RADIO - TELEVISION

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LESSON Nº 11

• RADIO FREQUENCY AMPLIFICATION •

IN THIS LESSON WE ARE GOING TO STUDY ABOUT ANOTHER AMPLIFIER BUT THIS TIME, THE AMPLIFIER IS LOCATED IN FRONT OF THE DETECTOR, SO THAT ALL INCOMING SIGNALS MUST PASS THROUGH IT BEFORE THEY EVER REACH THE DETECTOR.

SINCE ALL OF THE SIGNAL ENERGY PRECEDING THE DETECTOR IS IN THE FORM OF RADIO FREQUENCIES, WE LOGICALLY CLASSIFY ALL AMPLIFICATION BEFORE DETECTION AS BEING RADIO FREQUENCY AMPLIFICATION AND THE AMPLIFYING SYSTEM WHICH TAKES CARE OF THIS JOB IS CALLED A RADIO FREQUENCY AMPLIFIER OR SIMPLY AN R.F. AMPLIFIER. IN FIG. 1 YOU WILL SEE THE GENERAL "LAY-OUT" OF THE COMPLETE RECEIVER, CONSISTING OF THE ANTENNA, R.F. AMPLIFIER, DETECTOR, A.F. AMPLIFIER AND THE LOUD SPEAKER.

THE PURPOSE OF THE RADIO FREQUENCY AMPLIFIER

THE RADIO FREQUENCY AMPLIFIER DOES JUST EXACTLY WHAT ITS NAME INDICATES AND THAT IS, IT AMPLIFIES THE INCOMING SIGNALS WHILE THEY ARE STILL IN THE MODULATED WAVE-FORM, CONSISTING OF THE CARRIER AND AUDIO FREQUENCIES. FOR EXAMPLE, IF THE RECEIVER IS TUNED TO A STATION, WHICH IS BROADCASTING ON A FREQUENCY OF 850 KILOCYCLES, THEN THE RADIO FREQUENCY AMPLIFIER WILL AMPLIFY THESE SIGNALS AT THEIR CARRIER FREQUENCY OR 850 KILOCYCLES.

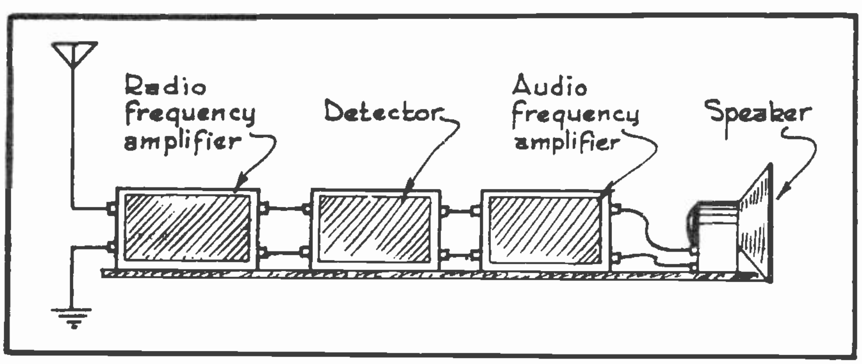

FIG. 1
Location of the Radio Frequency Amplifier in the Receiver.

LET US NEXT CONSIDER THE REASON FOR USING SUCH A RADIO FREQUENCY OR R.F. AMPLIFIER. TO BEGIN WITH, YOU ALREADY KNOW THAT THE SIGNAL ENERGY, WHICH IS COLLECTED BY THE ANTENNA, IS VERY FEEBLE SO THAT WE

HAVE AN EXTREMELY SMALL VOLTAGE INDUCED IN THE ANTENNA CIRCUIT TO BE IMPRESSED UPON THE DETECTOR TUBE.

IT SO HAPPENS THAT WHEN A DETECTOR CIRCUIT IS DIRECTLY COUPLED TO THE ANTENNA CIRCUIT, WEAK SIGNAL IMPULSES UPON THE DETECTOR TUBE'S GRID WILL PRODUCE WEAK SIGNAL CHANGES IN THE DETECTOR TUBE OUTPUT. NO DOUBT YOU ARE NOW THINKING THAT WE CAN COMPENSATE FOR THIS WEAK DETECTOR OUTPUT BY ADDING QUITE A NUMBER OF AUDIO FREQUENCY AMPLIFYING STAGES FOLLOWING THE DETECTOR.

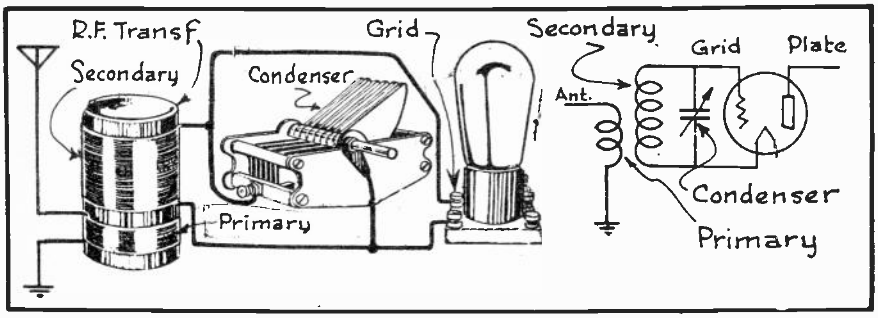

FIG. 2
One Stage of R.F. Amplification.

THIS, HOWEVER, WOULD NOT OVERCOME THIS DEFFICIENCY AS NICELY AS IT MIGHT AT FIRST APPEAR BECAUSE THERE IS A LIMIT TO THE NUMBER OF AUDIO FREQUENCY AMPLIFYING STAGES, WHICH CAN BE ADDED TO A RECEIVER WITHOUT DESTROYING THE TONE QUALITY. THEREFORE, THE LOGICAL THING TO DO IS TO PROVIDE THE DETECTOR WITH A STRONGER SIGNAL ENERGY, SO THAT THIS UNIT CAN OPERATE MORE EFFICIENTLY AND THE RADIO FREQUENCY AMPLIFIER OFFERS US THE SOLUTION TO THIS PROBLEM.

ANOTHER DECIDED ADVANTAGE OF USING R.F. AMPLIFICATION IS THAT THIS SECTION OF THE RECEIVER NOT ONLY ADDS TO THE SENSITIVITY OF THE RECEIVER, AS YOU WERE JUST TOLD, BUT IT ADDS TREMENDOUSLY TO THE SELECTIVITY OF THE RECEIVER AS WELL. THE REASON FOR THIS LATTER CONDITION IS THAT THE RADIO FREQUENCY AMPLIFIER CONSISTS OF A SERIES OF TUNED CIRCUITS AND THEY ALL WORK TOGETHER TO TUNE SHARPER TO ANY GIVEN FREQUENCY THAN WOULD BE POSSIBLE BY ANY SINGLE TUNED CIRCUIT. THIS, YOU SEE, WILL PREVENT TWO OR MORE STATIONS FROM COMING IN AT ONCE, MORESO THAN WOULD BE POSSIBLE FROM A SINGLE TUNED CIRCUIT.

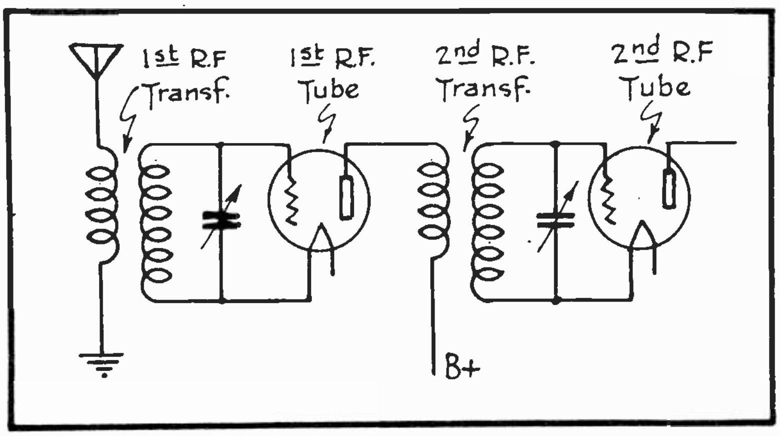

FIG. 3
Two Coupled R.F. Stages.

WITH THESE IDEAS UPPERMOST IN MIND, LET US NOW LOOK INSIDE OF SUCH AN R.F. AMPLIFIER AND FIND OUT WHAT IT CONSISTS OF.

A STAGE OF R. F. AMPLIFICATION

THE FIRST STAGE OF A TYPICAL R.F. AMPLIFIER IS ILLUSTRATED IN FIG. 2

AND AS YOU WILL OBSERVE, IT CONSISTS MERELY OF AN R.F. TRANSFORMER, A VARIABLE CONDENSER AND A VACUUM TUBE.

RADIATED WAVES OF ALL FREQUENCIES WILL STRIKE THE ANTENNA AND PRODUCE VOLTAGE CHANGES IN THE PRIMARY WINDING OF THE R.F. TRANSFORMER. BY VARYING THE CAPACITY OF THE CONDENSER, WE CAN TUNE THE SECONDARY WINDING OF THE TRANSFORMER TO ANY FREQUENCY WE CHOOSE AND ONLY THOSE SIGNAL VOLTAGES, TO WHICH THIS SECONDARY IS TUNED, WILL BE EFFECTIVE IN INDUCING VOLTAGE CHANGES ACROSS THIS SECONDARY CIRCUIT.

FOR EXAMPLE, IF THIS SECONDARY CIRCUIT IS TUNED TO 650 KILOCYCLES, THEN THE 650 KILOCYCLE WAVE TRAINS WILL INDUCE VOLTAGE CHANGES AT A 650 KC. FREQUENCY IN THIS SECONDARY CIRCUIT. THESE VOLTAGE CHANGES WILL THEN BE IMPRESSED UPON THE GRID OF THE TUBE AT THIS SAME FREQUENCY AND THEREFORE, THE PLATE CURRENT CHANGES IN THIS TUBE WILL ALSO VARY AT THIS SAME FREQUENCY.

NOTICE THAT IN THIS STAGE OF R.F. AMPLIFICATION WE MAKE USE OF THE TRANSFORMER TO OBTAIN A VOLTAGE STEP-UP AND BESIDES THIS, WE ALSO HAVE THE VOLTAGE AMPLIFICATION OF THE TUBE TO HELP US. SO BEAR IN MIND, THAT

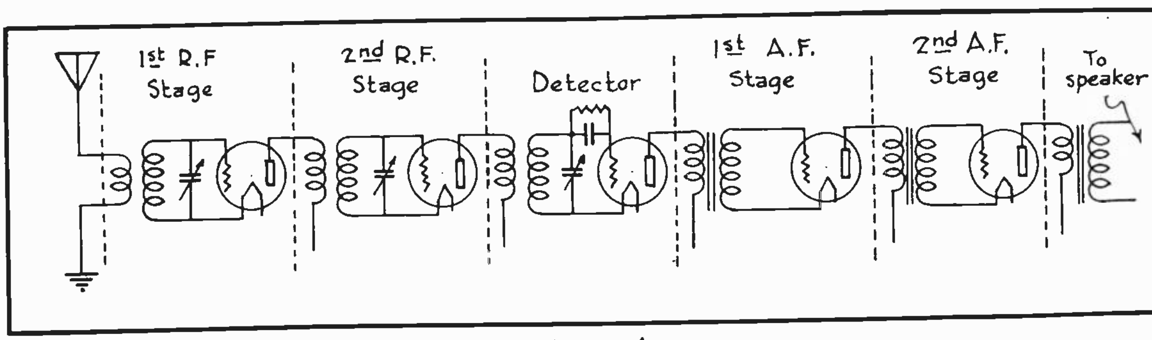

FIG. 4
Stage Arrangement In a Five Tube Receiver

THE CHANGES IN THIS 650 KC. VARIATION IN PLATE CURRENT FLOW WILL BE MUCH GREATER THAN THE 650 KC. CURRENT FLOW INDUCED IN THE PRIMARY OF THE TRANSFORMER BY THE INCOMING SIGNAL.

COUPLED R. F. STAGES

WE CAN INCREASE THIS SIGNAL ENERGY STILL MORE BY ADDING ANOTHER STAGE OF R.F. AMPLIFICATION AS SHOWN IN FIG. 3. IN THIS CASE, THE SECONDARY WINDING OF THE 2ND R.F. TRANSFORMER CAN BE TUNED BY ITS CONDENSER SO THAT IT WILL ALSO BE RESONANT TO THE INCOMING SIGNAL FREQUENCY.

BY DOING THIS, YOU CAN READILY SEE THAT THE PLATE CURRENT CHANGES, THROUGH THE PRIMARY WINDING OF THE 2ND R.F. TRANSFORMER WILL INDUCE VOLTAGE CHANGES OF CORRESPONDING FREQUENCY ACROSS THE SECONDARY OF THIS SAME TRANSFORMER. THESE VOLTAGE CHANGES, WHICH ARE STILL OF THE CARRIER SIGNAL FREQUENCY, WILL THEN IN TURN ACT UPON THE GRID OF THIS 2ND R.F. TUBE AND PRODUCE CURRENT CHANGES OF LIKE FREQUENCY IN ITS PLATE CIRCUIT.

DUE TO THE VOLTAGE GAIN OBTAINED BY THE TWO TRANSFORMERS AND THE 1ST R.F. TUBE, WE WILL HAVE GREATER WORKING VOLTAGE CHANGES IMPRESSED UPON THE GRID OF THE 2ND R.F. TUBE THAN UPON THE 1ST R.F. TUBE AND THEREFORE, THE PLATE CURRENT CHANGES IN THE 2ND R.F. TUBE WILL BE STILL

GREATER BUT STILL OF THE RECEIVED CARRIER FREQUENCY. NOW BY ADDING THESE TWO STAGES OF R.F. AMPLIFICATION IN FRONT OF OUR DETECTOR CIRCUIT, A COMPLETE 5 TUBE RECEIVER WOULD BE "LAID-OUT" IN THE MANNER SHOWN IN FIG. 4. HERE YOU WILL NOTE THAT WE HAVE TWO STAGES OF R.F. AMPLIFICATION PRECEDING THE DETECTOR AND THEN THE DETECTOR ITSELF, FOLLOWED BY TWO STAGES OF A.F. AMPLIFICATION AND FINALLY THE SPEAKER. FROM THIS, YOU WILL SEE THAT BY THE TIME THE SIGNAL IS "RELAYED" THROUGH THE R.F. AMPLIFYING STAGES, WE WILL HAVE CONSIDERABLE GREATER VOLTAGE CHANGES IMPRESSED UPON THE GRID OF THE DETECTOR THAN IF THE DETECTOR WERE COUPLED DIRECTLY TO THE ANTENNA. THIS WILL PERMIT THE DETECTOR TO OPERATE MUCH BETTER THAN IF ONLY EXTREMELY FEEBLE SIGNAL VOLTAGES WERE IMPRESSED UPON THE GRID OF THE DETECTOR TUBE.

ANOTHER IMPORTANT POINT TO OBSERVE IN FIG. 4 IS THAT WE HAVE A TUNED CIRCUIT IN THE 1ST R.F., THE 2ND R.F. AND IN THE DETECTOR STAGE, GIVING US THREE TUNED CIRCUITS ALTOGETHER. WITH EACH OF THESE CIRCUITS TUNED TO THE SAME FREQUENCY, THERE WILL BE LITTLE CHANCE FOR MORE THAN ONE BROADCAST FREQUENCY TO FILTER THROUGH THE R.F. AMPLIFIER.

THE SAME FIVE-TUBE RECEIVER, WITH ALL OF THE CIRCUIT CONNECTIONS INDICATED, IS SHOWN IN FIG. 5, SO STUDY THIS ILLUSTRATION CAREFULLY. THE EXTRA BY-PASS CONDENSER, WHICH IS LABELED IN THIS ILLUSTRATION, IS USED

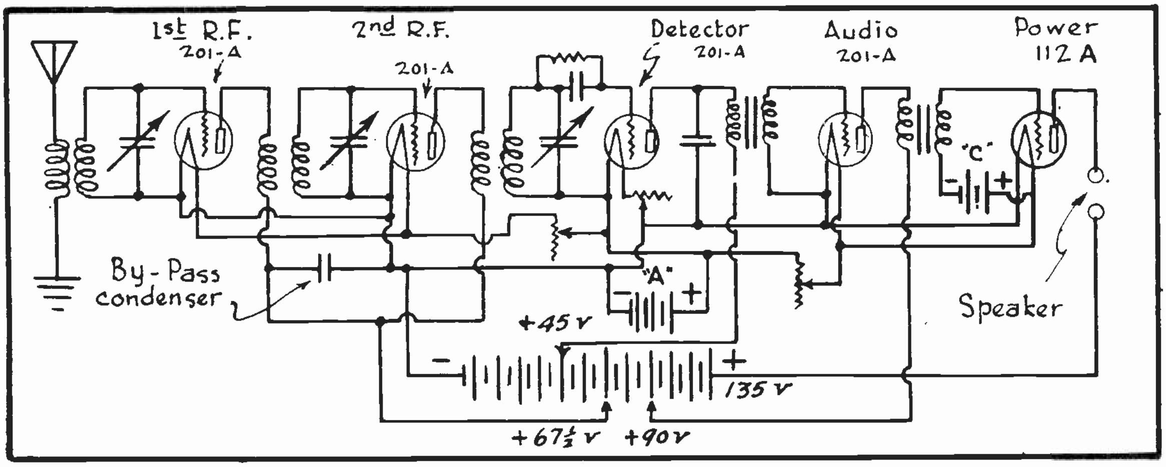

FIG. 5

A Complete Five Tube Receiver.

TO PERMIT THE OSCILLATIONS TO RETURN FROM THE PLATE CIRCUIT OF THE R.F. TUBES TO THE FILAMENTS, WITHOUT FIRST HAVING TO PASS ALL THE WAY AROUND THROUGH THE "B" BATTERY.

SOLENOID TYPE R.F. TRANSFORMERS

NOW THAT YOU UNDERSTAND THE CIRCUIT ARRANGEMENT FOR THESE SIMPLER R.F. AMPLIFIERS, LET US NEXT INVESTIGATE R.F. TRANSFORMERS A LITTLE MORE THOROUGHLY.

FORMERLY, IT WAS THE COMMON PRACTICE TO WIND THESE TRANSFORMER COILS ON TUBULAR MATERIAL SO THAT THE FINISHED COIL OR TRANSFORMER WAS ABOUT 3" IN DIAMETER. THE R.F. TRANSFORMERS IN MODERN RECEIVERS, HOWEVER, ARE QUITE A BIT SMALLER IN THAT THEIR DIAMETERS RUN AROUND 1 TO 2 INCHES AND THEIR LENGTH IS GENERALLY SOMEWHAT GREATER THAN THEIR DIAMETER.

YOU WILL SEE TWO MODERN SOLENOID TYPE TRANSFORMERS ILLUSTRATED IN FIG. 6. NOTICE HOW NEAT AND SLENDER THAT THEY ARE. ALSO NOTICE THAT

THE PRIMARY WINDING OF THE COIL AT THE LEFT IS WOUND SLIGHTLY BELOW THE SECONDARY, WHEREAS THE PRIMARY WINDING OF THE TRANSFORMER AT THE RIGHT OF FIG. 6 IS WOUND RIGHT OVER THE TOP OF THE SECONDARY.

THE RELATIVELY LOOSE COUPLING BETWEEN THE PRIMARY AND SECONDARY WINDINGS AS SHOWN AT THE LEFT OF FIG. 6 IS GENERALLY EMPLOYED ON R.F. TRANSFORMERS WHICH ARE TO BE USED IN THE FIRST STAGE OF RADIO FREQUENCY AMPLIFICATION, OR AS WE GENERALLY SAY, IN THE ANTENNA STAGE. CLOSE COUPLING BETWEEN THE PRIMARY AND SECONDARY WINDINGS AS ILLUSTRATED AT THE RIGHT OF FIG. 6, IS MOST GENERALLY USED IN THE R.F. STAGES FOLLOWING THE ANTENNA STAGE. QUITE OFTEN, YOU WILL ALSO HEAR OF R.F. TRANSFORMERS REFERRED TO AS R.F. COILS--EITHER EXPRESSION IS CONSIDERED AS BEING CORRECT.

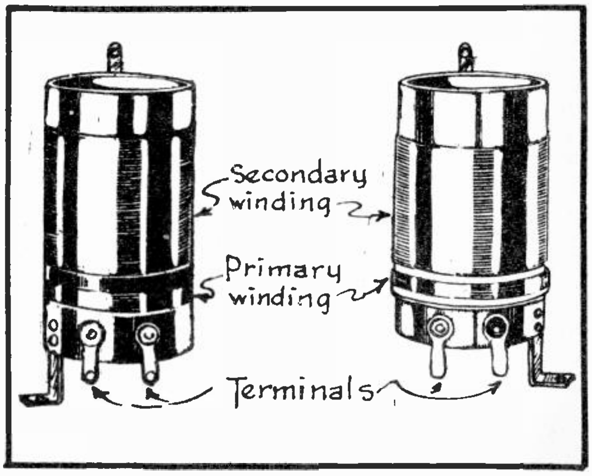

FIG. 6
Modern R.F. Transformers.

THE WIRE USED FOR THESE R.F. TRANSFORMERS MAY BE EITHER BARE WITH NO INSULATING COVERING AT ALL, OR ELSE IT MAY BE COTTON COVERED, SILK COVERED, OR ENAMEL COVERED. BARE WIRE IS BEST OF ALL BUT IN ORDER TO USE IT EFFECTIVELY, THE TURNS MUST BE SEPARATED BY AIR SPACE, GIVING US A SPACE-WOUND COIL, ABOUT WHICH YOU WILL HEAR MORE A LITTLE LATER ON.

COTTON COVERED WIRE IS ALSO FREQUENTLY USED BUT IN ORDER TO PREVENT IT FROM ABSORBING MOISTURE AND THEREBY UPSETTING THE EFFECTIVE INDUCTANCE OF THE WINDINGS, WE MUST COAT SUCH A WINDING THOROUGHLY WITH SHELLAC, HOT PARAFFIN OR SOME OTHER MOISTURE RESISTING WAX. SILK COVERED WIRE IS LIKEWISE USED CONSIDERABLY AND IT MUST ALSO BE IMPREGNATED WITH SOME SUCH MOISTURE RESISTING WAX. THEN LAST OF ALL, WE HAVE THOSE WIRES WHOSE ONLY INSULATION IS AN ENAMEL COATING AND THIS TYPE IS THE MOST COMMONLY USED OF ALL THOSE MENTIONED.

UP TO THIS TIME, THE SINGLE LAYER SOLENOID COIL, SUCH AS PICTURED IN FIG. 6, HAS BEEN FOUND THE MOST EFFICIENT TYPE, AS WELL AS THE EASIEST TO CONSTRUCT. THE FOLLOWING TABLES 1. AND 2. GIVE YOU THE APPROXIMATE SPECIFICATIONS TO USE FOR DIFFERENT COIL DIAMETERS, SO THAT YOU CAN WIND A TRANSFORMER SECONDARY COIL, WHICH WILL TUNE OVER THE BROADCAST BAND OF 550 TO 1,500 KC. WITH EITHER A .0005 MFD. VARIABLE CONDENSER OR A .00035 MFD. VARIABLE CONDENSER. THE WIRE SIZES, AS SPECIFIED IN THESE TABLES, ARE ALL BASED UPON THE B & S SYSTEM AND ADJACENT TURNS OF THE WINDING SHOULD BE PLACED SIDE BY SIDE TOUCHING EACHOTHER.

SOME R.F. COILS ARE WOUND WITH SMALL STRANDED WIRE, KNOWN AS LITZ WIRE, AND THIS TYPE OF WIRE HAS LESS HIGH FREQUENCY RESISTANCE THAN A SOLID CONDUCTOR. ANOTHER POINT TO NOTICE IS THAT THE SMALLER THE COIL DIAMETER USED, THE SMALLER WILL BE THE WIRE SIZE USED AND THIS EXPLAINS THE REASON WHY WE CAN WIND SMALL COILS, WHICH CAN COVER THE BROADCAST BAND JUST AS READILY AS THE LARGER COILS. IN FACT, THEY EVEN PERFORM BETTER IN ACTUAL PRACTICE THAN THE BULKIER TYPE OF COIL.

FOR THE PRIMARY WINDING OF SUCH A COIL, WHICH IS TO BE USED IN THE

ANTENNA STAGE, YOU WILL QUITE OFTEN FIND FROM 4 TO 16 TURNS OF THE SAME SIZE AND TYPE OF WIRE AS USED FOR THE SECONDARY AND A SEPARATION BETWEEN THE WINDINGS EQUIVALENT TO ABOUT 1/8" PER INCH OF COIL DIAMETER.

ON THE R.F. TRANSFORMERS FOR THE OTHER STAGES OF RADIO FREQUENCY

TABLE I

Coil Specifications for .00035 Mfd. Condensers

Diam.	Length	Wire	No Turns
3	1	26 S.C.C.	50
3	1½	24 D.S.C.	61
3	2	21 S.C.C.	60
3	2½	19 Enam.	65
3	3	18 D.S.C.	68
2½	1	27 D.S.C.	55
2½	1½	24 D.S.C.	53
2½	2	22 D.S.C.	69
2½	2½	21 S.C.C.	75
2½	3	19 Enam.	80
2	1	29 D.S.C.	66
2	1½	26 S.C.C.	75
2	2	24 D.S.C.	89
2	2½	22 Enam.	92
2	3	21 Enam.	99
1½	1	32 D.S.C.	84
1½	1½	27 Enam.	97
1½	2	25 Enam.	104
1½	2½	24 Enam.	115
1½	3	24 S.C.C.	123
1	1	37 D.S.C.	121
1	1¼	35 D.S.C.	132
1	1½	30 Enam.	136
1	2	32 S.C.C.	168
1	2½	29 S.C.C.	165
1	3	28 S.C.C.	180

Note:- S.C.C. = Single Cotton Cover
D.S.C. = Double Silk Cover
Enam. = Enamel.

TABLE II

Coil Specifications for .0005 Mfd. Condensers

Diam.	Length	Wire	No Turns
3	1	23 Enam.	42
3	1½	20 Enam.	45
3	2	19 S.C.C.	49
3	2½	18 S.C.C.	55
3	3	16 Enam.	57
2½	1	25 D.S.C.	46
2½	1½	22 Enam.	56
2½	2	20 Enam.	60
2½	2½	19 Enam.	61
2½	3	18 S.C.C.	66
2	1	25 Enam.	53
2	1½	23 Enam.	62
2	2	22 S.C.C.	70
2	2½	20 Enam.	75
2	3	19 Enam.	80
1½	1	28 Enam.	75
1½	1½	26 Enam.	86
1½	2	24 Enam.	94
1½	2½	23 Enam.	100
1½	3	22 Enam.	108
1	1	30 Enam.	95
1	1¼	32 D.S.C.	106
1	1½	28 Enam.	112
1	2	28 D.S.C.	132
1	2½	26 Enam.	140
1	3	25 Enam.	156

Note:- S.C.C. = Single Cotton Cover
D.S.C. = Double Silk Cover
Enam. = Enamel

AMPLIFICATION, A GREATER NUMBER OF PRIMARY TURNS IS GENERALLY USED. FOR EXAMPLE, ON AN R.F. TRANSFORMER HAVING A DIAMETER OF 1" AND WHICH IS TO BE USED IN A CIRCUIT EMPLOYING SCREEN-GRID TUBES, IT IS COMMON TO FIND SOMEWHERE AROUND 40 TURNS OF PRIMARY WINDING.

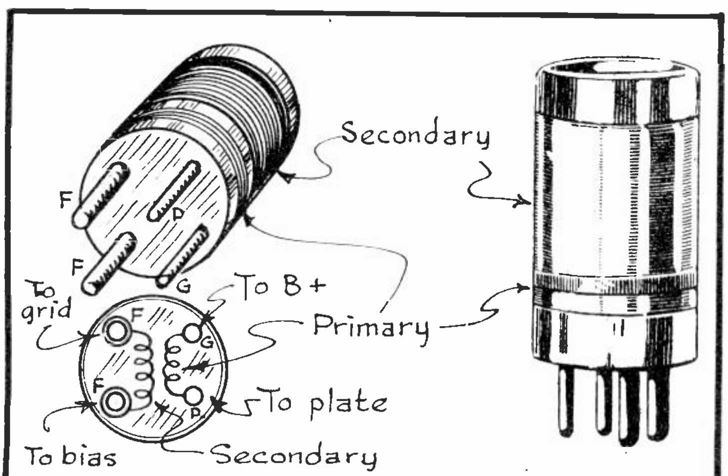

FIG. 7
"Plug-in" R. F. Transformer.

IN YOUR ADVANCED STUDIES, YOU WILL HAVE AN OPPORTUNITY OF STUDYING THE DESIGN AND CONSTRUCTION OF VARIOUS SPECIAL TYPES OF R.F. TRANSFORMERS.

ANOTHER POINT ABOUT R.F. TRANSFORMER CONSTRUCTION, WHICH IS VERY IMPORTANT, IS THE SUPPORTING MEMBER UPON WHICH THE WINDINGS ARE WOUND. ALTHOUGH IT IS POSSIBLE TO WIND THE COILS ON A PARAFFIN-IMPREGNATED CARDBOARD TUBE, YET THIS

TYPE OF SUPPORT PERMITS HIGH FREQUENCY LEAKAGES, WHICH CAUSE WHAT ARE KNOWN AS DIELECTRIC LOSSES, HOWEVER, FOR THE SAKE OF ECONOMY IN COMMERCIAL RECEIVERS, SUCH FORMS ARE USED A GREAT DEAL. TO REDUCE DIELECTRIC LOSSES, THESE COILS ARE FREQUENTLY WOUND ON THIN BAKELITE OR SPECIAL COMPOSITION TUBING. BAKELITE IS A PHENOL COMPOUND AND IT LOOKS VERY MUCH LIKE HARD RUBBER.

"PLUG-IN" TYPE R.F. TRANSFORMERS

ANOTHER CONVENIENT R.F. TRANSFORMER IS SHOWN AT THE RIGHT OF FIG. 7. THIS UNIT IS MOUNTED ON A TUBE BASE AND THE ENDS OF THE PRIMARY WINDING ARE CONNECTED TO TWO OF THE PRONGS AND THE ENDS OF THE SECONDARY WINDING ARE CONNECTED TO THE OTHER TWO PRONGS.

THIS TRANSFORMER IS KNOWN AS THE "PLUG-IN" TYPE, FOR IT CAN BE INSERTED INTO AN ORDINARY FOUR PRONG TUBE SOCKET, JUST AS IF IT WERE A RADIO TUBE.

THE SOCKET TERMINALS ARE CONNECTED UP TO THE RADIO CIRCUIT AS INDICATED AT THE LOWER LEFT OF FIG. 7 AND BY SIMPLY "PLUGGING-IN" THIS TRANSFORMER, OUR CONNECTIONS WILL ALREADY BE MADE. THIS TYPE OF CONSTRUCTION IS ESPECIALLY HANDY WHEN ONE WISHES TO EXCHANGE R.F. TRANSFORMERS, SO THAT THE RECEIVER CAN OPERATE OUTSIDE OF THE BROADCAST BAND, SUCH AS FOR SHORT WAVE RECEPTION ETC.

MISCELLANEOUS R.F. TRANSFORMERS

IN ORDER TO REDUCE DIELECTRIC LOSSES, DISTRIBUTED CAPACITY, ETC. OF R.F. TRANSFORMERS, VARIOUS IDEAS WERE WORKED OUT AND TRIED FROM TIME TO TIME. IN FIG. 8, FOR EXAMPLE, YOU WILL SEE FOUR COILS, WHICH ARE MORE OR LESS SELF SUPPORTING, SO THAT THEY ARE SURROUNDED BY AIR RATHER THAN BY SOME OTHER SUPPORTING SURFACE AS BAKELITE ETC.

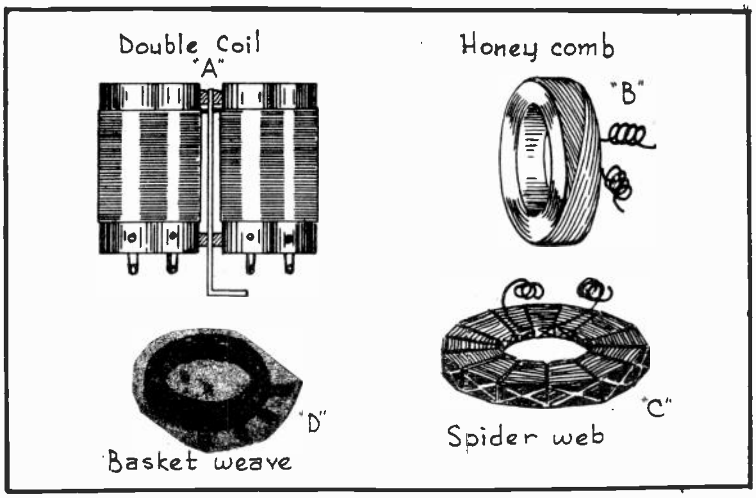

FIG. 8
Various Types of R.F. Transformers.

THE ARRANGEMENT IN "A" OF FIG. 8 IS A DOUBLE COIL AND THIS TYPE OF CONSTRUCTION PREVENTS THE COIL'S MAGNETIC FIELD FROM SPREADING OUT VERY FAR FROM THE UNIT AND THEREBY BRINGING ABOUT UNDESIRED COUPLING BETWEEN IT AND OTHER NEARBY RADIO PARTS.

THE COIL SHOWN IN "B" OF FIG. 8 IS KNOWN AS A HONEYCOMB COIL. THE CHIEF ADVANTAGES CLAIMED FOR THIS TYPE OF COIL ARE A RELATIVELY LARGE INDUCTANCE IN PROPORTION TO ITS SIZE.

A SPIDER WEB OR PANCAKE COIL IS SHOWN IN "C" OF FIG. 8. IT HAS LITTLE DISTRIBUTED CAPACITY DUE TO THE SPACING OF THE "TURNS" BUT THIS

AMOUNT OF SPACING REDUCES THE COIL'S INDUCTANCE.

THE COIL SHOWN AT "D" OF FIG. 8 IS A BASKET WEAVE COIL AND THE ADVANTAGES CLAIMED FOR IT ARE MUCH THE SAME AS THOSE OF THE SPIDER-WEB COIL. THESE COILS ARE COATED WITH A "BINDER" FLUID, WHICH ENABLES THEM TO HOLD THEIR SHAPE, EVEN THOUGH NO SUPPORTS ARE USED.

NONE OF THE COILS SHOWN IN FIG. 8, WITH THE EXCEPTION OF THE HONEYCOMB COIL, ARE USED IN MODERN COMMERCIAL RECEIVERS BUT IT IS WELL FOR YOU TO KNOW OF THEIR EXISTENCE, SO THAT YOU WILL BE FAMILIAR WITH THEM IN CASE THAT YOU SHOULD COME ACROSS ONE. ALSO NOTE THAT EACH AND EVERY ONE OF THE R.F. TRANSFORMERS SHOWN YOU MAKES USE OF AN AIR CORE.

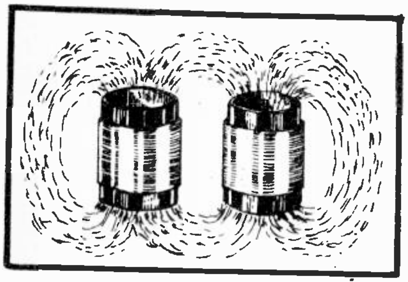

FIG. 9
Coupling Between Coils.

AIR, AS A CONDUCTOR FOR LINES OF FORCE, IS VERY "ELASTIC" IN NATURE AND AT RADIO FREQUENCIES, IT RESPONDS READILY TO A CHANGE OF POLARITY AS THE FLUCTUATING MAGNETIC FIELD OF THE COIL REVERSES ITSELF.

PLACING THE R.F. TRANSFORMERS IN A RECEIVER

THE NEXT POINT FOR US TO CONSIDER IS THE POSITION WHICH THE R.F. COILS SHOULD OCCUPY IN THE RECEIVER. IN FIG. 9, FOR INSTANCE, WE HAVE TWO R.F. COILS SO MOUNTED THAT A VERY UNDESIRABLE OCCURENCE IS TAKING PLACE BETWEEN THEM. THE TROUBLE HERE IS THAT THE MAGNETIC FIELD OF ONE AFFECTS THE OTHER AND THIS GIVES US INDUCTIVE COUPLING BETWEEN THE TWO COILS.

