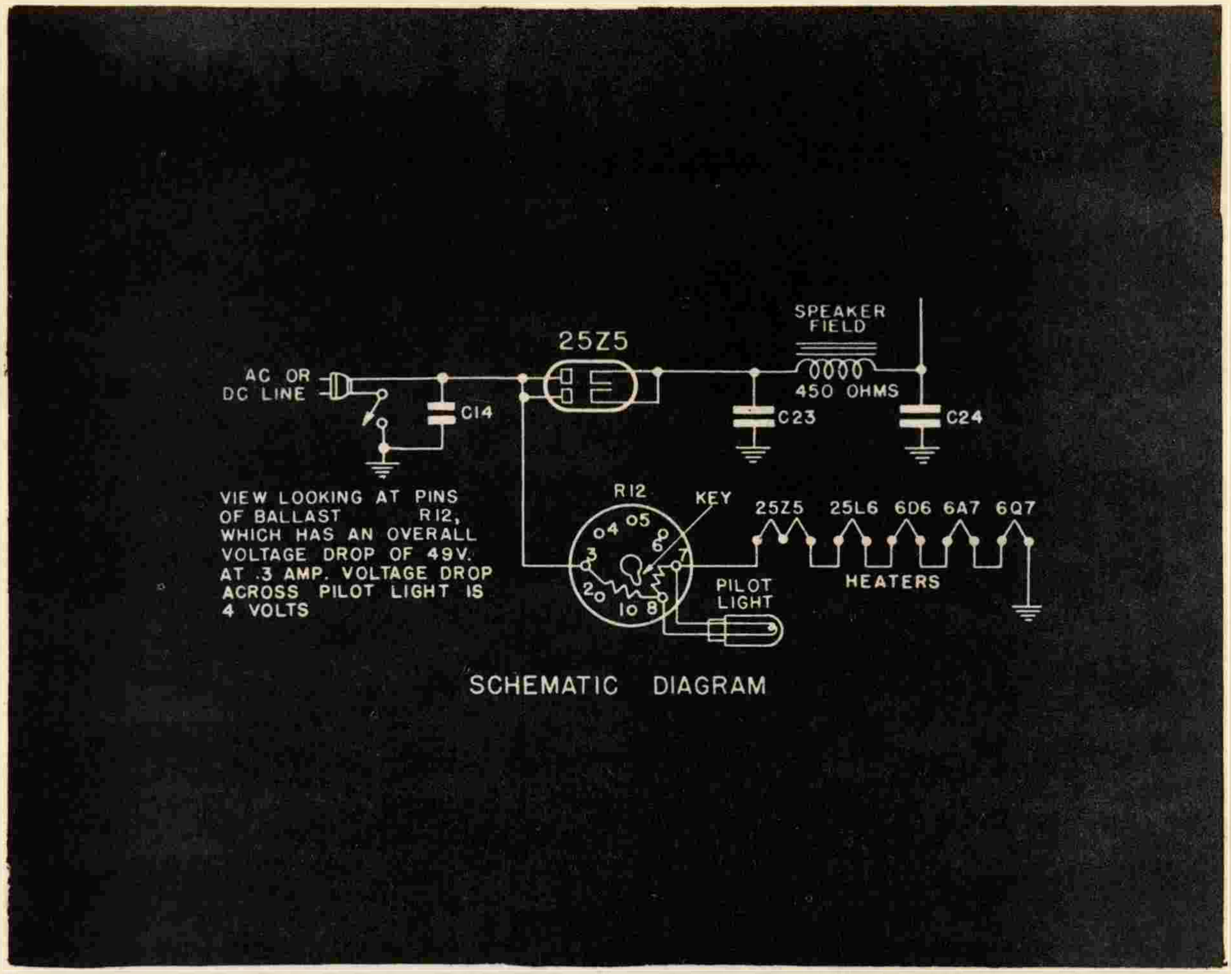


LESSON
41R

UNIVERSAL A.C. - D.C. RADIO RECEIVERS

RADIO-TELEVISION TRAINING SCHOOL, INC.
ESTABLISHED 1922
LOS ANGELES

RADIO-TELEVISION TRAINING SCHOOL, INC.
5100 SOUTH VERMONT AVENUE • LOS ANGELES 37, CALIFORNIA, U. S. A.

UNIVERSAL A.C.--D.C. RADIO RECEIVERS

GENERAL OPERATING PRINCIPLES. The so-called universal A.C.--D.C. radio receivers are electrically operated transformerless sets that can be operated from either 110-volt A.C., or D.C. lines. This A.C.--D.C. operating feature is made possible through the use of a half-wave rectifier connected into one side of the power line. On A.C. operation the rectifier rectifies the alternating current and furnishes direct current to the plate circuits of the tubes at practically line voltage (except for the drop in the rectifier tube and filter choke), and on D.C. operation the rectifier merely floats on the line like a low value series resistor. On D.C. mains the set must be connected so that the positive line goes to the plate side of the rectifier.

The filaments of the tubes in a universal A.C.--D.C. set are connected in series with a series resistor to reduce the current to the proper value. Such a series arrangement, however, demands that all filaments require the same current, otherwise some would be underheated and others overheated. Therefore, to adapt this plan to the different circuit systems, the majority of the newer special purpose tubes were designed to operate on the same heater current, namely, 0.3 ampere. Among these are the 77 and 78 radio frequency amplifiers, the 75 and 6B7 duo-diodes, the 6A7 pentagrid converter, the 43 output pentode, and the 12Z3 and 25Z5 rectifier tubes.

THE 12Z3 and 25Z5 RECTIFIER TUBES

The 12Z3 is a half-wave high vacuum type rectifier tube with an indirectly heated cathode, designed to supply direct current power from alternating current lines. The heater or filament draws a current of 0.3 ampere at a pressure of 12.6 volts, and the tube is adaptable for use in a series filament circuit. It will deliver a maximum direct current output of 60 milliamperes, and can be operated on A.C. circuits up to 250 volts per plate. The 12Z3 rectifier is especially suitable for use in transformerless sets of the universal A.C.--D.C. type. These sets generally employ four or five tubes, and consume a total plate current of from 30 to 40 milliamperes.

The 25Z5 also is a high vacuum type rectifier designed to supply direct current power from alternating current lines. However, this tube has two sets of elements, two plates and two cathodes, and each element is brought out to individual terminal base pins. This arrangement permits the use of the tube in a variety of ways--as a half-wave rectifier, with the two plates and the two cathodes tied together at the socket terminals, or as a half-wave rectifier with split cathode, one cathode for supplying the plate circuits of the tubes and the other the field of the dynamic speaker. Or the tube can be used as a full-wave rectifier with a voltage-doubling feature that provides twice the direct current voltage output obtained as a half-wave rectifier.

The heater of the 25Z5 draws a current of 0.3 ampere and requires a terminal pressure of 25 volts, and the tube can be used in a series filament circuit system. On account of the high heater voltage, less voltage need be dissipated in the series voltage dropping resistor. The tube is therefore excellently adapted for use in transformerless sets either of the universal A.C.--D.C. type or the straight A.C. operated type. In fact, it is in these two classes of receivers that the tube is used almost exclusively. However, it cannot be used on A.C. line voltages in excess of 125 volts per plate.

THE STEWART - WARNER SERIES 108 CHASSIS

The circuit arrangement is illustrated in Fig. 1. It consists of a tuned radio frequency stage with a type 39 pentode, a grid bias detector stage using a type 36 screen grid tube, and an audio output stage equipped with a type 38 power pentode.

