THE MARCH OF TELEVISION

# RADIO NEWS

March
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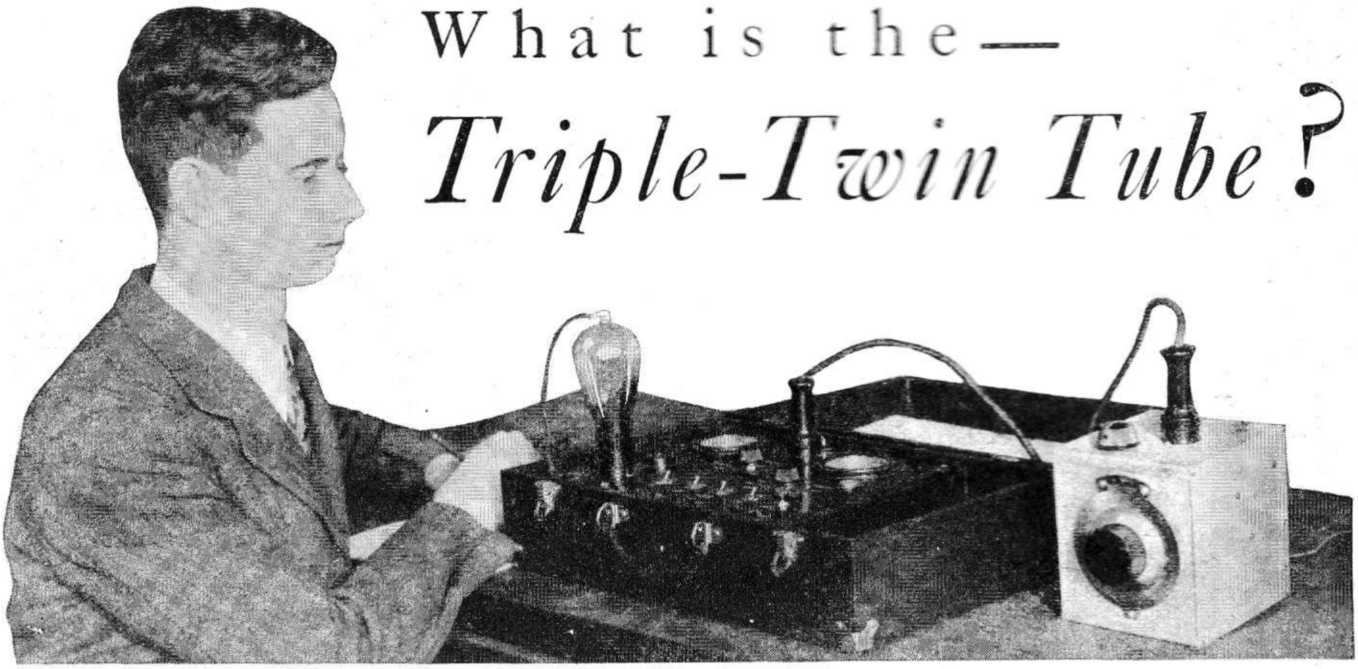
**Radio Surgery**
**Triple-Twin Tube**
**Newest Set Tester**

**Televising the "Races"**

# What is the—
# *Triple-Twin Tube?*



***A unique development in radio vacuum tubes that may do away with audio-frequency amplifiers, as well as detector tube, making possible two- and three-tube sets exclusive of the rectifier***

*By* John M. Borst

THE tube family has been increased by another "child" of unique possibilities. The latest arrival is expected to do away with the audio amplifiers in broadcast receivers.

With a signal on the grid of 4 volts, r.m.s. value, it is said to deliver 4½ watts undistorted output to the loudspeaker. This is about equal to three and a half times the output of a pentode and about twelve times the power of a single -45.

Apart from replacing the audio amplifier, it will take the place of the detector as well. With a 10-volt carrier on the grid it will deliver its 4½ watts to the loudspeaker as in the case of the amplifier.

A receiver with this tube in the output does not need any interstage coupling devices. The saving in space permits a midget receiver to be made with only two or three tubes and a rectifier which can supply the quality of reproduction of present-day consoles.