NOW IF THESE TWO COILS ARE BEING USED IN THE CIRCUIT OF TWO DIFFERENT R.F. AMPLIFYING STAGES, IT IS EVIDENT THAT WE WILL HAVE A FEED-BACK OF ENERGY BETWEEN THEM AND THIS CAUSES SERIOUS TROUBLE IN A RECEIVER.

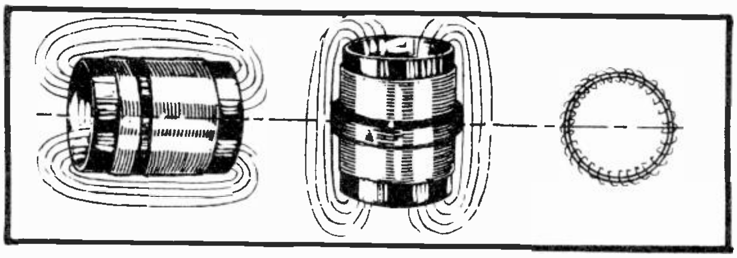

FIG. 10
Reducing Coupling Between Transformers.

TO AVOID SUCH A CONDITION, WE CAN PLACE THE COILS FARTHER APART, BUT BETTER STILL, IS TO MOUNT THE R.F. TRANSFORMERS OF THE DIFFERENT STAGES IN SUCH AN ARRANGEMENT AS PICTURED IN FIG. 10. HERE YOU WILL SEE THAT ALL THREE OF THESE TRANSFORMERS ARE PLACED AT RIGHT ANGLES TO EACH OTHER AND THEREFORE, THEIR FIELDS WILL HAVE NO TENDENCY TO INTERLINK. BEAR IN MIND, THAT EVEN IN THIS CASE, IT IS ADVISABLE TO KEEP THE COILS WELL SEPARATED FROM EACHOTHER.

STILL ANOTHER COIL ARRANGEMENT TO PREVENT AN INDUCTIVE COUPLING BETWEEN THEM IS SHOWN IN FIG. 11. HERE THE COILS ARE ALL INCLINED OR TILTED AT AN ANGLE OF APPROXIMATELY 56°. PROFESSOR HAZELTINE DISCOVERED MATHEMATICALLY THAT WHEN THE TRANSFORMERS ARE PLACED AT THIS ANGLE, THEN NO INDUCTIVE OR MAGNETIC COUPLING EXISTS BETWEEN THEM. THE RECEIVERS, IN WHICH THIS COIL ARRANGEMENT IS USED, ARE GENERALLY KNOWN AS NEUTRODYNE RECEIVERS AND THE R.F. TRANSFORMERS IN THIS CASE ARE GENERALLY SPOKEN OF AS

"NEUTROFORMERS".

MODERN TUNING CONDENSERS

NOW THAT YOU ARE FAMILIAR WITH R.F. TRANSFORMERS, LET US NEXT CONSIDER THE TUNING CONDENSERS FOR THIS AMPLIFIER IN GREATER DETAIL. FROM WHAT YOU HAVE SO FAR SEEN OF THE R.F. AMPLIFYING STAGES, YOU HAVE LEARNED THAT EACH STAGE HAD TO HAVE ITS TUNING CONDENSER AND THIS EXPLAINS THE REASON WHY THE OLDER RECEIVERS LITERALLY HAD THEIR PANELS COVERED WITH TUNING DIALS--EACH TUNING CONDENSERS HAVING ITS OWN DIAL CONTROL.

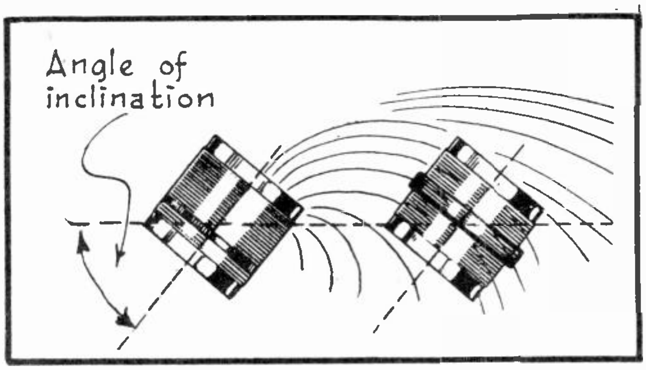

FIG. 11
Arrangement of Neutroformers.

PRESENT DAY RECEIVERS EVEN GO SO FAR AS TO USE A STILL GREATER NUMBER OF R.F. STAGES WITH THEIR ACCOMPANYING TUNING CONDENSERS AND YET THE CONTROL PANEL IS SIMPLE IN DESIGN AND WITH ONLY A SINGLE TUNING CONTROL, AS SHOWN IN FIG. 12. THE CENTER CONTROL KNOB IN THIS CASE IS THE TUNING CONTROL AND THIS SINGLE CONTROL TUNES ALL OF THE R.F. STAGES TO THE SAME FREQUENCY AND THERE IS NO NEED FOR JUGGLING AN ENTIRE SET OF CONTROLS IN ORDER TO TUNE ALL THE R.F. STAGES ALIKE.

IN ORDER TO BE ABLE TO TUNE ALL OF THE R.F. AND DETECTOR STAGES SIMULTANEOUSLY, ALL OF THE TUNING CONDENSERS ARE OPERATED BY A COMMON SHAFT. WE CALL A GROUPED CONDENSER ARRANGEMENT AS THIS A GANG CONDENSER AND IN FIG. 13 YOU WILL SEE A FOUR-GANG CONDENSER, WHICH IS ALSO KNOWN AS A QUADRUPLE CONDENSER.

NOTICE IN FIG. 13 THAT THE ROTOR OR MOVABLE PLATES OF EACH OF THE SECTIONS IN THIS CONDENSER GANG ARE MOUNTED ON A SINGLE SHAFT AND THEREFORE THEY MOST MOVE TOGETHER OR AS ONE UNIT WHENEVER THE CONTROL SHAFT IS TURNED.

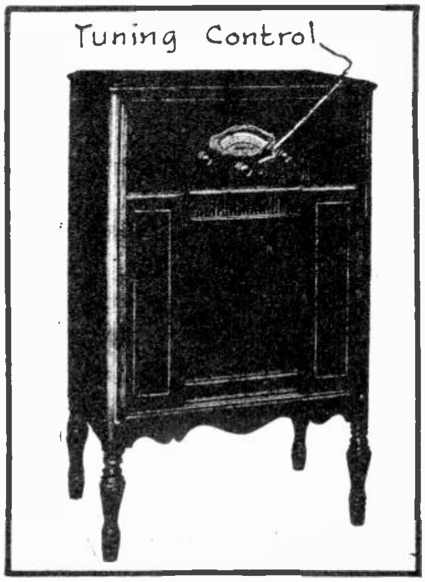

FIG. 12
Simple Controlled Receiver.

THE CONDENSER OF FIG. 13 IS DESIGNED ESPECIALLY FOR MOUNTING ON A METAL CHASSIS BASE OF THE RECEIVER AND THE CONDENSER FRAME WILL THEREFORE BE IN DIRECT CONTACT WITH THE CHASSIS BASE WHICH IN TURN IS GROUNDED, THEREFORE, THE ENTIRE CONDENSER FRAME AS WELL AS ALL ROTOR PLATES WILL BE GROUNDED IN COMMON. THE METAL SHIELD PLATES WHICH ARE PLACED BETWEEN EACH TUNING SECTION OF THE CONDENSER GANG IN FIG. 13 SERVES AS A SHIELD SO AS TO PREVENT ELECTROSTATIC COUPLING AND RESULTING INTER-ACTION BETWEEN THE VARIOUS CONDENSER SECTIONS.

THE TERMINALS, WHICH LEAD TO THE STATOR OR STATIONARY CONDENSER PLATES ARE MOUNTED ON THE SIDE OF THE UNIT AND IT IS TO THESE TERMINALS THAT WE CONNECT THE WIRES LEADING

TO THE GRIDS OF THE TUBES. THE TERMINAL OF THE ROTORS IS CONNECTED TO THE FILAMENT SIDE OF THE CIRCUIT AND WITH THE CONNECTIONS THUS MADE, WE DO NOT UPSET OUR TUNING WHENEVER WE BRING OUR HANDS NEAR THE TUNING CONTROL. THIS EFFECT OF ONE'S HANDS UPON TUNING IS KNOWN AS THE "HAND CAPACITY EFFECT."

WHEN YOU STUDY OVER THE CIRCUIT DIAGRAMS OF MODERN RECEIVERS, YOU WILL GENERALLY SEE THE VARIABLE CONDENSERS OF THE R.F. STAGES CONNECTED TOGETHER WITH DOTTED LINES, AS SHOWN IN FIG. 14. THIS MEANS THAT THE CONDENSERS, THUS INDICATED, ARE ALL OPERATED FROM A SINGLE TUNING CONTROL.

IN ORDER TO OPERATE SEPARATE TUNING CONDENSERS AS THIS TOGETHER AND STILL BE SUCCESSFUL IN TUNING ALL OF THE STAGES THE SAME, IT STANDS TO REASON THAT THE INDUCTANCES AND CAPACITIES IN EACH OF THESE STAGES MUST BE EXACTLY ALIKE. THIS MEANS THAT THE INDUCTANCES OF ALL THE COILS MUST BE PRECISELY MATCHED AND THE CIRCUIT WIRING IN EACH OF THESE STAGES MUST BE LAID OUT IN THE SAME WAY, SO THAT THERE WILL BE AS LITTLE VARIATION AS POSSIBLE IN THE DISTRIBUTED CAPACITY OF THESE COMMONLY CONTROLLED STAGES.

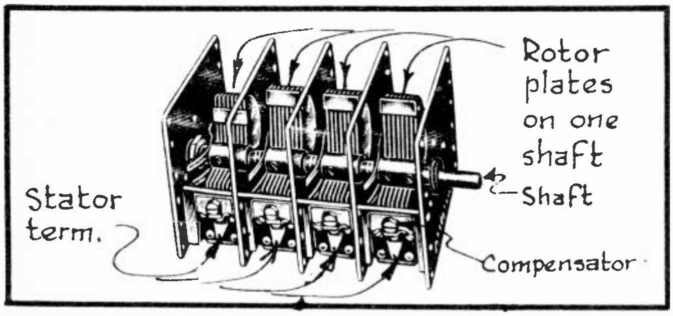

FIG. 13

A Four Gang Condenser.

COMPENSATING CONDENSERS

IN PRACTICE, OF COURSE, IT IS NOT ALWAYS POSSIBLE TO HAVE THINGS JUST AS WE WOULD WISH THEM AND SO IN ORDER TO COMPENSATE FOR SMALL TUNING VARIATIONS OF THE R.F. STAGES, SMALL COMPENSATING OR TRIMMER CONDENSERS ARE GENERALLY MOUNTED ON THE GANG CONDENSER AS SHOWN IN FIGS. 13 AND 15.

EACH OF THESE LITTLE TRIMMER CONDENSERS IS SHUNTED OR CONNECTED A-

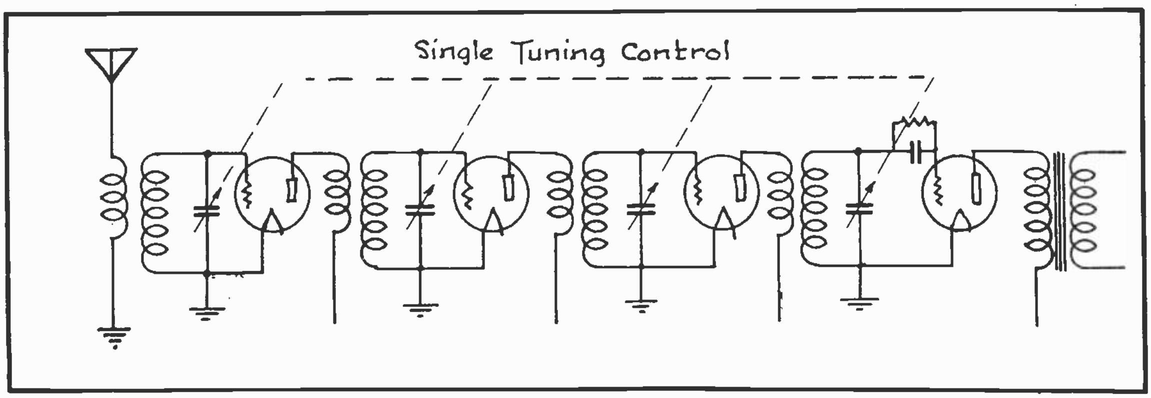

FIG. 14

Representing Single Tuning Control on a Diagram.

CROSS ONE OF THE TUNING CONDENSERS AS SHOWN IN FIG. 16. THIS MEANS THAT EACH OF THE TRIMMER CONDENSERS IS CONNECTED IN PARALLEL WITH ONE TUNING CONDENSER SECTION AND THEREFORE BY ALTERING THE CAPACITY OF THE TRIMMER CONDENSER, WE WILL LIKEWISE ALTER THE CAPACITY OF THE TUNING CONDENSER SECTION. THIS IN TURN WILL AFFECT THE TUNING OF THIS MAIN CONDENSER.

IN COMMERCIAL RECEIVERS, THESE TRIMMERS ARE NOT INTENDED TO BE TAMPERED WITH BY THE SET OWNER AND THE RADIO SERVICE MAN IS THE ONLY PERSON EXPECTED TO MAKE USE OF THEM. FOR THIS REASON, THE TRIMMERS ARE MADE SO THAT A SCREW DRIVER OR SPECIAL WRENCH IS GENERALLY REQUIRED TO CHANGE THEIR SETTING AND AFTER THE PROPER SETTING HAS BEEN MADE IN ALL STAGES, THE STAGES WILL TUNE TOGETHER AS THE SINGLE TUNING CONTROL IS OPERATED AND WE THEN SAY THAT THEY ARE "ALIGNED". AFTER THIS, THE TRIMMER ADJUSTMENTS SHOULD NOT BE DISTURBED AND THE AVERAGE SET OWNER DOESN'T EVEN KNOW THAT THEY EXIST AND SO HE TOO LEAVES THEM ALONE.

TO ALIGN THE R.F. STAGES BY EAR, WE PROCEED AS FOLLOWS: FIRST, WE TUNE THE RECEIVER TO SOME FAIRLY DISTANT STATION WHICH COMES IN SOMEWHERES AROUND THE CENTER OF THE TUNING DIAL AND WE ADJUST THE VOLUME CONTROL SO THAT THE SIGNALS COME IN WITH MEDIUM LOUDNESS. THIS DONE, WE MAKE SURE THAT THE TUNING CONTROL IS SET TO THAT POSITION, WHICH BRINGS IN THE SIGNALS LOUDEST. THE RECEIVER WILL NOW BE TUNED AS CLOSE AS POSSIBLE TO RESONANCE WITH THE STATION BEING LISTENED TO.

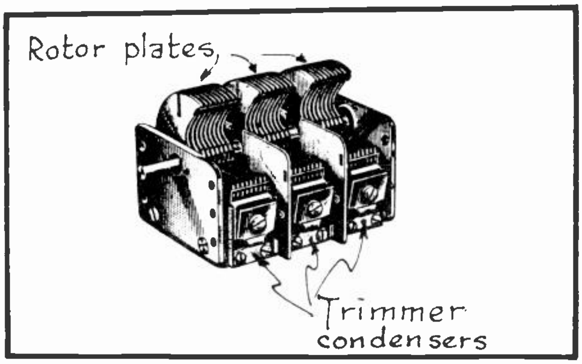

FIG. 15
Location of Trimmer Condensers.

OUR NEXT STEP IS TO INSERT THE TIP OF A SPECIAL BAKELITE SCREWDRIVER INTO THE SLOT PROVIDED FOR IT ON ONE OF THE TRIMMER CONDENSERS AND TURN IT VERY SLOWLY FIRST IN ONE DIRECTION AND THEN IN THE OTHER, LEAVING IT SET AT THAT POSITION WHERE THE SIGNALS COME IN LOUDEST. ABOVE ALL, REMEMBER, THAT YOU MUST NOT ALTER THE POSITION OF THE MAIN TUNING CONDENSERS ONE PARTICLE WHILE CARRYING OUT THIS ALIGNING WORK.

WITH THE FIRST TRIMMER SET SO THAT THE SIGNALS COME IN LOUDEST, PROCEED AND DO THE SAME THING WITH THE SECOND TRIMMER AND ADJUST IT TO THAT POINT, WHICH BRINGS THE SIGNALS IN LOUDEST WITH THAT PARTICULAR SETTING OF THE MAIN TUNING CONTROL AND VOLUME CONTROL.

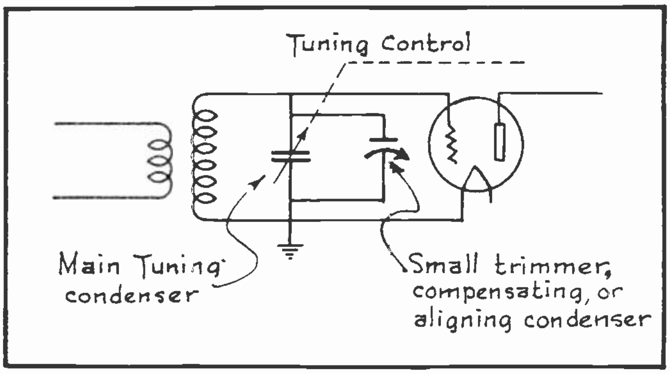

FIG. 16
Connection of The Trimmer Condenser in the Circuit.

SHOULD YOU USE A STANDARD METAL SCREW DRIVER FOR THIS ALIGNING JOB, YOU WILL FIND THAT WHEN BROUGHT IN CONTACT WITH THE TRIMMER ADJUSTMENT, IT WILL HAVE A PRONOUNCED EFFECT UPON THE TUNING. THEREFORE, YOU WILL HAVE TO MAKE A TRIAL TRIMMER ADJUSTMENT, REMOVE THE SCREW DRIVER AND NOTE THE PERFORMANCE OF THE RECEIVER FOLLOWED BY AN ADDITIONAL TRIMMER ADJUSTMENT, IF NECESSARY, AND AGAIN WITHDRAWING IT AND NOTING THE EFFECT OF THE ADJUSTMENT.

HOWEVER BY USING A SCREW DRIVER, WHICH YOU HAVE SHAPED OUT OF SOME SUCH INSULATIVE MATERIAL AS BAKELITE, YOU WILL BE ABLE TO MAKE YOUR TRIM-

MER ADJUSTMENTS WHILE NOTING THE EFFECT AT THE SAME TIME. YOU SEE, THIS INSULATING SCREW DRIVER HAS NO EFFECT UPON THE TUNING AS YOU HANDLE IT AND THEREFORE, YOU CAN MAKE A MORE ACCURATE ADJUSTMENT WITH IT, AS WELL AS DOING THIS IN A SHORTER TIME.

SOMETIMES YOU WILL COME ACROSS A GANG CONDENSER WITH NO TRIMMERS MOUNTED ON IT. THEN WHEN IT BECOMES NECESSARY TO ALIGN SUCH A UNIT, YOU CAN DO THIS BY SLIGHTLY BENDING THE OUTER ROTOR PLATES OF EACH CONDENSER SECTION. THE FARTHER OUTWARD THAT THESE PLATES ARE BENT, THE LESS WILL BE THE CAPACITY OF THAT ONE CONDENSER SECTION AND VICE VERSA.

BY BENDING THE OUTER ROTOR PLATES OF EACH CONDENSER SECTION BY THE CORRECT AMOUNT, THEY CAN ALL BE MADE TO TUNE ALIKE. SOME OF THESE GANGED CONDENSERS EVEN HAVE THE OUTER ROTOR PLATES OF EACH INDIVIDUAL SECTION PROVIDED WITH SLOTS AS SHOWN IN FIG. 15 SO AS TO MAKE BENDING EASIER. IN SUCH A CASE, WE CAN BEND PORTIONS OF THESE PLATES MORE THAN OTHERS AND THEREBY HAVE A MORE UNIFORM BALANCE BETWEEN THE CONDENSERS ACROSS THEIR ENTIRE TUNING RANGE.

TYPES OF TUNING CONDENSERS

VARIABLE CONDENSERS ARE DIVIDED INTO FOUR MAIN TYPES, NAMELY: STRAIGHT LINE CAPACITY, STRAIGHT LINE WAVE LENGTH, STRAIGHT LINE FREQUENCY.

THE ROTOR PLATES OF THE STRAIGHT LINE CAPACITY CONDENSER ARE SHAPED IN THE FORM OF SEMI-CIRCLES WITH THE SHAFT RUNNING THROUGH THEIR CENTER. WITH THIS ARRANGEMENT, THE CAPACITY VARIES DIRECTLY WITH THE POSITION OF THE PLATES. THAT IS, WITH THE ROTOR PLATES MESHED EXACTLY HALF-WAY WITH THE STATIONARY PLATES, THE CAPACITY AT THIS INSTANT WILL BE JUST ONE-HALF THE MAXIMUM OR RATED CAPACITY OF THE CONDENSER. WITH THE ROTOR PLATES MESHED ONE-FOURTH OF THE WAY WITH THE STATOR PLATES, THE CAPACITY WILL BE ONE-FOURTH THAT OF THE MAXIMUM CAPACITY, ETC.

THIS CONDENSER IS MAINLY SUITABLE FOR RADIO TESTING EQUIPMENT WHERE ACCURATE CAPACITY MEASUREMENTS ARE TO BE MADE. THE STRAIGHT LINE CAPACITY CONDENSER IS NOT SUITABLE FOR USE IN PRESENT DAY RECEIVERS BECAUSE THE LOWER WAVELENGTH STATIONS WILL BE CROWDED CLOSELY TOGETHER ON THE DIAL, WHEREAS THE UPPER WAVELENGTH STATIONS WILL BE WIDELY SEPARATED ON THE DIAL.

IN THE CASE OF THE STRAIGHT LINE WAVELENGTH CONDENSER, THE ROTOR PLATES ARE SHAPED SO THAT WHEN USED IN CONJUNCTION WITH A GIVEN COIL IN ORDER TO FORM A TUNED CIRCUIT, THE WAVELENGTH TO WHICH THE CIRCUIT IS TUNED WILL VARY DIRECTLY WITH THE POSITION OF THE ROTOR PLATES. FOR INSTANCE, IF A STRAIGHT LINE WAVELENGTH CONDENSER IS USED IN CONJUNCTION WITH A CERTAIN COIL SO THAT THE CIRCUIT WILL TUNE OVER A RANGE OF FROM 200 TO 600 METERS, THEN WITH THE ROTOR PLATES HALF WAY IN MESH WITH THE STATOR PLATES, THE CIRCUIT WILL BE TUNED TO 400 METERS ETC. THIS CONDENSER WAS COMMONLY USED A FEW YEARS AGO WHILE THE BROADCAST STATIONS WERE ALL RATED ACCORDING TO WAVE LENGTHS INSTEAD OF FREQUENCY.

LATER WHEN THE BROADCAST STATIONS WERE ALL SEPARATED EQUALLY OR BY 10 KILOCYCLES TO BE EXACT, THEN THE STRAIGHT LINE FREQUENCY CONDENSER CAME INTO PROMINENCE.

THIS CONDENSER DIFFERS FROM THE PREVIOUS ONE IN THAT INSTEAD OF THE

WAVELENGTH BEING ALTERED IN PROPORTION TO THE POSITION OF THE ROTOR PLATES, THE FREQUENCY IS AFFECTED IN THIS MANNER. THE MAIN DISADVANTAGE OF THIS CONDENSER, HOWEVER, IS THAT THE CONDENSER MUST HAVE A CONSIDERABLE MAXIMUM CAPACITY, THEREFORE MAKING THIS UNIT QUITE LARGE. FURTHERMORE, STATIONS IN THE UPPER EXTREMITY OF THE WAVE LENGTH RANGES ARE QUITE CLOSE TOGETHER AT THE UPPER END OF THE DIAL.

THE CONDENSER, WHICH IS MOST USED NOW IN COMMERCIAL RECEIVERS, IS KNOWN AS A STRAIGHT LINE TUNING CONDENSER OR MODIFIED STRAIGHT LINE FREQUENCY CONDENSER. GENERALLY SPEAKING, IT IS A CROSS BETWEEN A STRAIGHT LINE WAVE LENGTH CONDENSER AND A STRAIGHT LINE FREQUENCY CONDENSER. WITH THIS CONDENSER INSTALLED IN A TUNING CIRCUIT, CONSIDERABLE DIAL SEPARATION WILL BE OBTAINED BETWEEN THE HIGH FREQUENCY STATIONS, WHEREAS THE LOWER FREQUENCY STATIONS WILL BE CLOSER TOGETHER ON THE DIAL. THIS CONDITION, HOWEVER, IS NOT OBJECTIONABLE BECAUSE OUR PRESENT DAY RECEIVERS ARE NATURALLY MORE SELECTIVE AT THE LOWER FREQUENCIES ANYWAY.

ANOTHER THING TO BEAR IN MIND IS THAT MODERN TUNING CONDENSERS ARE GENERALLY RATED ACCORDING TO THEIR MAXIMUM CAPACITY. THE MINIMUM CAPACITY OF THE UNIT WILL THEN BE ABOUT ONE-TENTH OF THE MAXIMUM CAPACITY. THAT IS, IF A CERTAIN CONDENSER IS RATED AS HAVING A MAXIMUM CAPACITY OF .0005 MFD, THEN YOU CAN EXPECT ITS MINIMUM CAPACITY TO BE APPROXIMATLY 1/10 OF THIS AMOUNT OR .00005 MFD. THIS RANGE IN CAPACITY, WHEN USED WITH A PROPER COIL, PERMITS THE TUNED CIRCUIT TO COVER THE BROADCAST RANGE EASILY.

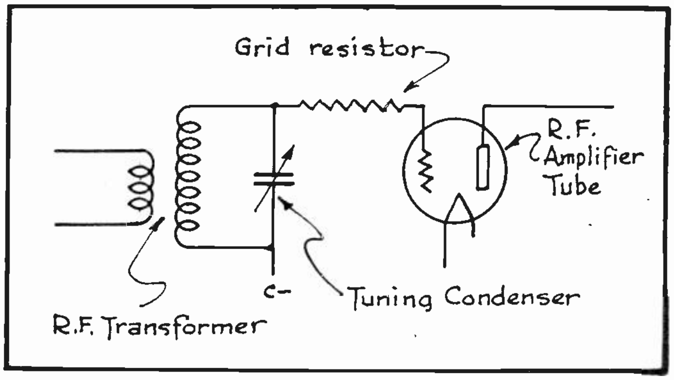

FIG. 17

Preventing Oscillation With a Grid Resistor.

R.F. FEED-BACKS

NOW WE ARE GOING TO BUMP UP AGAINST A MIGHTY BIG PROBLEM IN RADIO FREQUENCY AMPLIFIERS AND THIS IS BROUGHT ABOUT BY THE "FLIGHTINESS" OF THESE EXTREMELY HIGH FREQUENTCY CURRENTS, WHICH THE R.F. CIRCUITS ARE EXPECTED TO HANDLE. THAT IS, RADIO FREQUENCY CURRENTS HAVE A TENDENCY TO LEAVE THEIR INTENDED PATH WHEREVER THEY GET A CHANCE TO AND THEN THEY BEGIN STRAYING AROUND LOOKING FOR TROUBLE AND THEY SURELY FIND IT.

ONE OF THE MOST LIKELY PLACES THROUGH WHICH THE R.F. CURRENTS PASS, IN ORDER TO CAUSE US TROUBLE, IS THROUGH THE CAPACITY EXISTING BETWEEN THE GRID AND PLATE OF THE R.F. AMPLIFYING TUBES. YOU WERE ALREADY SHOWN IN A PREVIOUS LESSON HOW WE OBTAIN REGENERATION BY PERMITTING SOME R.F. ENERGY TO FEED-BACK FROM THE PLATE CIRCUIT OF A VACUUM TUBE, THROUGH THE GRID-PLATE CAPACITY OF THIS TUBE AND THENCE INTO ITS GRID CIRCUIT. THIS CONDITION IS PERFECTLY ALRIGHT, AS LONG AS THE AMOUNT OF THIS FEED-BACK ENERGY IS CONTROLLED BUT IF TOO MUCH OF IT GETS THROUGH THIS TUBE CAPACITY, THEN THE CIRCUIT BEGINS TO OSCILLATE AND ALL KINDS OF SQUEALS COME OUT OF THE LOUD SPEAKER.

USE OF GRID RESISTORS

TO PREVENT SUCH SELF-SUSTAINED OSCILLATIONS IN THE CIRCUITS OF OUR

AMPLIFIER, WE CAN USE QUITE A VARIETY OF METHODS. THE SIMPLEST OF THESE IS ILLUSTRATED IN FIG. 17. HERE YOU WILL NOTE THAT A RESISTOR HAS BEEN INSERTED IN THE GRID CIRCUIT OF THE R.F. AMPLIFYING TUBE.

NOW WE CAN SEE THAT WHEN THE FEED-BACK ENERGY PASSES THROUGH THE PLATE-GRID CAPACITY OF THE TUBE, IT MUST MEET THE RESISTANCE OR OPPOSITION OF THE GRID RESISTOR, BEFORE IT CAN GET INTO THE TUNED CIRCUIT.

IN THIS WAY, WE CAN PREVENT THIS FEED-BACK ENERGY FROM CAUSING THE TUNED CIRCUIT OF THIS TUBE TO OSCILLATE. THERE IS ONE DISADVANTAGE OF CONSIDERABLE IMPORTANCE CONNECTED WITH THIS METHOD OF STOPPING OSCILLATION AND THAT IS, THAT THIS ADDITIONAL RESISTANCE IN THE GRID CIRCUIT OF THE AMPLIFYING TUBE CAUSES THE CIRCUIT TO TUNE BROADER. THIS MEANS THAT A DECREASE IN SELECTIVITY IS BEING BROUGHT ABOUT BUT YET THERE IS ALSO THE ARGUMENT CONFRONTING US WHERE WE KNOW THAT EXCESSIVELY SHARP TUNING WILL DESTROY THE TONE QUALITY OF A RECEIVER.

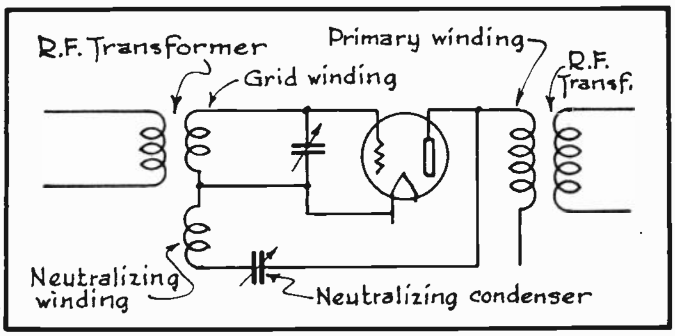

FIG. 18
The Principle of Neutralization.

THESE GRID RESISTORS ARE ALSO KNOWN AS GRID SUPRESSORS AND WHEN THIS SYSTEM IS BEING USED, YOU WILL FIND ONE SUCH RESISTOR IN THE GRID CIRCUIT OF EACH OF THE R.F. AMPLIFYING TUBES. A RESISTANCE VALUE OF 800 OHMS IS FREQUENTLY USED FOR THIS PURPOSE.

NEUTRALIZING CIRCUITS

NOW ANOTHER SYSTEM, WHICH WAS WIDELY USED TO PREVENT OSCILLATION, IS BASED UPON NEUTRALIZING PRINCIPLES. FOR EXAMPLE, IN FIG. 18, YOU WILL OBSERVE THAT AN EXTRA WIRE LEADS OFF FROM THE PLATE CIRCUIT OF THE R.F. TUBE AND IT IS CONNECTED TO A SMALL NEUTRALIZING CONDENSER. THE OTHER END OF THIS NEUTRALIZING CONDENSER IS CONNECTED TO ONE END OF A NEUTRALIZING WINDING, WHICH IS PLACED IN AN INDUCTIVE RELATIONSHIP WITH THE GRID WINDING.

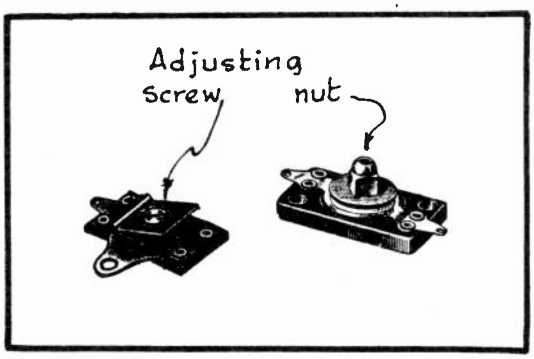

FIG. 19
Neutralizing Condensers.

A CERTAIN AMOUNT OF R.F. ENERGY WILL FIND ITS WAY FROM THE PLATE CIRCUIT OF THIS TUBE, THROUGH ITS GRID-PLATE CAPACITY AND INTO THE GRID WINDING. NOW BY ADJUSTING THE NEUTRALIZING CONDENSER PROPERLY, WE CAN PERMIT AN EQUAL AMOUNT OF ENERGY TO BE FED BACK FROM THE PLATE CIRCUIT THROUGH THIS NEUTRALIZING CONDENSER AND INTO THE NEUTRALIZING WINDING.

BY WINDING THE NEUTRALIZING COIL IN THE PROPER DIRECTION, WE CAN CAUSE THE R.F. CURRENT WHICH FLOWS THROUGH IT, TO ACT UPON THE GRID WINDING IN A DIRECTION OPPOSITE TO THAT OF THE GRID-PLATE CAPACITY FEED-BACK. IN THIS WAY, THE ENERGY WHICH IS BY-PASSED THROUGH THE NEUTRALIZING CON-

DENSER WOULD TEND TO NEUTRALIZE THAT PASSING THROUGH THE CAPACITY OF THE TUBE AND BY ADJUSTING THE NEUTRALIZING CONDENSER TO THE PROPER POINT, THESE TWO FEED-BACKS CAN BE MADE TO CANCEL EACHOTHER OUT AND THEREFORE NO FEED-BACK WILL BE EFFECTIVE AND NO OSCILLATION CAN OCCUR.

THESE NEUTRALIZING CONDENSERS ARE SOMEWHAT SIMILAR TO TRIMMER CONDENSERS AND IN FIG. 19, YOU WILL SEE WHAT TWO OF THESE POPULAR NEUTRALIZING CONDENSERS LOOK LIKE. NOTICE THAT EACH OF THEM IS PROVIDED WITH AN ADJUSTING SCREW, BY MEANS OF WHICH WE CAN CHANGE THEIR CAPACITY.

THERE ARE DIFFERENT WAYS IN WHICH THESE NEUTRALIZING CONDENSERS CAN BE USED AND IN FIG. 20, YOU WILL SEE HOW THE NEUTRALIZING ENERGY CAN BE OBTAINED FROM THE SECONDARY WINDING OF AN R.F. TRANSFORMER.

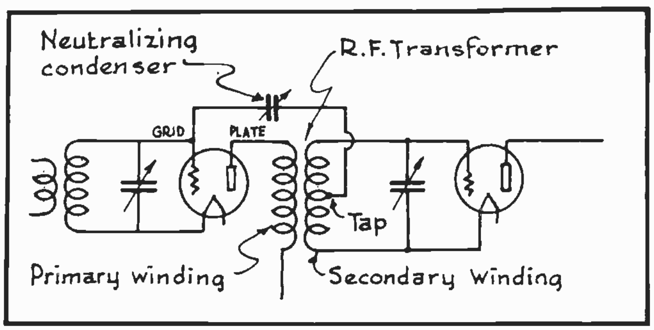

FIG. 20

Neutralizing With a Tapped Secondary.