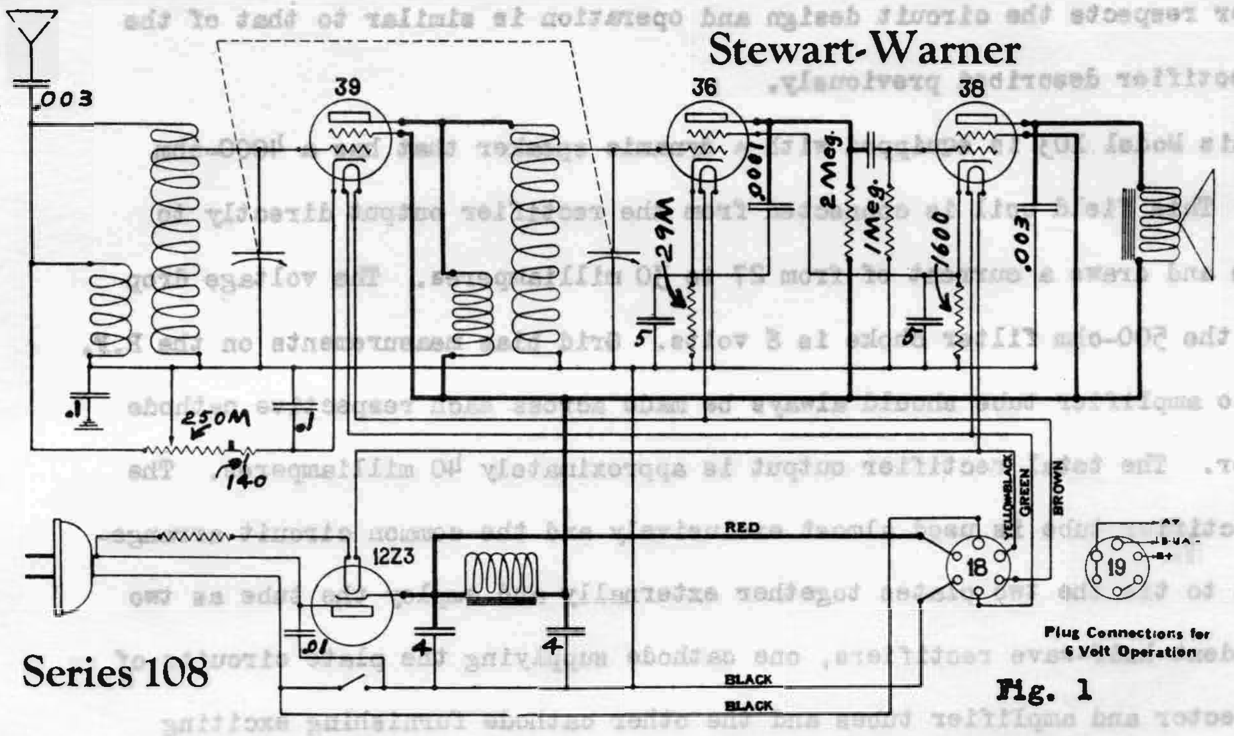


Fig. 1

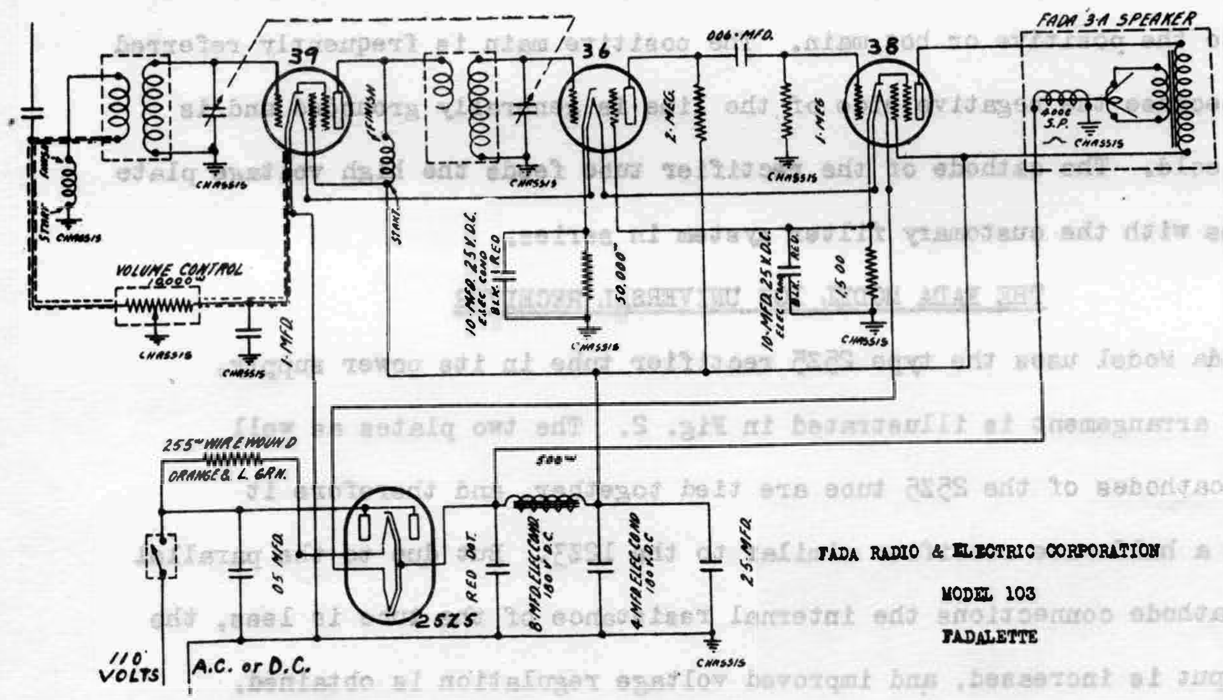
The filament of the 12Z3 rectifier is connected in series with the other tubes. The plate of the tube is connected directly to one side of the line, and when the set is operated on direct current mains, this plate lead must be connected to the positive or hot main. The positive main is frequently referred to as hot because the negative side of the line is generally grounded and is said to be cold. The cathode of the rectifier tube feeds the high voltage plate supply lines with the customary filter system in series.

THE FADA MODEL 103 UNIVERSAL RECEIVER

The Fada Model uses the type 25Z5 rectifier tube in its power supply. The circuit arrangement is illustrated in Fig. 2. The two plates as well as the two cathodes of the 25Z5 tube are tied together, and therefore it operates as a half-wave rectifier similar to the 12Z3. But due to the parallel plate and cathode connections the internal resistance of the tube is less, the current output is increased, and improved voltage regulation is obtained.

In other respects the circuit design and operation is similar to that of the 12Z3 rectifier described previously.

This Model 103 is equipped with a dynamic speaker that has a 4000-ohm field. This field coil is connected from the rectifier output directly to chassis and draws a current of from 27 to 30 milliamperes. The voltage drop across the 500-ohm filter choke is 8 volts. Grid bias measurements on the R.F. or audio amplifier tube should always be made across each respective cathode resistor. The total rectifier output is approximately 40 milliamperes. The 25Z5 rectifier tube is used almost exclusively and the common circuit arrangement is to tie the two plates together externally and employ the tube as two independent half-wave rectifiers, one cathode supplying the plate circuits of the detector and amplifier tubes and the other cathode furnishing exciting current for the speaker field. This system is frequently referred to as using a split cathode.



FADA RADIO & ELECTRIC CORPORATION

MODEL 103

FADALETTE

THE EMERSON MODEL BH203

The Emerson Model BH203 is a typical A.C.-D.C. superheterodyne receiver employing a type 6A7 as a composite pentagrid oscillator and modulator as a first detector. The circuit diagram is illustrated in Fig. 3. The arrangement is that of a typical superheterodyne with the incoming signal impressed on the control grid of the first tube, the 6A7. The elements of this 6A7 pentagrid converter are as follows. Looking at the diagram, the first grid is the oscillator control grid and is attached to the secondary of the oscillator coil. The second grid is the plate or anode of the oscillator which is attached to the primary of the oscillator coil. The third grid is the control grid of the R.F. tube. The next grid acts as an electrostatic shield and screen grid of the tube, which has a positive potential placed upon it with the plate and cathode comprising the whole structure of the tube.

