate dependent upon the gain of the driver. Since the gain of the driver must be less than unity due to the degenerative action of the circuit, the increase in Eg is faster than the increase in Eo. Not until Eg overtakes Eo, will the grid draw current.

With these fundamental principles qualitatively established, it appears possible to design a single tube, comprising both sections, which would have the desired characteristics. In spite of the power required by the driver, the overall plate efficiency of the combination would be high. The overall sensitivity would be well up because the loss due to degeneration in the driver would be well overbalanced by the high gain of the output section. The distortion would be low, and void of high frequency transient terms since there are no discontinuities in the characteristic curves. The simplicity of the arrangement is conspicuous by the absence of the usual circuit component parts.

The above theory is thoroughly confirmed by the result of this development - - the new Triadyne 6B5. Both the characteristic and curve data for this tube is the quantitative proof.

TRIAD MANUFACTURING CO., INC.

FACTS OF INTEREST REGARDING THE COMPANY BEHIND THE PRODUCT

This ownership management has been pioneering in Radio advancement since 1920 with the result that today we are one of very few in the entire industry and the only privately owned manufacturing company making a complete line of radio tubes.

A complete modern laboratory including radio circuit development is maintained for cooperation with set manufacturers the world over, and to this are given the services of a large staff of renowned engineers.

Close supervision of our business and an intimate understanding of the problems of our customers achieved the remarkable sales record in 1934 of 100% gain over 1933.

Complete warehouse stocks are maintained at branch offices in Chicago, New York, Los Angeles and Seattle for the prompt servicing of Triad customers. Year in and year out, Triad has made steady forward strides because of our policy of customer satisfaction first, last and always.

We dedicate ourselves not only to our customers and own improvement, but to the betterment of the entire industry.

TRIAD MANUFACTURING CO., INC.

Factory and Home Office

#18A

Radio Manufacturers Association

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R.M.A. DATA BUREAU
90 West Street
New York, N. Y.

RELEASE NO. 18A

SEP 29 1939

To
Tube Engineers:

The inclusion of a resistor in the structure of the 6B5 requires the modification of the basing designation applicable to this tube type.

As originally announced, the assigned basing designation was 6D.

To the modified basing the designation 6AS has been assigned.

Respectfully yours,

RMA DATA BUREAU

By: L.C.F. Horle