BY REGULATING THE ADJUSTMENT OF THIS NEUTRALIZING CONDENSER, WE CAN CONTROL THE AMOUNT OF NEUTRALIZING EFFECT. THAT IS, BY DECREASING THE CAPACITY OF THE NEUTRALIZING CONDENSER, WE CAN GET A CERTAIN AMOUNT OF REGENERATIVE EFFECT THROUGH THE GRID-PLATE CAPACITY. THEN BY INCREASING THE CAPACITY OF THE NEUTRALIZING CONDENSER, MORE R.F. ENERGY WILL BE PASSED BY IT TO ACT UPON THE GRID CIRCUIT SO AS TO NEUTRALIZE THE REGENERATIVE FEED BACK THROUGH THE TUBE CAPACITY.

STILL ANOTHER METHOD OF OBTAINING NEUTRALIZATION IS SHOWN IN FIG. 21 AND IN THIS CASE, A SEPARATE OR NEUTRALIZING WINDING IS ADDED TO THE END OF THE PRIMARY WINDING IN THE PLATE CIRCUIT.

A NEUTRALIZING CONDENSER IS THEN INCLUDED IN SERIES BETWEEN THIS NEUTRALIZING WINDING AND THE GRID CIRCUIT OF THE PRECEDING TUBE JUST AS SHOWN. ALWAYS BEAR IN MIND THAT THIS BY-PASSED R.F. ENERGY THROUGH THE NEUTRALIZING CONDENSER EFFECTS THE GRID CIRCUIT OF THE TUBE IN JUST THE OPPOSITE WAY TO THAT IN WHICH THE REGENERATIVE, EFFECT THROUGH THE TUBE CAPACITY ACTS UPON IT AND THAT IS WHY WE OBTAIN NEUTRALIZATION.

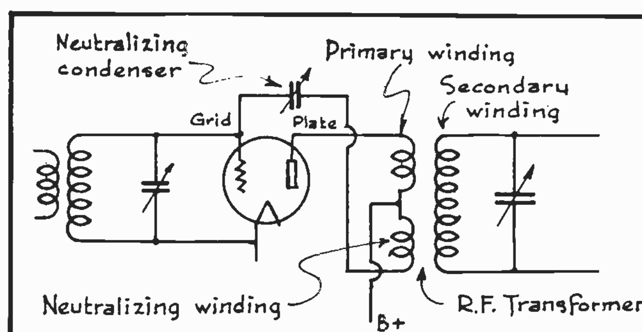

FIG. 21

Neutralizing Winding Connected to Primary of Transformer.

ALTHOUGH THESE NEUTRALIZING CONDENSERS ARE MOUNTED ON THE RECEIVER'S CHASSIS, YET THEY ARE ONLY TO BE USED AS A SERVICE ADJUSTMENT BY THE RADIO TECHNICIAN AND NOT BY THE SET OWNER. IN THE MOST MODERN RECEIVER CIRCUITS EMPLOYING SCREEN-GRID TUBES, SUCH NEUTRALIZING SYSTEMS ARE NO LONGER NECESSARY, NEVERTHELESS, IT IS ADVISABLE THAT YOU BE FAMILIAR WITH THESE CIRCUITS AND THEIR CORRESPONDING SERVICE ADJUSTMENTS. ALL OF THESE DETAILS WILL BE FURNISHED YOU IN LATER LESSONS, AS WELL AS IN YOUR JOB SHEETS.

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LESSON NO. 12

RADIO BATTERIES

Thus far, we have frequently referred to the "A", "B", and "C" supply for battery-operated receivers, but we have not discussed these sources of electrical energy thoroughly, as will be done in this lesson.

Consider first the DRY CELL as sometimes used for the "A" supply. This is the ordinary type of dry battery used extensively for such purposes as for bell circuits, alarm systems, etc., and to identify it from other types of dry cells it is known to the industry as the No. 6 dry cell.

DRY CELL CONSTRUCTION

The internal construction of this dry cell is shown in Fig. 2; although its name might lead you to believe that it is completely dry, that is not the case, for in reality this cell is internally moist. Even though the constructional details of the various makes of dry cells may differ, their principles of construction and operation is the same.

Fig. 1
Operating Recording Equipment At National

In Fig. 2 you will observe that this dry battery comprises a zinc cup can, having an inner lining of blotting paper and cheese-cloth. A carbon rod is placed in the axial center of the cell, and this rod is surrounded with a powdered and moistened mixture of manganese dioxide, sal ammoniac (ammonium chloride) and powdered carbon, which forms the electrolyte. A cardboard washer and sealing wax close the top of the cell airtight; the carbon rod and

ZINC CUP ARE EACH PROVIDED WITH AN EXTERNAL TERMINAL.

THE CARBON ROD ACTS AS THE POSITIVE ELECTRODE; WHEREAS, THE ZINC CUP ACTS AS THE NEGATIVE ELECTRODE. WHEN THESE ELECTRODES ARE CONNECTED TO AN EXTERNAL CIRCUIT A CHEMICAL ACTION TAKES PLACE WITHIN THE CELL, AND BY THAT PROCESS AN EMF OR ELECTRICAL PRESSURE IS GENERATED WHICH WILL CAUSE A CURRENT TO FLOW THROUGH THE COMPLETED CIRCUIT, WHICH INCLUDES THE ZINC CUP, THE ELECTROLYTE, THE CARBON ROD, AND THE EXTERNAL CIRCUIT. IN THE CHEMICAL ACTION THE ZINC IS ATTACKED MORE THAN THE CARBON, AND IS EATEN AWAY SOONER. WHEN MOST OF THE ZINC HAS BEEN EATEN AWAY THE CELL BECOMES INOPERATIVE.

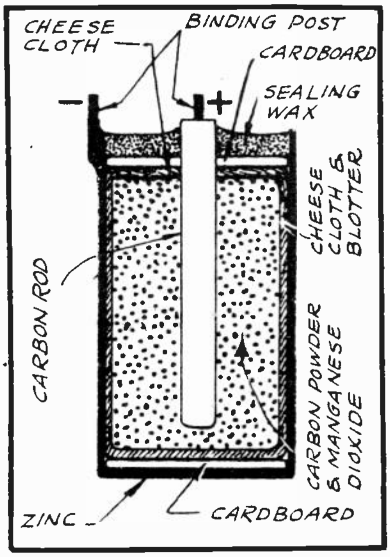

FIG. 2
DRY CELL CONSTRUCTION

DRY CELL VOLTAGE AND CAPACITY

AN INTERESTING POINT TO REMEMBER IS THAT THIS CHEMICAL ACTION IS CAPABLE OF PRODUCING AN ELECTRICAL PRESSURE OF ONLY $1\frac{1}{2}$ VOLTS, WHETHER THE CELL IS SMALL ENOUGH TO FIT INTO A FLASH-LIGHT OR AS LARGE AS A BARREL. THE MAIN DIFFERENCE BETWEEN A SMALL CELL AND A LARGE ONE IS THAT THE LARGE CELL CONTAINS MORE ACTIVE MATERIAL TO BE CONSUMED. IN OTHER WORDS, AT THE SAME RATE OF DISCHARGE IT WILL TAKE LONGER TO DISCHARGE THE LARGE CELL, BUT THEIR VOLTAGES REMAIN EQUAL. THIS CAPABILITY OF A CELL TO CONTINUE A STEADY DISCHARGE FOR A FIXED TIME IS CALLED ITS CAPACITY.

CONNECTING DRY CELLS IN PARALLEL

TO INCREASE CAPACITY IT WOULD NOT BE PRACTICAL TO BUILD AN ENORMOUSLY LARGE CELL, BUT INSTEAD, SEVERAL STANDARD-SIZED CELLS CAN BE CONNECTED IN PARALLEL, AS SHOWN IN FIG. 3, WHICH SHOWS FOUR SUCH CELLS IN PARALLEL. THAT IS, ALL OF THE POSITIVE TERMINALS ARE ELECTRICALLY CONNECTED TOGETHER, AND ALL OF THE NEGATIVE TERMINALS. BY THIS CONNECTION THE TOTAL VOLTAGE WHICH WILL BE FURNISHED BY THEM WILL STILL BE ONLY $1\frac{1}{2}$ VOLTS, OR THE SAME AS THAT OF ONE CELL, BUT THE GROUP OF CELLS WILL BE CAPABLE OF FURNISHING FOUR TIMES AS MUCH CURRENT AS THE SINGLE CELL.

AS A GENERAL RULE, IT IS NOT ADVISABLE TO DEMAND MORE THAN 1/4 AMPERE FROM ANY ONE No. 6 DRY CELL IF A NORMAL LIFE IS EXPECTED. IF A CURRENT GREATER THAN 1/4 AMPERE IS REQUIRED BY A CIRCUIT IN WHICH DRY CELLS ARE TO BE EMPLOYED, CONNECT A GROUP OF CELLS IN PARALLEL. FOR INSTANCE, IF THE CURRENT DEMAND IS TO BE 1 AMPERE,

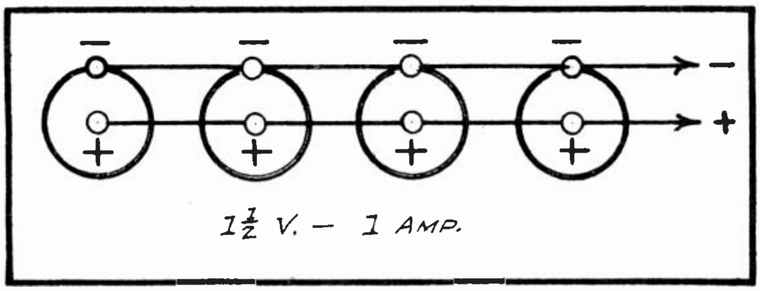

FIG. 3
PARALLEL CELL CONNECTIONS

THEN IT IS ADVISABLE TO CONNECT FOUR CELLS IN PARALLEL; IF THE DEMAND IS TO BE 2 AMPERES, CONNECT EIGHT DRY CELLS IN PARALLEL, ETC.

SERIES CONNECTIONS INCREASE VOLTAGE

IF YOU WISH TO OBTAIN MORE THAN $1\frac{1}{2}$ VOLTS TO MEET THE REQUIREMENTS OF SOME PARTICULAR CIRCUIT, THEN CONNECT THE DRY CELLS IN SERIES, AS ILLUSTRATED IN FIG. 4. AS YOU WILL OBSERVE, THE CELL TERMINALS ARE CONNECTED TOGETHER, POSITIVE TO NEGATIVE, TO OBTAIN THE SERIES ARRANGEMENT.

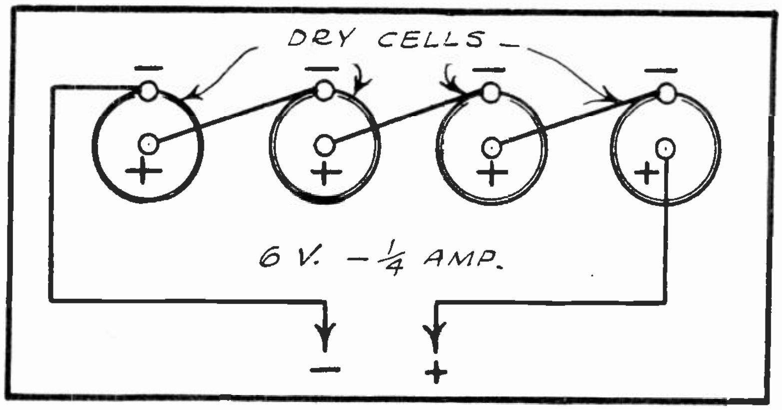

FIG. 4
SERIES CELL CONNECTIONS

WHEN SO CONNECTED IN SERIES, THE TOTAL VOLTAGE OF THE GROUP WILL EQUAL THE VOLTAGE OF ONE CELL, MULTIPLIED BY THE NUMBER OF CELLS. THAT IS, IN THE CASE OF FIG. 4, THE FOUR SERIES-CONNECTED CELLS WILL TOGETHER PROVIDE A VOLTAGE OF FOUR TIMES ONE AND ONE-HALF VOLTS, OR SIX VOLTS. THE CURRENT, HOWEVER, WILL BE EQUAL ONLY TO THAT WHICH A SINGLE CELL CAN FURNISH.

WHENEVER CELLS ARE CONNECTED IN A GROUP, REGARDLESS OF THEIR ARRANGEMENT, WE SPEAK OF THE ENTIRE CELL-GROUP AS A BATTERY.

SERIES-PARALLEL CELL CONNECTIONS

SINCE A PARALLEL CELL CONNECTION INCREASES THE CURRENT CAPACITY OF THE GROUP; WHEREAS, A SERIES CELL CONNECTION INCREASES THE VOLTAGE OF THE GROUP, THEN IT IS ONLY LOGICAL THAT A COMBINATION OF SERIES AND PARALLEL CONNECTIONS SHOULD PERMIT A SIMULTANEOUS INCREASE IN BOTH THE VOLTAGE AND THE CURRENT CAPACITY. IN FIG. 5, FOR EXAMPLE, ARE SHOWN TWO SERIES-CONNECTED CELL GROUPS OF FOUR CELLS PER GROUP, AND THESE TWO GROUPS ARE THEN CONNECTED IN PARALLEL WITH EACH OTHER. SUCH A CELL ARRANGEMENT AS THIS IS CALLED A SERIES-PARALLEL COMBINATION, AND SOMETIMES A SERIES-MULTIPLE COMBINATION.

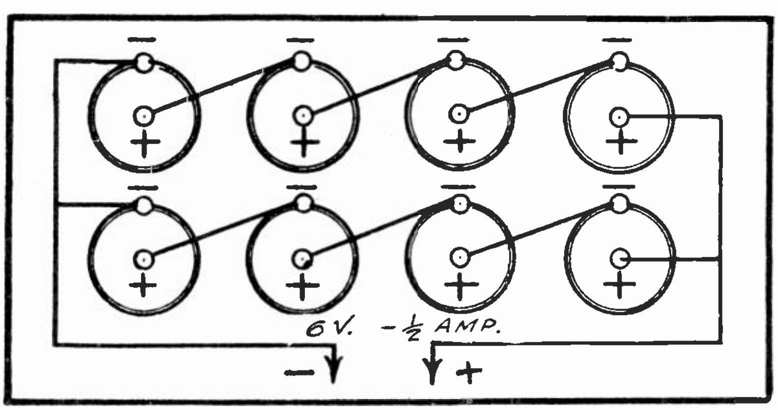

FIG. 5
SERIES-PARALLEL CONNECTION OF CELLS

IN ANY SERIES-PARALLEL CELL GROUP THE TOTAL VOLTAGE WILL BE EQUAL TO THE VOLTAGE PER CELL, MULTIPLIED BY THE NUMBER OF CELLS WHICH ARE SERIES-CONNECTED IN ANY ONE GROUP. THE TOTAL CURRENT THAT CAN BE DRAWN FROM SUCH

A COMBINATION WILL BE EQUAL TO THE CURRENT WHICH A SINGLE CELL IS CAPABLE OF FURNISHING, MULTIPLIED BY THE NUMBER OF PARALLEL CELL GROUPS THAT ARE INCLUDED IN THE COMBINATION. IN FIG. 5, FOR INSTANCE, THERE ARE FOUR CELLS CONNECTED IN SERIES IN EACH GROUP, AND SO THE TOTAL VOLTAGE OF THE COMBINATION WILL BE EQUAL TO FOUR TIMES $1\frac{1}{2}$ VOLTS, OR SIX VOLTS. THEN, SINCE THERE ARE TWO CELL GROUPS CONNECTED IN PARALLEL, THE TOTAL CURRENT WHICH THE COMBINATION CAN SAFELY SUPPLY WILL BE TWICE 1/4 AMPERE, OR $\frac{1}{2}$ AMPERE.

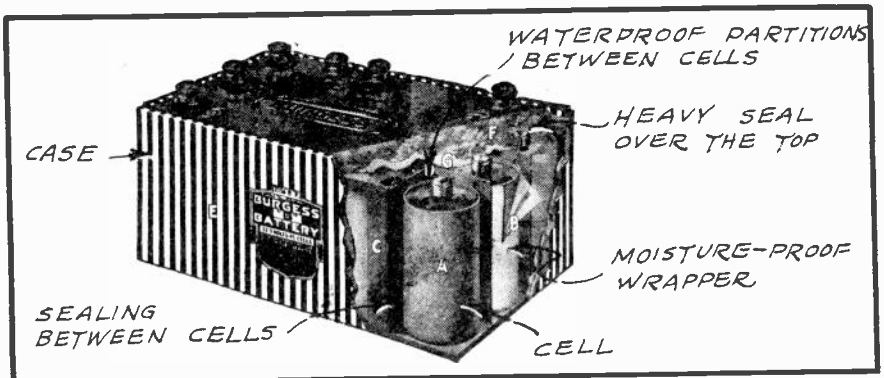

FIG. 6
CONSTRUCTION OF A "B" BATTERY

"B" BATTERIES

NEXT WE COME TO THE "B" BATTERIES, WHICH FURNISH THE PLATE SUPPLY; HERE WE AGAIN CAN MAKE USE OF EITHER THE STORAGE OR DRY TYPES OF PRIMARY BATTERY. THE STORAGE "B" BATTERY, HOWEVER, IS NOT AS POPULAR AS IT WAS IN THE EARLY YEARS OF RADIO, AND THE DRY "B" BATTERY IS NOW USED ALMOST EXCLUSIVELY IN BATTERY-TYPE RECEIVERS.

A PICTURE OF A 22.5 VOLT DRY "B" BATTERY, WITH A PORTION OF ITS CASING REMOVED, IS SHOWN IN FIG. 6. OBSERVE THAT THIS BATTERY CONSISTS OF A GROUP OF SMALL DRY CELLS CONNECTED TOGETHER IN A SERIES ARRANGEMENT. THEN, SINCE EACH OF THESE STANDARD DRY CELLS WILL PRODUCE AN ELECTROMOTIVE FORCE OF 1.5 VOLTS, IT IS EVIDENT THAT THE MORE OF THEM THAT ARE CONNECTED IN SERIES, THE GREATER WILL BE THE VOLTAGE OF THE COMPLETE BATTERY. FOR EXAMPLE, A 22.5 VOLT "B" BATTERY OF THIS TYPE WILL CONTAIN 15 OF THESE SMALL CELLS, AND ALTHOUGH THE CURRENT CAPACITY OF EACH IS SMALL, A GREAT DEAL OF CAPACITY IS NOT NEEDED BECAUSE THE PLATE CURRENT DEMAND IS ALSO VERY SMALL.

IN FIG. 7 IS SHOWN A MODERN TYPE OF "B" BATTERY CONSTRUCTION; THIS IS A CROSS-SECTIONAL VIEW OF THE 45-VOLT "LAYER-BUILT" EVEREADY BATTERY. POSITIVE AND NEGATIVE ELECTRODES ARE ARRANGED IN LAYERS AND EMBEDDED IN THE ELECTROLYTE, SO THAT THEY ARE AUTOMATICALLY CONNECTED IN SERIES AND NO WIRED INTER-CELL CONNECTIONS ARE NEEDED. THIS TYPE OF BATTERY CONSTRUCTION ELIMINATES THE CHANCE FOR OPEN CIRCUITS CAUSED BY THE BREAKAGE OF THE WIRES WHICH CONNECT TOGETHER THE CELLS OF THE CONVENTIONAL "B" BATTERY, AND

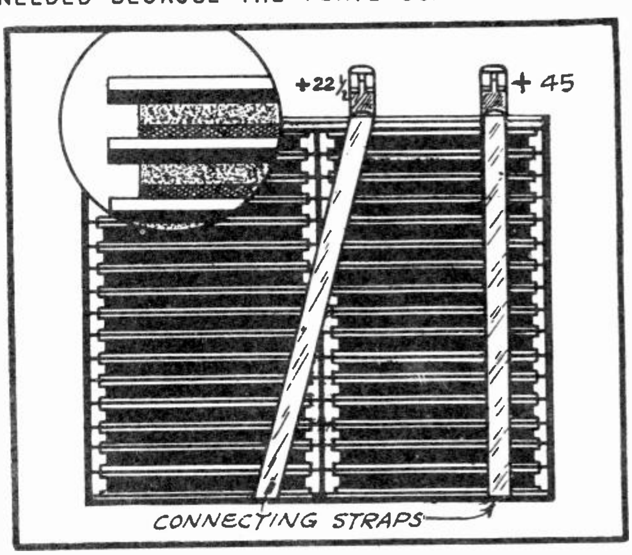

FIG. 7
CONSTRUCTION OF LAYER-BUILT BATTERY

also permits the battery to be built rigidly and compactly. The arrangement of the terminals on a 7-terminal 45-volt battery is shown in Fig. 8. The terminal at the lower left is the common negative terminal for all voltage connections. If a wire is attached to this (-) terminal and another to the terminal marked 16.5, the circuit would include only 11 of the small cells, and the Emf across the open ends of these two wires would be 16.5 volts. The 16.5 terminal would now be serving as a B+ terminal and the (-) post as the B- or negative terminal.

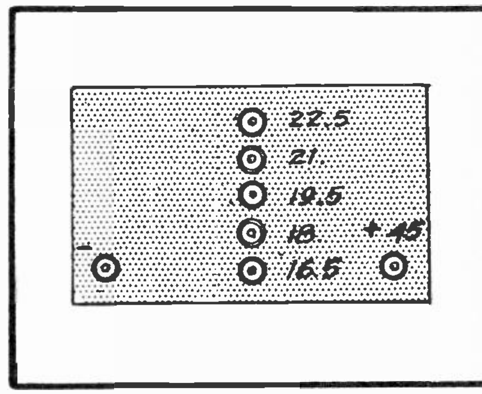

Fig. 8
Terminal Arrangement

The 45-volt battery is made up of 30 such small cells, all connected in series, but all of them are in circuit only when the circuit connections are made to the (-) and the "45" terminals.

In some receivers it is not convenient to use large flat "B" batteries, and for such cases a vertical type of battery is available. Such a battery, with a 22.5 volt rating, is illustrated in Fig. 9; it is tall and slender, and only two terminals are provided, one acting as the (-) terminal and the other as the +22.5 volt terminal.

Some 45-volt "B" batteries have three terminals, as shown in Fig. 10. One of the end terminals is a (-) terminal, the center one a +22.5 volt, and the other end terminal a +45 volt. When the circuit connections are made to the (-) and 22.5 volt terminals, only 15 of the series connected cells are in circuit. Should the connections be made to the (-) and 45 volt terminals, then all 30 of the cells will be in use.

BATTERY CONNECTIONS

The next point to consider is the possible connections which can be made between the "A" and "B" batteries. In Fig. 11, for example, you will see the negative "B" terminal connected to the positive "A" terminal. This means that the "A" and "B" batteries are really connected in SERIES with each other. Now, since the actual plate voltage of the tube is measured between its plate and the negative side of its filament, it is obvious that with the battery connections as shown in Fig. 11, the plate voltage of the tube will be equal to the "B" battery voltage PLUS the "A" battery voltage. This in itself is not serious, but it has been found that better receiver performance is obtained if the "B-" line is not at a voltage higher than that of the "A-" line; therefore, this type of battery connection is no longer popular.

Fig. 9
Vertical Type
Battery

Fig. 12 shows the same circuit, except that the negative "B" terminal is connected to the NEGATIVE "A" terminal. The true plate voltage, when measured

BETWEEN THE PLATE AND THE NEGATIVE SIDE OF THIS TUBE'S FILAMENT, WILL BE EQUAL TO THE ACTUAL VOLTAGE FURNISHED BY THE "B" BATTERY ALONE. THE NEGATIVE "B" TERMINAL WILL NOW BE AT THE SAME POTENTIAL AS THE NEGATIVE "A" TERMINAL, AND THE "A" BATTERY WILL BE EXCLUDED FROM THE PLATE CIRCUIT ALTOGETHER. THIS IS THE MODERN PRACTICE, AND YOU WILL FIND THAT FROM THE STANDPOINT OF RECEIVER PERFORMANCE IT IS REALLY THE BETTER OF THE TWO ARRANGEMENTS.

IN FIG. 13 YOU WILL SEE HOW TO CONNECT TWO 45-VOLT BATTERIES TO OPERATE THE TUBE AT A PLATE VOLTAGE OF 67½ VOLTS. NOTICE THAT THESE TWO "B" BATTERIES ARE CONNECTED IN SERIES, SO THAT THERE IS ALTOGETHER 45 VOLTS PLUS 22½ VOLTS, OR A TOTAL OF 67½ VOLTS, IMPRESSED UPON THE TUBE'S PLATE. THE REMAINING "B" BATTERY CONNECTIONS, FROM THE NEGATIVE TERMINAL OF BATTERY #1 AND THE 45 V TERMINAL OF BATTERY #2, FURNISH A TOTAL OF 90 VOLTS, AS REQUIRED BY THE OTHER TUBES OF THE RECEIVER.

FIG. 10
A THREE-TERMINAL "B" BATTERY

TO OBTAIN STILL HIGHER "B" VOLTAGES, CONNECT ADDITIONAL "B" BATTERIES IN SERIES, AND MAKE YOUR VOLTAGE CONNECTIONS ACCORDINGLY.

FIXED FILAMENT RESISTORS

NO DOUBT YOU HAVE NOTICED IN FIGS. 11, 12, AND 13 THAT THE FILAMENT RESISTOR IS NOT INDICATED AS BEING VARIABLE. FIXED FILAMENT RESISTORS ARE NOW MUCH USED IN THE LATER RECEIVERS, TO ENABLE THE TUBES TO OPERATE CONTINUALLY AT THEIR MAXIMUM EFFICIENCY. THE VOLUME IS THEN CONTROLLED BY OTHER MEANS, AS YOU WILL LEARN LATER. A TYPICAL FIXED FILAMENT RESISTOR IS SHOWN IN FIG. 14; THIS PARTICULAR MAKE IS KNOWN TO THE RADIO INDUSTRY AS THE "AMPERITE," AND IT IS A CARTRIDGE-SHAPED RESISTOR WHICH LOOKS MUCH LIKE A FUSE, MOUNTED ON A BASE BY MEANS OF SPRING CLIPS. IT IS INSTALLED IN SERIES WITH THE FILAMENT CIRCUIT, AND THE CONNECTIONS ARE MADE AS INDICATED IN THE ILLUSTRATION.

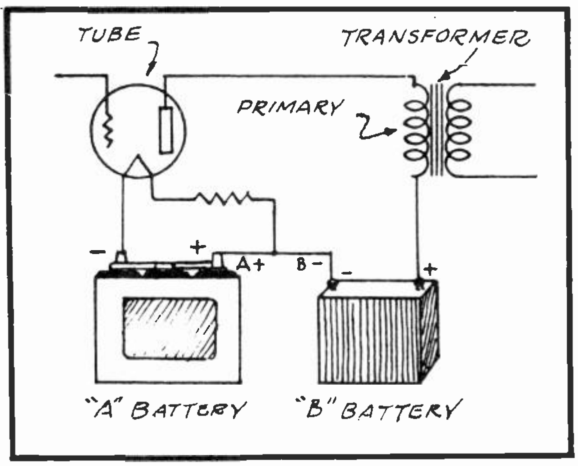

FIG. 11
THE B- TERMINAL CONNECTED TO THE A+ TERMINAL

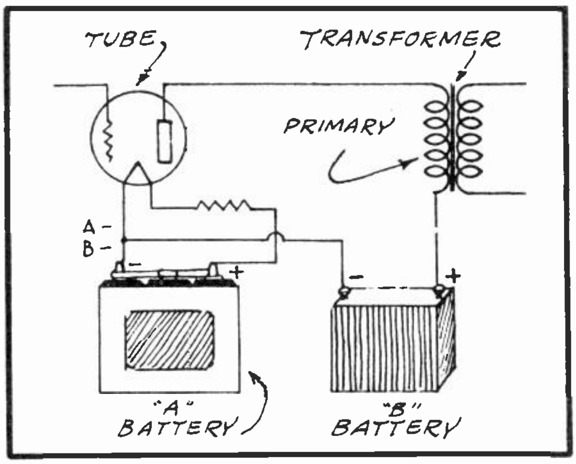

FIG. 12
THE B- TERMINAL CONNECTED TO THE A- TERMINAL

An iron-alloy resistance element is contained within this cartridge, and its characteristics are such that when heated, its resistance increases rapidly, thereby providing a regulation of the current flow. That is, if the battery voltage is up to par, then this resistor will allow only that amount of current to flow thru it which is required by the tube or tubes, and its resistance is such as to offer the proper voltage drop with a fully-charged battery. As the battery becomes discharged its voltage will decrease, and so will the current flow. With smaller amount of current flowing thru this filament resistor its temperature -- and therefore its resistance -- becomes LESS, thereby automatically permitting a more normal flow of filament current.

These "Amperites" are not rated according to their ohmic resistance, but rather, according to the tubes with which they are to be used and the current which they will pass.

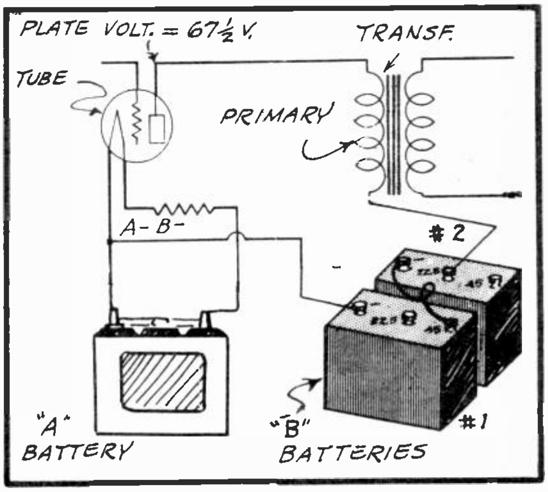

Fig. 13
Obtaining A Plate Voltage Of 67½V

THE "C" BATTERY

Two typical "C" batteries are shown in Fig. 15. These are essentially the same as the dry "B" batteries; the smallest type "C" battery has a maximum voltage of 4½ volts and contains 3 small series-connected cells. Sometimes, only two terminals are provided on these batteries, in which case one will be the (+) terminal and the other the (-) terminal, with a voltage of 4½ volts between. Other types are equipped with three or four terminals, with connections somewhat as shown in Fig. 15. The largest "C" battery available has a maximum voltage of -40½ volts, and is provided with several intermediate voltage taps.

A typical "C" battery connection is shown in Fig. 16. The negative "C" battery terminal is connected to the grid of the tube through the SECONDARY winding of the transformer, and the POSITIVE "C" battery terminal is connected to the POSITIVE "A" battery terminal, as well as to the positive side of the filament. These connections must always be made in this manner, which keeps the grid of the tube constantly at a NEGATIVE potential. Since no grid current flows in this circuit, it is obvious that no "C" battery CURRENT is ever used, and only the VOLTAGE of this battery is needed. For this reason, "C" batteries will last a year or better when used under normal conditions; practically as long as if standing idle on a store shelf.

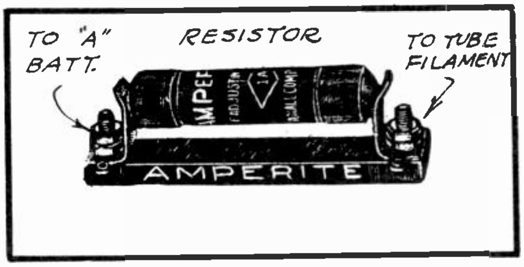

Fig. 14
A Fixed Filament Resistor

Finally, in Fig. 17 all three of these batteries are shown properly connected to a single tube. At the upper portion of this illustration this hookup is shown in picture form, and in the lower portion of the illustration this same circuit is shown in diagram form. Study this illustration carefully.

DISCHARGED BATTERIES

As time goes on, such batteries gradually become discharged. This will become apparent when the volume of the receiver gradually becomes lower and lower, although other troubles are also able to cause decreasing volume. For the present, the batteries are our only concern. Not only will the volume of the receiver be affected in this way, but the tone quality will also suffer. The most pronounced symptom of a discharged "A" battery is that the tubes do not light up as brilliantly as formerly, which is due to the deficiency in filament current.

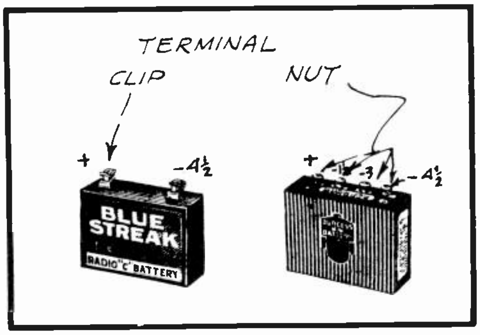

Fig. 15
"C" Batteries

To test dry cells a meter is used as shown in Fig. 18. This instrument is a combination voltmeter and ammeter, with a maximum voltage reading of 50 volts, and a maximum current reading of 40 amperes. To test #6 dry cells, connect this meter across the cell as shown, with the test point marked (+AMPS) in contact with the positive post of the cell, and the test point of the flexible cable connected to the negative cell terminal. If the cell is in a good condition, the ammeter will read 20 or more amperes; if less than this, the cell is more or less discharged, and the reading tells the approximate condition.

To use this same meter when testing "B" batteris, connect it across the battery as shown in Fig. 19, being careful that the (+VOLTS) terminal of the meter is connected to the positive battery terminal. A new battery will generally give a voltage reading a trifle higher than that stamped on the battery terminals, but as the battery is used its voltage gradually decreases. A 20% drop in voltage is usually permissible. That is, if the voltage reading of a 22.5-volt battery is less than 18 volts, or that of a 45-volt battery less than 36 volts, then it should be replaced with a new one.

"C" batteries are tested in this same way, and the voltage reading of a good "C" battery should be the same as that indicated on the terminals across which the test is made. A voltage of 20% less is the lowest allowable limit.

Batteries of all types have the disadvantage of becoming discharged as they are being used, and in battery-type radio receivers this effect is most noticeable with the "A" battery from which most of the current is being withdrawn. If using a storage battery for this purpose, it of course becomes necessary to remove and recharge the battery occasionally, or to make provisions for recharging it without its removal from the receiver cabinet.

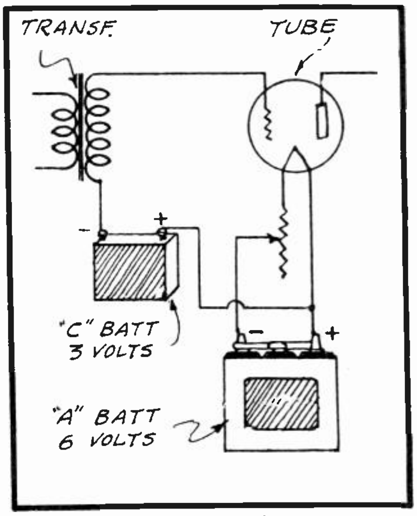

Fig. 16
"C" Battery Connections

DEFECTS OF BATTERY-TYPE RECEIVERS

THE OPERATION OF BATTERY-OPERATED RECEIVERS IN DISTRICTS WHERE NO ELECTRIC LIGHTING SUPPLY IS AVAILABLE HAS ALWAYS BEEN A PROBLEM. IF A STORAGE BATTERY IS USED FOR THE "A" SUPPLY, THE TIME COMES ONLY TOO SOON WHEN IT WILL NEED A RECHARGE. IF DRY CELLS ARE USED FOR THE "A" SUPPLY TO '99 OR '20 TYPE TUBES, THEN THESE CELLS WILL SOON RUN DOWN SO THAT NEW ONES MUST BE SUBSTITUTED.