The duty of the oscillator section is to set up a high oscillating current wave of equal amplitude throughout. The incoming signal is then modulated with the high frequency current set up in the oscillator section, and when mixed together with the incoming R.F. frequency produces the beat frequency or I.F. frequency which in this case is 456 kc. This beat frequency is also called the intermediate frequency. This intermediate frequency is passed through the first I.F. coil, which is usually a loose coupled transformer (marked in the diagram T2) to the 6D6 I.F. or intermediate frequency amplifying tube, which is then carried on through a close coupled I.F. transformer (marked T3) to the 6Q67G which is a diode detector and audio frequency amplifier, and also the A.V.C. tube, where it is demodulated so that the audio signal can then pass through the resistance coupling to the 25L6G which is a beam power output tube. You will notice that there are two beam forming plates in this tube which act as suppressor

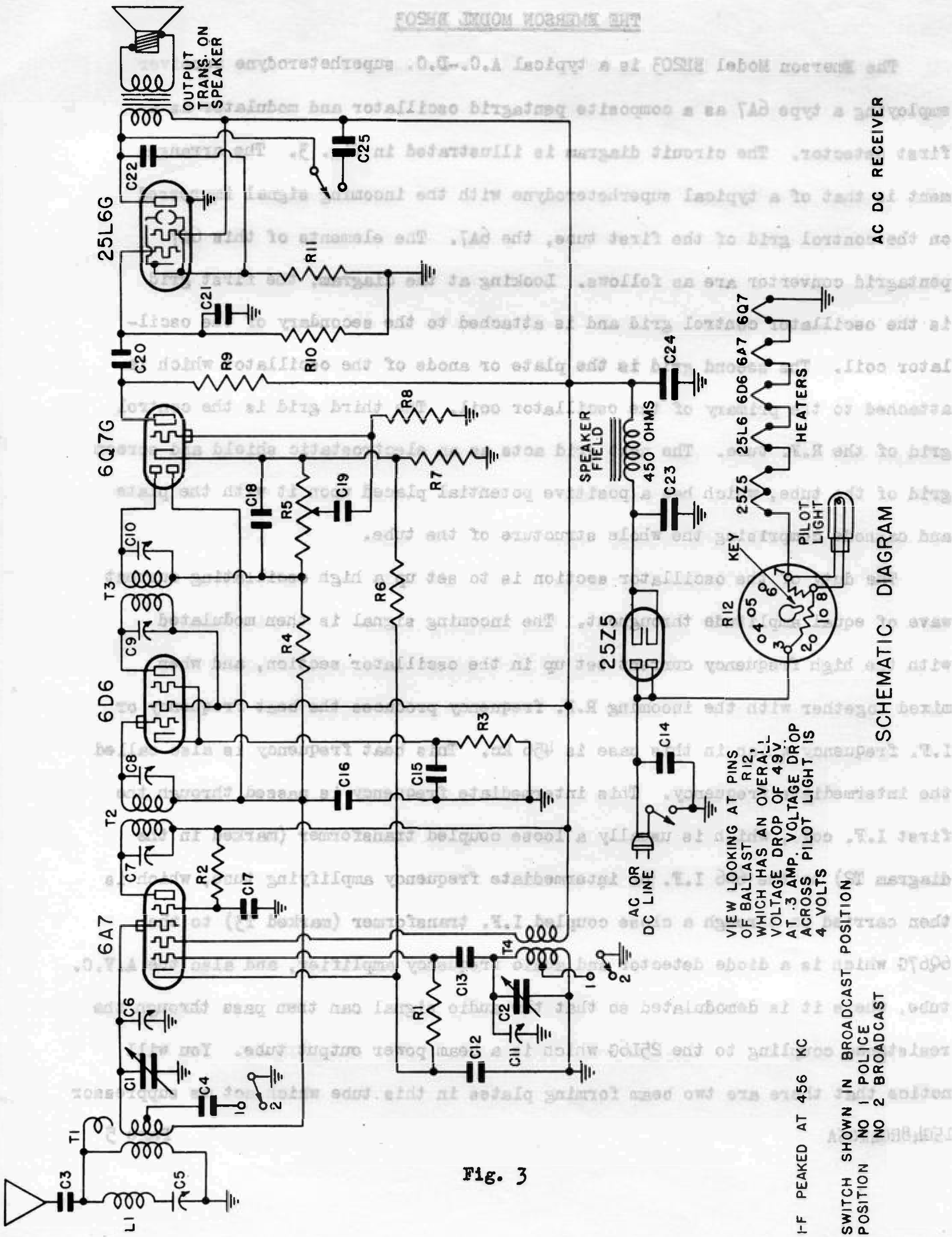

AC DC RECEIVER
SCHEMATIC DIAGRAM
OUTPUT TRANS. ON SPEAKER
25L6G
6Q7G
6D6
6A7
25Z5
SPEAKER FIELD
450 OHMS
HEATERS
25Z5 25L6 6D6 6A7 6Q7
PILOT LIGHT
KEY
R12
AC OR DC LINE
VIEW LOOKING AT PINS OF BALLAST R12, WHICH HAS AN OVERALL VOLTAGE DROP OF 49V. AT .3 AMP. VOLTAGE DROP ACROSS PILOT LIGHT IS 4 VOLTS
I-F PEAKED AT 456 KC
SWITCH SHOWN IN BROADCAST POSITION
POSITION NO 1 POLICE
NO 2 BROADCAST
C1 C2 C3 C4 C5 C6 C7 C8 C9 C10 C11 C12 C13 C14 C15 C16 C17 C18 C19 C20 C21 C22 C23 C24 C25
R1 R2 R3 R4 R5 R6 R7 R8 R9 R10 R11
T1 T2 T3 T4 L1

Fig. 3

grids. You will also notice in the power supply at this time that all the filaments of the tubes are connected in series. This receiver also employs all octal bases so that the tubes may be replaced with either metal or octal base glass tubes.

A type 25Z5 tube is used as a half-wave rectifier with the plates tide together, also the cathodes tide together and connected in series directly with the speaker field which has a resistance of 450 ohms. When the set is operated on direct current lines or batteries the tube merely floats on the line and a continuous flow of current feeds the plate circuit and speaker field. On alternating current lines the tube acts as a half-wave rectifier, and a pulsating unidirectional current flows. This is properly filtered by the speaker field and the two condensers C-23 and C-24.

In this set we also have a ballast resistor (marked R12) which uses pins No. 3 and No. 7, and is connected from the 25Z5 in series with the pilot light and filaments of the tubes. The voltage drop at the 25Z5 cathode is --130 volts. The voltage drop across the speaker field is --30 volts. The drop across the ballast resistor (pins No. 3 and No. 7) is --49 volts, and the drop across the pilot light section (pins No. 8 and No. 7) is --4 volts.