The size and cost of the midgets can be further reduced for those who wish an economical instrument.

The tube was developed in the laboratories of the Cable Tube Corporation and will be known as the Speed type 295 tube. It is expected that it will not take very long for the manufacturers to use it in production, as the circuit does not necessitate any special parts. The load impedance necessary for maximum output is equal to the plate impedance of the tube, which is 4000 ohms. The transformers in present-day use are designed for this load so they may be used in the circuit as usual. The minimum distortion of the amplifier, as a whole, is about 5%, and this minimum is obtained with the same load as the maximum output.

The characteristic curves show that the tube, with the circuit designed for it, has a nearly straight frequency response curve from 30 cycles to 50,000 cycles. This quality makes it especially suitable for television.

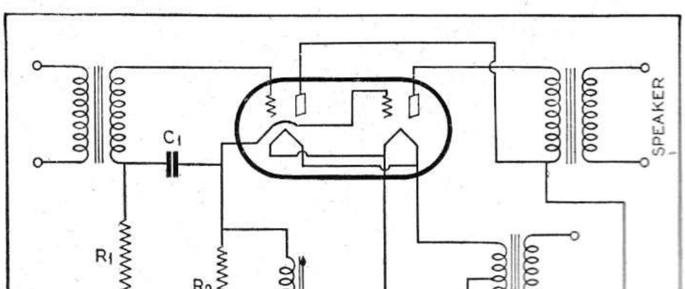
### *Construction of the Tube*

The 295 consists of two triodes built in a single glass bulb. We all know that multiple tubes have been made in Germany a few years ago, but somehow they never became popular. The novelty of this tube is not the fact that it is a multiple one, but is in the circuit that goes with it.

In this article the two triodes which make up this tube will be called the first and second sections, or the input and output sections. The mounting of these two sections are entirely separate, so as to avoid static coupling as much as possible. The filaments are in parallel, and in order to insulate the different circuits, the input section is an indirectly heated tube and the output section is a heater type similar to the -50. The filament takes the standard 2½ volts a.c.

The two sections are coupled together in a "direct coupled" circuit. There is no need, however, of a double B battery. The cathode of the input section is connected to the grid of the output section. This is the only interstage connection inside the tube. This circuit would not deliver the 4½ watts power if it were not for the fact that the grid of the output section goes "positive." It does not affect, however, the quality of reproduction, because of the peculiarities in design of the circuit and the tube together, which we hope to make clear to the reader.

The tube fits in the standard five-prong socket. By inspection of the photograph it can easily be seen that the two triodes are so mounted that the fields do




AMPLIFIER CIRCUIT

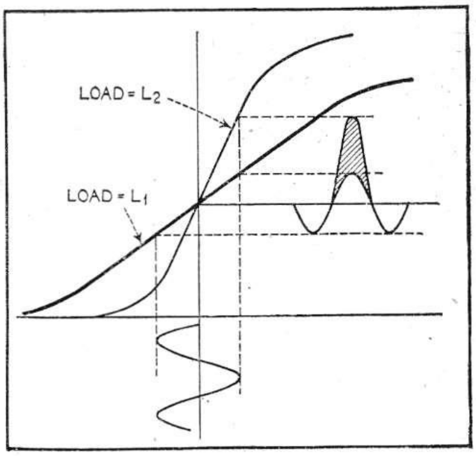
*Figure 1. This diagram shows the connections for the tube when used as an amplifier*

not interfere with each other. The cap on top of the tube is connected to the grid of the first section; both plates are brought out to the base of the tube.

Incidentally, the plate voltage for both sections is 250 volts. Although a direct coupling is used, the plates are at the same potential.