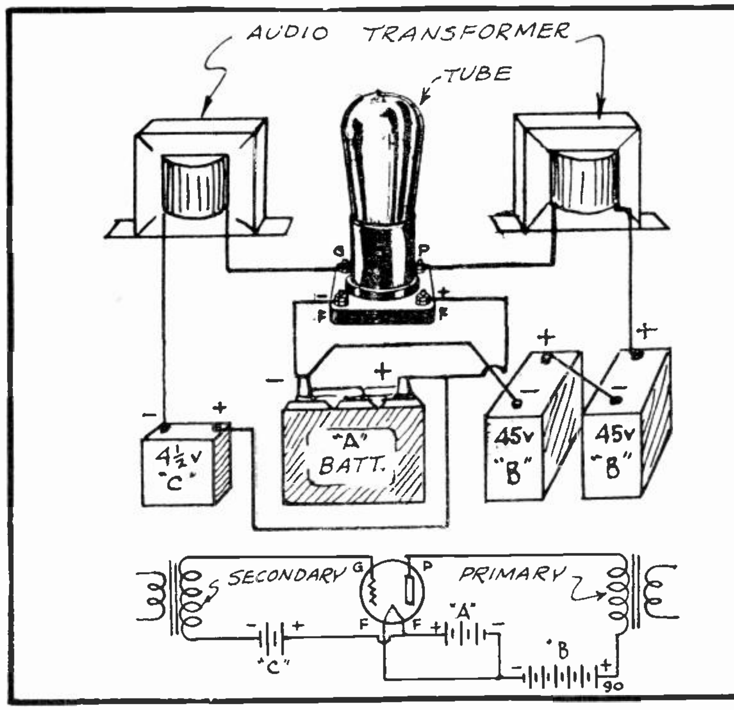

FIG. 17
THE BATTERY CONNECTIONS

NOT ONLY DO THE DRY CELLS REQUIRE FREQUENT REPLACEMENT, BUT THE TUBES OF THE '99 AND '20 TYPES ARE QUITE FRAIL, AND THEIR FILAMENTS ARE EASILY BURNT OUT IF THE SET OPERATOR DOES NOT WATCH FILAMENT VOLTAGE CAREFULLY. THE FIRST STEP TAKEN TO IMPROVE THIS CONDITION WAS THE DEVELOPMENT OF BETTER DRY CELL TUBES, NOW BEARING THE TYPE NUMBERS '30, '31, '32, '33 AND '34 ETC., BUT EVEN THOUGH THESE TUBES ARE MORE DURABLE, CONSUME LESS FILAMENT CURRENT, AND PRODUCE BETTER RADIO RESULTS THAN DID THEIR PREDECESSORS, THEY WILL NOT GIVE SATISFACTORY RESULTS IF OPERATED ON EXCESSIVE FILAMENT VOLTAGE. THE STANDARD DRY CELL, WHEN NEW, DEVELOPS NEARLY 1.5 VOLTS, BUT THIS VOLTAGE DIMINISHES STEADILY WITH USE TO ABOUT 1.1 VOLTS AT THE END OF THE SERVICEABLE LIFE OF THE CELL. THUS IT IS SEEN THAT THE VOLTAGE-VARIATION OF THE ORDINARY DRY CELL IS NEARLY 1/3 DURING ITS USEFUL LIFE.

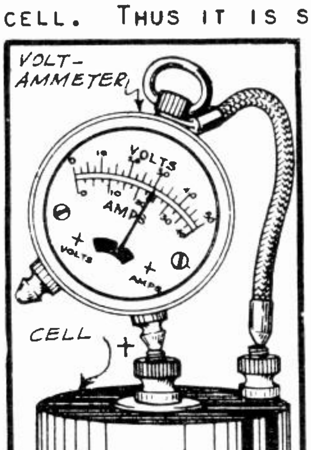

FIG. 18
TESTING A #6
DRY CELL

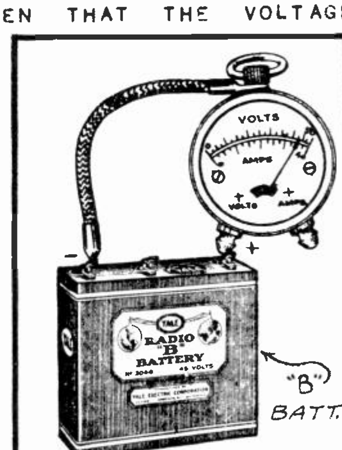

FIG. 19
TESTING A "B"
BATTERY

TO OBTAIN FROM DRY CELLS THE 2 VOLTS REQUIRED FOR THESE NEW TUBES IT IS NECESSARY TO CONNECT TWO CELLS IN SERIES, AND TO THEN REDUCE THIS VOLTAGE TO 2 VOLTS AT THE TUBE SOCKETS BY MEANS OF A RHEOSTAT OR RESISTOR. TO SUPPLY SUFFICIENT CURRENT TO THE RECEIVER IT IS GENERALLY NECESSARY TO CONNECT SEVERAL CELLS IN PARALLEL. FOR EXAMPLE, TO OPERATE A 7-TUBE, 2-VOLT RECEIVER, WOULD REQUIRE

EIGHT DRY CELLS CONNECTED IN TWO GROUPS OF FOUR CELLS EACH, THE CELLS IN EACH GROUP BEING CONNECTED IN PARALLEL AND THE TWO GROUPS CONNECTED TOGETHER IN SERIES, ACROSS THE SUPPLY CIRCUIT. IF THE FILAMENT VOLTAGE IS KEPT CAREFULLY ADJUSTED, THIS BANK OF DRY CELLS WILL LAST ABOUT 80 DAYS, BASED UPON A 3-HOUR DAILY USE OF THE RECEIVER. THE FILAMENT VOLTAGE MUST BE CONTINUALLY KEPT ADJUSTED PROPERLY BY MEANS OF A RHEOSTAT, TO ENABLE THE TUBES TO OPERATE AT THEIR MAXIMUM EFFICIENCY, AND AT THE SAME TIME TO PREVENT TUBE BURN-OUTS.

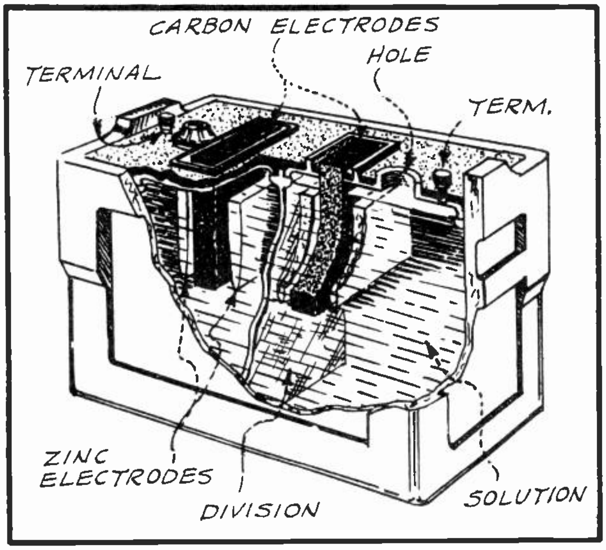

FIG. 20
THE NEW AIR CELL

THE "AIR-CELL" BATTERY

THE BATTERY-OPERATED RECEIVER SITUATION WAS FURTHER RELIEVED BY THE INTRODUCTION OF A NEW TYPE OF "A" BATTERY ESPECIALLY ADAPTABLE TO BE USED IN CONJUNCTION WITH THE TWO-VOLT, DRY-CELL TYPE TUBES, AND KNOWN AS THE "AIR CELL". FIG. 20 ILLUSTRATES ITS INTERNAL CONSTRUCTION; NOTE THAT THE ELECTRODES ARE CARBON AND ZINC AS IN ORDINARY DRY CELLS, BUT THEIR SHAPE AND ARRANGEMENT IS DIFFERENT. IN FACT, THE PHYSICAL APPEARANCE OF THE AIR CELL IS ENTIRELY DIFFERENT FROM THAT OF THE DRY CELL.

DURING THE TIME THAT A DRY CELL IS BEING USED, HYDROGEN GAS IS LIBERATED AT THE CARBON ELECTRODE, FORMING THEREON AN INSULATING LAYER OF GAS BUBBLES THAT REDUCES OR STOPS THE FLOW OF CURRENT. TO LENGTHEN THE LIFE OF THE DRY CELL BY RETARDING THIS HYDROGEN-COLLECTING TENDENCY, MANGANESE DIOXIDE IS ADDED TO THE ELECTROLYTE MIXTURE BECAUSE THIS SUBSTANCE HAS THE IMPORTANT CHEMICAL PROPERTY OF READILY GIVING UP ITS OXYGEN, WHICH COMBINES WITH THE HYDROGEN AND FORMS WATER. IN THIS WAY, THE INSULATING LAYER OF HYDROGEN IS DESTROYED AND THE CELL MOISTURE MAINTAINED.

THE MANGANESE DIOXIDE IS ABLE TO DO THIS REASONABLY WELL FOR A TIME, BUT ONLY A DEFINITE QUANTITY OF MANGANESE DIOXIDE CAN BE INCORPORATED IN THE CELL AT THE TIME OF ITS CONSTRUCTION, AND WHEN ITS AVAILABLE OXYGEN HAS BEEN USED THE CHEMICAL ACTION LESSENS, AND THE VOLTAGE DEVELOPED BY THE CELL DROPS LOWER AND LOWER UNTIL THE CELL FINALLY BECOMES USELESS.

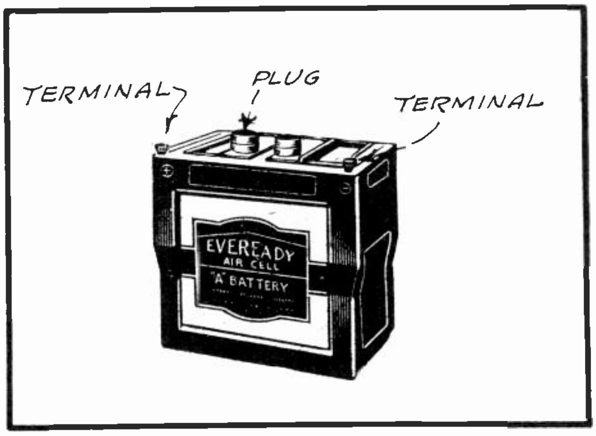

FIG. 21
OUTER APPEARANCE OF THE AIR CELL

THE AIR-CELL BATTERY DEPENDS FOR ITS ELECTRO-CHEMICAL ENERGY ON A REACTION BETWEEN ZINC, WHICH IS IN THE FORM OF HEAVY ELECTRODES

SUSPENDED ON EACH SIDE OF A CARBON ELECTRODE, AND A SOLUTION OF SODIUM HYDROXIDE IN WHICH ALL OF THE ELECTRODES ARE SUSPENDED.

THE AIR CELL "BREATHES"

IN THE CARBON ELECTRODE LIES THE WHOLE SECRET OF THIS CELL'S REMARKABLE OPERATION, FOR A SPECIAL FORM OF CARBON IS USED WHICH HAS THE VALUABLE PROPERTY OF ABSORBING OXYGEN FROM THE AIR, TRANSFERRING IT TO THE SURFACES EXPOSED TO THE SOLUTION, AND THUS AUTOMATICALLY FORMING WATER OUT OF THE HYDROGEN LAYER AS FAST AS IT IS DEPOSITED UPON THE CARBON.

NOTICE HOW MUCH OF THE SURFACE OF THE CARBON ELECTRODE SHOWN IN FIG. 20 IS EXPOSED TO THE AIR. THE OXYGEN IS ACTUALLY ABSORBED BY THIS SURFACE, THUS ALSO ATTACHING THE NAME OF "BREATHING CELL" TO THIS UNIT. SHOULD THIS EXPOSED SURFACE OF CARBON BE COVERED WITH A LAYER OF WAX IT WOULD NO LONGER BE ABLE TO BREATHE, AND WOULD SOON SMOTHER AND DIE JUST AS WILL A PERSON WHOSE AIR SUPPLY IS CUT OFF.

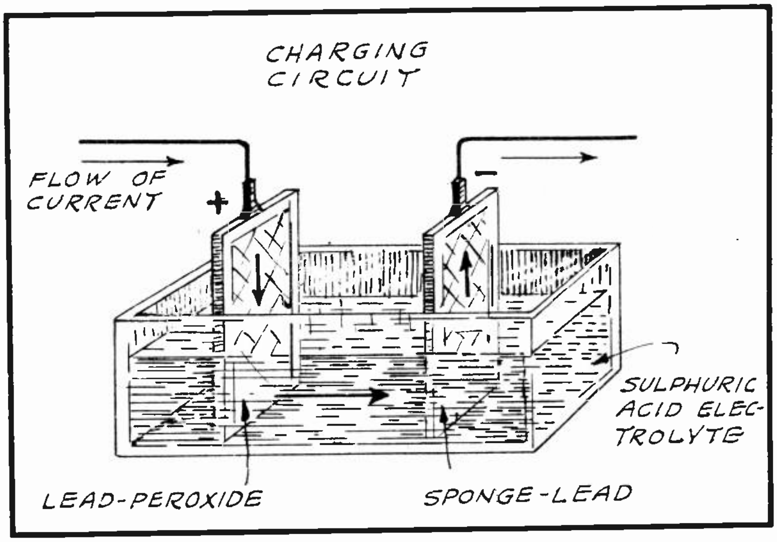

FIG. 22
STORAGE CELL CHARGING

THE WORKING ABILITY OF THE AIR CELL

THIS "A" BATTERY CONSISTS OF TWO CELLS INTERNALLY CONNECTED IN SERIES, AND IT HAS A CAPACITY OF 600 A.H. (AMPERE-HOURS) WHICH MEANS THAT IT WILL RUN A SEVEN-TUBE SET EMPLOYING THE 2-VOLT TUBES, 3 HOURS A DAY FOR A WHOLE YEAR. DURING THIS TIME THE BATTERY REQUIRES NO ATTENTION OTHER THAN THE OCCASIONAL ADDITION OF WATER TO REPLACE EVAPORATION. ANY GOOD DRINKING WATER CAN BE USED; DISTILLED WATER IS NOT NEEDED. THIS BATTERY IS NOT A STORAGE BATTERY, AND THEREFORE CANNOT BE RECHARGED.

THE AIR CELL PROVIDES SO UNIFORM A VOLTAGE THROUGHOUT ITS ENTIRE USEFUL LIFE THAT NO RHEOSTAT ADJUSTMENT IS REQUIRED IN THE FILAMENT CIRCUIT OF THE TUBES, AFTER THE FIRST ADJUSTMENT. THE RESISTANCE FOR THE FILAMENT CIRCUIT CAN THUS BE MADE A FIXED PART OF THE CIRCUIT, AND THE SET REQUIRES NO ATTENTION TO ITS FILAMENT CIRCUIT OTHER THAN TO TURN THE SWITCH ON OR OFF, JUST AS THOUGH THE RECEIVER WERE BEING OPERATED FROM AN A-C LIGHTING CIRCUIT.

THE WORKING VOLTAGE OF THIS BATTERY IS 2.53 VOLTS, BUT THIS VOLTAGE SHOULD BE REDUCED TO 2 VOLTS AT THE TUBE SOCKET TERMINALS. AN EASY WAY TO DETERMINE THE VALUE OF THE FIXED RESISTOR REQUIRED FOR THIS PURPOSE IS TO CALCULATE THE TOTAL FILAMENT CURRENT USED BY ALL TUBES OF THE RECEIVER, AND THEN DIVIDE .53 BY THIS TOTAL FILAMENT CURRENT. THE RESULT WILL BE THE VALUE OF THE REQUIRED FIXED RESISTOR, EXPRESSED IN OHMS.

THE COMPLETE "AIR-CELL" BATTERY HAS BUT TWO TERMINALS TO CONNECT TO THE FILAMENT CIRCUIT, AS SHOWN IN FIG. 21, AND IT HAS A MAXIMUM CONTINUOUS CURRENT OUTPUT OF .75 AMPERE, WHICH IS ABOUT 50% MORE THAN THAT USUALLY REQUIRED BY THE FILAMENT CIRCUIT OF THE RECEIVER IN WHICH THE 2-VOLT TYPE TUBES ARE USED. SHOULD THIS LOAD BE EXCEEDED, THE "BREATHING" CARBON ELECTRODE IS UNABLE TO ABSORB SUFFICIENT OXYGEN, AND AS A RESULT THE BATTERY WILL BE RUINED.

AIR CELLS ARE SHIPPED DRY, AND THEREFORE THERE IS NO DETERIORATION WHILE IN THE HANDS OF THE DEALER. THE PURCHASER NEED ONLY FILL EACH OF THE TWO CELLS WITH ORDINARY DRINKING WATER, AND THE UNIT IS THEN READY TO GO INTO OPERATION.

THE STORAGE-TYPE "A" BATTERY

THE MOST OUTSTANDING DISADVANTAGE OF ALL DRY BATTERIES IS THAT THEY ARE OF NO FURTHER VALUE AFTER ONCE HAVING BECOME DISCHARGED. ALSO, DRY CELLS FOR "A" USE ARE PRACTICAL FOR FURNISHING ONLY RELATIVELY SMALL FILAMENT CURRENTS; FOR GREATER CURRENTS THE FIRST COST OF THE "A" SUPPLY WOULD INCREASE RAPIDLY, AS MORE DRY CELLS ARE ADDED TO THE BATTERY. ON THE OTHER HAND, THE "LEAD-ACID" STORAGE BATTERY IS CAPABLE OF FURNISHING LARGE FILAMENT CURRENTS, AND ALSO HAS THE ADVANTAGE OF BEING RE-CHARGEABLE.

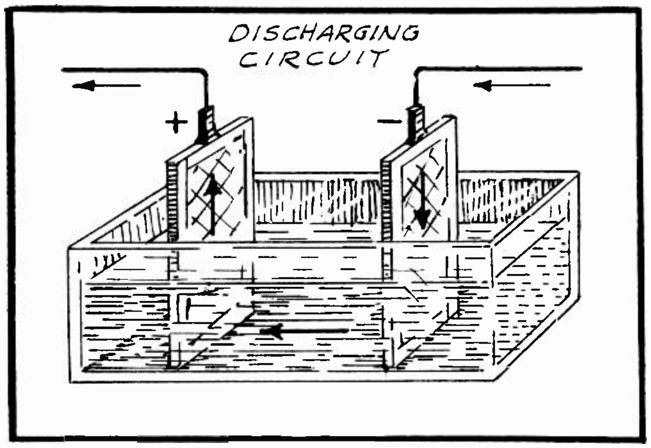

FIG. 23
STORAGE CELL DISCHARGING

THE CONSTRUCTION AND COMPOSITION OF THE MODERN STORAGE BATTERY PERMITS A REVERSIBLE CHEMICAL REACTION. IN OTHER WORDS, WHEN AN ELECTRIC CURRENT IS PASSED THROUGH THE BATTERY, A CHEMICAL ACTION TAKES PLACE WHICH PRODUCES THE FLOW OF AN ELECTRIC CURRENT WHEN AN ATTACHED OUTSIDE CIRCUIT IS COMPLETED. IN THIS PROCESS THE CHEMICAL CHARACTER OF SOME OF THE BATTERY ELEMENTS IS CHANGED, BUT WHEN THE BATTERY IS RECHARGED BY CONNECTING IT TO A SUITABLE SUPPLY OF DIRECT CURRENT, THE CHARGING CURRENT, IN FLOWING THROUGH IN A DIRECTION OPPOSITE TO THE DISCHARGE FLOW, REVERSES THE CHEMICAL ACTION AND RESTORES THE BATTERY SUBSTANTIALLY TO ITS FORMER CHEMICAL CONDITION. THIS REVERSIBLE NATURE OF THE STORAGE BATTERY ENABLES IT TO OPERATE SATISFACTORILY FOR A LONG TIME.

ESSENTIAL PARTS OF A SECONDARY CELL

THE ESSENTIAL PARTS OF A SIMPLE LEAD-ACID STORAGE CELL OR SECONDARY CELL, AS IT IS FREQUENTLY CALLED, DURING THE CHARGING PERIOD, ARE ILLUSTRATED IN FIG. 22. THE CELL CONSISTS OF A POSITIVE ELECTRODE AND A NEGATIVE ELECTRODE, BOTH IMMERSED IN AN ELECTROLYTE. THE ACTIVE SUBSTANCE OF THE POSITIVE ELECTRODE IS PEROXIDE OF LEAD, AND THE ACTIVE SUBSTANCE OF THE NEGATIVE ELECTRODE IS PURE LEAD IN A SPONGY STATE. THE ELECTROLYTE CONSISTS OF A MIXTURE OF DISTILLED WATER AND SULPHURIC ACID. NOTICE

THAT THE TWO ELECTRODES, OR PLATES, AS THE BATTERY MAN CALLS THEM, ARE SEPARATED FROM EACH OTHER BY THE ELECTROLYTE.

ACTION OF THE CELL WHILE BEING CHARGED

IF THE CELL WERE IN A COMPLETELY DISCHARGED STATE, WHICH CONDITION REALLY CANNOT BE PRODUCED IN PRACTICAL USE, THE ELECTROLYTE WOULD THEN CONSIST ONLY OF WATER, AND THE PLATES WOULD CONTAIN MUCH LEAD SULPHATE. THEN, IF A DIRECT ELECTRICAL CURRENT FROM SOME OUTSIDE SOURCE SHOULD BE FORCED THRU THIS CELL, SO THAT THE CURRENT ENTERS AT THE POSITIVE PLATE AND LEAVES THE CELL BY WAY OF THE NEGATIVE PLATE, THE CELL WOULD BE CHARGING. DURING THIS TIME OF CHARGING, THE SULPHATE IS BROKEN DOWN INTO LEAD AND SULPHUR, AND THE SULPHUR IS DRIVEN OUT OF THE PLATES AND INTO THE SOLUTION WHERE IT RE-COMBINES WITH WATER TO FORM SULPHURIC ACID. THE POSITIVE PLATE WILL THEN CONSIST OF LEAD PEROXIDE, AND THE NEGATIVE PLATE OF SPONGY LEAD. WITH THE CHEMICAL CONDITION OF THE CELL IN THIS STAGE, AN EMF CAN BE PRODUCED WHEN THE EXTERNAL CIRCUIT IS CLOSED, AND THIS ELECTRICAL PRESSURE IS CAPABLE OF CAUSING A CURRENT TO FLOW THRU THE RESISTANCE OF THE CIRCUIT, WHICH INCLUDES THE INTERNAL RESISTANCE OF THE CELL ITSELF, AS IT IS A PART OF THE COMPLETED CIRCUIT.

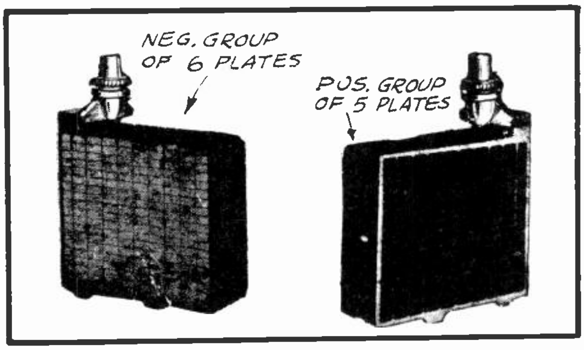

FIG. 24
THE POSITIVE AND NEGATIVE GROUP

ACTION OF THE CELL WHILE DISCHARGING

THE ACT IN THIS SIMPLE CELL WHILE DISCHARGING IS ILLUSTRATED IN FIG. 23. AT THIS TIME THE CHEMICAL ACTION IS REVERSED. CURRENT FLOWS OUT OF THE POSITIVE TERMINAL OF THE BATTERY, THENCE THRU THE EXTERNAL CIRCUIT, AND RETURNS TO THE CELL THRU THE NEGATIVE PLATE. DURING THIS DISCHARGING PERIOD THE ACID IS DRIVEN OUT OF THE ELECTROLYTE AND INTO THE PLATES, AND AS THE LEAD SULPHATE IS FORMED AND DEPOSITED WITHIN THE ACTIVE MATERIAL OF THE PLATES, THE CELL BECOMES MORE AND MORE DISCHARGED AND THE ELECTROLYTE VERY MUCH LESS ACID. BEAR IT IN MIND THAT THESE CHEMICAL CHANGES TAKE PLACE GRADUALLY, BUT THE HIGHER THE RATE OF CHARGE OR DISCHARGE, THE MORE RAPID THE CHEMICAL ACTION.

SIMPLIFIED FORM OF THE CHEMICAL REACTIONS

TO MAKE THESE CHEMICAL REACTIONS MORE SIMPLE, THINK OF THE CELL IN THE FOLLOWING WAY: DURING CHARGE, THE ACID IS DRIVEN OUT OF THE PLATES AND INTO THE ELECTROLYTE. DURING DISCHARGE, THE ACID GOES INTO THE PLATES. THESE TWO STATEMENTS ARE NOT EXACTLY CORRECT, TECHNICALLY, BUT THEY WILL HELP YOU TO REMEMBER THE CHEMICAL SCHEME OR CYCLE OF OPERATION.

VOLTAGE OF THE LEAD-ACID CELL

THE DRY CELL, YOU WILL REMEMBER, WAS CAPABLE OF PRODUCING A VOLTAGE OF $1\frac{1}{2}$ VOLTS, BUT A COMPLETELY CHARGED CELL OF THE LEAD-ACID TYPE WILL PRODUCE A VOLTAGE OF 2.2 VOLTS WHILE ON OPEN CIRCUIT. BY "OPEN CIRCUIT" IT IS MEANT THAT THE VOLTAGE READING IS TAKEN DIRECTLY ACROSS THE TERMIN-

ALS OF THE CELL DURING THE TIME THAT NO CURRENT IS BEING DRAWN FROM THE CELL.

CAPACITY OF THE STORAGE CELL

YOU WILL RECALL THAT IN THE DISCUSSION OF THE DRY CELL IT WAS STATED THAT THE LARGER THE CELL, OR THE GREATER THE QUANTITY OF ITS ACTIVE MATERIAL, THE GREATER WILL BE THE CAPACITY OF THE CELL. THIS ALSO APPLIES TO THE LEAD-ACID STORAGE CELL, BECAUSE REGARDLESS OF THE CELL SIZE, THE CHEMICAL ACTION WILL PRODUCE A MAXIMUM ELECTRICAL PRESSURE OF NO MORE THAN 2.2 VOLTS. TO INCREASE THE CAPACITY OF THE CELL, THE AMOUNT OF ACTIVE MATERIAL IN IT MUST BE INCREASED. TO DO THIS A CONVENIENT-SIZED PLATE IS USED; INSTEAD OF USING ONLY ONE POSITIVE AND ONE NEGATIVE PLATE, THE CELL MAY CONSIST OF SEVERAL POSITIVE AND SEVERAL NEGATIVE PLATES. IT IS COMMON TO USE 7, 9, 11, 13, OR 15 PLATES PER CELL IN STORAGE BATTERIES FOR "A" USE, DEPENDING UPON THE REQUIREMENTS OF THE CIRCUIT WHICH THE BATTERY IN QUESTION IS TO SERVE. THE TOTAL NUMBER OF PLATES PER CELL IS ALWAYS AN ODD NUMBER FOR THE REASON THAT THERE IS ALWAYS ONE MORE NEGATIVE PLATE PER CELL THAN THE TOTAL OF POSITIVE PLATES, TO PERMIT EACH SIDE OF EACH POSITIVE PLATE TO BE EXPOSED TOWARD A NEGATIVE PLATE.

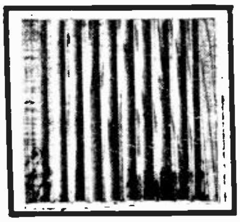

FIG. 25
A WOODEN SEPARATOR

THE POSITIVE PLATES IN EACH CELL ARE ALL JOINED TO A PLATE STRAP IN SUCH A MANNER THAT THEY WILL BE SLIGHTLY SEPARATED FROM EACH OTHER. THE NEGATIVE PLATES ARE SIMILARLY CONNECTED TO A PLATE STRAP, AND THE RESULTING POSITIVE AND NEGATIVE PLATE GROUPS ARE SHOWN IN FIG. 24, IN WHICH CASE 5 PLATES CONSTITUTE THE POSITIVE PLATE GROUP AND 6 PLATES THE NEGATIVE PLATE GROUP. EACH PLATE STRAP IS ATTACHED TO A TERMINAL POST. THE POSITIVE AND NEGATIVE PLATE GROUPS ARE THEN INTER-LEAVED OR MESHED TOGETHER, AND TO PREVENT POSITIVE PLATES FROM COMING IN DIRECT CONTACT WITH NEGATIVE PLATES, SEPARATORS ARE INSTALLED BETWEEN THE PLATES.

SEPARATORS

SEVERAL TYPES OF SEPARATORS ARE MARKETED, AMONG THE MOST COMMON BEING WOOD, RUBBER, SPUN GLASS PADS, AND VARIOUS COMPOSITION SEPARATORS. THE CHEAPEST AND MOST USED SEPARATORS ARE MADE OF WOOD, AND THE WOODS MOST USED FOR THIS PURPOSE ARE CEDAR, CYPRESS, AND BASS-WOOD. ONE SIDE OF EACH SEPARATOR IS GROOVED WITH SHALLOW PARALLEL GROOVES; THE OPPOSITE SURFACE IS LEFT SMOOTH.

A TYPICAL WOODEN SEPARATOR IS SHOWN IN FIG. 25, INSTALLED BETWEEN THE PLATES SO THAT THE GROOVED SIDE OF THE SEPARATOR FACES THE POSITIVE PLATE, WITH THE GROOVES IN A VERTICAL POSITION. WITH THE SEPARATORS THUS PLACED, THE ELECTROLYTE MAY READILY CIRCULATE AROUND THE ACTIVE MATERIAL OF THE POSITIVE PLATES, AND ANY

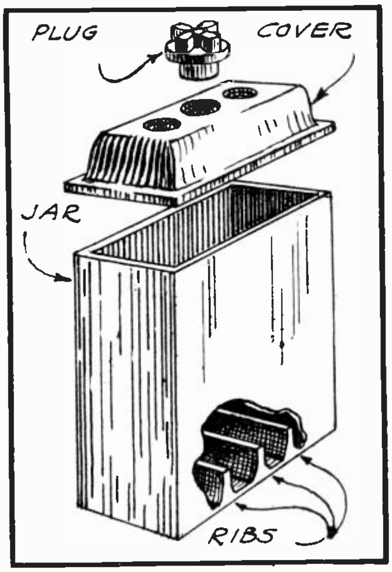

FIG. 26
JAR, COVER & PLUG

MATERIAL WHICH IN TIME WILL "SHED" FROM THE POSITIVE PLATES CAN PASS DOWNWARD THRU THE GROOVES AND DEPOSIT IN THE SEDIMENT BASINS IN THE BOTTOM OF THE CELLS OR JARS. ANY GAS LIBERATED AT THE POSITIVE PLATES WILL PASS TO THE SURFACE OF THE ELECTROLYTE FREELY.

SPECIAL TYPES OF SEPARATORS

THE WILLARD BATTERY USES A "THREADED RUBBER" SEPARATOR IN WHICH THOUSANDS OF THREADS ARE IMBEDDED IN THE RUBBER COMPOSITION, LEADING FROM ONE FACE OF THE PLATE TO THE OTHER AND THEREBY AIDING IN THE CIRCULATION OF THE ELECTROLYTE FROM PLATE TO PLATE.

SOME BATTERIES ARE EQUIPPED WITH DOUBLE SEPARATORS, ONE OF THE WOOD AND THE OTHER A THIN SHEET OF RUBBER COMPOSITION PIERCED WITH MANY TINY PERFORATIONS TO PERMIT A MORE FREE CIRCULATION OF THE ELECTROLYTE. IN SUCH A CASE, THE RUBBER SEPARATOR IS INSERTED BETWEEN THE POSITIVE PLATE AND THE WOODEN SEPARATOR.

THE MOST RECENT DEVELOPMENT IN THE LEAD-ACID STORAGE BATTERY IS CALLED THE KANTATHODE TYPE, IN WHICH THE PLATES ARE SEPARATED FROM EACH OTHER AND FROM THE CELL WALLS BY MEANS OF MATS OR PADS WOVEN FROM THREADS THAT ARE BUILT UP OF GLASS FILAMENTS OR FIBRES MANY TIMES SMALLER THAN A HAIR. THESE PADS ARE NOT ATTACKED BY THE ACID, AND ARE SUFFICIENTLY POROUS TO PERMIT CIRCULATION OF THE ELECTROLYTE, BUT THE PORES ARE TOO FINE TO PASS MUCH ACTIVE MATERIAL FROM THE PLATES.

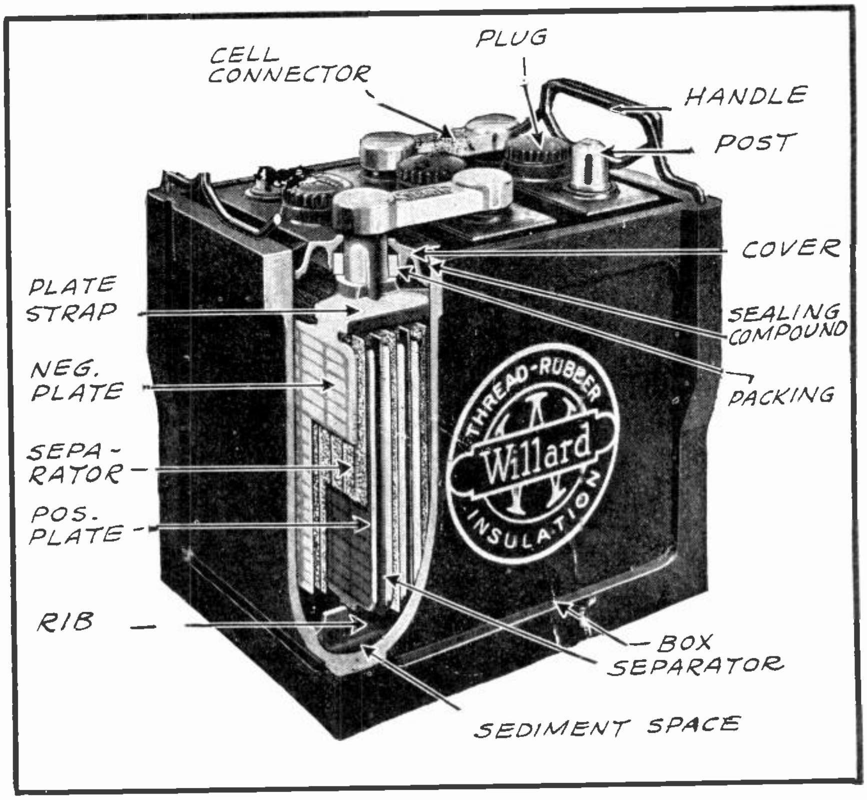

FIG. 27
CROSS SECTIONAL VIEW OF ONE CELL

IT IS CLAIMED THAT THIS CONSTRUCTION NOT ONLY VASTLY INCREASES THE USEFUL LIFE OF THE BATTERY, BUT RESULTS IN GREATER CAPACITY IN A CELL OF ANY GIVEN DIMENSIONS, BECAUSE THE SPACE FORMERLY USED BY THE THICKER SEPARATORS AND FOR THE SEDIMENT BASINS CAN BE USED TO PROVIDE ROOM FOR MORE PLATE MATERIAL. A LESSER AMOUNT OF ELECTROLYTE IS REQUIRED.

THE ELEMENT

THE POSITIVE AND NEGATIVE PLATE GROUPS, TOGETHER WITH THE SEPARATORS,

CONSTITUTE THE ELEMENTS OF THE STORAGE BATTERY CELL. THESE ELEMENTS ARE CONTAINED IN A JAR SUCH AS IS ILLUSTRATED IN FIG. 26. THE JARS ARE USUALLY MADE OF RUBBER COMPOSITION, THOUGH GLASS JARS ARE SOMETIMES USED. THE BOTTOM EDGES OF THE PLATES REST ON THE RIBS, WHICH BOTH SUPPORT THE ELEMENTS AND FORM THE POCKETS OR SEDIMENT BASINS INTO WHICH ACTIVE MATERIAL MAY COLLECT WITHOUT CONTACTING THE BOTTOM EDGES OF THE PLATES AND THEREBY SHORT-CIRCUITING THE CELL.

THE COVER IS PROVIDED WITH THREE HOLES, THOSE AT THE ENDS ENCLOSE THE POSTS OF THE POSITIVE AND NEGATIVE PLATE GROUPS,AND THE CENTRAL HOLE IS INTERNALLY THREADED TO RECEIVE A VENT PLUG. THE SMALL VENT IN THIS PLUG PERMITS THE ESCAPE OF THE GAS GENERATED WHILE THE CELL IS IN ACTION, AND REMOVAL OF THE PLUG PERMITS ADDING DISTILLED WATER TO THE ELECTROLYTE TO REPLACE EVAPORATION. SOME RUBBER COMPOSITION BATTERY CASES HAVE SPECIAL CROSS RIBS OR PARTITIONS MOLDED INTO THEM, SO THAT THE INDIVIDUAL CELL JARS BECOME INTEGRAL WITH THE BATTERY CASE.