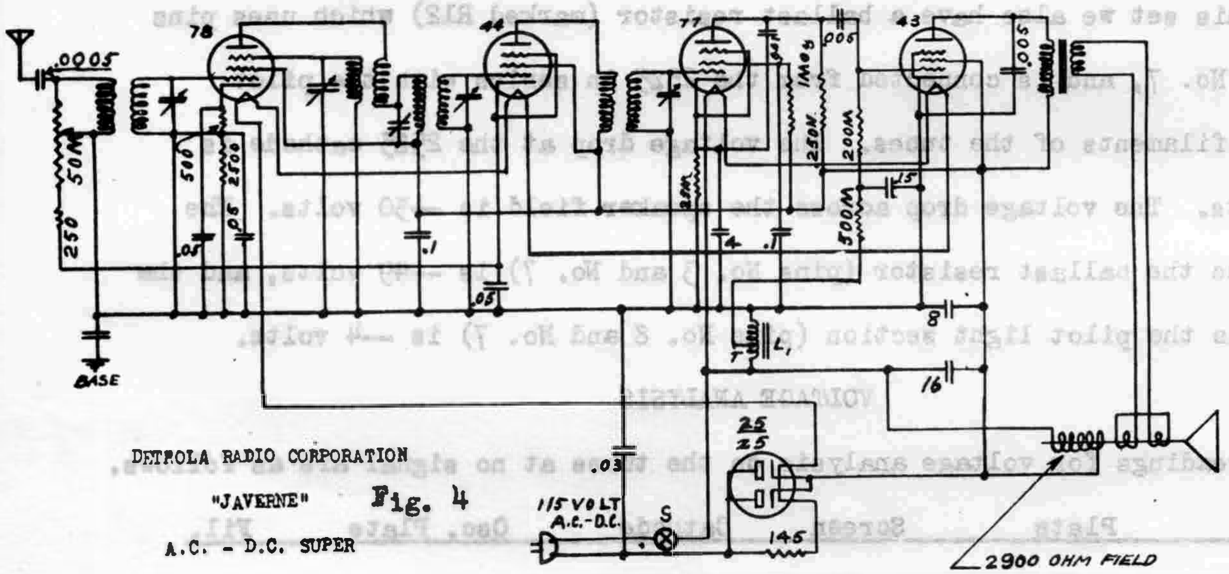
VOLTAGE ANALYSIS

The readings for voltage analysis on the tubes at no signal are as follows.

Tube	Plate	Screen	Cathode	Osc. Plate	Fil.
5A7	100	50	2.3	100	6.3
6D6	100	100	3.5	---	6.3
6Q7G	43	---	1.2	---	6.3
25L6G	92	100	6.5	---	25.0

The voltage rating of the entire set is from 105 to 125 volts with a power consumption of 43 watts. One side of the power line is directly grounded to the chassis base, and under no circumstances should a ground wire be permitted to come in contact with any metal parts of the receiver because this would cause a very high short circuit. When operating the receiver on a DC line, it is necessary to reverse the line plug to obtain the correct polarity. Sometimes if an AC-DC receiver of this type does not work properly or does not work at all it can be again brought into operation by simply reversing the line plug in its receptacle. The color coding of the I.F. transformer leads are as follows. The green wire runs to the grid of the tube, the black wire is the grid return, the blue wire is connected to the plate of the tube, and the red wire to B+. This receiver also employs a wave trap which is adjusted for maximum signal rejection at 456 kc. The antenna and oscillator coils for broadcast and police bands are wound on one form.

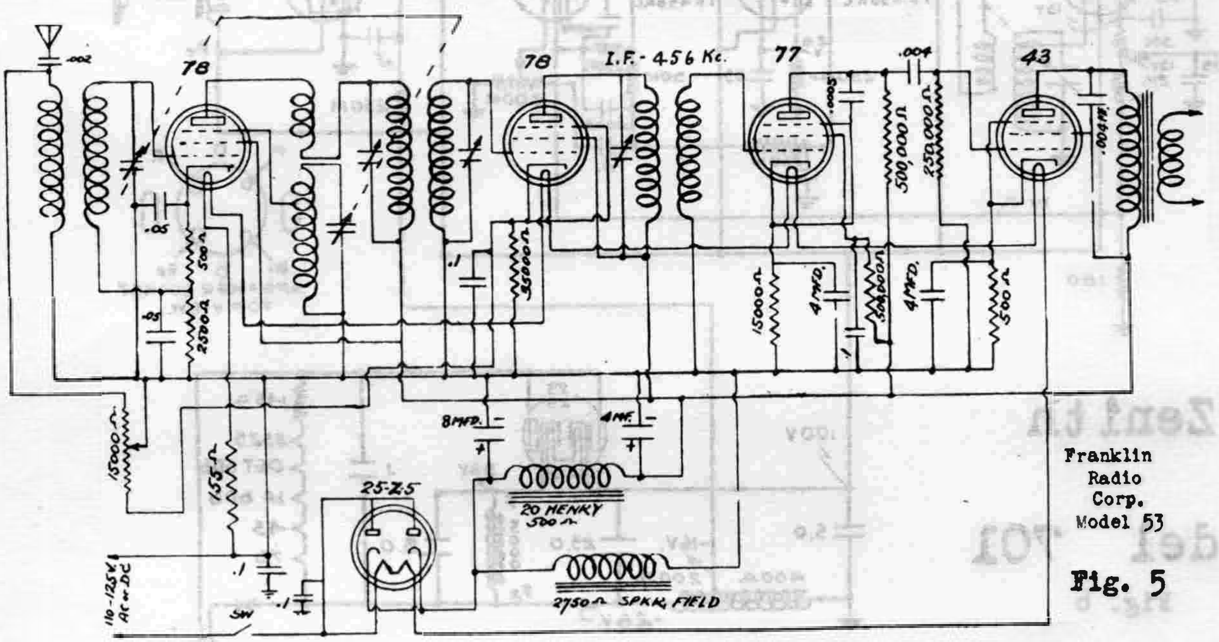
THE DETROLA "JAVERNE" 5-TUBE SUPERHETERODYNE



DETROLA RADIO CORPORATION
"JAVERNE" Fig. 4
A.C. - D.C. SUPER

The power supply system is typical, with the filaments of the tubes connected in series and through a 145-ohm voltage reducing resistor across the line. The 145-ohm value seems to be a little low, 155 ohms would serve the purpose better. A type 25Z5 rectifier tube is used with the two plates as well as the two cathodes tied together externally. The cathode output circuit, however, divides, one branch furnishing exciting current to the 2900-ohm field of the dynamic speaker, and the other branch feeding the plate and screen circuits of the four operating tubes. The grid bias for the power pentode is provided by the 400-ohm section between chassis and tap T on the filter choke coil L-1, through which the plate return current of the four tubes passes.