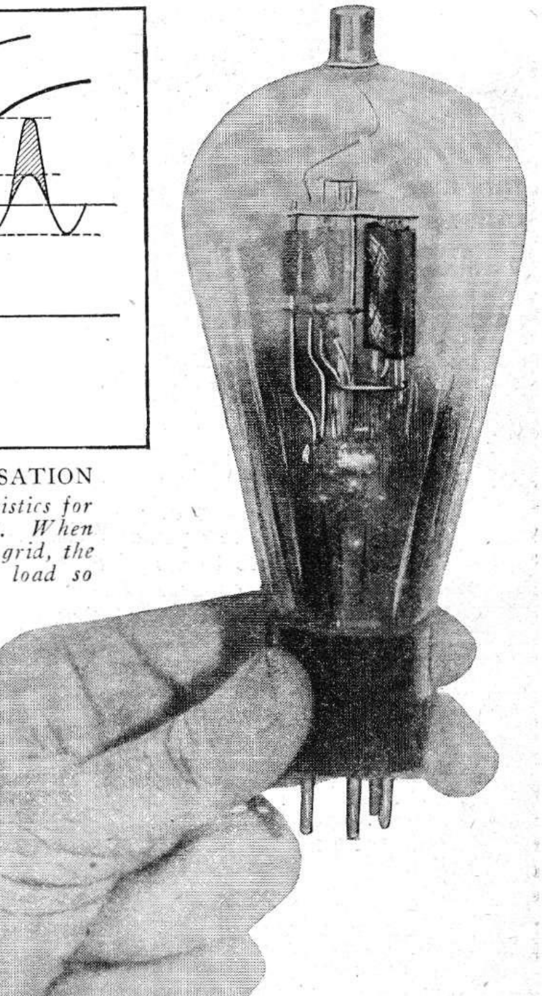
## *The Circuit Employed*

Let us first discuss the working of the triple-twin tube as an amplifier. The circuit is shown in Figure 1. In the cathode lead—that is, in the plate circuit—there is a resistance R2 and an audio-frequency choke across it. The audio-frequency choke serves to provide a low resistance path for the direct-current component of the plate current. This does away with the loss of voltage in the coupling resistor R2. The direct-current component then goes through the choke, but the signal, at audio frequency, finds the choke a too high impedance path and most of it will flow through the resistance R2. For all practical purposes, we can say that the signal flows through R2 and this is the "load." In the circuit of Figure 1 this load is connected across the cathode and grid of the second section of the tube.




GRID CURRENT COMPENSATION

*Figure 2. Dynamic characteristics for single tube at different loads. When a signal is impressed on the grid, the tube automatically varies its load so that a steepening characteristic is obtained for lowered load impedances*



THE NEW TRIPLE TWIN

*This photograph shows the construction of the two separate elements, really two triodes in one, which uses a positive grid swing on the second unit*

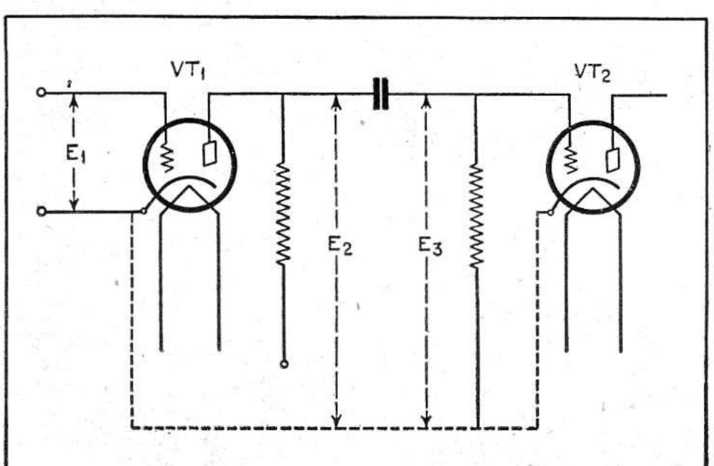
The bias to the first tube is provided by the voltage drop across the resistance R4, which carries the plate current of both the second and first tube. A small additional bias is obtained by the voltage drop across the choke. If we made the grid return (of the first section) to ground, as is usual in amplifier circuits, there would be a large resistance in the grid circuit. To provide a low-impedance return path to the cathode for the signal, the condenser C1, of 2 microfarads, is provided. This again necessitates the resistance R1, for without it the load would be short-circuited.