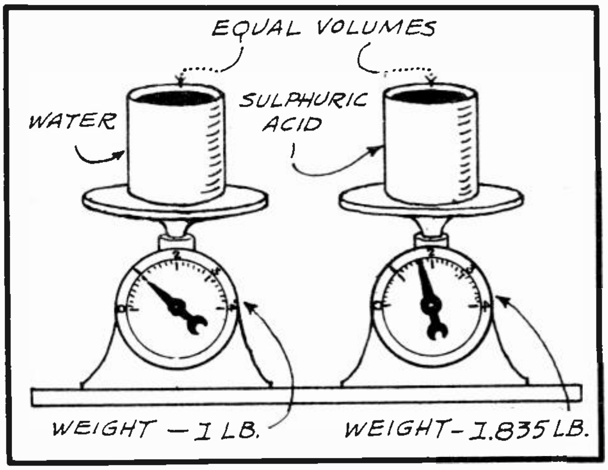

FIG. 28
A SPECIFIC GRAVITY EXPERIMENT

THE COMPLETE BATTERY

ALL CELLS OF A BATTERY ARE CONSTRUCTED ALIKE, AND IF A SIX-VOLT BATTERY IS DESIRED, THREE SUCH CELLS ARE CONNECTED IN SERIES, AS ILLUSTRATED IN FIG.27, LARGE LEAD STRAP CONNECTORS BEING USED FOR THIS PURPOSE. IN THE CASE OF A TWELVE-VOLT STORAGE BATTERY, SIX CELLS WILL BE CONNECTED IN SERIES. IN SOME OF THE MOST MODERN BATTERIES THE STRAPS ARE UNDER THE COVER.

ONE CORNER OF THE BATTERY SHOWN IN FIG. 27 HAS BEEN CUT AWAY SO THAT YOU MAY GAIN A CLEAR MENTAL PICTURE OF THE END CELL'S INNER STRUCTURE.

MEANING OF THE TERM AMPERE-HOUR

THE CAPACITY OF A CELL IS MEASURED IN UNITS CALLED AMPERE HOURS (ABBREVIATED A.H.) ONE A.H. REPRESENTS THE FLOW OF ONE AMPERE FOR ONE HOUR. THEORETICALLY, IT MEANS THAT A BATTERY HAVING A CAPACITY OF 80 A.H., COULD BE DISCHARGED AT THE RATE OF ONE AMPERE FOR APPROXIMATELY 80 HOURS. HOWEVER,THESE FIGURES DO NOT WORK OUT SO EXACTLY IN ACTUAL PRACTICE. THE GREATER THE RATE OF DISCHARGE, IN AMPERES, THE LESS WILL BE THE TOTAL A.H. OUTPUT OF THE BATTERY.

MEANING OF "SPECIFIC GRAVITY"

CHEMICALLY PURE (C.P.) SULPHURIC ACID HAS A SPECIFIC GRAVITY OF 1.835. THE TERM"SPECIFIC GRAVITY" CAN BE EXPLAINED AS FOLLOWS: IN FIG. 28 YOU WILL SEE TWO SPRING SCALES, SUPPORTING CONTAINERS OF EQUAL SIZE. ONE OF THESE CONTAINERS IS FILLED WITH ENOUGH PURE DISTILLED WATER TO WEIGH 1 POUND, AND THE VOLUME OF THIS POUND OF WATER IS CAREFULLY

MEASURED. THEN, IF AN EQUAL VOLUME OF CHEMICALLY PURE SULPHURIC ACID IS PLACED IN THE OTHER CONTAINER, IT WILL BE FOUND THAT THIS SAME VOLUME OF SULPHURIC ACID WEIGHS 1.835 LBS. IN OTHER WORDS, CHEMICALLY PURE SULPHURIC ACID IS 1.835 TIMES AS HEAVY AS AN EQUAL VOLUME OF PURE DISTILLED WATER.

THE SPECIFIC GRAVITY OF BATTERY ELECTROLYTE

THIS CHEMICALLY PURE SULPHURIC ACID IS NOT USED AS THE BATTERY ELECTROLYTE; IT IS DILUTED WITH DISTILLED WATER TO PRODUCE A MIXTURE OF ABOUT 30% SULPHURIC ACID, AND 70% DISTILLED WATER, BY VOLUME. THEREFORE, INSTEAD OF THE BATTERY ELECTROLYTE HAVING A SPECIFIC GRAVITY OF 1.835, ITS SPECIFIC GRAVITY IS FROM 1.280 TO 1.300.

THE EFFECT OF CHARGE AND DISCHARGE UPON SPECIFIC GRAVITY

IN THE EARLY PAGES OF THIS LESSON YOU LEARNED THAT AS THE BATTERY DISCHARGED, THE ACID IS DRIVEN OUT OF THE ELECTROLYTE; WHILE ON THE OTHER HAND, WHEN THE BATTERY IS CHARGED, THE ACID IS DRIVEN BACK INTO THE ELECTROLYTE. CONSEQUENTLY, IF THE ELECTROLYTE OF A FULLY-CHARGED CELL HAS A SPECIFIC GRAVITY OF 1.280 OR 1.300, IT IS OBVIOUS THAT AS THE CELL BECOMES DISCHARGED AND MUCH OF THE ACID GOES INTO THE PLATES, THE SPECIFIC GRAVITY WILL BE LOWERED AND WILL GRADUALLY APPROACH THE SPECIFIC GRAVITY OF DISTILLED WATER. THE SPECIFIC GRAVITY OF THE ELECTROLYTE OF A CELL WHEN COMPLETELY DISCHARGED IS CONSIDERED AS 1.150; WHEREAS, PURE DISTILLED WATER HAS A SPECIFIC GRAVITY OF 1.000.

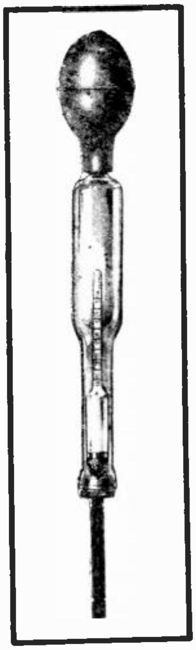

FIG. 29
THE HYDROMETER

THE HYDROMETER

THE NEXT QUESTION IS: HOW CAN THE SPECIFIC GRAVITY OF THE ELECTROLYTE BE DETERMINED EASILY? IT IS DONE BY USE OF AN INSTRUMENT KNOWN AS THE HYDROMETER, ILLUSTRATED IN FIG. 29, AND CONSISTING OF A SEALED GLASS TUBE CONTAINING A WEIGHT OF LEAD SHOT IN ITS BASE, AND ITS STEM CORRECTLY CALIBRATED (GRADUATED) TO REGISTER THE SPECIFIC GRAVITY OF THE ELECTROLYTE. THIS SEALED GLASS TUBE IS LOOSELY ENCLOSED WITHIN THE GLASS BARREL OF A SYRINGE WHICH HAS A RUBBER BULB AT ITS UPPER END AND A RUBBER TUBE AT ITS LOWER END. IN THIS WAY, THE HYDROMETER CANNOT FALL OUT OF THE SYRINGE, BUT ELECTROLYTE CAN BE DRAWN INTO THE SYRINGE SO THAT THE HYDROMETER WILL FLOAT IN IT, AND ITS SPECIFIC GRAVITY CAN BE TESTED. WHEN THE ELECTROLYTE HAS BEEN TESTED, IT CAN BE EXPELLED INTO THE CELL FROM WHICH IT WAS WITHDRAWN.

PRINCIPLE OF THE HYDROMETER

SINCE THE ACID, WHICH IS HEAVIER THAN WATER, RETURNS TO THE ELECTROLYTE WHEN THE BATTERY IS FULLY CHARGED, IT IS OBVIOUS THAT THE ELECTROLYTE THEN BECOMES HEAVIER, AND THEREFORE OFFERS MORE BUOYANCY TO THE HYDROMETER, SO THAT THE HYDROMETER IS CAUSED TO FLOAT WITH MORE OF ITS STEM ABOVE THE FLUID LEVEL. WHEN THE BATTERY BECOMES DISCHARGED, THE ACID GOES OUT OF THE ELECTROLYTE, CAUSING IT TO BECOME LIGHTER, OFFERING LESS BUOYANCE, AND THEREFORE THE HYDROMETER WILL SINK LOWER INTO THE FLUID.

TESTING THE SPECIFIC GRAVITY OF A FULLY CHARGED CELL

To make your understanding of the hydrometer more clear, carefully examine the illustration at the left of Fig. 30. In this case the vent plug was removed from a cell and a portion of electrolyte was withdrawn by means of the syringe. The hydrometer then rose to such a level that the line marked 1.300 was even with the surface of the electrolyte. As far as this hydrometer test is concerned, the gravity is up to the required point, indicating that the cell is fully charged.

TESTING THE SPECIFIC GRAVITY OF A DISCHARGED CELL

As the battery becomes discharged, the buoyancy will become less, and the reading of the hydrometer will drop as low as 1.150, as illustrated at the right of Fig. 30, indicating that the battery is fully discharged.

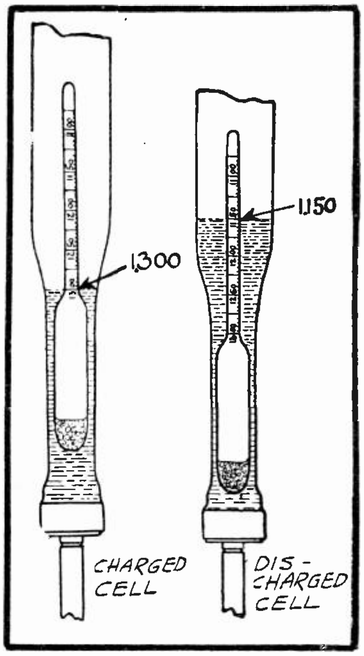

Fig. 30
Hydrometer Readings

THE NECESSITY OF MAKING A VOLTAGE TEST IN CONJUNCTION WITH THE HYDROMETER TEST

Hydrometer tests in themselves are not sufficient to determine accurately a cell's state of charge, for the reason that should some of the electrolyte have been spilled and replaced with water, the electrolyte would be out of balance, or weakened. Therefore, even if the cell is completely charged, the specific gravity of the electrolyte is still low. On the other hand, should someone carelessly add strong acid to replace evaporation of the water, the specific gravity would be raised abnormally high. Therefore, to make an accurate test of the state of charge of a cell, the cell voltage should be checked in conjunction with the specific gravity.

THE INITIAL CHARGE

When a newly constructed battery has been filled with electrolyte it is allowed to stand idle for about 12 hours, and then is placed on the charging line and given a very slow charge. After it has become fully charged, it is discharged at a slow rate, and then again charged. We call this charging and discharging of a battery, CYCLING, and new batteries are cycled several times, so that the plates will become active and will "hold a charge" for a considerable time. The battery is then ready for service.

In later lessons you will receive complete instructions in regard to testing, servicing, charging, and repairing storage batteries. You will find this information of special value, because storage batteries are still extensively used with radio receivers in some territories, and in broadcasting equipment, sound pictures, television, etc., where an absolutely uniform direct current is imperative.

What Is Your Target?

The secret of success is to set a goal and then study and work until that goal is reached. When you reach it then set another goal a little further ahead and study and work some more.

And always shoot AT THE TARGET. If you waste your energy in striving to be the best pool player in town or the champion good-fellow among your acquaintances you are just lessening your chance of hitting your target—your goal. Someone has said—

The *price* of the gun never hits the bull's eye
  And the *bang* never rattles the bells.
It's the hand on the trigger
  That cuts the real figger
The aim is what counts—
  That's what brings big amounts.
Are you hitting or just wasting shells?

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LESSON Nº 13

TRICKLE CHARGERS
BATTERY ELIMINATORS AND LOUD SPEAKERS

At one time Trickle Chargers and Battery Eliminators were in very common use. However, that was before battery receivers reached the advanced stage in which we now find them. In those days, all receivers were battery-operated and the frequent replacement of "A" and "B" batteries brought a serious problem for the radio engineer.

As a temporary solution of the problem -- until A-C operated tubes and circuits were developed -- it was decided to use some sort of device which would keep the "A" battery charged with current from the A-C lighting circuits. As a result, trickle chargers and battery eliminators, were put on the market.

Although trickle chargers and battery eliminators are no longer in common use today, nevertheless, the principles of operation are of interest and will be of value to you. Therefore, at this time we will devote some of our time to a general discussion of them.

As we have stated before, one of the devices was designed so as to provide a means whereby a storage battery could be subjected to a charge while installed in the receiver cabinet and this resulted in the extensive use of TRICKLE CHARGERS. A trickle charger does just exactly what its name indicates and that is, it sends a small or trickling charging current thru the battery even though the battery is connected to the receiver circuits. This charging

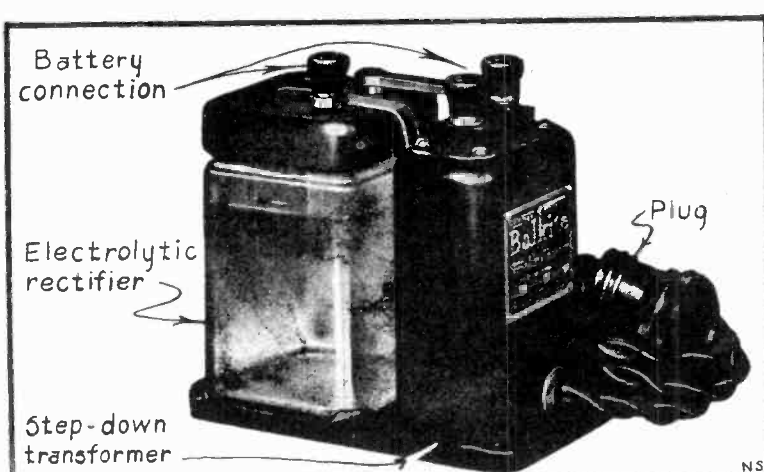

FIG. 1
Electrolytic Trickle Charger

CURRENT GENERALLY RUNS AROUND 1/2 AMPERE OR LESS AND IN MOST CASES IS OBTAINED FROM THE A.C. LIGHTING CIRCUIT.

ELECTROLYTIC TYPE TRICKLE CHARGERS

A TYPICAL ELECTROLYTIC TYPE TRICKLE CHARGER IS SHOWN YOU IN FIG. 1 AND AS YOU WILL OBSERVE, IT CONSISTS OF A STEP-DOWN TRANSFORMER, AN ELECTROLYTIC RECTIFIER, A CORD AND PLUG WITH WHICH TO CONNECT THE UNIT TO THE 110 VOLT A.C. LIGHTING SUPPLY AND A SET OF TERMINALS WHICH ARE TO BE CONNECTED TO THE STORAGE BATTERY TERMINALS.

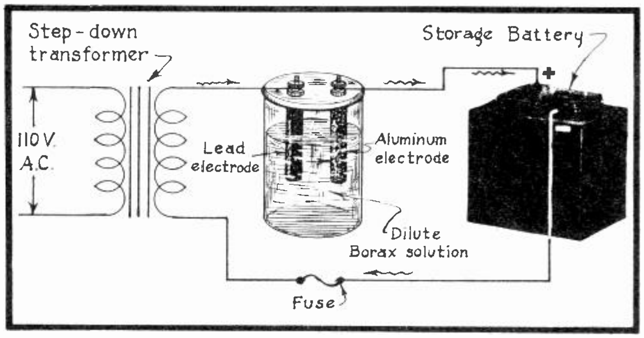

FIG. 2
Operation of the Trickle Charger

THE RECTIFIER OF THIS CHARGER TAKES CARE OF CONVERTING THE ALTERNATING HOUSE-LIGHTING CURRENT INTO A DIRECT CURRENT, WHICH IS USEABLE FOR BATTERY CHARGING. THE RECTIFIER PORTION OF THE CHARGER OF FIG. 1 IS CONTAINED WITHIN A GLASS JAR AND IT CONSISTS OF A POSITIVE ELECTRODE MADE OF TANTALUM AND A NEGATIVE ELECTRODE MADE OF LEAD. BOTH OF THESE ELECTRODES ARE IMMERSED IN A DILUTE SULPHURIC ACID SOLUTION.

IT IS ALSO POSSIBLE TO MAKE SUCH AN ELECTROLYTIC RECTIFIER BY USING A POSITIVE ELECTRODE OF ALUMINUM AND A NEGATIVE ELECTRODE OF LEAD, WITH BOTH OF THEM IMMERSED IN A DILUTE BORAX SOLUTION. WE HAVE SUCH AN ARRANGEMENT IN FIG. 2.

THIS CHARGER IN FIG. 2 OPERATES AS FOLLOWS: THE PRIMARY OF THE TRANSFORMER IS CONNECTED ACROSS THE 110 VOLT A.C. LIGHTING CIRCUIT OF THE HOME AND THIS ALTERNATING CURRENT INDUCES AN ALTERNATING CURRENT IN THE SECONDARY OF THE TRANSFORMER BUT THE VOLTAGE HERE IS ONLY AROUND 7-1/2 VOLTS ON ACCOUNT OF THE TRANSFORMER STEP-DOWN RATIO.

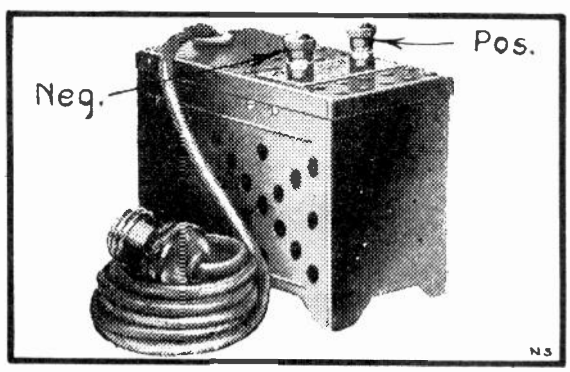

FIG. 3
Dry Type Trickle Charger.

THIS INDUCED ALTERNATING CURRENT MUST ALL FLOW THROUGH THE ELECTROLYTIC RECTIFIER, AS WELL AS THRU THE STORAGE BATTERY IN ORDER TO COMPLETE ITS CIRCUIT BUT THE RECTIFIER ONLY PERMITS CURRENT TO FLOW THRU THE BORAX SOLUTION FROM THE LEAD ELECTRODE OVER TO THE ALUMINUM ELECTRODE AND CURRENT CANNOT FLOW THROUGH IT IN THE OPPOSITE DIRECTION. THEREFORE, ONLY HALF OF THE INDUCED CURRENT CAN FLOW THROUGH THE BATTERY AND THIS IS ONLY DURING THE ALTERNATION WHEN THE CURRENT IS FLOWING THRU THE RECTIFIER CIRCUIT AS INDICATED BY THE ARROWS IN FIG. 2.

NOTICE THAT THIS CHARGING CURRENT IS FLOWING INTO THE POSITIVE BAT-

TERY TERMINAL AND THAT THE ALUMINUM ELECTRODE IS CONNECTED TO THE POSITIVE POST OF THE BATTERY.

DRY-TYPE TRICKLE CHARGERS

STILL ANOTHER TYPE OF TRICKLE CHARGER IS SHOWN IN FIG. 3. THIS CHARGER DOES NOT MAKE USE OF ANY LIQUID IN ORDER TO RECTIFY ALTERNATING CURRENT. INSTEAD, SPECIALLY TREATED COPPER DISCS ARE CLAMPED TOGETHER AND THEIR COMPOSITION IS SUCH AS TO ONLY PERMIT AN ELECTRIC CURRENT TO FLOW THROUGH THEM IN ONE DIRECTION, THEREFORE, THE ALTERNATING CURRENT IS RECTIFIED AND MADE USEABLE FOR BATTERY CHARGING PURPOSES.

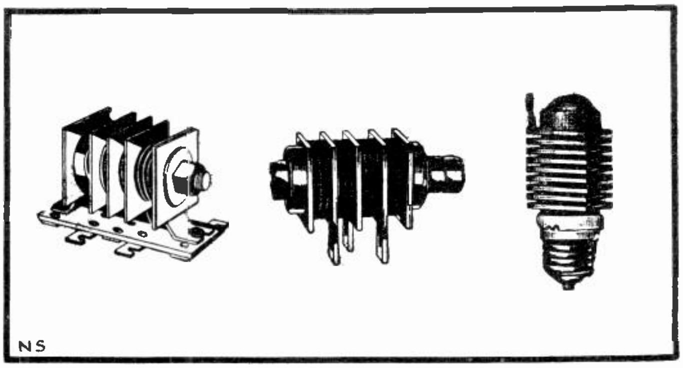

FIG. 4
Metallic Rectifier Units.

METALLIC RECTIFYING UNITS

SOMETIMES THESE DISC TYPE RECTIFIER UNITS ARE REFERRED TO AS "METALLIC RECTIFIERS" OR CONTACT RECTIFIERS AND IN FIG. 4, YOU WILL SEE THE RECTIFIER ELEMENT ITSELF IN THREE DIFFERENT FORMS. ALTHOUGH THE RECTIFIERS AS EMPLOYED IN MOST TRICKLE CHARGERS ONLY FURNISH A LOW CURRENT AS ALREADY MENTIONED IN THIS LESSON, YET UNITS OF THIS TYPE ARE AVAILABLE WHICH WILL HANDLE CONSIDERABLE CURRENT. THE UNIT AT THE LEFT OF FIG. 4, FOR EXAMPLE, IS RATED AT 3 AMPS. THE UNIT AT THE CENTER OF FIG. 4 CAN BE OBTAINED IN SEVERAL DIFFERENT SIZES, SUCH AS 1 AMP AT SIX VOLTS, 2.5 AMPS AT 4 VOLTS, 2 AMPS AT 6 VOLTS AND 1 AMP AT 8 VOLTS. UNITS WITH A SCREW BASE, SUCH AS ILLUSTRATED AT THE RIGHT OF FIG. 4, ARE AVAILABLE IN CURRENT RATINGS FROM 0.6 AMP TO 2.5 AMPS.

IN FIG. 5 YOU WILL SEE A DETAILED ILLUSTRATION WHICH WILL ENABLE YOU TO MORE CLEARLY VISUALIZE THE CONSTRUCTION AND OPERATION OF ONE OF THESE UNITS. IN THIS PARTICULAR CASE, COPPER DISCS ARE "SANDWICHED" BETWEEN LEAD DISCS AND THE ENTIRE GROUP OF DISCS ARE THEN TIGHTLY CLAMPED TOGETHER.

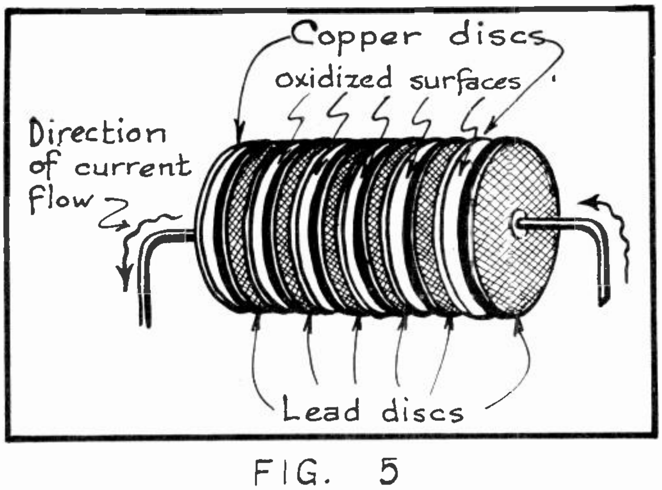

FIG. 5
Detail of the Copper Oxide Rectifying Unit

ONE SURFACE OF EACH OF THE COPPER DISCS IS OXIDIZED, THAT IS, COVERED WITH A TARNISHING FILM MUCH AS RUST WOULD COAT A PIECE OF IRON, WHILE THE OTHER SURFACE OF THE COPPER DISCS IS COMPLETELY FREE FROM ANY OXIDE DEPOSIT.

A COPPER DISC IN THIS CONDITION POSSESSES A PECULIAR AND VALUABLE PROPERTY AND THAT IS, IF A VOLTABE BE APPLIED ACROSS THE TWO SURFACES OF THE DISC, CURRENT WILL FLOW THROUGH THE DISC FROM THE

OXIDIZED SURFACE TOWARDS THE PURE COPPER SURFACE BUT NOT IN THE OPPOSITE DIRECTION. IN OTHER WORDS, IT HAS RECTIFYING CHARACTERISTICS.

THE PURPOSE OF THE LEAD DISCS IN FIG. 5 IS SIMPLY TO OFFER A SEPARATION BETWEEN ADJACENT COPPER DISCS, WHILE AT THE SAME TIME SERVING AS AN ELECTRICAL CONDUCTOR BETWEEN THEM. IF AN ALTERNATING VOLTAGE BE APPLIED ACROSS THE ENTIRE UNIT OF FIG. 5, THE CURRENT WILL ONLY FLOW THROUGH THE UNIT IN THE DIRECTION INDICATED IN THIS ILLUSTRATION AND THUS BRING ABOUT RECTIFICATION.

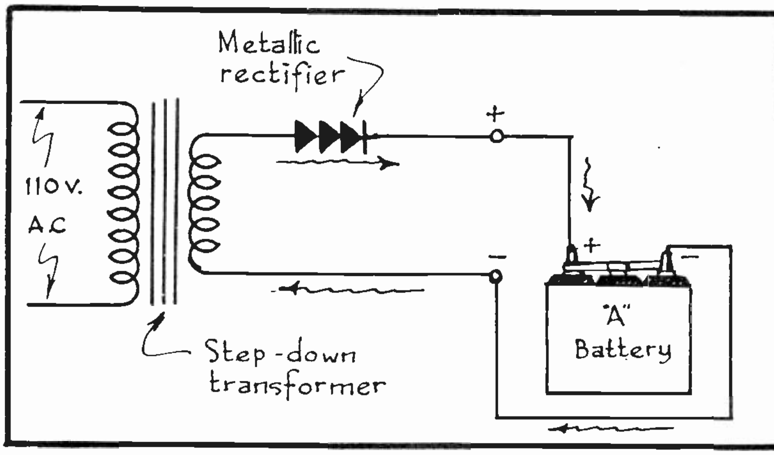

FIG. 6
Trickle Charger with Half-Wave Rectifier

ON ACCOUNT OF THE IMPORTANT EFFECTS PRODUCED BY THE COPPER AND COPPER OXIDE IN THIS SYSTEM OF RECTIFICATION, THIS TYPE OF RECTIFIER IS GENERALLY CLASSIFIED AS A COPPER-OXIDE RECTIFIER.

IT IS ALSO POSSIBLE TO OBTAIN RECTIFICATION BY THIS SAME METHOD THROUGH THE USE OF COPPER SULPHIDE DISCS IN CONJUNCTION WITH ALUMINUM OR MAGNESIUM DISCS. THESE DISCS ARE STACKED ALTERNATELY AND CLAMPED TOGETHER FIRMLY SO THAT THE UNIT WILL HAVE THE SAME APPEARANCE AS THE ONE SHOWN IN FIG. 5 ONLY THAT COPPER SULPHIDE DISCS WILL REPLACE THE COPPER DISCS AND ALUMINUM OR MAGNESIUM WILL REPLACE THE LEAD DISCS. CURRENT WILL THEN ONLY PASS THROUGH THIS ASSEMBLY FROM THE COPPER SULPHIDE DISCS TOWARDS THE ALUMINUM OR MAGNESIUM DISCS. RECTIFIERS OF THIS TYPE ARE GENERALLY CLASSIFIED AS COPPER-SULPHIDE RECTIFIERS.

THE CHARGING CIRCUIT

IN FIG. 6 WE HAVE A CHARGING CIRCUIT EMPLOYING A METALLIC RECTIFIER. NOTICE THAT THE RECTIFIER UNIT IS CONNECTED IN SERIES WITH THE SECONDARY WINDING OF THE TRANSFORMER AND THE STORAGE BATTERY. ALSO OBSERVE HOW WE REPRESENT SUCH A RECTIFYING UNIT IN THE FORM OF A SYMBOL.

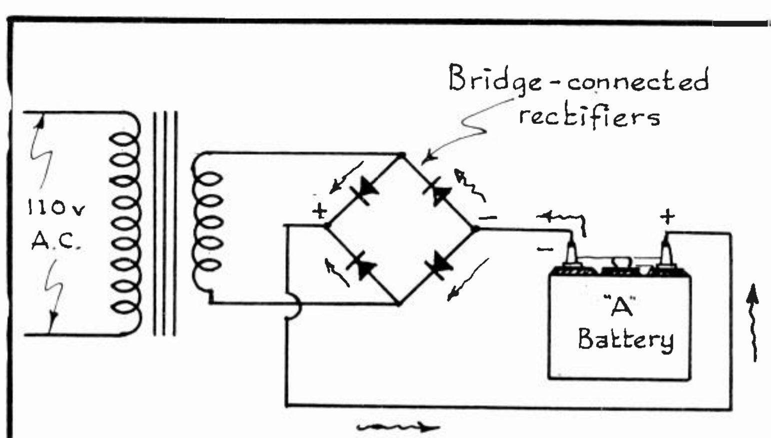

FIG. 7
Full-Wave Trickle Charger.

A.C. VOLTAGES ARE OF COURSE INDUCED INTO THE SECONDARY WINDING OF THE TRANSFORMER AND IN THIS WAY APPLIED ACROSS THE BATTERY AND RECTIFIER. THIS LATTER UNIT, HOWEVER, ONLY PERMITS THE CURRENT TO FLOW THROUGH IT IN ONE DIRECTION AND THEREFORE THE CHARGING CURRENT PASSES THROUGH THE STORAGE BATTERY IN THE DIRECTION HERE INDICATED. SINCE ONLY ONE-HALF OF THE A.C. CYCLE IS IN THIS WAY USED, THE SYSTEM OF FIG. 6 FURNISHES HALF-

WAVE RECTIFICATION.

IN ORDER TO UTILIZE BOTH HALVES OF THE A.C. CYCLE FOR THIS CHARGING PURPOSE, SEVERAL RECTIFIER ELEMENTS CAN BE GROUPED TOGETHER INTO THE ARRANGEMENT PICTURED IN FIG. 7. HERE, FOUR SUCH ELEMENTS ARE ARRANGED INTO WHAT IS KNOWN AS A BRIDGE CONNECTION. IN THIS WAY, IT MAKES NO DIFFERENCE IN WHICH DIRECTION THAT THE A.C. VOLTAGE IS APPLIED TO THE SYSTEM BY THE SECONDARY WINDING OF THE TRANSFORMER, THE CHARGING CURRENT WILL ALWAYS FLOW IN THE DIRECTION HERE INDICATED.

QUITE OFTEN, YOU WILL FIND THE RECTIFIER ELEMENTS SERIES---PARALLEL CONNECTED. THE SERIES CONNECTION WILL DISTRIBUTE THE TOTAL APPLIED VOLTAGE IN SUCH A MANNER SO THAT LESS VOLTAGE WILL BE IMPRESSED ACROSS EACH UNIT WHILE THE PARALLEL CONNECTION WILL REDUCE THE AMOUNT OF CURRENT WHICH WILL BE PASSED BY EACH OF THE RECTIFIER UNITS. BOTH OF THESE FACTORS WILL INCREASE THE LIFE AND EFFICIENCY OF THE RECTIFIER.

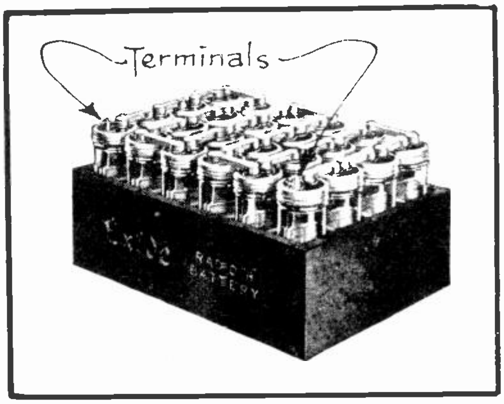

FIG. 8
Storage Type "B" Battery.

IN SOME RECEIVERS, A SPECIAL SWITCH IS USED, WHICH WILL TURN ON THE CHARGER AT THE SAME TIME THAT THE RECEIVER IS TURNED OFF AND VICE VERSA, WHILE OTHERS SIMPLY TURN ON THE LIGHTING SWITCH WHENEVER THEY WANT THEIR CHARGER TO BE IN OPERATION. ALTHOUGH ONLY A SMALL CHARGING CURRENT IS FURNISHED BY THESE CHARGERS, YET IT IS SUFFICIENT TO KEEP A GOOD STORAGE BATTERY IN A CHARGED CONDITION, PROVIDED OF COURSE THAT THE RECEIVER AND CHARGER ARE BOTH USED INTELLIGENTLY.

AVOIDING "B" BATTERY REPLACEMENTS

THE TRICKLE CHARGER ADDS CONVENIENCE AS FAR AS THE STORAGE TYPE "A" BATTERY IS CONCERNED BUT THE REPLACEMENT OF "B" BATTERIES HAS ALSO ALWAYS BEEN AN EXPENSE LOOKED UPON AS UNFAVORABLE BY OWNERS OF BATTERY OPERATED RECEIVERS. IN ORDER TO DO AWAY WITH THE NEED FOR REPLACING THE DRY TYPE

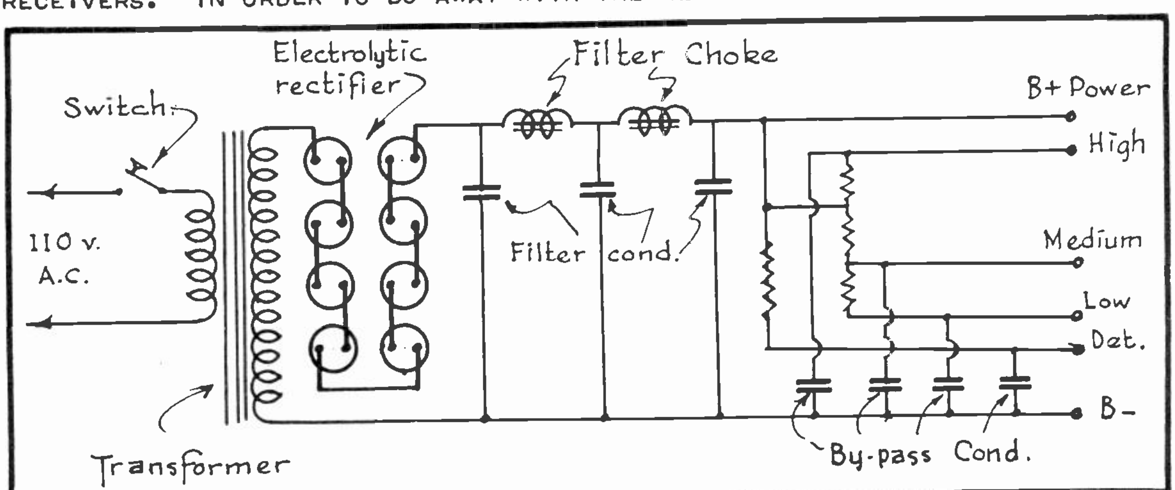

FIG. 9
An Electrolytic "B" Eliminator.

"B" BATTERIES WHEN THEY BECOME DISCHARGED, A NUMBER OF RECEIVER OWNERS EMPLOYED STORAGE TYPE "B" BATTERIES SUCH AS SHOWN IN FIG. 8.

BATTERIES AS THIS CONSIST OF 24 INDIVIDUAL LEAD-ACID CELLS ALL CONNECTED IN SERIES AND PLACED TOGETHER IN A SINGLE CONTAINER TO FORM A "B" BATTERY. EACH CELL CONSISTS OF ONE OR TWO NEGATIVE PLATES AND ONE POSITIVE PLATE IMMERSED IN A SULPHURIC ACID SOLUTION. THE COMPLETE BATTERY FURNISHES A "B" VOLTAGE OF 48 VOLTS AND ALTHOUGH CAPABLE OF BEING RECHARGED, IT NEVERTHELESS IS QUITE EXPENSIVE.

THE NEXT STEP WHICH WAS TAKEN BY THE RADIO INDUSTRY TO SOLVE THIS PROBLEM OF DRY "B" BATTERY REPLACEMENTS WAS TO DO WITHOUT THEM ALTOGETHER AND TO SUBSTITUTE "B" ELIMINATORS IN THEIR PLACE.