FRANKLIN MODEL 53 UNIVERSAL SUPER



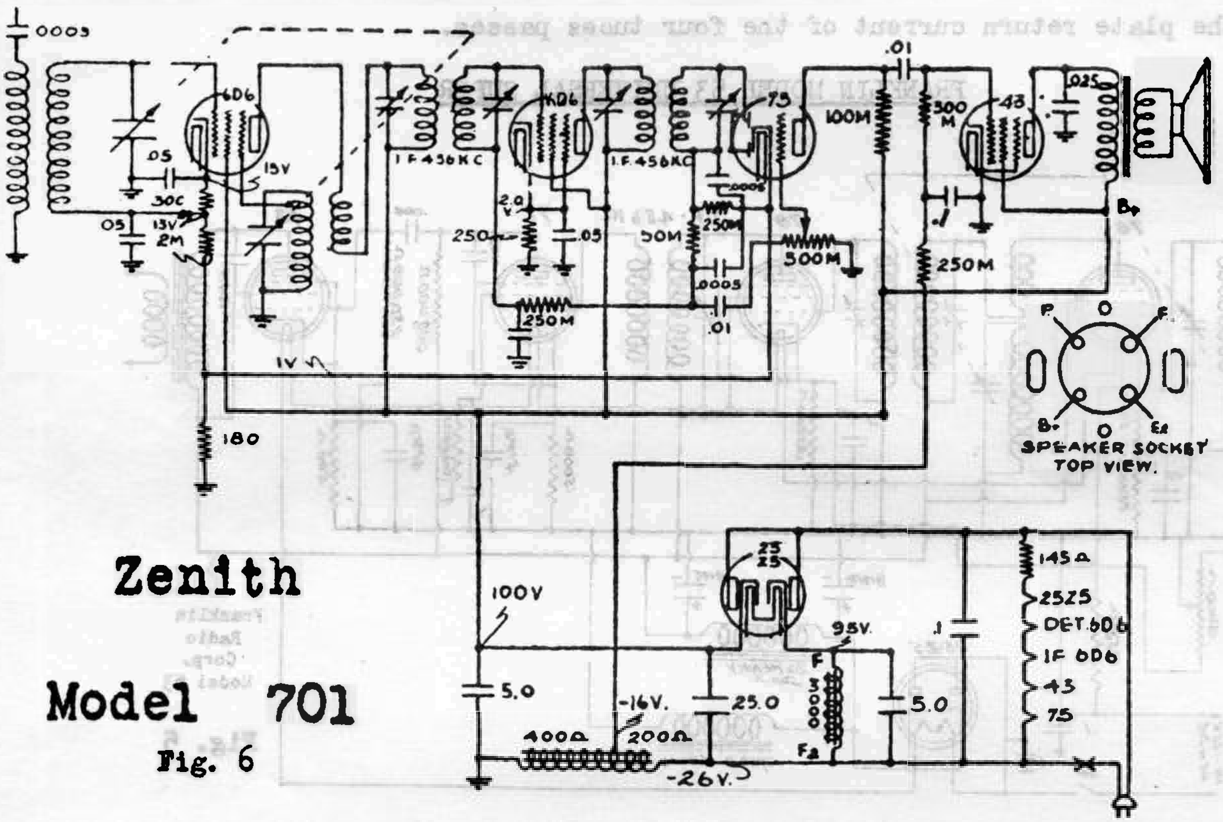
Franklin Radio Corp. Model 53

Fig. 5

This model employs a type 78 tube as composite 1st detector-oscillator with the oscillator coil system in the suppressor grid circuit and feedback effected through a tickler coil in the plate circuit. A type 78 tube is also used as I.F. amplifier and a type 77 in the 2nd detector stage. The latter is resistance coupled to a type 43 power output pentode. The grid bias for this output pentode is provided by a 500-ohm resistor (bypassed by a 4-mfd dry electrolytic condenser) in the cathode return line.

In the power supply system a type 2525 rectifier tube is used with the two plates tied together as well as the two cathodes, the latter feeding a branched circuit one part of which supplies the plate and screen circuits of the operating tubes and the other the 2750-ohm field of the dynamic speaker.

THE ZENITH MODEL 701 A.C.-D.C. SUPERHETERODYNE



Zenith

Model 701

Fig. 6

The Zenith Model 701 receiver is also a 5-tube A.C.-D.C. superheterodyne, but employs a type 6D6 tube (similar to the 78) as a composite 1st detector-oscillator with the oscillator coil system in the suppressor grid line and feed-back effected through a tickler coil in the plate circuit of the tube. The I.F. amplifier is also a 6D6 pentode operating at a frequency of 456 kilocycles. And in the 2nd detector stage a type 75 duo diode triode is used that serves as a diode detector, first audio amplifier, and automatic volume control, the latter being operative on the grid of the I.F. amplifier tube.

The triode section is resistance coupled to a type 43 power pentode. The manual volume control consists of a 500,000-ohm potentiometer in the grid circuit of the triode section of the No. 75 tube.

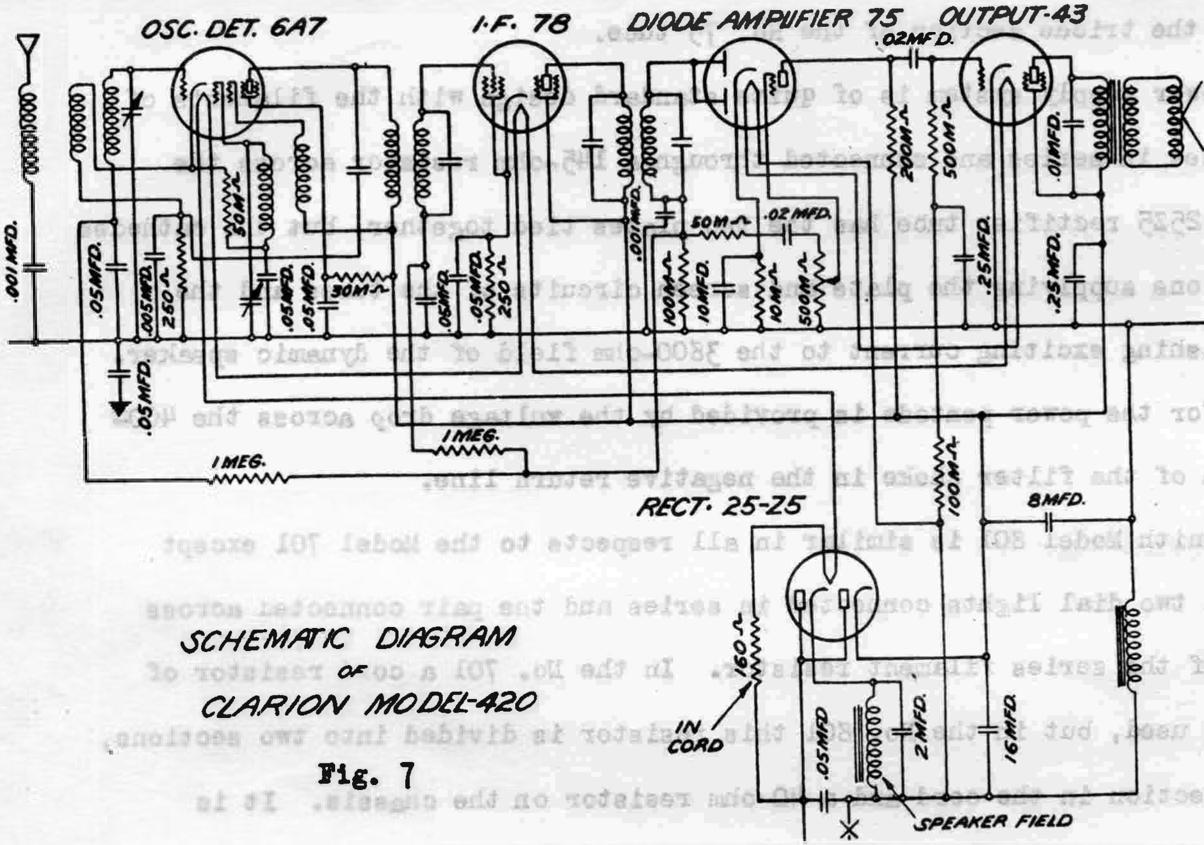
The power supply system is of quite standard design with the filaments of all the tubes in series and connected through a 145-ohm resistor across the line. The 25Z5 rectifier tube has the two plates tied together, but the cathodes are split, one supplying the plate and screen circuits of the tubes and the other furnishing exciting current to the 3800-ohm field of the dynamic speaker. Grid bias for the power pentode is provided by the voltage drop across the 400-ohm section of the filter choke in the negative return line.

The Zenith Model 801 is similar in all respects to the Model 701 except that it has two dial lights connected in series and the pair connected across a section of the series filament resistor. In the No. 701 a cord resistor of 145 ohms is used, but in the No. 801 this resistor is divided into two sections, a 126-ohm section in the cord and a 40-ohm resistor on the chassis. It is across this 40-ohm resistor that the two pilot lamps are connected. Otherwise the circuits of the two receivers are identical.

THE CLARION MODEL 420

The Clarion Model 420 A.C.-D.C. receiver is a good example of a receiver employing the 6A7 pentagrid converter tube in a composite 1st detector-oscillator stage. The circuit arrangement is illustrated in Fig. 7. The oscillator tuned tank coil is connected into the circuit of grid No. 1 with the feedback or tickler coil in the circuit of grid No. 2 (the anode grid). The combined action between these two grids and the cathode results in the generation of a pulsating stream of electrons that is further modulated by the incoming signal which is impressed on grid No. 4, the control grid. A combination or beat frequency is thus produced that appears in the plate circuit at an intermediate frequency of 175 kc.