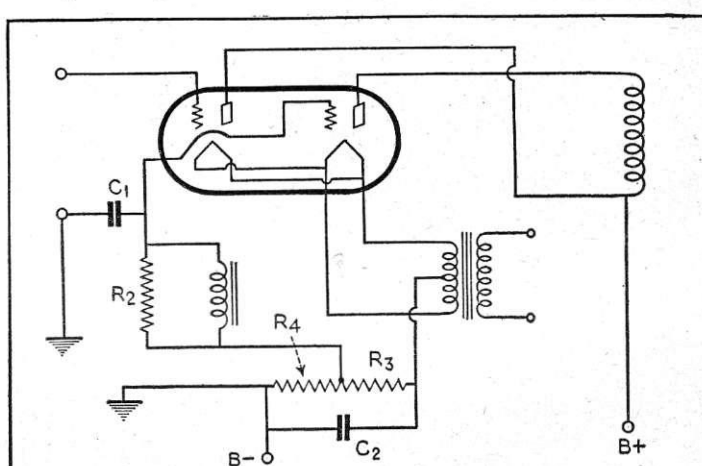
The signal is then amplified in the first section and develops an a.f. potential across the load which is connected to the grid and cathode of the next tube. However, the bias of the second tube is much smaller than that of the first. The grid of this tube, therefore, goes "positive" and it will draw current. One of the merits of the circuit is that this fact does not cause any distortion, for the circuit is so designed as to compensate for the additional current, which is drawn by the grid circuit.

We assume that the reader understands the causes for distortion in the ordinary coupled circuits, if the grid goes positive. In that case, current is drawn, and during that part of the cycle the impedance of the grid circuit changes and so the applied voltage, during that part of the cycle, drops, thus distorting the signal.

Let us draw the dynamic characteristic of a tube for a certain load L1 (see Figure 2). This represents the grid-voltage, plate-current curve for the tube (first section) when R2 is the load and the grid of the second section is still negative. Then at a certain point the grid becomes positive and makes the load impedance less. The dynamic characteristic then becomes steeper for this new load, L2, and it intersects the first one at the point where the conditions change.

When we now consider a sinusoidal signal, which is being impressed on the grid, we see that the part of the cycle which causes the second grid to go positive falls on the characteristic of L2 and that part causes a larger variation in plate current, thus providing additional current for (*Continued on page* 802)




RESISTANCE-COUPLED PHASE RELATIONS DETECTOR AND OUTPUT CIRCUIT

*Figure 3. (Left) In standard resistance-coupled amplifiers the voltage E2 between the plate and cathode is 180 degrees out of phase when the signal voltage E1 is impressed between the grid and cathode. The voltage E3 is approximately 70 degrees advanced over E2 and about 110 degrees retarded behind E1. Figure 4. (Right) This is the electrical circuit diagram for using the triple twin tube as a combined detector and audio amplifier*

# What Is the Triple-Twin Tube?

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the grid current. In other words, this increase by the change in the characteristic is just equal to the current the grid draws and the current through the load R2 remains the same: a sinusoidal wave.

Of course, the compensation will not be exactly equal to the grid current unless the tube is carefully designed to do just that. Also, the load L2 varies during this half cycle; the more grid current, the lower the load, and we really would have to draw a whole family of curves.

### *The Phase Relation*

So far we have only spoken about the compensation for grid current during a part of the cycle and did not consider whether the compensation came at the right part of the cycle. In order for it to do so, the plate current will have to be in phase with the voltage on the grid of the next tube. It is, in this particular circuit, but not in any of the other conventional circuits. If such a compensation was attempted with a standard hook-up, it would come at the negative half of the cycle and would make matters worse instead of better.

In Figure 3 is shown a standard resistance-coupled circuit. We all know that when during the positive half of the cycle the control grid of VT1 becomes less negative, the plate current will increase, and during the negative half it will decrease. The plate current is then in phase with the incoming signal on the grid.