"B" ELIMINATORS CAN BE CLASSIFIED INTO THREE DISTINCT GROUPS ACCORDING TO THE SYSTEM OF RECTIFICATION THEY EMPLOY. THAT IS, WE HAVE THE ELECTROLYTIC, DRY METALLIC DISC AND THE TUBE TYPES. AT THE PRESENT TIME, THE TUBE TYPES ARE BY FAR THE MOST POPULAR, NEVERTHELESS, IT IS ALSO ADVIS-

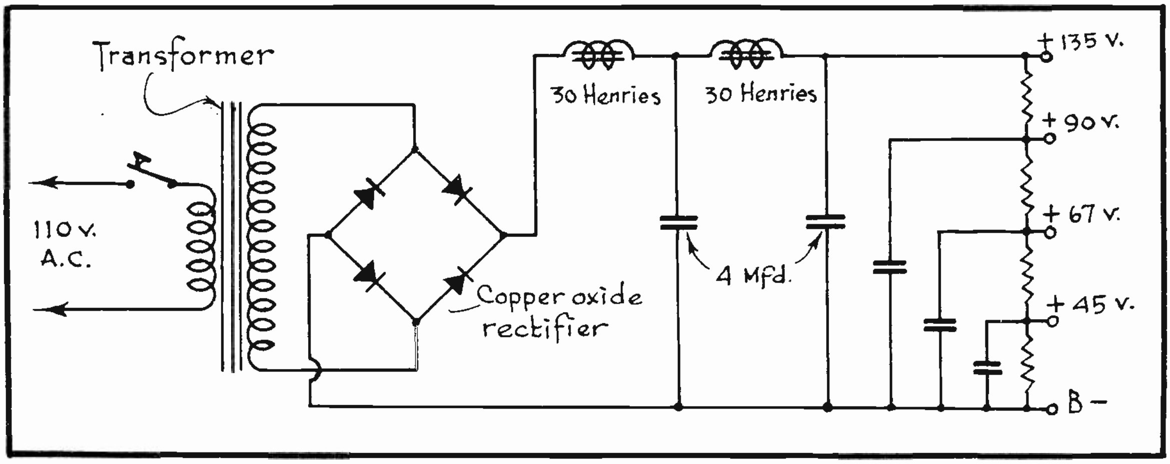

FIG. 10
"B" Eliminator With a Copper Oxide Rectifier.

ABLE THAT YOU BECOME FAMILIAR WITH THE OTHER TYPES.

GENERALLY SPEAKING, "B" ELIMINATORS DERIVE THEIR ENERGY FROM THE 110 VOLT A.C. LIGHTING CIRCUIT AND IN TURN FURNISH A DIRECT CURRENT WHICH IS SUITABLE FOR "B" PURPOSES. WE SHALL CONSIDER THE ELECTROLYTIC TYPE "B" ELIMINATOR FIRST.

ELECTROLYTIC TYPE "B" ELIMINATORS

THE CONSTRUCTION OF ONE SUCH ELECTROLYTIC "B" ELIMINATOR IS ILLUSTRATED FOR YOU IN THE DIAGRAM OF FIG. 9. THE PRIMARY WINDING OF THE TRANSFORMER IS CONNECTED ACROSS THE 110 VOLT A.C. CIRCUIT AND THE SECONDARY WINDING IS CONNECTED TO A SERIES-CONNECTED GROUP OF ELECTROLYTIC RECTIFIER CELLS. THESE RECTIFYING CELLS ARE SIMILAR TO THE ONES SHOWN YOU IN RESPECT TO TRICKLE CHARGERS EARLIER IN THIS LESSON, ONLY THAT THEY ARE SMALLER IN SIZE.

THE TRANSFORMER IN THIS CASE IS OF THE STEP-UP TYPE AND THEREFORE DELIVERS A HIGHER A.C. VOLTAGE TO THE RECTIFYING SYSTEM. THE DIRECT CURRENT

AS FURNISHED AT THE OUTPUT OF THE RECTIFIER IS SOMEWHAT UNEVEN OR PUL-- SATING INSTEAD OF BEING SMOOTH AND UNIFORM IN VALUE AS A BATTERY CURRENT AND SO IN ORDER TO SMOOTHEN IT, WE PASS IT THROUGH A SYSTEM OF IRON-CORE CHOKES AND CONDENSERS WHICH CONSTITUTE A FILTER CIRCUIT.

THESE FILTER CHOKES ARE SOMEWHAT SIMILAR IN CONSTRUCTION TO AN A.F. CHOKE, THAT IS, THEY CONSIST OF A SINGLE WINDING ON AN IRON CORE AND EACH OF THEM HAVE AN INDUCTANCE RATING OF ABOUT 30 HENRIES. THE FILTER CONDENSERS GENERALLY HAVE A CAPACITY RATING OF FROM 2 TO 8 MFDS.

AT THE OUTPUT OF THE FILTER, THE MAXIMUM "B" VOLTAGE WILL BE OBTAINED ACROSS THE TWO TERMINALS WHICH ARE MARKED "B+ POWER" AND "B-." A RESISTANCE NETWORK OR VOLTAGE DIVIDER IS THEN CONNECTED ACROSS THE OUTPUT SO THAT BETWEEN THE B- AND THE REMAINING TERMINALS, VARIOUS "B" VOLTAGE VALUES WILL BE AVAILABLE. SO THAT NONE OF THE R.F. OR A.F. CURRENTS OF THE RE-- CEIVER CIRCUITS WILL FLOW THROUGH THE VARIOUS RESISTORS OF THE VOLTAGE DIVIDER, BY-PASS CONDENSERS RATED FROM 1 TO 2 MFD. ARE CONNECTED BETWEEN THE B- AND THE INTERMEDIATE VOLTAGE TERMINALS AS HERE SHOWN--- IN THIS WAY, THE TONE QUALITY WILL BE IMPROVED.

FIG. 11
A "B" Eliminator.

THE "DRY" B ELIMINATOR

IN FIG. 10 YOU WILL SEE A CIRCUIT ARRANGEMENT OF A "B" ELIMINATOR IN WHICH A COPPER-OXIDE RECTIFIER IS EMPLOYED. AS A WHOLE, THE CIRCUIT IS QUITE SIMILAR TO THE ONE OF FIG. 9, THE CHIEF DIFFERENCE BEING THAT IN FIG. 10 A COPPER OXIDE RECTIFIER IS CONNECTED IN A BRIDGE ARRANGEMENT SO AS TO PROVIDE FULL WAVE RECTIFICATION. THE FILTER CIRCUIT AND VOLTAGE DIVIDER ARE CONVENTIONAL AND "B" VOLTAGE RANGES FROM 45 TO 135 VOLTS ARE AVAILABLE FROM THIS UNIT.

FIG. 12
Full-Wave Rectifying Tube.

A "B" ELIMINATOR WITH GASEOUS RECTIFIER

ANOTHER TYPE OF "B" ELIMINATOR, WHICH HAS BEEN EXTENSIVELY USED, EMPLOYS A RAYTHEON GASEOUS RECTIFYING TUBE. AN ELIMINATOR OF THIS TYPE IS SHOWN YOU IN FIG. 11.

NOTICE HOW THE DIFFERENT "B" TERMINALS ARE ALL MOUNTED TOGETHER AND THAT AN "OFF-ON" SWITCH, AS WELL AS THREE RHEOSTAT-TYPE VOLTAGE CONTROLS, ARE INCLUDED AS A PART OF THIS UNIT.

THE RHEOSTAT CONTROL AT THE LEFT OF THIS "B" EL-

IMINATOR PERMITS ONE TO ADJUST THE DETECTOR PLATE VOLTAGE, THE ONE AT THE RIGHT ADJUSTS THE AMPLIFIER TUBE PLATE VOLTAGE AND THE ONE AT THE LOWER CENTER PROVIDES A MEANS FOR ADJUSTING THE POWER TUBE "B" VOLTAGE.

THE RAYTHEON RECTIFYING TUBE IS SHOWN YOU IN FIG. 12. THIS TUBE IS FILLED WITH HELIUM GAS AND A PLATE IS USED AS THE CATHODE. TWO SMALL ANODES ARE CONNECTED ACROSS THE SECONDARY WINDING OF A STEP-UP TRANSFORMER, AS SHOWN IN FIG. 13 AND CURRENT CAN ONLY FLOW THROUGH THIS TUBE FROM THE SMALL ANODES OVER TO THE CATHODE OR PLATE BUT NOT IN THE OPPOSITE DIRECTION.

NOW IF YOU WILL LOOK AT FIG. 13 CLOSELY, WE WILL DISCUSS THE OPER-

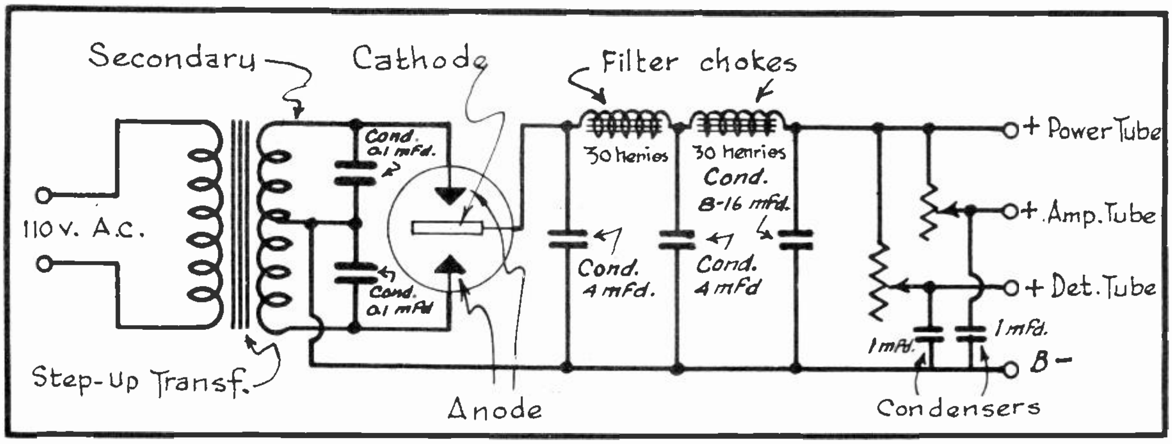

FIG. 13

Circuit of a Typical "B" Eliminator.

ATION OF THE "B" ELIMINATOR, WHOSE CIRCUITS AND CONSTRUCTION ARE ILLUSTRATED IN THIS DIAGRAM.

THE PRIMARY WINDING OF THE STEP-UP TRANSFORMER IS CONNECTED ACROSS THE 110 VOLT-A.C. HOUSELIGHTING SUPPLY AND THE TURNS RATIO OF THIS TRANSFORMER IS SUCH, SO THAT A 700 VOLT A.C. VOLTAGE WILL BE GENERATED ACROSS THE ENDS OF THE SECONDARY WINDING. THE ANODES OF THE RAYTHEON TUBE ARE CONNECTED ACROSS THIS SECONDARY AND THE SECONDARY ALTERNATING CURRENT WILL FLOW FROM EITHER OF THESE ANODES OVER TO THE CATHODE, DEPENDING UPON WHICH ANODE IS POSITIVE AT THAT INSTANT.

THROUGH THE USE OF TWO ANODES IN THIS TUBE, IT IS OBVIOUS THAT BOTH ALTERNATIONS OF THE A.C. CYCLE WILL PASS THROUGH THE TUBE SO THAT THIS TUBE IS A FULL-WAVE RECTIFIER. FURTHERMORE, ALL OF THE CURRENT WHICH REACHES THE PLATE OR CATHODE OF THIS TUBE, WILL FLOW OUT OF THE TUBE INTO THE EXTERNAL CIRCUIT AND THEREFORE THE LINE, WHICH IS CONNECTED TO THIS PLATE, WILL BE THE (+) "B" LINE.

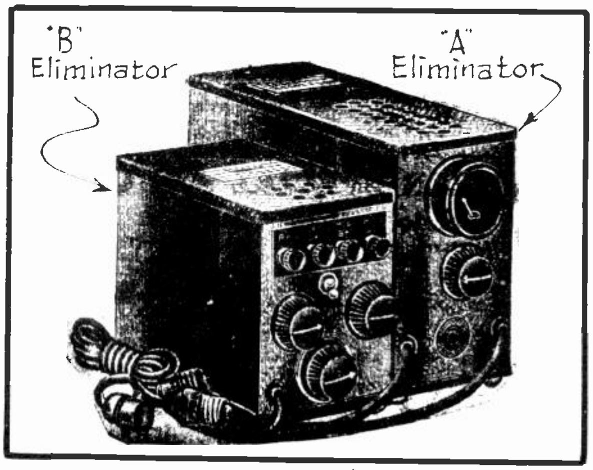

FIG. 14

"A" and "B" Eliminator

IN THIS TYPE OF "B" ELIMINATOR, A FILTER SYSTEM IS ALSO USED TO MAKE THE RECTIFIED CURRENT

MORE UNIFORM IN VALUE.

THE MAXIMUM "B" VOLTAGE OBTAINABLE FROM THIS PARTICULAR ELIMINATOR WILL BE APPROXIMATELY 180 VOLTS AND THIS VOLTAGE WILL EXIST BETWEEN THE (+) TERMINAL LABELED "POWER TUBE" AND THE B- TERMINAL. SO TO DROP THIS VOLTAGE DOWN TO THE CORRECT B VALUE TO OPERATE THE AMPLIFIER AND DETECTOR TUBES, WE USE THE VARIABLE RESISTORS AS SHOWN. NOTICE THAT A BY-PASS CONDENSER IS CONNECTED FROM THE (+) AMPLIFIER AND DETECTOR TERMINALS TO THE (B-) SIDE OF THE LINE, SO THAT THE AUDIO AND R.F. FREQUENCIES CAN FLOW THROUGH THEM WITHOUT HAVING TO FLOW THROUGH THE RHEOSTATS.

THE B- LINE, YOU WILL OBSERVE, IS CONNECTED TO THE CENTER OF THE TRANSFORMER SECONDARY WINDING AND A FIXED CONDENSER OF 0.1 MFD. EACH IS CONNECTED FROM THE CENTER TAP OF THE SECONDARY TO EACH OF ITS ENDS. THE PURPOSE OF THESE CONDENSERS IS TO PREVENT THE TRANSMISSION OF LINE NOISES INTO THE "B" SUPPLY.

"A" ELIMINATORS

HAVING ELIMINATED THE "B" BATTERY, THE NEXT THING TO BE DONE WAS TO GET RID OF THE "A" BATTERY AS WELL AND IN ORDER TO DO THIS, "A" ELIMINATORS WERE PUT ON THE MARKET.

THESE "A" ELIMINATORS IN THEIR GENERAL PRINCIPLES ARE MUCH THE SAME AS THE "B" ELIMINATOR. THAT IS, THEY CONSISTS OF A TRANSFORMER, RECTIFIER, FILTER AND VOLTAGE CONTROL. THE TRANSFORMER IN THIS LATTER CASE, HOWEVER, IS A STEP-DOWN TRANSFORMER AND THE RECTIFIER IS GENERALLY SOME DRY TYPE, SUCH AS YOU SAW AMONG THE TRICKLE CHARGERS IN THIS LESSON. THIS RECTIFIED LOW VOLTAGE CURRENT IS THEN FILTERED SIMILAR TO OUR "B" SUPPLY AND WE USE THIS LOW VOLTAGE "A" CURRENT TO SEND THROUGH THE FILAMENTS OF THE REGULAR BATTERY-TYPE RADIO TUBES.

IN FIG. 14, YOU WILL SEE THE "A" AND "B" ELIMINATOR TOGETHER. THE VOLTMETER AND RHEOSTAT ON THE "A" ELIMINATOR ARE ALSO SHOWN AND THEY ENABLE THE SET OPERATOR TO ADJUST THE FILAMENT VOLTAGE TO THE PROPER AMOUNT.

THERE ARE VARIOUS KINDS OF BATTERY ELIMINATORS AVAILABLE AND SOME OF THEM EVEN HANDLE THE "C" BATTERY JOB AS WELL, GIVING US ALTOGETHER AN "A", "B", AND "C" ELIMINATOR. THE ENTRANCE OF BATTERY ELIMINATORS INTO THE RADIO WORLD WAS REALLY PART OF OUR RADIO EVOLUTION, GRADUALLY LEADING UP TO THE A.C. SETS AS WE KNOW THEM TODAY AND ABOUT WHICH YOU SHALL STUDY VERY SOON.

IN FIG. 15 YOU ARE SHOWN A CIRCUIT DIAGRAM OF A TYPICAL A-B AND C ELIMINATOR. UPON STUDYING THIS DIAGRAM VERY CAREFULLY, YOU WILL SEE THAT WE HAVE FIRST A TRANSFORMER. THE PRIMARY WINDING IS CONNECTED TO THE 110 VOLT A.C. LIGHTING CIRCUIT AND IS TAPPED AT THREE POINTS AT WHICH A SWITCH MAKES CONTACT IN ORDER TO COMPENSATE FOR EITHER A HIGH OR LOW LINE VOLTAGE. THAT IS, IF THE A.C. LINE VOLTAGE IS ONLY 95 VOLTS, THE HIGH- LOW LINE SWITCH IS SET SO AS TO MAKE CONTACT WITH THE 95V TERMINAL; IF THE LINE VOLTAGE IS 105 VOLTS, THIS SWITCH IS SET AT THE 105 V POSITION ETC. THIS SERVES TO CHANGE THE TURNS RATIO OF THE TRANSFORMER AND IN THIS WAY RAISE OR LOWER THE SECONDARY VOLTAGES ACCORDINGLY.

THREE SEPARATE SECONDARY WINDINGS ARE FURNISHED ON THIS TRANSFORMER.

ONE OF THESE LOW-VOLTAGE SECONDARIES SUPPLIES THE FILAMENT VOLTAGE WHICH IS TO BE APPLIED ACROSS A TYPE-80 FULL-WAVE RECTIFIER TUBE AND AT THE SAME TIME, SERVES AS THE HIGH SIDE OF THE "B" CIRCUIT. ANOTHER LOW VOLTAGE SECONDARY WINDING IS CONNECTED TO A COPPER-OXIDE RECTIFIER AND THUS SUPPLIES THE "A" VOLTAGE---THIS WINDING IS ALSO TAPPED AND PROVIDED WITH A SWITCHING ARRANGEMENT, SO THAT THE "A" VOLTAGE CAN BE ADJUSTED WITHIN FIXED LIMITS. THE HIGH VOLTAGE SECONDARY HAS ITS EXTREMETIES CONNECTED TO THE TWO PLATES WHICH ARE CONTAINED WITHIN THE -80 RECTIFIER TUBE, WHILE ITS CENTER TAP SERVES AS THE B- AND C SIDE OF THE CIRCUIT.

BRIEFLY THEN, WE HAVE THE -80 TUBE SUPPLYING THE HIGH D.C. VOLTAGES AT LOW CURRENT FOR "B" AND "C" USE AND THE COPPER-OXIDE RECTIFIER, THE LOW D.C. VOLTAGE AT GREATER CURRENT FOR "A" USE.

A SEPARATE FILTER CIRCUIT IS USED FOR THE RECTIFIED "A" SUPPLY AND THE "A" VOLTAGE AVAILABLE IN THIS PARTICULAR CASE IS 6 VOLTS. AN INDIVIDUAL FILTER SYSTEM IS USED FOR THE RECTIFIED "B" SUPPLY AND A RESISTANCE

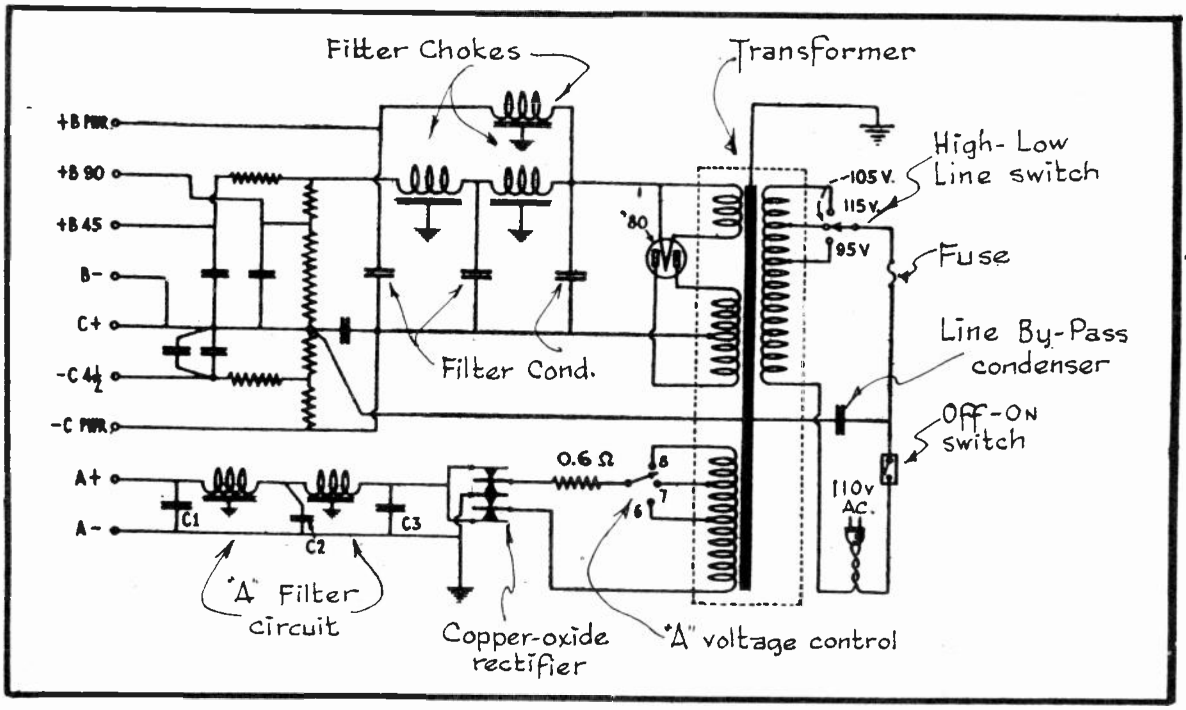

FIG. 15

Circuit Diagram of An "A"-"B"- and "C" Eliminator.

NETWORK PERMITS "B" VOLTAGES OF 250, 90 AND 45 VOLTS TO BE AVAILABLE AT THE OUTPUT TERMINALS, IN ADDITION TO "C" VOLTAGES OF $-4\frac{1}{2}$ AND -9 VOLTS.

ALL CHOKE AND TRANSFORMER CORES ARE GROUNDED SO AS TO REDUCE HUM AS MUCH AS POSSIBLE.

SINCE THE "B" AND "C" SECTIONS OF THIS BATTERY ELIMINATOR OPERATE UPON THE SAME PRINCIPLES AS IN A.C. RECEIVERS USING A TYPE-80 TUBE, AS A RECTIFIER, WE SHALL NOT SPEND ANY MORE TIME NOW UPON ITS OPERATING THEORY BUT IT WILL BE EXPLAINED TO YOU THOROUGHLY A LITTLE LATER ON IN A LESSON DEALING EXCLUSIVELY WITH POWER PACKS FOR A.C. RECEIVERS. NEVERTHELESS, THE DIAGRAM IN FIG. 15 WILL SERVE ITS PURPOSE OF FAMILIARIZING YOU WITH THE CIRCUIT ARRANGEMENT OF AN A, B AND C TYPE BATTERY ELIMINATOR.

EVEN THOUGH BATTERY ELIMINATOR UNITS ARE NOT BEING USED NOW AS EXTENSIVELY AS A FEW YEARS AGO ON ACCOUNT OF THE PRESENT POPULARITY OF A.C. RECEIVERS, YET A NUMBER OF THEM STILL ARE IN USE AND BEING SOLD. THEREFORE, YOU SHOULD CONSIDER IT AS A PART OF YOUR RADIO EDUCATION TO FAMILIARIZE YOURSELF WITH THEM.

HAVING INVESTIGATED BATTERY ELIMINATORS QUITE THOROUGHLY, LET US NEXT TURN OUR ATTENTION TO THE LOUD SPEAKERS, WHICH ARE USED IN RADIO.

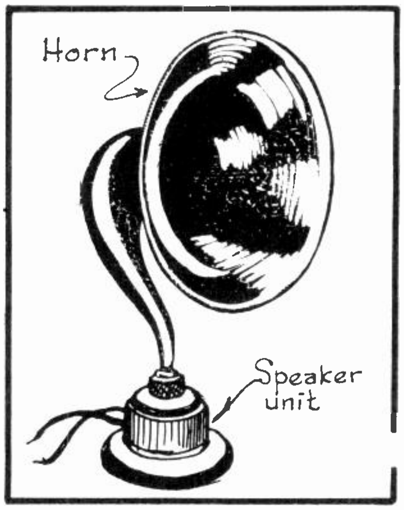

FIG. 16.
Old Type Speaker

LOUD SPEAKERS

SPEAKERS HAVE BEEN A SORT OF WEAK LINK IN THE RADIO ENSEMBLE BUT THEY HAVE GRADUALLY BEEN IMPROVED UNTIL TODAY, OUR SPEAKERS PERFORM REMARKABLY WELL.

ONE OF THE EARLY TYPE SPEAKERS IS SHOWN IN FIG. 16 AND IT CONSISTED OF NOTHING MORE THAN A LARGE HEADPHONE UNIT WITH THE CUSTOMARY METALLIC DIAPHRAGM AND A LONG GOOSE-NECKED HORN MOUNTED OVER THE OPENING. CONSEQUENTLY, WHEN THE DIAPHRAGM WAS CAUSED TO VIBRATE BY THE VARIATION OF PLATE CURRENT THROUGH ITS WINDINGS, THE COLUMN OF AIR WITHIN THE HORN WAS CAUSED TO UNDERGO CORRESPONDING VIBRATIONS AND THEREBY SEND THE SOUNDS OUT THROUGH THE OPENING OF THE HORN.

ALTHOUGH THIS DEVICE SERVED AS A LOUD SPEAKER, YET IT WAS A MIGHTY POOR ONE, EMITTING ALL KINDS OF HARSH AND SCREETCHING SOUNDS EVEN IF A FIRST CLASS RECEIVING SET WERE BEING USED WITH IT.

CONE SPEAKERS

THE NEXT BIG STEP IN SPEAKER DESIGN WAS TAKEN WHEN THE CONE TYPE SPEAKER WAS DEVELOPED. YOU WILL SEE SUCH A CONE SPEAKER IN FIG. 17 AND HERE THE METALLIC DIAPHRAGM IS REPLACED BY A GOOD GRADE OF PAPER, WHICH IS SHAPED INTO THE FORM OF A CONE. THIS PAPER HAS A NATURAL LOW FREQUENCY VIBRATING PERIOD AND THEREFORE THIS TYPE OF SPEAKER IS CAPABLE OF REPRODUCING THE LOW NOTES MUCH BETTER THAN THE EARLIER SPEAKERS HAVING METALLIC DIAPHRAGMS.

FIG. 17
A Cone Speaker

THE PARTICULAR CONE SPEAKER IN FIG. 17 IS NOT INTENDED TO BE USED INSIDE OF A RECEIVER CABINET BUT INSTEAD, IT IS TO BE MOUNTED IN SOME CONSPICUOUS AND HANDY PLACE, SUCH AS ON TOP OF THE RECEIVER CABINET. IN CASE YOU PLACE

A SPEAKER AS THIS ON TOP OF A RECEIVER CABINET, HOWEVER, BE SURE THAT THE BASE OF THE SPEAKER IS WELL PADDED WITH FELT, SO AS TO AVOID THE TRANSFER OF VIBRATIONS FROM THE SPEAKER TO THE RADIO TUBES BECAUSE THIS CONDITION FREQUENTLY CAUSES HOWLS TO BE EMITTED FROM THE SPEAKER.

AN INTERNAL VIEW OF THIS SAME CONE SPEAKER IS SHOWN IN FIG. 18 AND HERE YOU WILL SEE HOW THE DRIVING UNIT IS PLACED INSIDE OF IT. THIS DRIVING UNIT IS THUS CONCEALED WITHIN THE SPEAKER, SO THAT IT CANNOT BE SEEN BY THOSE LISTENING TO A RADIO PROGRAM.

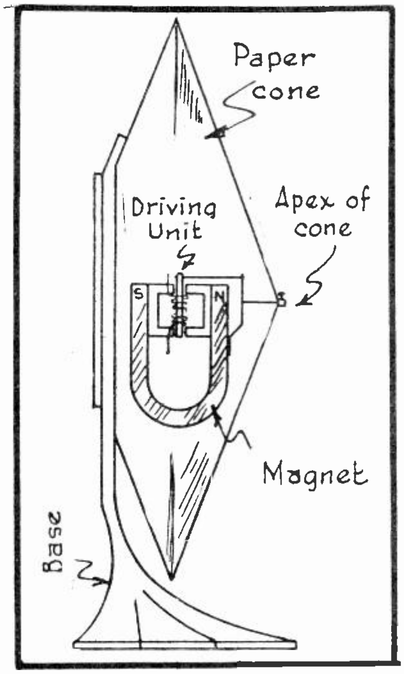

FIG. 18
The Driving Unit.

NOW IN CASE THAT A CONE SPEAKER IS GOING TO BE INSTALLED WITHIN THE RECEIVER CABINET, THEN THE SPEAKER IS INVERTED AND WE HAVE A UNIT AS SHOWN IN FIG. 19. THE MAIN DIFFERENCE BETWEEN THESE TWO SPEAKERS, YOU WILL NOTE, IS THAT THE SOUND WAVES OF THE SPEAKER IN FIGS. 17 AND 18 ARE INTENDED TO BE RADIATED FROM THE CONE SURFACE AS SHOWN IN "A" OF FIG. 20 AND THE SOUND WAVES OF THE SPEAKER IN FIG. 19 ARE INTENDED TO BE RADIATED FROM THE CONE SURFACE AS SHOWN IN "B" OF FIG. 20. HOWEVER, IN BOTH CASES, BOTH SIDES OF THE CONE WILL TO SOME EXTENT RADIATE SOUND WAVES.

BOTH OF THESE SCHEMES, AS YOU WILL OBSERVE IN FIG. 20, OFFER DIRECTIONAL QUALITIES. THAT IS, THE CONE AT "A" TENDS TO RADIATE THE SOUND OUTWARDS, WHEREAS THE ARRANGEMENT AT "B" OF FIG. 20 TENDS TO FOCUS THE SOUND TOWARDS THE CENTER. BUT NOW LET US GO ON AND SEE HOW THE PAPER CONE IN BOTH THESE CASES IS MADE TO VIBRATE SO AS TO PRODUCE SOUND.

BALANCED ARMATURE TYPE SPEAKERS

THE DRIVING UNIT OF THESE TWO CONE SPEAKERS, WHICH YOU WERE JUST SHOWN, IS CALLED A BALANCED ARMATURE TYPE UNIT AND THESE TWO SPEAKERS ARE GENERALLY REFERRED TO AS BEING BALANCED ARMATURE OPERATED SPEAKERS, OR SIMPLY "MAGNETIC SPEAKERS."

IN FIG. 21 THIS DRIVING UNIT IS SHOWN IN DETAIL AND IT OPERATES AS FOLLOWS: A SOFT IRON ARMATURE OR BAR IS PIVOTED AT ITS CENTER BETWEEN THE POLE PIECES OF A HORSESHOE PERMANENT MAGNET.

A COIL OR ELSE TWO SERIES CONNECTED COILS SURROUND THIS SOFT IRON ARMATURE. ASSUMING THAT THESE COILS ARE IN SERIES WITH THE PLATE CIRCUIT OF THE FINAL TUBE OF THE RECEIVER, WE FIND THE FOLLOWING ACTIONS TAKING PLACE:

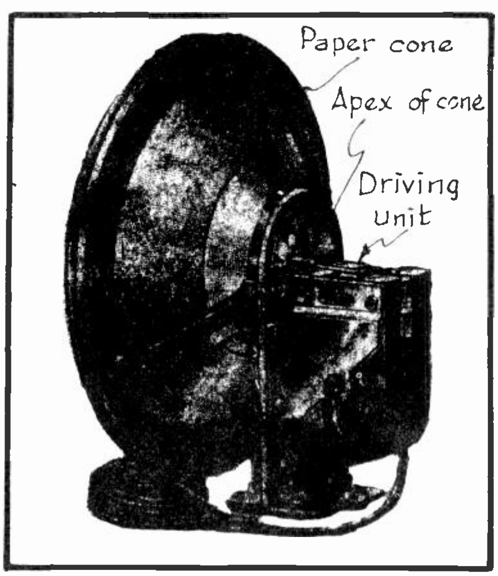

FIG. 19
Cone Speaker for Cabinet.

When no plate current is flowing through this speaker winding, the armature will be in a straight up and down position because the attractive forces of the poles of the horseshoe magnet will be equal on both sides of it. Now if plate current should flow through this speaker coil in the direction shown in Fig. 21, then the upper end of the armature will be magnetized to a SOUTH polarity. Therefore, this upper end of the armature will be repelled by the south pole piece and attracted by the north piece and consequently, the upper end of this armature will tilt toward the LEFT.

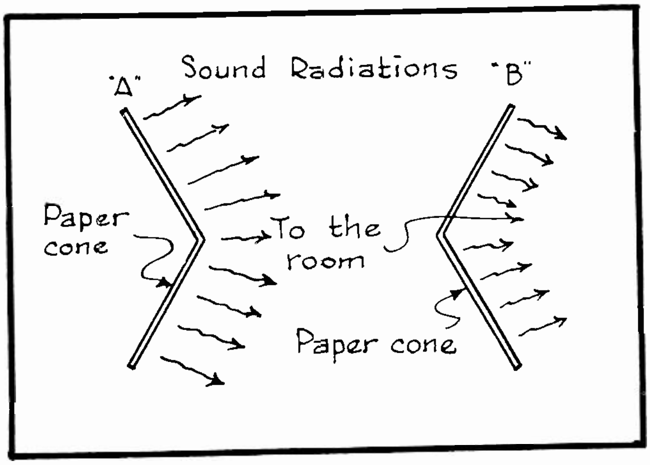

FIG. 20
Sound Radiation from Cone Surfaces.

At this same instant, the lower end of the armature will be magnetized to a NORTH polarity by the current flow through the windings, causing the lower end of the armature to be attracted to the south pole piece and repelled by the north pole piece, thus assisting in tilting the armature on its pivot.

This motion of the armature will be transmitted to the apex of the paper cone by means of the connecting rods and levers and as a result, the apex of the cone will be pulled toward the left at this particular instant.

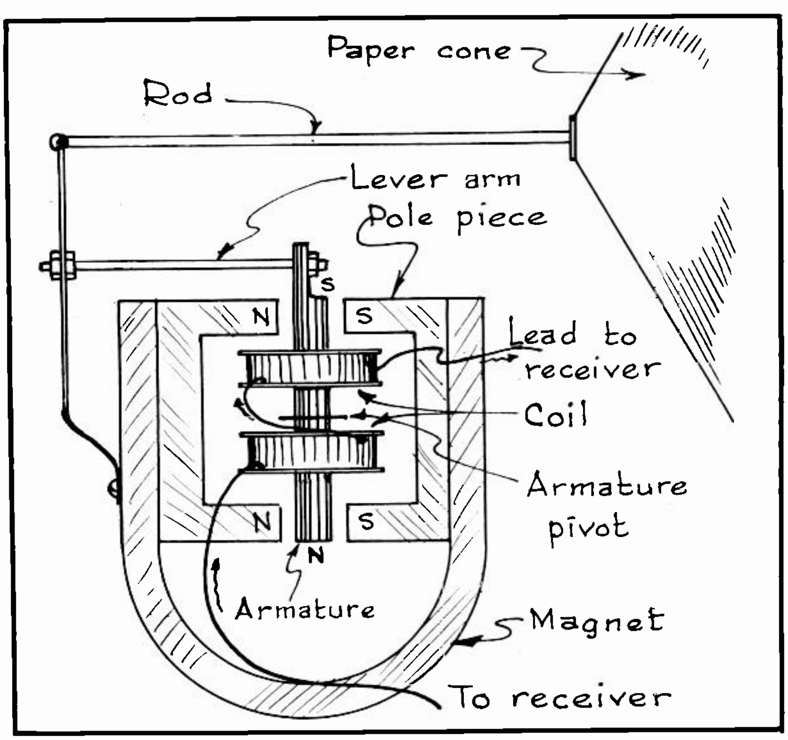

FIG. 21
The Balanced Armature Driving Unit.