This signal is then further amplified in a type 78 pentode that performs as an I.F. amplifier.



SCHEMATIC DIAGRAM OF CLARION MODEL-420

Fig. 7

In the 2nd detector stage a type 75 duo diode high-mu triode is used, that serves as detector, 1st audio amplifier, and automatic volume control. The automatic volume control is operative on the modulator grid of the 6A7 tube and the control grid of the No. 78 I.F. amplifier. The manual volume control consists of a 500,000-ohm potentiometer in the grid of the triode section of the type 75 tube. Grid bias for the output pentode is provided by the voltage drop across the filter choke, which in this receiver is in the negative return line. In the power supply system the plates of the 25Z5 rectifier tube are tied together while the two cathodes are connected into a split circuit arrangement.

THE U. S. RADIO & TELEVISION MODEL 3092

The U. S. Radio & Television Company's Model 3092 is a 5-tube A.C.-D.C. superheterodyne that employs a type 6F7 triode-pentode as a composite 1st detector and oscillator. The circuit arrangement is illustrated in Fig. 8. The triode section of the 6F7 tube functions as the oscillator, and the pentode section as the detector or mixer. A type 78 tube is used as intermediate frequency amplifier and a type 75 duo diode as 2nd detector. The two diode plates are tied together and form a half-wave rectifier, and the audio voltage built up across the 250,000-ohm load resistor is impressed on the grid of the triode section, which then acts as a 1st audio amplifier stage and is resistance coupled to a type 43 output pentode.

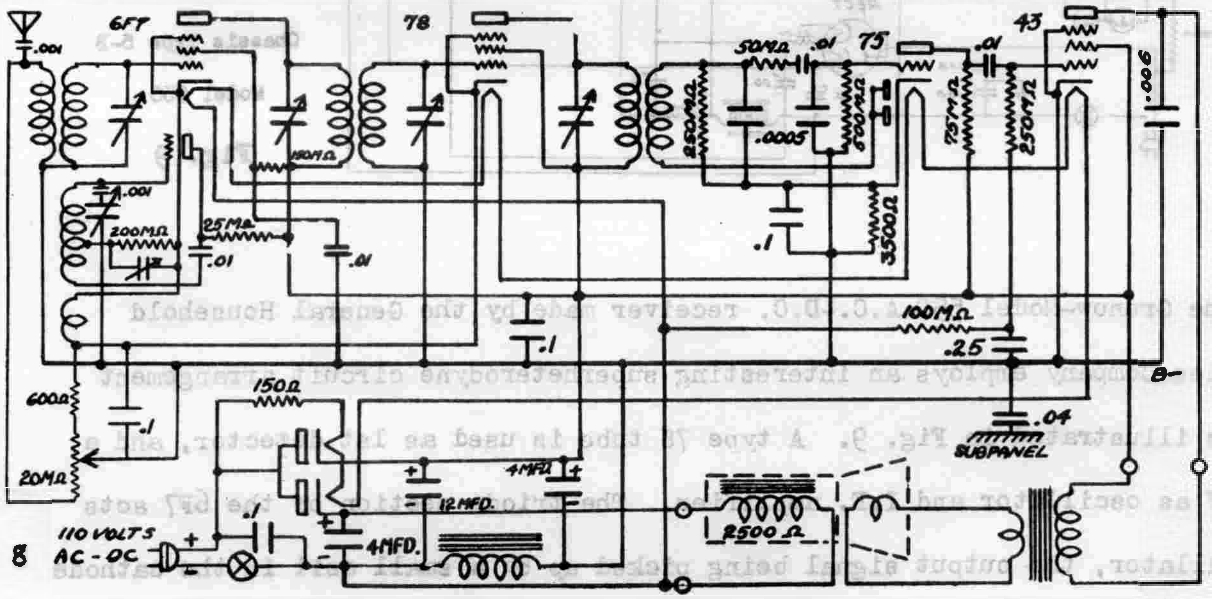
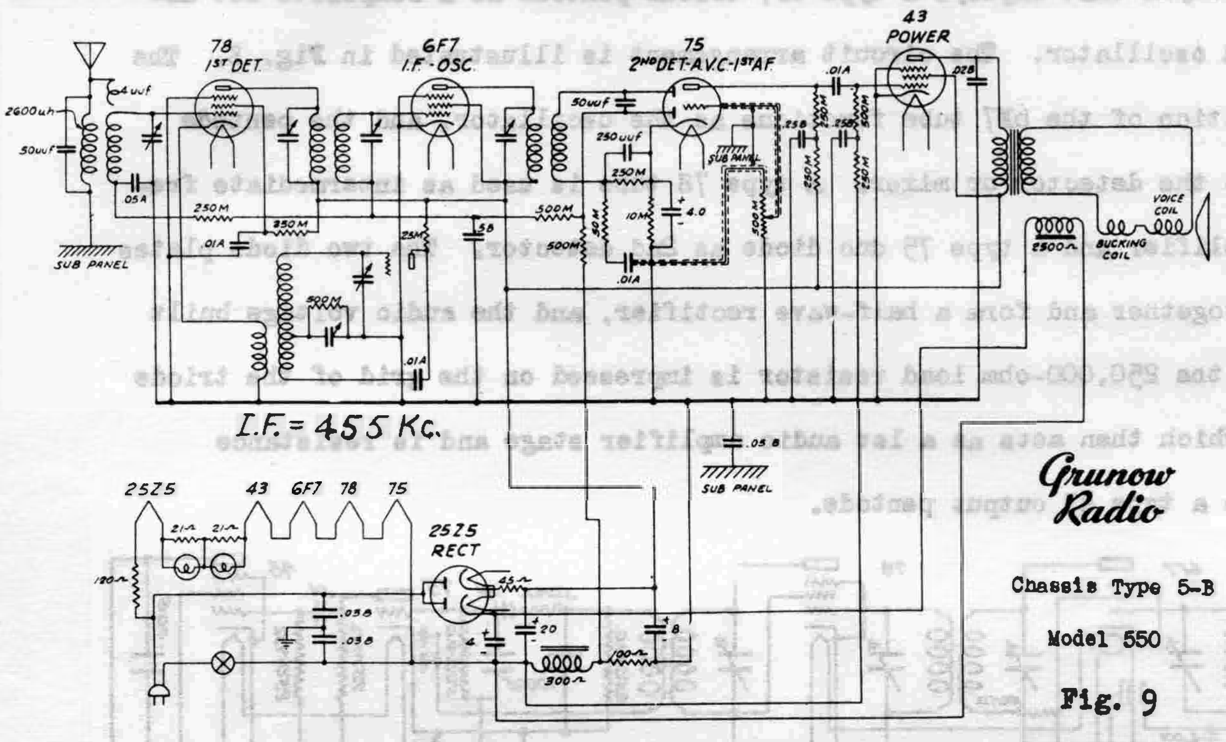


Fig. 8

In the power supply system a type 25Z5 rectifier tube is used with the two plates in parallel and each cathode feeding an individual circuit, one the plate circuits of the operating tubes and the other the field of the dynamic speaker. The manual volume control consists of a 20,000-ohm potentiometer that regulates the antenna input as well as the bias of the I.F. amplifier tube and of the pentode section of the 6F7 tube. The rest of the circuit is of standard design and construction.