### *Operating Characteristics*

When the plate current increases, the voltage drop across the resistance R increases and the remaining part of the B-voltage is what is left for the tube, so the plate voltage drops when the plate current increases and it increases during the negative half of the cycle. The plate voltage, from cathode to plate, is opposite in phase to the grid voltage and the incoming signal. The voltage across the load R1 is in phase with the signal, but we do not usually connect that to the grid circuit of the tube. The latter circuit is generally coupled to the plate and cathode. The condenser in the resistance-coupled amplifier brings an additional phase difference. But it should be seen that, whatever type of coupling is used, the voltage on the grids of the two tubes will be out of phase and no compensating could be accomplished with the above described method.

### *Compensating Current*

Now let us look at Figure 1. Here the voltage across the load R2 is in phase with the signal applied on the grid of the first tube. This signal is directly connected across the grid and the heater of the second tube, and therefore the voltages on the first and second grid are in phase. This shows that the increase in plate current, due to a change in the load, will come at the right time to compensate for the grid current.

It was found that R3 was necessary to eliminate hum. This one tube, with the circuit shown in Figure 1, is all that is needed for a phonograph pick-up. The output in the plate of the tube will be as much as the dynamic speaker can handle, if not too much.

### *The Detector Circuit*

According to data supplied to us by the Cable Tube Company, the triple-twin tube will deliver 4½ watts to the speaker when used as a C-bias detector. To obtain this output the carrier has to be 10 volts.

In Figure 4 is shown the hook-up for the detector circuit. The difference between this and the amplifier circuit is mainly in the values of the components. The condenser C1 has now become .0005 mfd., which is a low impedance for the radio-frequency component. The signal across the load—that is, the audio component—which is applied to the second section of the tube, finds this condenser a high-impedance path. Therefore, the grid return can be connected to ground without short-circuiting the load.

In this case the resistor R4 is larger, so as to get the proper bias on the input section. The bias on the output section remains the same as in the amplifier.

In this case the grid will go positive again and there will be just the right amount of compensation, as described above, because of the shifting of the characteristic as soon as the grid draws current.

### *Other Applications*

One of the great problems in television is to design an audio amplifier with a nearly straight-frequency characteristic. At present the audio-frequency band seems to go up to 50 kc. only, but soon this is expected to be increased. The frequency characteristic is substantially straight from 30 to 50,000 cycles. This should be a great help for designers of television receivers.

### *Photo-Cell Amplifiers*

The plate circuit of the 295 tube draws 50 ma. The variation in plate current for a given change in grid voltage is larger than that of most tubes generally used for photo-electric cell amplifiers.

It seems to the writer that the triple-twin tube increases the possibilities of industrial applications of the photo-electric cell. With the greater amplification possible, relays do not have to be so delicate and can be made to control the power circuit directly.

In the sound-film industry, also, this new amplifier should find wide application. It would greatly simplify the construction of the amplifier in the projection booth, with less chance of breakdown, not to speak of the reduction in cost.

### *Engineering Data*

By courtesy of the Cable engineers, we give below some of the characteristics which were obtained by experiments in their laboratory:

| | |
|---|---|
| Filament voltage | 2.5 volts a.c. |
| Filament current | 4 amperes |
| Plate voltage, first section | 250 volts |
| Plate voltage, output section | 250 volts |
| Mutual conductance, first section | 1150 } approximately |
| Mutual conductance, output section | 3700 } approximately |
| Plate current | 50 ma. |
| Grid bias input | 6 volts |
| Plate impedance | 4000 ohms |
| Recommended load impedance | 4000 ohms |
| Maximum undistorted output | 4.5 watts |

The minimum harmonic distortion is 5% at 4000 ohms. It is 8% at 2000 ohms and at 9800 ohms. This is the second and third harmonic combined. Note that the minimum distortion is at 4000 ohms, which is the impedance needed for maximum power output. There is no need for designing special transformers, as with the pentode. A standard output transformer designed for -45 type tubes or for -50 type tubes will do. It must be able, however, to stand the 50 ma. plate current.

In the diagram of Figure 1, R1 = .1 megohm, R2 = 12,500 ohms, R3 = 70 ohms, R4 = 210 ohms, approximately.