In this way, it can been seen that as the current thru the speaker coils VARIES at audio frequencies, the armature movement will vary correspondingly and the apex of the paper cone is therefore pushed and pulled in step with it. This movement of the paper cone causes the variation of air pressures at its surface and thus sends forth the sounds.

THE ELECTRODYNAMIC SPEAKER

Now we come to another modern speaker, namely, the MOVING COIL type speaker, or as it is today generally called the ELECTRODYNAMIC speaker.

A PICTURE OF AN ELECTRODYNAMIC SPEAKER IS SHOWN IN FIG. 22 AND IN FIG. 23 THE CIRCUITS FOR THIS SAME SPEAKER ARE SHOWN.

LOOKING AT FIGURES 22 AND 23 TOGETHER, YOU WILL SEE THAT THE FIELD COIL OF THE SPEAKER'S FIELD MAGNET IS PROVIDED WITH A $7\frac{1}{2}$ VOLT DIRECT CURRENT SUPPLY. THIS D.C. SUPPLY IS OBTAINED BY REDUCING THE 110-VOLT A. C. HOUSE LIGHTING SUPPLY DOWN TO 12 VOLTS BY MEANS OF THE STEP-DOWN TRANSFORMER. THIS LOW VOLTAGE A.C. IS THEN IMPRESSED UPON THE COPPER-OXIDE RECTIFIER AND THIS UNIT IN TURN SUPPLIES THE SPEAKER FIELD COIL WITH THE $7\frac{1}{2}$ VOLT D.C. SUPPLY.

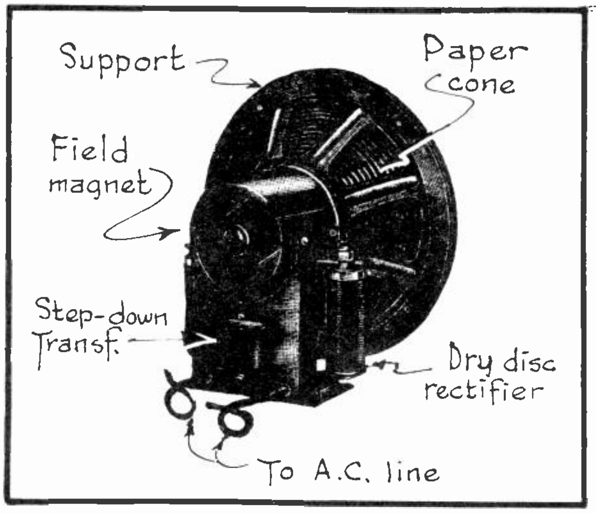

FIG. 22
An Electro-Dynamic Speaker.

ALTHOUGH THIS RECTIFIED CURRENT WILL BE SOMEWHAT PULSATING IN NATURE, YET FOR THE PURPOSE FOR WHICH IT IS BEING USED, THE PULSATIONS DO LITTLE HARM. HOWEVER, YOU WILL FIND CASES WHERE THESE PULSATIONS ARE BEING SMOOTHED OUT BY CONNECTING A CONDENSER ACROSS THE RECTIFIER OUTPUT.

THE MOVING COIL OR VOICECOIL YOU WILL NOTE IN FIG. 23 IS CONNECTED TO THE LAST AMPLIFYING TUBE OR POWER TUBE OF THE RECEIVER THROUGH THE SPEAKER COUPLING TRANSFORMER AND THE EXTRA SMALL COIL, WHICH IS LABELED "NEUTRALIZING COIL", IS SIMPLY USED TO REDUCE HUM.

A DYNAMIC SPEAKER WHICH IS SUPPLIED WITH EQUIPMENT FOR FURNISHING ITS OWN FIELD COIL CURRENT FROM AN A.C. SUPPLY, AS ILLUSTRATED HERE, IS CLASSIFIED AS AN A.C. TYPE DYNAMIC SPEAKER. THERE ARE, HOWEVER, OTHER METHODS FOR OBTAINING SUCH A FIELD COIL CURRENT AS YOU SHALL LEARN IN LATER LESSONS.

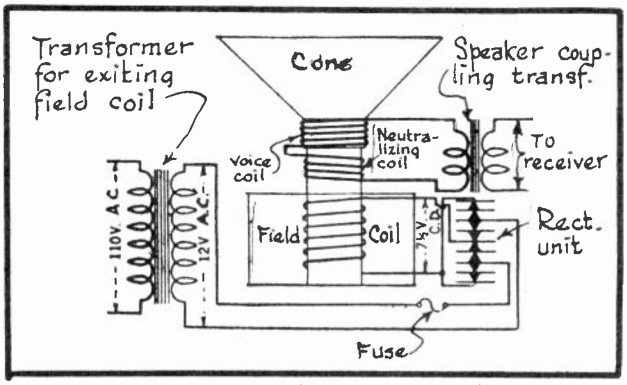

FIG. 23
Circuit Connections of the Dynamic Speaker.

HAVING THE GENERAL CONSTRUCTION OF THE DYNAMIC SPEAKER IN MIND, LET US NEXT SEE HOW IT OPERATES. SO NOW INSPECT FIG. 24 CAREFULLY AS WE GO THROUGH THE DISCUSSION OF THIS MOVING COIL TYPE SPEAKER.

IN FIG. 24 YOU WILL OBSERVE THAT THE SPEAKER FIELD COIL IS WOUND ON THE CENTER ARM OF AN "E" SHAPED IRON SHELL. WITH A DIRECT CURRENT FLOWING THROUGH THIS FIELD COIL AS INDICATED BY THE ARROWS, IT IS OBVIOUS THAT THE RIGHT END OF THIS CENTER ARM WILL BE A SOUTH POLE OF A MAGNET.

THE OTHER ENDS OF THIS IRON FORM ACT AS THE OTHER ENDS OF THIS SAME MAGNET AND THEREFORE BOTH OF THESE EXTREMETIES WILL BE OF A NORTH POLARITY.

NOW THE SMALL MOVING COIL OR VOICE COIL, WHICH CONSISTS OF ONLY A VERY FEW TURNS OF WIRE, IS CEMENTED TO THE HOLLOW SLEEVE, WHICH IS RIGIDLY FASTENED AT THE PEAK OR APEX OF THE CONE. THIS HOLLOW SLEEVE IS SO MOUNTED THAT IT WILL FREELY SLIDE BACK AND FORTH OVER THE CENTER ARM OF THE IRON SHELL BUT WITHOUT TOUCHING IT AND AS IT DOES SO, THE PAPER CONE WILL BE MOVED BACK AND FORTH SLIGHTLY, USING THE SOFT FLEXIBLE LEATHER WASHER AS ITS PIVOT.

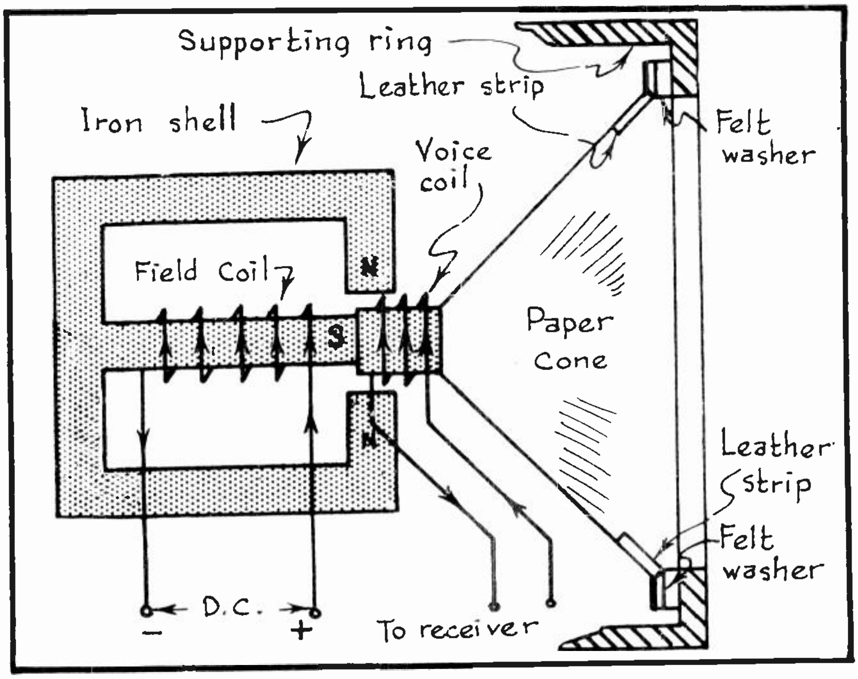

FIG. 24
Operation of the dynamic Speaker.

THE VOICE COIL IS CONNECTED TO THE OUTPUT OF THE RECEIVER, SO THAT THE PLATE CURRENT VARIATION PRODUCED BY THE INCOMING SIGNAL WILL BE TRANSFERRED TO THIS COIL BY INDUCTION AND THEREFORE, A CORRESPONDINGLY VARYING CURRENT WILL FLOW THRU THE VOICE COIL.

SHOULD THE CURRENT BE FLOWING THROUGH THE VOICE COIL IN THE DIRECTION AS SHOWN IN FIG. 24, THEN THE LEFT END OF THIS COIL WILL BE OF A NORTH POLARITY. SINCE UNLIKE MAGNETIC POLES ATTRACT, IT IS CLEAR THAT THE MOVING COIL WILL MOVE TOWARDS THE LEFT SLIGHTLY, AS IT IS ATTRACTED BY THE SOUTH POLARITY OF THE CENTER ARM OF THE FIELD COIL'S SHELL. THIS MOTION OF THE MOVING COIL WILL BE TRANSMITTED TO THE PAPER CONE AND AS THE SIGNAL CURRENT THROUGH THIS COIL VARIES IN STRENGTH, THE MOVING COIL, TOGETHER WITH THE PAPER CONE, WILL UNDERGO A VIBRATING ACTION AND THIS VIBRATION OF THE CONE PRODUCES THE SOUNDS.

THE USE OF BAFFLE BOARDS

WHENEVER, A CONE IS MADE TO VIBRATE, IT IS OBVIOUS THAT THESE VIBRATIONS WILL AFFECT THE AIR IN FRONT OF THE CONE, AS WELL AS THAT IN BACK OF THE CONE AND THE RESULT IS THAT WE HAVE A PUMPING ACTION SOMEWHAT AS ILLUSTRATED IN FIG. 25 AND THE CONE OR DIAPHRAGM ACTS AS A PISTON. NOTICE IN THIS ILLUSTRATION THAT THE AIR MOVEMENT ON BOTH SIDES OF THE CONE SURFACE IS OPP-

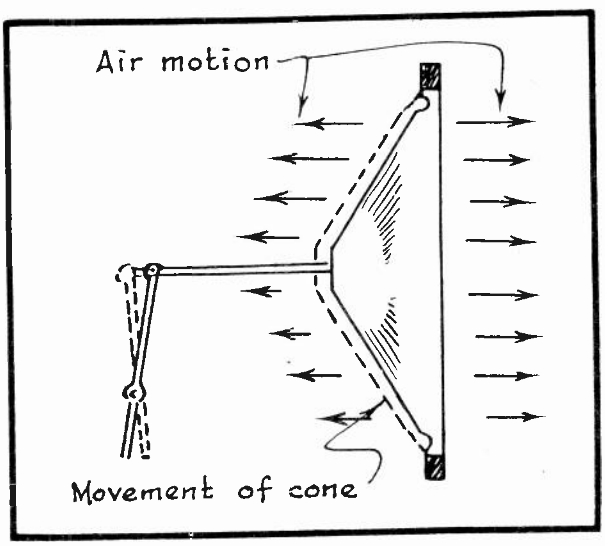

FIG. 25
Pump Action of the Cone.

OSITE IN DIRECTION. THEREFORE, AS THE DIAPHRAGM VIBRATES BACK AND FORTH, THE AIR PRESSURE ON ONE OF ITS SIDES WILL ALWAYS BE GREATER THAN THAT ON THE OTHER SIDE AND FOR THIS REASON, A CERTAIN AMOUNT OF AIR WILL ALWAYS "LEAK" AROUND THE EDGES OF THE CONE. THIS LEAKAGE WILL ALWAYS BE FROM THE HIGHER PRESSURE SIDE TO THE LOWER PRESSURE SIDE AND THE SOUND WAVES GENERATED AT BOTH SIDES OF THE DIAPHRAGM WILL THUS TEND TO NEUTRALIZE EACHOTHER. THIS EFFECT IS MORE PROUNCED AT THE LOWER VIBRATING FREQUENCIES OF THE CONE SURFACE AND THEREFORE, THE REPRODUCTION OF THE LOWER AUDIO FREQUENCIES WILL NOT BE SATISFACTORY.

IN ORDER TO GET AWAY FROM THIS ACTION, WE MOUNT THE OPENING OF THE CONE OVER A HOLE IN A BOARD SURFACE MADE OF SOME NON-RESONANT MATERIAL AND WE CALL SUCH AN ARRANGEMENT A BAFFLE BOARD OR SIMPLY A BAFFLE. IN FIG. 26 YOU WILL SEE HOW THE OPENING OF THE SPEAKER CONE IS MOUNTED AGAINST THE BAFFLE. NOTICE THAT NOW WHEN THE SOUNDS ARE RADIATED FROM THE CONE SURFACES, THE AIR MOTION IN FRONT AND IN BACK OF THE CONE HAVE LITTLE CHANCE OF INTERFERING WITH EACHOTHER BECAUSE THE BAFFLE BOARD OFFERS SUCH A GREAT DISTANCE AROUND WHICH THE AIR MOTION MUST TRAVEL IN ORDER TO GET FROM ONE SIDE OF THE CONE TO THE OTHER.

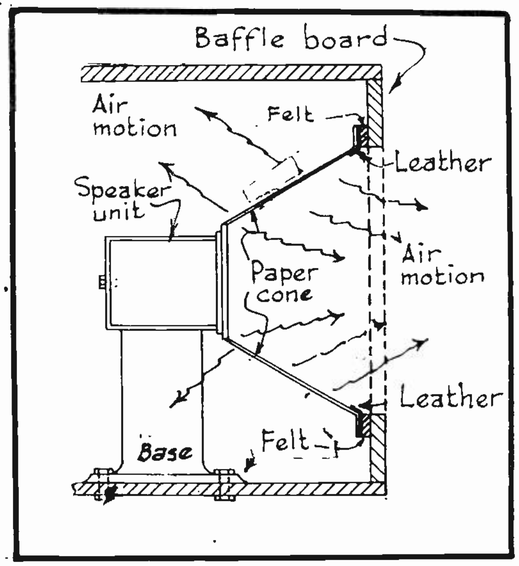

FIG. 26
Use of the Baffle

THE GREATER THE AREA OF THE BAFFLE, THE BETTER WILL BE THE REPRODUCTION OF THE LOW NOTES.

ANOTHER POINT TO REMEMBER IS THAT IT IS NOT ADVISABLE TO PLACE THE SPEAKER INSIDE OF A CABINET IN WHICH THE BACK IS TIGHTLY SEALED SHUT. THIS WOULD ACT AS AN AIR TRAP IN BACK OF THE SPEAKER CONE AND WOULD THEREBY CAUSE THE CONE ACTION TO BE SLUGGISH. FOR THIS REASON, YOU WILL GENERALLY FIND RADIO CABINETS OPEN AT THE BACK AND THIS TYPE OF CONSTRUCTION HELPS TO REDUCE THOSE HOLLOW ECHOING SOUNDS.

THE CRYSTAL SPEAKER

A NEW TYPE OF SPEAKER HAS RECENTLY MADE ITS APPEARANCE IN THE INDUSTRY. IT IS KNOWN AS THE "CRYSTAL SPEAKER" AND A PHOTOGRAPH OF THE UNIT IS SHOWN YOU IN FIG. 27. THIS SPEAKER IS BEING MANUFACTURED BY THE BRUSH LABORATORIES OF THE UNITED STATES.

THE OPERATING PRINCIPLES OF THE "CRYSTAL SPEAKER" ARE QUITE UNIQUE IN THAT IT DOES NOT EMPLOY ANY PERMANENT MAGNETS, NOR ANY FIELD FOR POLARIZATION. ALL OF THE ELECTRODYNAMIC SPEAKER PARTS ARE REPLACED BY A SMALL CRYSTAL UNIT ACTUATING A CONVENTIONAL PAPER-CONE DIAPHRAGM THROUGH A LEVER-TYPE MOVEMENT.

THE PARTICULAR SPEAKER UNIT SHOWN IN FIG. 27 IS KNOWN AS THE TYPE R-95 CRYSTAL SPEAKER. IT HAS A DIAMETER OF $9\frac{1}{2}$", A DEPTH OF 3 3/4 " AND WEIGHS BUT TWO POUNDS. THIS IS A LIGHT-WEIGHT SPEAKER AS COMPARED TO THE $5\frac{1}{2}$ LBS. WEIGHT OF AN ELECTRODYNAMIC SPEAKER UNIT BUT IN ADDITION TO ITS

LIGHT WEIGHT, IT OFFERS HIGH SENSITIVITY AND REMARKABLY FINE TONE QUALITY.

IN FIG. 28 YOU ARE SHOWN THE OPERATING MECHANISM OF THIS NEW SPEAKER. THE HEART OF THIS INTERESTING DRIVING UNIT CONSISTS OF ROCHELLE-SALT CRYSTALS AND IN THE PARTICULAR MODEL BEING DESCRIBED, TWO SLABS OF ROCHELLE-SALT CRYSTALS MEASURING $2\frac{1}{2}$ INCHES SQUARE AND 1/8" THICK ARE METAL-FOILED ON EACH SURFACE AND CEMENTED TOGETHER.

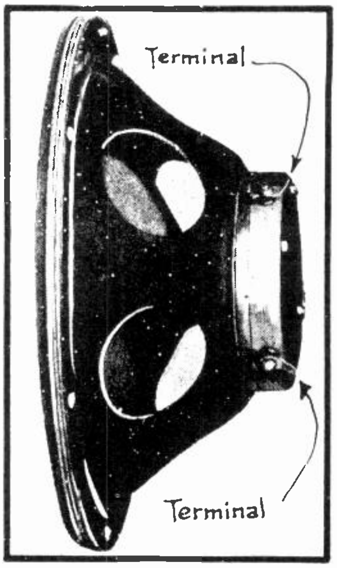

FIG. 27
The Crystal Speaker.

THIS CRYSTAL ELEMENT IS HELD IN PLACE BY SOFT RUBBER SUPPORTS WHICH ARE PROVIDED AT THREE OF ITS CORNERS, WHILE THE FOURTH CORNER IS CONNECTED TO THE CENTER (APEX) OF THE CONE DIAPHRAGM THROUGH THE LEVER SYSTEM.

UPON APPLYING SIGNAL VOLTAGES ACROSS THIS SPECIAL CRYSTAL ELEMENT, THE CORNER OF THE CRYSTAL ASSEMBLY, WHICH IS INTER-CONNECTED WITH THE CONE DIAPHRAGM, WILL VIBRATE IN A DIRECTION VERTICAL TO THE FLAT SURFACES OF THE CRYSTALS, THEREBY CAUSING THE SPEAKER CONE TO UNDERGO A CORRESPONDING VIBRATING MOTION AND THUS RESULTING IN THE EMISSION OF SOUND WAVES.

THIS MOVING ACTION OF THE CRYSTAL ELEMENT IS SIMILAR TO THAT FOUND IN THERMOSTATS, WHERE THE EXPANSION OF ONE METAL AND THE CONTRACTION OF ANOTHER METAL WILL PRODUCE A "WIGGLING MOTION." IN THE CASE OF THE CRYSTAL SPEAKER ELEMENT, HOWEVER, THIS MOTION IS DUE TO AN ELECTRICAL PHENOMENA WHICH IS BROUGHT ABOUT BY THE "PIEZO ELECTRICAL" CHARACTERISTICS OF THE ROCHELLE-SALT CRYSTALS. (PIEZO-ELECTRICAL PROPERTIES ARE DEMONSTRATED IN QUARTZ AND OTHER CRYSTALS AND HAVE BEEN EMPLOYED IN RADIO TRANSMITTER CIRCUITS FOR SOME TIME IN ORDER TO PRODUCE THE PRESENTLY POPULAR "CRYSTAL CONTROL" FOR TRANSMITTERS. THE THEORY OF THIS CRYSTAL'S OPERATION IS SOMEWHAT COMPLEX AND IS THEREFORE EXPLAINED IN GREATER DETAIL IN ONE OF YOUR MORE ADVANCED LESSONS.)

SINCE THE CRYSTAL SPEAKER IS STRICTLY "VOLTAGE-OPERATED," ITS POWER CONSUMPTION IS VERY LOW, AS IT REQUIRES NEITHER FIELD CURRENT NOR POLARIZING VOLTAGE. IT IS THEREFORE, ESPECIALLY ADAPTABLE TO MULTI SPEAKER INSTALLATIONS FOR PUBLIC ADDRESS SYSTEMS, AS WELL AS FOR RADIO RECEIVERS IN GENERAL.

THIS NEW TYPE OF SPEAKER ALSO SATISFACTORILY COVERS A MUCH WIDER RANGE OF FREQUENCIES THAN IS EXPERIENCED WITH OTHER PRESENT-DAY TYPES OF SPEAKERS. IN FACT, THE CRYSTAL ELEMENT ITSELF WILL REACT THROUGH A FREQUENCY RANGE OF FROM 0 TO 500,000 CYCLES PER SECOND AND

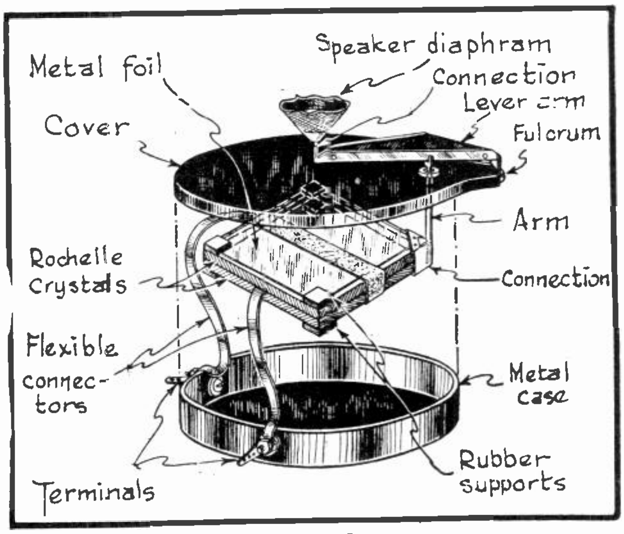

FIG. 28
Driving mechanism of the Crystal Speaker.

SO THE LIMIT OF THE SPEAKER SOUND REPRODUCTION IS ONLY THAT IMPOSED BY MATERIALS USED IN THE TONE ARM AND CONE.

IN FIG. 29, YOU WILL SEE THE MANNER IN WHICH THE CRYSTAL SPEAKER IS CONNECTED TO THE OUTPUT OF POPULAR TYPE POWER STAGES.

CRYSTAL SPEAKERS ARE MANUFACTURED, IN VARIOUS SIZES RANGING FROM THE 2-WATT SIZES AND UPWARDS. THE 8-WATT CRYSTAL SPEAKER IS A POPULAR UNIT FOR PUBLIC ADDRESS WORK.

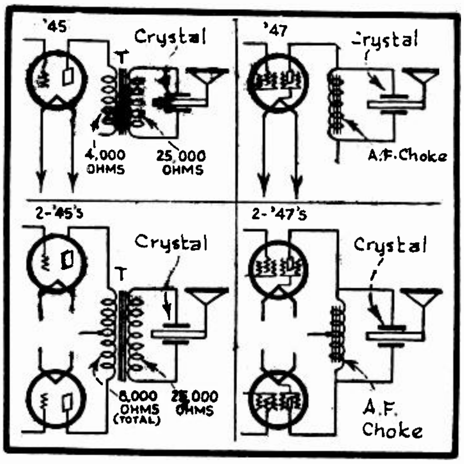

FIG. 29
Crystal Speaker Connections.

THE INDUCTOR-TYPE SPEAKER

THIS IS A TYPE OF SPEAKER THAT WAS EXTENSIVELY USED AT ONE TIME, HOWEVER, IT IS SELDOM USED TODAY. THE DRIVING UNIT OF THIS SPEAKER IS ILLUSTRATED FOR YOU IN FIG. 30.

UPON STUDYING THIS DRAWING VERY CAREFULLY, YOU WILL OBSERVE THAT IT IS BUILT AROUND A PERMANENT MAGNET OF THE HORSESHOE TYPE, HAVING A SET OF SPECIAL POLE PIECES MOUNTED AT EACH OF ITS POLES, AROUND WHICH ARE PLACED TWO COILS.

TWO IRON BLOCKS OR "ARMATURES" ARE CONNECTED TOGETHER BY A TIE-ROD AND ONE END OF THE TIE-ROD IS IN TURN CONNECTED TO THE APEX OF THE SPEAKER CONE. THE POSITION OF THIS TIE-ROD AND ARMATURES ARE IMPORTANT AND YOU SHOULD ALWAYS HAVE IT IN MIND SO AS TO FULLY UNDERSTAND ITS FUNCTIONING. IT IS A NATURAL TENDENCY FOR A FREELY SUSPENDED PIECE OF IRON TO BE DRAWN INTO THE MOST INTENSE REGION OF A MAGNETIC FIELD AND THEREFORE, THE IRON BLOCK AT THE RIGHT END OF THE TIE-ROD WILL BE PULLED TOWARDS THE LEFT INTO THE MOST DENSE REGION OF THE MAGNETIC FIELD EXISTING AT THIS POINT, WHILE THE LATTER WILL HAVE THE TENDENCY OF DOING THE SAME TOWARDS THE RIGHT.

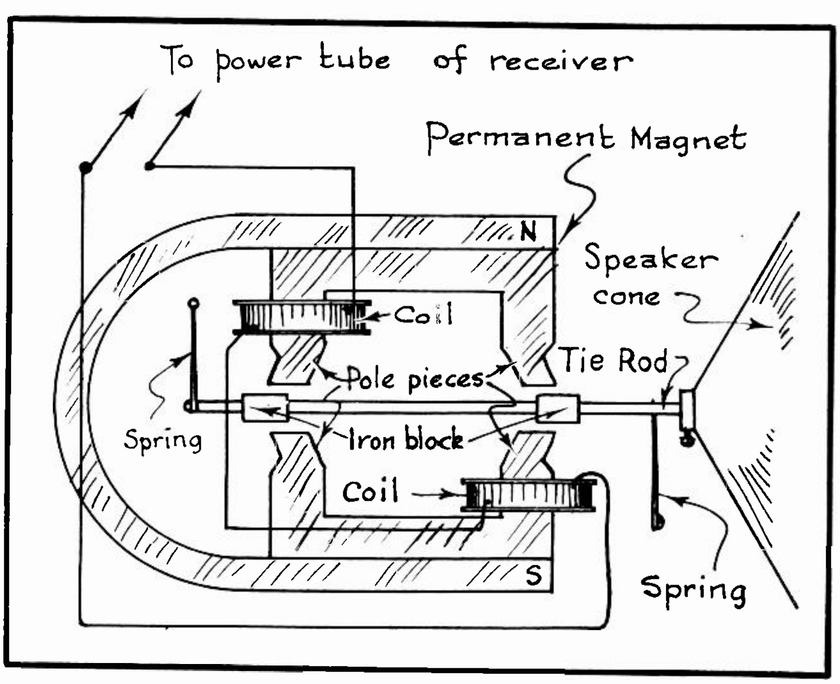

FIG. 30
Driving Unit of the Inductor Speaker.

HOWEVER, IF BOTH MAGNETIC FIELDS ARE OF THE SAME INTENSITY THE TWO FORCES WOULD BE

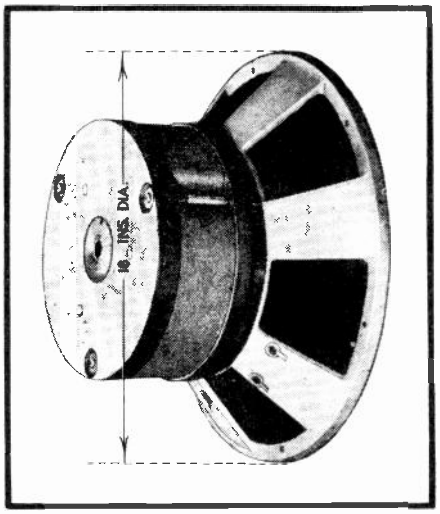

FIG 31
P.M. Dynamic Speaker

THE SAME AND AS THEY ARE OPPOSED, THE ARMATURE BAR AND CONE WILL REMAIN STATIONARY.

THE ABOVE IS TRUE WHEN NO SIGNAL VOLTAGE IS APPLIED ACROSS THE SPEAKER TERMINALS BUT WHEN AN A.F. CURRENT PASSES IN ONE DIRECTION, THE NORTH POLE WILL BE WEAKENED, WHILE THE SOUTH POLE IS INTENSIFIED. THEN, WHEN THE CURRENT REVERSES ITS DIRECTION THE OPPOSITE EFFECT OCCURS. UNDER THESE CONDITIONS, IT IS CLEAR TO SEE THAT FIRST, ONE OF THE IRON BLOCKS WILL BE BROUGHT INTO ITS STRONGER FIELD AND THEN THE SAME WILL HAPPEN WITH THE OTHER, SO THAT THE TIE-ROD WILL BE OSCILLATING. IN THIS MANNER, THE SPEAKER CONE WILL UNDERGO A VIBRATING MOTION, IN KEEPING WITH THE MOVEMENT OF THE TIE-ROD AS CAUSED BY THE VARIATION OF THE SIGNAL CURRENT THROUGH THE TWO SPEAKER COILS.

PERMANENT MAGNET TYPE DYNAMIC SPEAKERS

THE DYNAMIC SPEAKERS SO FAR DESCRIBED IN THIS LESSON WERE OF THE ELECTRO-DYNAMIC FIELD TYPES, THAT IS, THEY EMPLOYED A FIELD COIL THAT HAD TO BE EXCITED BY AN EXTERNAL D-C VOLTAGE, USUALLY FROM THE AMPLIFIER'S POWER SUPPLY.

HOWEVER, WITH THE DISCOVERY OF A NEW ALLOY THAT IS CAPABLE OF BEING SO STRONGLY MAGNETIZED THAT IT COULD RETAIN ITS MAGNETISM PERMANENTLY, A NEW TYPE OF DYNAMIC SPEAKER WAS DEVELOPED THAT REQUIRED NO FIELD COIL. IN FIG. 31 YOU ARE SHOWN AN ILLUSTRATIVE VIEW OF THIS TYPE OF SPEAKER AND IN FIG. 32 IS SHOWN A CUTAWAY VIEW OF THE CONSTRUCTION USUALLY EMPLOYED. UPON A CLOSE INSPECTION OF THESE ILLUSTRATIONS, YOU WILL OBSERVE THAT THIS TYPE OF DYNAMIC SPEAKER IS VERY SIMILAR TO THE ELECTRO-DYNAMIC FIELD TYPES, WITH THE ONE EXCEPTION THAT NO FIELD COIL IS EMPLOYED.

THIS FEATURE HAS MADE THIS TYPE OF P.M. (PERMANENT MAGNET) DYNAMIC SPEAKER VERY DESIRABLE IN INSTALLATIONS REQUIRING ADDITIONAL SPEAKERS, SINCE IT IS NOT NECESSARY TO HAVE AN EXTERNAL D-C VOLTAGE AVAILABLE FOR ITS OPERATION AND THUS BEING ABLE TO ELIMINATE THE EXTRA WIRES AND CONNECTIONS FROM THE AMPLIFIER AND POWER SUPPLY.

AS IN THE CASE OF THE ELECTRO-DYNAMIC SPEAKERS, THEY EMPLOY A VOICE COIL AND THEY HAVE TO BE USED IN COMBINATION WITH AN OUTPUT TRANSFORMER THAT WILL PROVIDE THE PROPER LOAD IMPEDANCE FOR THE AUDIO OUTPUT POWER TUBES. IN MANY CASES THE SPEAKER MANU-

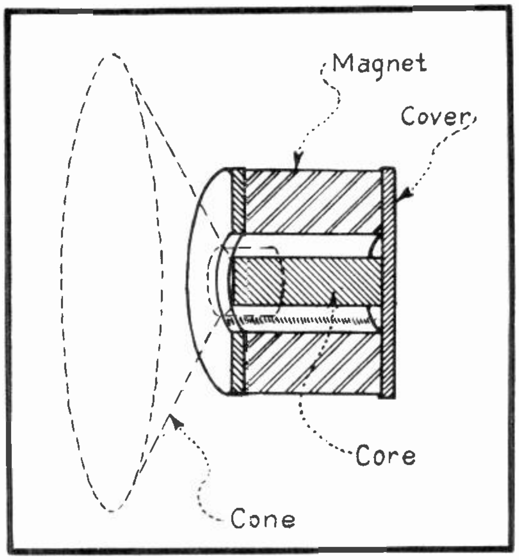

FIG. 32
Construction of P.M. Speaker

FACTURER INCLUDES THIS OUTPUT TRANSFORMER AS PART OF THE SPEAKER ASSEMBLY. HOWEVER, IN INSTALLATIONS REQUIRING SUCH A SPEAKER -- AS IS TRUE IN ALL SPEAKER INSTALLATION -- THE SPEAKER MUST BE CAPABLE OF HANDLING THE OUTPUT LOAD OF THE FINAL AMPLIFIER WITHOUT OVERLOADING, WHICH WOULD OTHERWISE RESULT IN DISTORTION. THAT IS, IF THE FINAL AMPLIFIER HAD AN OUTPUT OF 15 WATTS AND THE SPEAKER WAS RATED AT ONLY 6 WATTS, THE SPEAKER WOULD BE EASILY OVERLOADED, WHICH WOULD RESULT IN DISTORTION.

YOU WILL RECEIVE ADDITIONAL INFORMATION CONCERNING VARIOUS TYPES OF SPEAKERS AND THEIR CONNECTIONS IN LATER LESSONS.

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EXAMINATION QUESTIONS

LESSON NO. 13

1. - WHY ARE TRICKLE CHARGERS USED?

2. - DESCRIBE THE CONSTRUCTION OF ONE TYPE OF TRICKLE CHARGER.

3. - DESCRIBE THE CONSTRUCTION AND OPERATING PRINCIPLES OF A COPPER-OXIDE RECTIFIER.

4. - DRAW A CIRCUIT DIAGRAM OF A "B" ELIMINATOR EMPLOYING A COPPER-OXIDE RECTIFIER.

5. - DRAW A CIRCUIT DIAGRAM OF A "B" ELIMINATOR EMPLOYING A RAYTHEON GASEOUS RECTIFIER TUBE.

6. - DESCRIBE THE CONSTRUCTION AND OPERATING PRINCIPLES OF ONE TYPE OF "A" ELIMINATOR.

7. - EXPLAIN HOW A BALANCED-ARMATURE TYPE SPEAKER OPERATES.

8. - (A) DESCRIBE THE CONSTRUCTION AND OPERATING PRINCIPLES OF A DYNAMIC SPEAKER.
   (B) EXPLAIN THE CHIEF DIFFERENCE BETWEEN THE ELECTRO AND PERMANENT MAGNET TYPES.

9. - WHY IS A SUITABLE BAFFLE DESIRED FOR A SPEAKER?

10.- DESCRIBE THE CONSTRUCTION AND OPERATION OF AN INDUCTOR-TYPE SPEAKER.

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Established 1905

Los Angeles, California

LESSON NO. 14

SCREEN GRID TUBES

In your study of radio frequency amplifiers, you were told about the possibility of oscillation as caused by R.F. feed-backs through the inter-element capacity of triodes. At that time, you were also familiarized with methods whereby the effects of oscillation in the R.F. amplifier could be reduced or eliminated altogether through the use of grid suppressor resistors and neutralizing circuits. Of these two methods, that employing neutralizing circuits was the most popular but offered the disadvantage of complicating circuit designs.