THE GRUNOW MODEL 550 UNIVERSAL RECEIVER



Chassis Type 5-B

Model 550

Fig. 9

The Grunow-Model 550 A.C.-D.C. receiver made by the General Household Utilities Company employs an interesting superheterodyne circuit arrangement that is illustrated in Fig. 9. A type 78 tube is used as 1st detector, and a No. 6F7 as oscillator and I.F. amplifier. The triode section of the 6F7 acts as oscillator, the output signal being picked up by a small coil in the cathode return of the type 78 1st detector. The incoming R.F. signal is supplied to the control grid of this tube and the resulting beat or difference frequency appears in the plate circuit at 455 kilocycles. This intermediate frequency signal is then impressed on the control grid and amplified in the pentode section of the 6F7 tube. The amplified signal is finally impressed on one of the diode plates of the type 75 2nd detector where it undergoes half-wave rectification. The other diode plate is used for automatic volume control. The triode section serves as a 1st audio stage and is resistance coupled to a type 43 output pentode. The manual volume control consists of a 500,000-ohm potentiometer in the grid circuit of the triode section of the No. 75 tube.

The power supply system is of the customary design and arrangement, using a type 25Z5 rectifier tube with the plates in parallel and the two cathodes supplying individually the plate circuits and the speaker field respectively. Two pilot lights are used, one for the tuning condenser control and the other for the volume control; and since these light bulbs do not require the same current of 0.3 ampere that is drawn by the radio tubes connected in series with them, each bulb is shunted by a 21-ohm resistor.

THE 25Z5 AS A VOLTAGE DOUBLER

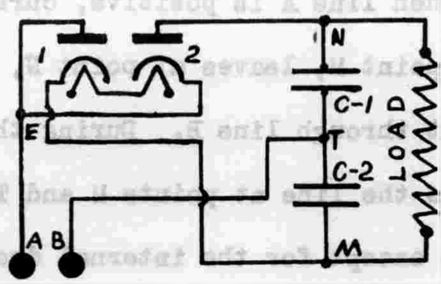


Fig. 10

The 25Z5 is a high-vacuum rectifier of the heater-cathode type with two independent rectifying diodes, the elements of each diode being brought out to individual terminal base pins. This arrangement permits the tube to operate as a full-wave rectifier with the additional feature of being able to deliver double the voltage output obtainable when used as a half-wave rectifier. The advantage of such a system is that when a large amount of power is not needed, the power transformer can be dispensed with, for a 220-volt output can be obtained by operating the rectifier directly from a 110-volt A.C. line. This is an ideal arrangement for small transformerless A.C. receivers.

The voltage doubling action is brought about through the use of the circuit arrangement shown in Fig. 10. The two diode units, one reversed with respect to the other, are connected to two condensers which are in series across the load. One side of the 110-volt A.C. line is connected to the plate of diode No. 1 and the cathode of diode No. 2, while the other side of the line is connected to the midtap T between the two condensers C-1 and C-2. The plate of diode No. 2 is then connected to the other side of C-1, and the cathode of diode No. 1 to the other side of C-2.

During the 1st half cycle when line A is positive, current flows through diode No. 1, enters the load at point M, leaves at point N, flows through condenser C-1 to point T, and out through line B. During this interval condenser C-2 is virtually connected across the line at points M and T, and is charged to practically full line voltage except for the internal drop across diode No. 1. During the next half cycle line B is positive and current flows in at point T, through condenser C-2 into the load at point M, out at N, through diode No. 2 to point E, and out through line A. At the same time condenser C-1 is across the line at points N and T and, therefore, is charged to practically line voltage except for the drop across diode No. 2.

It is thus evident that with the two condensers C-1 and C-2 connected in series and each charged in the same direction to nearly line voltage, the total voltage operative across the load is double the input line voltage. From another point of view--during the 1st half cycle condenser C-2 is charged to nearly line voltage and during the 2nd half cycle current enters through line B and flows through condenser C-2, which means that there is added on to the line voltage the discharge voltage across condenser C-2, causing the total operative voltage to be equal to twice the line voltage. During the next half cycle the voltage of condenser C-1 is added on to the line voltage, and the total operating voltage is again doubled. In other words, from either angle the rectified voltage output is equal to twice the input line voltage.

THE VOLTAGE DOUBLING PRINCIPLE APPLIED TO A.C.-D.C. SETS

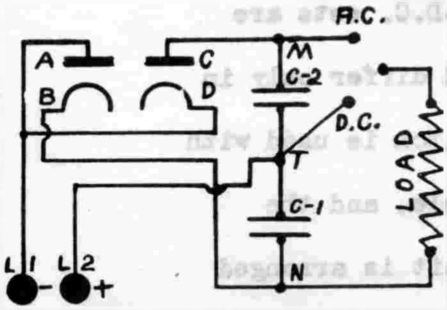


Fig. 11

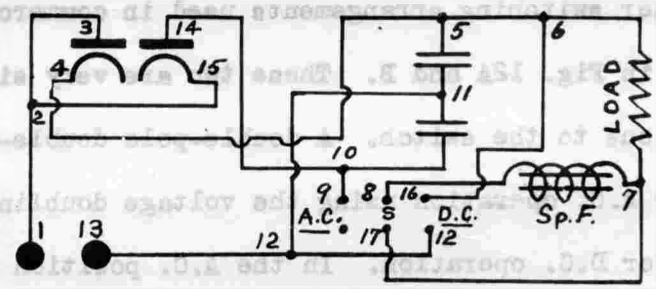


Fig. 12A

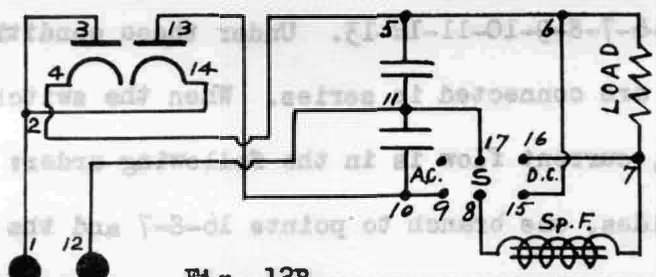


Fig. 12B

Since the action of the voltage doubling arrangement depends upon the alternate charging and discharging of the two condensers connected in series across the load, it is evident that this system is applicable only to operation on alternating current lines. However, the system is employed in a number of universal A.C.-D.C. sets, but in such cases a special switching arrangement is used to change the circuit somewhat for direct current operation.

The simplest A.C. to D.C. switching system is that illustrated in Fig. 11. Here a single-pole, double-throw (S.P.D.T.) switch is used which connects the load either to a point A.C. or D.C. With the switch in position A.C., the circuit is the typical voltage doubling arrangement explained in the previous section and is the position for alternating current operation. For direct current operation the switch is thrown into the lower position labeled D.C. In this case L-1 must be connected to the positive side of the line and current can then flow from L-1 through diode A-B and enter the load at N. After leaving the load it flows through the switch to point T and out through line L-2. The diode C to D is inactive during direct current operation.

The other switching arrangements used in commercial A.C.-D.C. sets are illustrated in Fig. 12A and B. These two are very similar and differ only in the connections to the switch. A double-pole double-throw switch is used with one side for A.C. operation using the voltage doubling principle, and the other side for D.C. operation. In the A.C. position the circuit is arranged for voltage doubling, and in Fig. 12A current flows in the following order through the circuit 1-2-3-4-5-6-7-8-9-10-11-12-13. Under these conditions the load and speaker field S.P.F. are connected in series. When the switch is thrown into the D.C. position, current flow is in the following order: 1-2-3-4-5-6- and here the current divides, one branch to points 16-8-7 and the other through the load to point 7 where the two currents again combine and continue to points 17-12 and out at 13. The dividing of the circuit at point 6 puts the load and speaker field S.P.F. in parallel during direct current operation.

Also diode 14-15 is inactive during this time.

In Fig. 12B current flow is in the following order during one half cycle of alternating current operation: 1-2-3-4-5-6-7-8-9-10-11-12, and during the other half cycle in this order: 12-11-5-6-7-8-9-10-13-14-2-1. During direct current operation current flow is in the following order: 1-2-3-4-5-6, and here the current divides, one branch to 15-8-7 and the other through the load to 7, and here the currents unite and continue to 16-17-11-12. During alternating current operation the load and speaker field are in series, and during direct current operation they are in parallel. Other switching arrangements are possible, but those illustrated are the ones most commonly used.

THE ATWATER-KENT MODEL 275 A.C.-D.C. RECEIVER

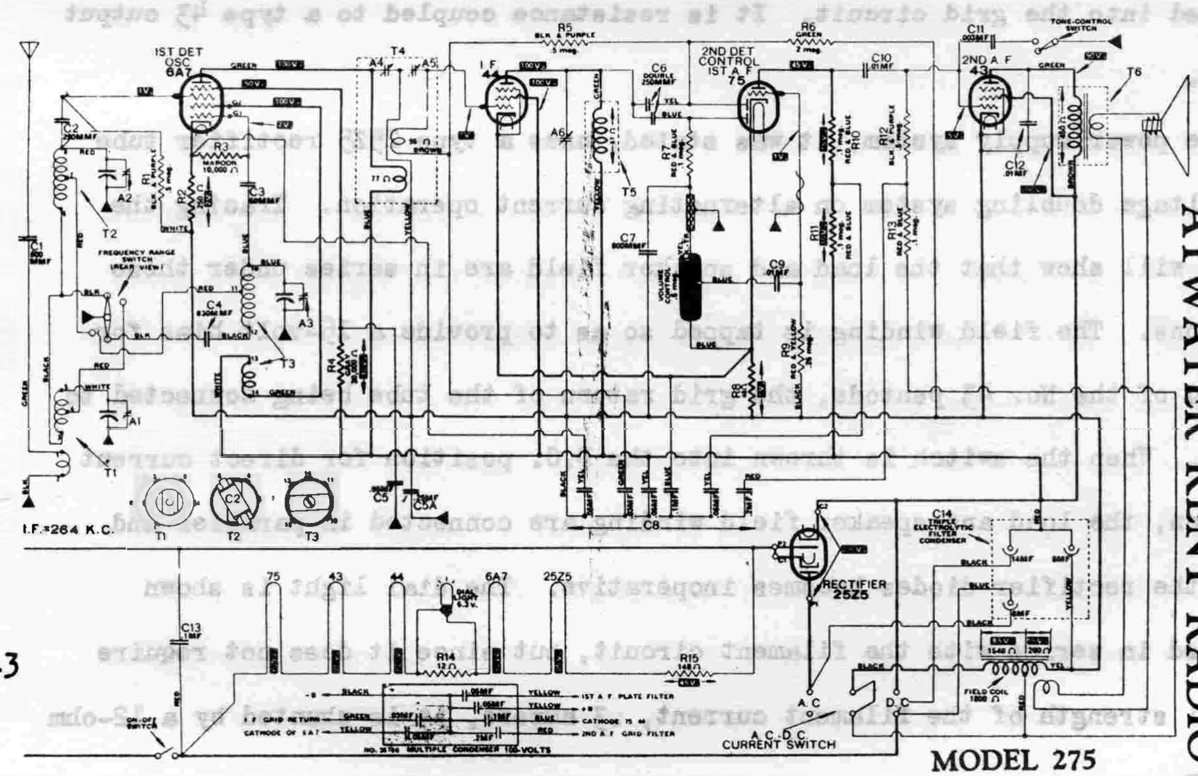


Fig. 13

The Atwater-Kent Model 275 is a 5-tube universal A.C.-D.C. superheterodyne receiver that employs the 25Z5 tube as a voltage doubler on alternating current operation. It is also equipped with a D.P.D.T. switch for shifting the circuit arrangement for operation on direct current lines. The complete circuit arrangement is illustrated in Fig. 13.

A double-range or two-band tuning system is used, one band for regular broadcast reception and the other for short wave reception. A type 6A7 pentagrid converter is used as a composite 1st detector and oscillator, and a No. 44 R.F. pentode as intermediate frequency amplifier. In the 2nd detector staga a type 75 duo diode is used with one plate for half-wave detector rectification and the other for automatic volume control, the latter being operative on the grid of the No. 44 pentode. The triode section of the 75 tube functions as the first audio stage with the manual volume control, a .5-megohm potentiometer, connected into the grid circuit. It is resistance coupled to a type 43 output pentode.

The power supply system, it was stated, uses a type 25Z5 rectifier tube in a voltage doubling system on alternating current operation. Tracing the circuit will show that the load and speaker field are in series under these conditions. The field winding is tapped so as to provide a 15-volt bias for the grid of the No. 43 pentode, the grid return of the tube being connected to the tap. When the switch is thrown into the D.C. position for direct current operation, the load and speaker field winding are connected in parallel and one of the rectifier diodes becomes inoperative. The dial light is shown connected in series with the filament circuit, but since it does not require the full strength of the filament current, .3 ampere, it is shunted by a 12-ohm resistor.

HOW TO DETERMINE THE SERIES FILAMENT RESISTOR VALUE

It has been explained that it is common practice in these universal A.C.-

D.C. sets to connect the filaments of the various tubes in series and to employ an additional series resistor to reduce the voltage to the proper value for the group so that rated current will flow through each tube filament. Since the current in every part of a series circuit is the same, all tubes in such a series hook-up must require the same filament current and it is for this reason that practically all of the later 6.3-volt tubes, as well as a number of special tubes, have been designed to operate on the same filament current, 0.3 ampere.

The question arises: how is the correct value of the series voltage dropping resistor determined. This is another simple application of Ohm's Law and really an easy problem to solve. The method of procedure is as follows:

1. From a tube data chart observe the filament voltage rating of each tube.
2. Determine the total voltage required by adding the voltages of each tube.
3. Assuming a line voltage of 115, the volts to be dissipated in the series resistor are equal to 115 less the total voltage required as determined in "2."
4. Obtain resistor ohms by dividing volts to be dissipated by current flow or .3.

To illustrate the application of this process, consider a 5-tube superheterodyne employing these tubes: 6A7, 78, 75, 43, and a 25Z5 rectifier.

1. From a tube data table the following filament voltages are obtained: 6A7-6.3, 78-6.3, 75-6.3, 43-25, and 25Z5-25.
2. Total voltage required is then equal to the sum of 6.3, 6.3,

6.3, 25, and 25 or 68.9.

3. Volts to be dissipated in the resistor are equal to 115 less 68.9 or 46.1 volts.

4. Value of the resistor in ohms is equal to 46.1 divided by .3, which is 153.3 ohms.

Therefore, a resistor of 153.3 ohms connected in series with the five tubes mentioned will reduce the line volts to the value needed by the group of five tubes so that the correct current will flow through each heater filament.

HEAT DISSIPATION IN RESISTOR AND BUILT-IN RESISTOR CORDS

The amount of power or watts dissipated in this series resistor is calculated by squaring the current (multiplying it by itself) and then multiplying the result by the number of ohms. For example, the resistor calculated above has a value of 153.3 ohms, and the current flow through it is .3 ampere. The current squared or .3 x .3 is equal to .09, and this multiplied by 153.3 equals 13.797. This is considerable power to be dissipated and, therefore, the resistor will become quite hot unless a higher wattage resistor is used. Consequently it is common practice to use a 25-watt resistor in such cases, for the temperature rise in such resistors will not be nearly so high.

In the early universal sets this series filament resistor like the other units was mounted on the chassis, and on account of the large amount of heat dissipated by the resistor the cabinets became rather hot and tended to warp and crack. This condition was later corrected by building the resistor into the line cord used for connecting the set into the electric outlet. This removed the heat entirely from the cabinet; and since the resistor was then in the form of a wire equal to the full length of the cord, the temperature rise was not nearly so high.