Today, however, these neutralizing circuits are no longer being employed and this is made possible through the use of SCREEN GRID TUBES, which were introduced to the industry in 1929. Not only have these screen grid tubes done away with the need for elaborate neutralizing circuits but in addition, they offer GREATER AMPLIFICATION and better all around performance than triodes, when used in the R.F. stages of a receiver. Your next step then will be to familiarize yourself with these screen grid tubes which are being so extensively used at the present time.

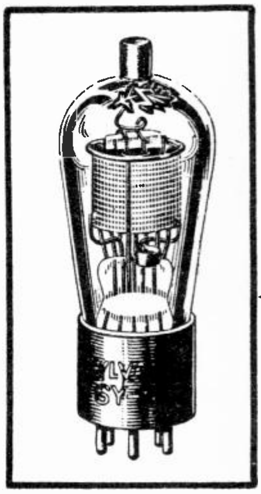

FIG. 1
A Screen Grid Tube.

A typical screen-grid tube is shown you in Fig. 1 and as you will observe, its external appearance greatly resembles that of the triodes with which you are already familiar, with the exception that a metallic cap is mounted on top of the glass bulb.

Now let us open up one of these tubes, so that you can become better acquainted with its internal construction and operation. The arrangement of the elements within the tube will then appear as shown you in Fig. 2.

Upon studying this illustration very carefully, you will observe that the filament is mounted in a vertical position at the center of the assembly and is surrounded by a spirally-wound molibdenum wire which constitutes the control grid. This control grid serves the same purpose as the grid within the triodes about which you already studied

AND IT IS SEPARATED FROM THE FILAMENT BY A DEFINITE SPACE ALTHOUGH BEING LOCATED QUITE CLOSE TO THE FILAMENT.

THE CONTROL GRID IS SURROUNDED BY ANOTHER SPIRALLY-WOUND MOLIBDENUM WIRE GRID AND SINCE THIS SECOND GRID IS INSERTED BETWEEN THE CONTROL GRID AND THE PLATE SO THAT IT ACTS AS A SHIELD BETWEEN THESE TWO ELEMENTS, WE LOGICALLY CALL IT A "SHIELD GRID" OR SCREEN GRID. THE TERM "SCREEN GRID" IS MORE EXTENSIVELY USED AND SINCE THERE ARE TWO SCREEN GRIDS IN THIS PARTICULAR TUBE, WE WILL CALL THIS THE INNER SCREEN GRID SO AS NOT TO CONFUSE IT WITH THE OUTER SCREEN WHICH SURROUNDS THE PLATE. A CONVENTIONAL CYLINDRICAL PLATE SURROUNDS THE INNER SCREEN GRID BUT IT IS SEPARATED FROM THE FILAMENT AND CONTROL GRID BY A MUCH GREATER SPACE THAN IS THE CASE IN TRIODES. FURTHERMORE, THE INNER SCREEN GRID IS LOCATED CLOSER TO THE CONTROL GRID THAN IT IS TO THE PLATE. FINALLY, WE HAVE A CYLINDRICAL-SHAPED WIRE MESH OR PERFORATED PLATE WHICH SERVES AS A SHIELD AROUND THE OUTER SURFACE OF THE REGULAR PLATE, AND WE CALL THIS THE OUTER SCREEN. THE OUTER SCREEN IS SEPARATED FROM THE PLATE BY A DEFINITE DISTANCE BUT IS MECHANICALLY AND ELECTRICALLY CONNECTED TO THE INNER SCREEN GRID THROUGH THE DISC-SHAPED PLATE WHICH SERVES AS A COVER FOR THE ENTIRE ASSEMBLY OF ELEMENTS. THUS THE PLATE ELEMENT OF THE TUBE IS COMPLETELY SHIELDED BY THE TWO SCREENS AND SINCE THE TWO SCREENS ARE INTERCONNECTED WITHIN THE TUBE, WE GENERALLY CONSIDER THEM AS ONE AND SIMPLY REFER TO THEM AS THE SCREEN GRID.

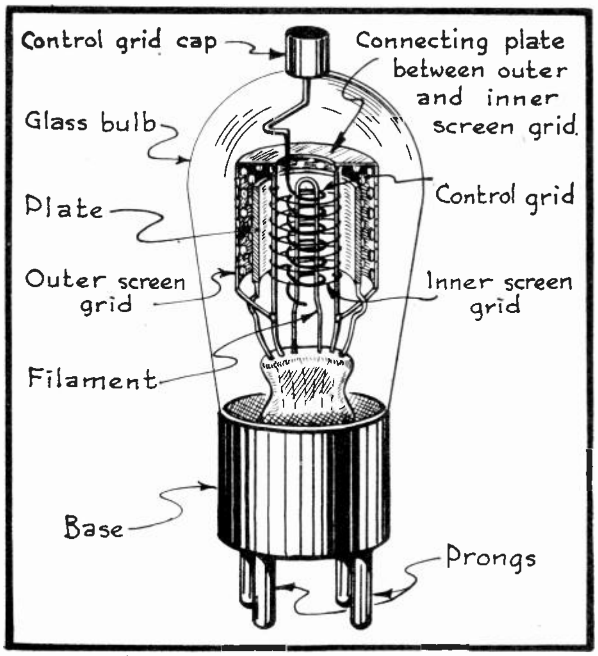

FIG. 2
Construction of the Screen Grid Tube.

IN FIG. 3 YOU ARE SHOWN A DIAGRAMMATIC REPRESENTATION WHICH MORE CLEARLY ILLUSTRATES THE ARRANGEMENT AND RELATIVE DISTANCES BETWEEN THE VARIOUS ELEMENTS OF THIS SCREEN GRID TUBE AS SEEN WHEN LOOKING DOWN UPON THE ASSEMBLY FROM ABOVE.

THE ELEMENT CONNECTIONS TO THE TUBE BASE PRONGS AND CAP, AS WELL AS THE CORRESPONDING CONNECTIONS AT THE TUBE SOCKET, ARE POINTED OUT TO YOU IN FIG. 4. NOTICE THAT THE ENDS OF THE FILAMENT ARE CONNECTED TO THE TWO LARGER BASE PRONGS, THE PLATE IS CONNECTED TO ONE OF THE SMALLER BASE PRONGS AND THE SCREEN GRID TO THE REMAINING SMALL PRONG, THUS ACCOUNTING FOR THE FOUR BASE PRONGS WHICH ARE PROVIDED ON THIS TUBE. THE CONTROL GRID CONNECTION, AS MENTIONED BEFORE, IS MADE AT THE SMALL METALLIC CAP ON TOP OF THE GLASS BULB. THE SYMBOL FOR THIS SCREEN GRID TUBE IS SHOWN

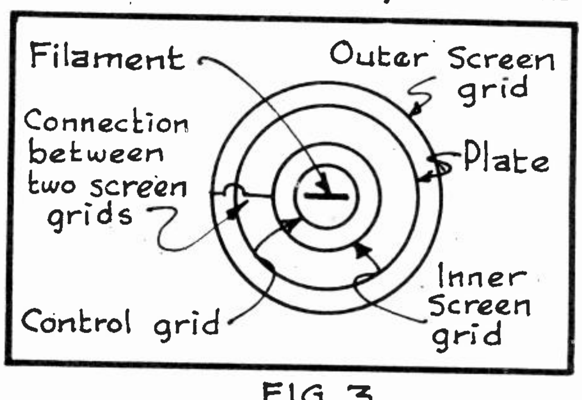

FIG. 3
Arrangement of elements.

YOU IN FIG. 5, WITH THE VARIOUS ELEMENTS POINTED OUT FOR YOUR CONVENIENCE.

WITH THE CONSTRUCTIONAL FEATURES OF THIS TUBE WELL IN MIND, LET US NOW CONTINUE WITH AN INVESTIGATION OF ITS OPERATING PRINCIPLES.

OPERATION OF THE SCREEN GRID TUBE

IN FIG. 6 YOU WILL SEE A DIAGRAM, SHOWING YOU HOW THE SCREEN GRID TUBE IS CONNECTED TO THE "A" AND "B" BATTERIES OF THE RECEIVER. NOTICE THAT THE RELATION BETWEEN THE "A" AND "B" BATTERIES IS CONVENTIONAL BUT THAT THE SCREEN GRID OF THE TUBE HAS BEEN CONNECTED TO THE "B" BATTERY, SO THAT A POSITIVE POTENTIAL OF 45 VOLTS IS IMPRESSED UPON IT, WHILE A POSITIVE POTENTIAL OF 135 VOLTS IS IMPRESSED UPON THE PLATE OF THE TUBE.

YOU WILL NOT FIND THESE EXACT "B" VOLTAGES HOLDING TRUE IN ALL THE SCREEN GRID TUBES OF ALL RECEIVERS BUT THE SCREEN GRID OF THE TUBE, WHEN THE TUBE IS USED IN THIS MANNER, WILL ALWAYS BE AT A POSITIVE POTENTIAL OF A VALUE EQUAL TO APPROXIMATELY ONE-THIRD THAT OF THE POSITIVE VOLTAGE, WHICH IS IMPRESSED UPON THE PLATE.

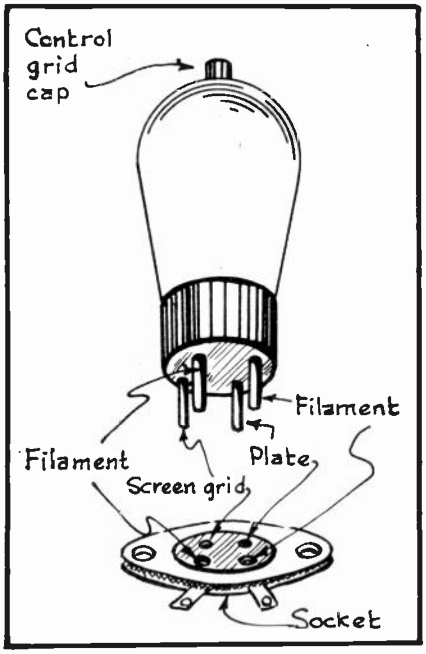

FIG. 4
Connections for the Screen grid Tube.

SINCE THE PLATE OF THIS TUBE IS SO WIDELY SEPARATED FROM THE FILAMENT, AS WAS ALREADY STATED, VERY FEW ELECTRONS WOULD BE ATTRACTED TO IT FROM THE FILAMENT, EVEN IF A VERY HIGH POSITIVE POTENTIAL WERE APPLIED TO THE PLATE. THE INNER SCREEN GRID, HOWEVER, IS ONLY ABOUT AS FAR FROM THE FILAMENT AS THE PLATE IN A CONVENTIONAL THREE-ELEMENT TUBE AND THEREFORE, BY HAVING A POSITIVE POTENTIAL IMPRESSED UPON THIS SCREEN-GRID, IT IS OBVIOUS THAT IT WILL HAVE THE ATTRACTING POWER OF PULLING ELECTRONS AWAY FROM THE FILAMENT AND TOWARD ITSELF, JUST AS THOUGH IT WERE A REGULAR PLATE.

THEN BY HAVING THE PLATE OF THE TUBE AT A POSITIVE POTENTIAL STILL HIGHER THAN THAT OF THE SCREEN-GRID, THE ELECTRONS WHICH ARE ATTRACTED TO THE SCREEN GRID, WILL IN TURN BE ATTRACTED FROM THE SCREEN-GRID OVER TO THE HIGHER POSITIVELY CHARGED PLATE. IN THIS WAY, WE ARE ABLE TO OVERCOME THE EFFECT OF THE GREAT DISTANCE BETWEEN THE PLATE AND THE FILAMENT AND THE SCREEN GRID SO FAR ACTS AS A RELAY, WHICH HELPS THE FLOW OF ELECTRONS FROM THE FILAMENT OVER TO THE PLATE.

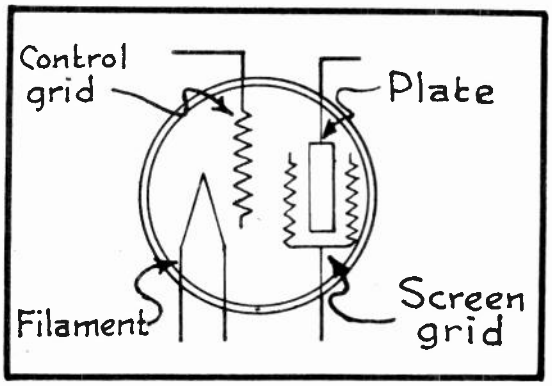

FIG. 5
Symbol of the Screen grid Tube.

DUE TO THE FACT THAT THE INNER SCREEN-GRID IS NOT A SOLID BODY BUT ONLY A SPIRALLY-WOUND WIRE, ONE CAN READILY SEE THAT IT WILL OFFER BUT LITTLE INTERFERENCE TO THE FLOW OF

ELECTRONS BETWEEN THE FILAMENT AND THE PLATE. THE SIGNAL VOLTAGE CHANGES UPON THE CONTROL GRID STILL CONTROLS THE FLOW OF ELECTRONS AND PLATE CURRENT BETWEEN THE PLATE AND FILAMENT, THE SAME AS IN A TRIODE. THEN TOO, THE HIGHER THE POSITIVE POTENTIAL OF THE SCREEN-GRID, THE GREATER WILL BE THE NUMBER OF ELECTRONS ATTRACTED BY IT.

IT IS ALSO TRUE THAT SOME OF THE ELECTRONS WILL BE RETAINED BY THE POSITIVELY CHARGED SCREEN-GRID BUT IN ACTUAL PRACTICE, ONLY ABOUT ONE-THIRD OF THE TOTAL ELECTRON FLOW PASSES THROUGH THE SCREEN CIRCUIT, WITH THE BALANCE OF IT FLOWING THROUGH THE PLATE CIRCUIT.

NOW THAT YOU UNDERSTAND THE EFFECT, WHICH THE SCREEN GRID HAS UPON THE ELECTRON FLOW, OUR NEXT STEP WILL BE TO SEE HOW THE TUBE AVOIDS THE FEED-BACK OF R.F. ENERGY THROUGH THE ELEMENTS.

PREVENTING OSCILLATION

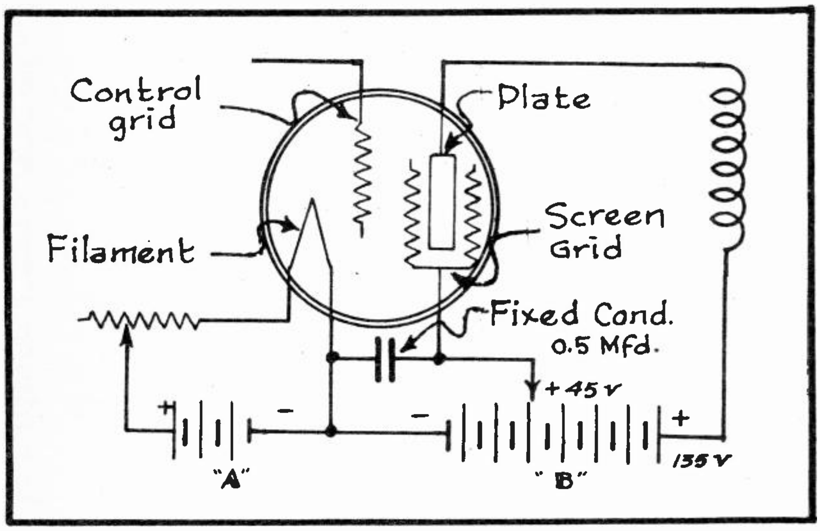

FIG. 6
Screen Grid Tube Connections to "A" & "B" Batteries.

AS YOU WILL RECALL FROM YOUR EARLIER STUDIES, THE CAPACITY EXISTING BETWEEN THE PLATE AND GRID OF THE TRIODE IS RESPONSIBLE FOR THE EXCESSIVE R.F. FEED-BACKS BETWEEN THE PLATE AND GRID CIRCUITS IN WHICH SUCH A TUBE IS EMPLOYED. IN THE SCREEN GRID TUBE, HOWEVER, THE DISTANCE BETWEEN THE PLATE AND CONTROL GRID IS MADE MUCH GREATER, THUS RESULTING IN AN APPRECIABLE DECREASE IN THE CAPACITIVE EFFECT BETWEEN THESE TWO ELEMENTS. IN ADDITION TO THIS REDUCTION IN THE INTER-ELEMENT CAPACITY, THE CIRCUIT CONNECTIONS ARE MADE IN SUCH A MANNER SO AS TO LESSEN THE POSSIBILITY OF R.F. FEED-BACK THROUGH THE TUBE STILL MORE, AS WILL BECOME APPARENT UPON STUDYING THE FOLLOWING EXPLANATIONS.

BY LOOKING AT FIG. 6 AGAIN, YOU WILL OBSERVE THAT A BY-PASS CONDENSER IS CONNECTED ACROSS THE SCREEN GRID AND THE FILAMENT CONNECTIONS OF THE TUBE.

WHENEVER ANY RADIO FREQUENCY ENERGY HAS A TENDENCY TO PASS FROM THE PLATE OVER TO THE CONTROL GRID, IT MUST FIRST STRIKE THE SCREEN-GRID. THEN SINCE THE SCREEN GRID PRACTICALLY SHIELDS THE PLATE FROM THE CONTROL GRID, ANY R.F. ENERGY WHICH MIGHT BE RADIATED FROM THE PLATE WILL BE COLLECTED OR "PICKED-UP" BY THE SCREEN GRID. A BY-PASS CONDENSER IS THEN CONNECTED ACROSS THE SCREEN GRID AND FILAMENT TUBE CONNECTIONS AND SINCE THE CAPACITY RATING OF THIS CONDENSER IS QUITE LARGE AS COMPARED TO THE PLATE- -CONTROL GRID CAPACITY OR EVEN THE SCREEN GRID-CONTROL GRID CAPACITY WITHIN THE TUBE, THE R.F. ENERGY AT THE SCREEN GRID WILL HAVE A NATURAL TENDENCY TO PASS TO THE FILAMENT CIRCUIT THROUGH THE BY-PASS CONDENSER RATHER THAN THRU

MORE DIFFICULT PATH OFFERED BY THE SCREEN GRID—CONTROL GRID CAPACITY. IN THIS WAY, THESE R.F. FEED-BACKS NEVER REACH THE CONTROL GRID TO CAUSE TROUBLE. THEY CAUSE NO TROUBLE AT ALL AT THE FILAMENT SINCE THIS ELEMENT IS AT A NEGATIVE B POTENTIAL.

TO GIVE YOU A STILL BETTER IDEA OF THE RELATIVE CAPACITIES INVOLVED IN SUCH CIRCUITS, WE MIGHT ADD AT THIS TIME THAT THE GRID-PLATE CAPACITY OF THE AVERAGE TRIODE IS ANYWHERES BETWEEN 6 TO 15 MICRO-MICROFARADS, WHEREAS THE GRID-PLATE CAPACITY OF THE AVERAGE SCREEN GRID TUBE IS ONLY AROUND 0.01 TO 0.1 MICRO-MICROFARAD. THE BY-PASS CONDENSERS AS GENERALLY USED FOR THIS PURPOSE HAVE A RATED CAPACITY OF .1 MFD., .25 MFD. OR .5 MFD.

IN ADDITION TO ITS FREEDOM FROM OSCILLATION WHEN CORRECTLY USED IN A CIRCUIT, THE SCREEN GRID TUBE ALSO POSSESSES A MUCH HIGHER AMPLIFICATION FACTOR THAN A TRIODE AND THUS MAKES GREATER AMPLIFICATION IN THE R.F. STAGES POSSIBLE. THIS FEATURE, OF COURSE, ASSISTS IN THE CONSTRUCTION OF RECEIVERS OFFERING A HIGHER DEGREE OF SENSITIVITY.

VARIOUS TYPES OF SCREEN GRID TUBES FOR BATTERY OPERATED RECEIVERS ARE NOW AVAILABLE AND IN THE FOLLOWING PAGES WE SHALL CONSIDER THE OPERATING CHARACTERISTICS AND CIRCUIT REQUIREMENTS OF THE MOST POPULAR OF THESE TUBES.

THE TYPE-22 TUBE

THE FIRST OF THE SCREEN GRID TUBES WHICH WAS USED IN BATTERY OPERATED RECEIVERS IS KNOWN AS THE TYPE-22 AND A PHOTOGRAPH OF IT APPEARS IN FIG. 7. THE FILAMENT VOLTAGE REQUIRED BY THIS TUBE IS 3.3 VOLTS AND ITS NORMAL FILAMENT CURRENT IS 0.132 AMP.

FIG. 7
The -22 Tube.

WITH A PLATE VOLTAGE OF +135 VOLTS, A SCREEN GRID VOLTAGE OF +45 VOLTS AND A GRID BIAS OF -1.5 VOLTS ARE RECOMMENDED. THE TUBE WILL UNDER THESE CONDITIONS DRAW A NORMAL PLATE CURRENT of 1.5 MILLIAMPERES. IF THE PLATE VOLTAGE IS +135 VOLTS, THE SCREEN +67.5 VOLTS AND THE GRID BIAS -1.5 VOLTS, THEN THE NORMAL PLATE CURRENT WILL BE 3.3 MILLIAMPERES. THE BIAS VOLTAGE IN THE CASE OF SCREEN GRID TUBES IS OF COURSE APPLIED TO THE CONTROL GRID.

WITH +45 VOLTS ON THE SCREEN AND +135 VOLTS ON THE PLATE, THE AMPLIFICATION FACTOR OF THE -22 TUBE IS RATED AT 350 AND WITH +67.5 VOLTS APPLIED TO THE SCREEN, THE RATED AMPLIFICATION FACTOR IS INCREASED TO 480. THESE HIGH AMPLIFICATION FACTORS, HOWEVER, ARE NOT ACTUALLY REALIZED IN PRACTICE.

THE TYPE -32 TUBE

THE -32 TUBE IS THE SCREEN GRID MATE TO THE TYPE -30 AND -31 TUBES WITH WHICH YOU ARE ALREADY FAMILIAR. THAT IS, ITS FILAMENT IS ALSO DESIGNED TO UTILIZE AN "A" VOLTAGE OF 2 VOLTS FURNISHED BY DRY CELLS, THUS MAKING IT ADAPTABLE TO BATTERY OPERATED RECEIVERS WHICH EMPLOY "TWO- VOLT TUBES" THROUGHOUT. THE FILAMENT CURRENT WHICH IS TAKEN BY THE -32 TUBE AMOUNTS TO ONLY .060 AMPERE.

THE MAXIMUM PLATE VOLTAGE GENERALLY USED WITH THIS TUBE IS 135 VOLTS TOGETHER WITH A 67.5 VOLT POSITIVE POTENTIAL APPLIED TO THE SCREEN GRID. THE CONTROL GRID SHOULD HAVE A NEGATIVE BIAS VOLTAGE OF 3 VOLTS IMPRESSED UPON IT AND THE NORMAL PLATE CURRENT WILL THEN BE APPROXIMATELY 1.5 MILLIAMPERES.

THE AMPLIFICATION FACTOR FOR THE -32 IS RATED AT 500 BUT AS IS THE CASE WITH THE -22, THIS HIGH VALUE ISN'T REALIZED IN ACTUAL PRACTICE.

BESIDES AN R.F. AMPLIFIER TUBE, THE -32 CAN ALSO BE USED AS A POWER DETECTOR. TO USE THE TUBE IN THIS MANNER, ITS PLATE CIRCUIT SHOULD BE CONNECTED TO A +135 VOLT "B" SUPPLY, ITS SCREEN VOLTAGE SHOULD BE +45 VOLTS AND ITS GRID BIAS, $-4\frac{1}{2}$ VOLTS.

FIG. 8
The -32 Tube.

A COMPLETE RECEIVER WITH SCREEN GRID TUBES

IN FIG. 9 YOU ARE SHOWN A COMPLETE CIRCUIT DIAGRAM OF A SIX-TUBE RECEIVER EMPLOYING TWO-VOLT TYPE TUBES EXCLUSIVELY. TYPE-32'S ARE USED IN THE TWO R.F. STAGES, AS WELL AS IN THE POWER DETECTOR STAGE. THE FIRST A.F. TUBE IS A TYPE-30 AND TWO TYPE-31'S ARE USED IN A PUSH-PULL POWER STAGE. THIS RECEIVER IS INTENDED TO BE USED WITH EITHER A MAGNETIC OR DYNAMIC SPEAKER AND ALL VALUES FOR THE VARIOUS PARTS OF THE CIRCUIT ARE SPECIFIED DIRECTLY ON THE DIAGRAM.

BY STUDYING THIS DIAGRAM IN CONJUNCTION WITH THE EXPLANATIONS IMMEDIATELY TO FOLLOW, YOU SHOULD HAVE NO DIFFICULTY IN UNDERSTANDING HOW THIS CIRCUIT OPERATES.

THE "A" SUPPLY IS FURNISHED BY TWO SERIES CONNECTED DRY CELLS AND SINCE THE FILAMENTS OF ALL TUBES ARE RATED AT 2 VOLTS, THEY CAN ALL BE CONNECTED IN PARALLEL ACROSS THE "A" BATTERY TERMINALS AND WITH A RHEOSTAT OF 6 OR 10 OHM RATING CONNECTED IN SERIES WITH THE ENTIRE GROUP OF FILAMENTS. THIS RHEOSTAT IS THEN ADJUSTED SO THAT EXACTLY 2 VOLTS IS IMPRESSED ACROSS THE FILAMENT TERMINALS OF THE TUBE SOCKETS.

THE THREE TUNING CIRCUITS ARE CONVENTIONAL, CONSISTING OF A THREE GANG CONDENSER WITH EACH OF ITS SECTIONS CONNECTED ACROSS THE SECONDARY WINDING OF AN R.F. TRANSFORMER. ONE SIDE OF EACH OF THE TUNING CIRCUITS IS CONNECTED TO THE CONTROL GRID OF ITS RESPECTIVE -32 TUBE WHILE THE OTHER SIDE OF THE TUNED CIRCUIT IS GROUNDED.

BY GROUNDING IN THIS CASE, WE MEAN THAT THE RECEIVER IS BUILT UPON A METAL CHASSIS BASE AND ALL PARTS WHICH ARE ELECTRICALLY CONNECTED TO THIS METALLIC CHASSIS BASE ARE SAID TO BE GROUNDED. IN THIS WAY, THE CHASSIS BASE IS USED JUST AS THOUGH IT WERE A WIRE AND THUS SERVES TO COMPLETE VARIOUS PORTIONS OF THE CIRCUIT. THE GROUND TERMINAL OF THE RECEIVER IS THEN FASTENED DIRECTLY TO THE CHASSIS BASE AND THE WHOLE METALLIC CHASSIS ASSEMBLY IS THEN GROUNDED TO AN EXTERNAL GROUNDING SYSTEM IN THE CONVENTIONAL MANNER.

THIS METHOD OF WIRING IS BEING EXTENSIVELY USED AT THE PRESENT TIME,

SINCE IT SAVES WIRE AND AT THE SAME TIME SIMPLIFIES THE TASK OF WIRING AND AIDS MAKING THE APPEARANCE OF THE ASSEMBLED RECEIVER MORE ATTRACTIVE.

RETURNING TO THE RECEIVER OF FIG. 9, WE FIND THE POSITIVE TERMINAL OF A 4½ VOLT "C" BATTERY CONNECTED TO THE A+ TERMINAL WHILE ITS -3 VOLT TERMINAL IS CONNECTED TO GROUND THROUGH THE 200 OHM FIXED RESISTOR AND VOLUME CONTROL. SINCE THIS -3 VOLT "C" BATTERY TERMINAL IS IN THIS WAY GROUNDED AND ONE END OF THE SECONDARY WINDING OF THE FIRST TWO R.F. TRANSFORMERS IS ALSO GROUNDED TO THE CHASSIS, A -3 VOLT "C" BIAS VOLTAGE WILL BE APPLIED TO THE CONTROL GRIDS OF THE FIRST TWO R.F. TUBES--THE CHASSIS BASE ITSELF ASSISTING TO COMPLETE THIS GRID BIAS CIRCUIT.

FOR THE -32 POWER DETECTOR TUBE, A GRID BIAS OF -4½ VOLTS IS REQUIRED AND THEREFORE ONE END OF THE THIRD R.F. TRANSFORMER'S SECONDARY WINDING IS CONNECTED TO THE -4½ VOLT "C" BATTERY TERMINAL. THEN SINCE THE THE -3 VOLT TERMINAL OF THE "C" BATTERY IS GROUNDED TO THE CHASSIS AS ALREADY DESCRIBED, AND ONE SIDE OF THE DETECTOR STAGE TUNING CONDENSER IS ALSO GROUNDED TO THE CHASSIS, THE SECONDARY WINDING OF THE THIRD R.F. TRANSFORMER WILL STILL BE CONNECTED ACROSS THIS TUNING CONDENSER ALTHOUGH IT MAY NOT APPEAR AS SUCH UPON FIRST GLANCE.

THE "B" BATTERY CONSISTS OF THREE 45 VOLT "B" BATTERIES CONNECTED IN SERIES. THE PLATES OF THE TWO R.F. TUBES ARE CONNECTED TO THE +135 VOLT "B" BATTERY TERMINAL WITH THE PRIMARY WINDINGS OF THEIR RESPECTIVE R.F. TRANSFORMERS IN SERIES. THE .5 MFD. BY-PASS CONDENSER WHICH IS CONNECTED BETWEEN THIS COMMON PLATE CIRCUIT AND GROUND OFFERS AN EASY PATH FOR THE R.F. CURRENTS IN THESE PLATE CIRCUITS TO BE BY-PASSED TO GROUND AND THUS BE ELIMINATED FROM THE CIRCUIT WITHOUT WANDERING ABOUT THROUGH THE REST OF THE CIRCUITS.

THE SCREEN GRID OF THE TWO R.F. TUBES ARE TOGETHER CONNECTED TO

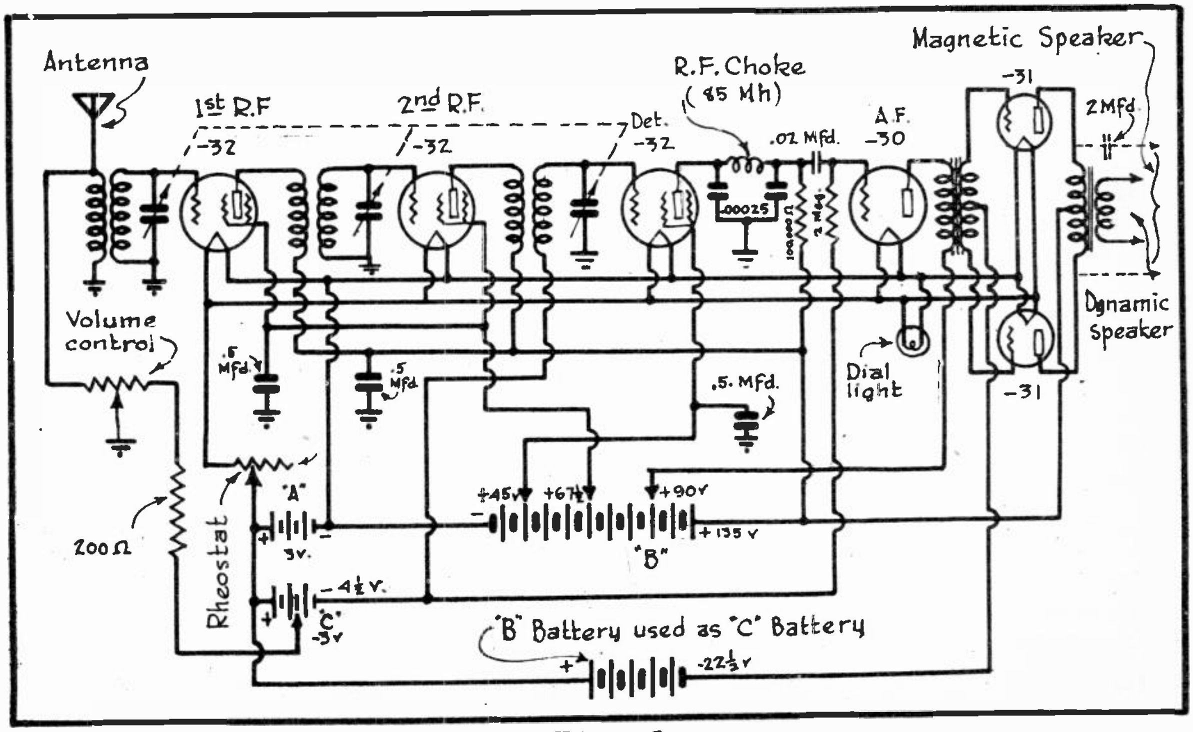

FIG. 9

A Six-Tube Screen Grid Receiver.

THE $+67\frac{1}{2}$ VOLT "B" BATTERY TERMINAL AND THE SINGLE .5 MFD. FIXED CONDENSER, WHICH IS CONNECTED BETWEEN THIS CIRCUIT AND GROUND, SERVES THE PURPOSE OF THE BY-PASS CONDENSER IN THE CIRCUIT OF FIG. 6.

THE SCREEN GRID OF THE DETECTOR TUBE IS CONNECTED TO THE +45 VOLT TERMINAL OF THE "B" BATTERY AND AN INDIVIDUAL .5 MFD. BY-PASS CONDENSER BETWEEN THIS CIRCUIT AND GROUND OFFERS THE R.F. PATH TO PREVENT OSCILLATION.

THE DETECTOR TUBE IS RESISTANCE-CAPACITY COUPLED TO THE A.F. AMPLIFIER TUBE AND AN EFFICIENT R.F. FILTER IS INSERTED IN THE PLATE CIRCUIT OF THE DETECTOR TUBE SO THAT ALL RADIO FREQUENCY CURRENTS WILL BE BY-PASSED DIRECTLY TO GROUND WITHOUT CAUSING TROUBLE BY WANDERING AROUND IN THE CIRCUIT. THIS FILTER CONSISTS OF AN 85 MILLIHENRY CHOKE COIL WITH A .00025 MFD. FIXED CONDENSER CONNECTED BETWEEN EACH OF ITS ENDS AND GROUND.

THE GRID RETURN END OF THE 2 MEGOHM LEAK RESISTOR OF THE -30 A.F. TUBE IS CONNECTED TO THE $-4\frac{1}{2}$ VOLT "C" BATTERY SO THAT A "C" BIAS VOLTAGE OF $-4\frac{1}{2}$ VOLTS WILL BE IMPRESSED UPON THE GRID OF THIS TUBE.

A $22\frac{1}{2}$ VOLT "B" BATTERY IS USED AS A "C" BATTERY SO AS TO FURNISH THE BIAS OF $-22\frac{1}{2}$ VOLTS FOR THE TYPE -31 POWER TUBES AND THE VOLUME IS CONTROLLED BY THE POTENTIOMETER WHICH IS CONNECTED TO THE ANTENNA CIRCUIT OF THE RECEIVER. BY MOVING THE GROUNDED ARM OF THIS UNIT ACROSS ITS RESISTANCE ELEMENT SO THAT IT APPROACHES THE END OF THIS RESISTANCE ELEMENT WHICH IS CONNECTED TO THE ANTENNA TERMINAL OF THE RECEIVER, THE ANTENNA CIRCUIT WILL BECOME MORE NEARLY GROUNDED OUT SO THAT THE VOLUME WILL BE DECREASED ACCORDINGLY.

BY MOVING THE POTENTIOMETER ARM IN THE OPPOSITE DIRECTION, THE RESISTANCE BETWEEN THE ANTENNA TERMINAL AND GROUND THROUGH THE POTENTIOMETER WILL BE INCREASED. THEREFORE, THE RESISTANCE OF THE PRIMARY WINDING OF THE FIRST R.F. TRANSFORMER WILL BE SO SMALL IN COMPARISON TO THAT THROUGH THE POTENTIOMETER THAT ALL SIGNAL ENERGY WILL PREFERABLY PASS BETWEEN THE ANTENNA AND GROUND THROUGH THE PRIMARY TRANSFORMER WINDING, THEREBY USING THIS WINDING TO THE FULLEST EXTENT TO INDUCE SIGNAL VOLTAGES INTO THE SECONDARY WINDING OF THIS SAME R.F. TRANSFORMER. THE VOLUME WILL THEREFORE INCREASE APPRECIABLY.

AN OUTPUT PUSH-PULL TRANSFORMER IS INCLUDED IN THE PLATE CIRCUIT OF THE -31 POWER TUBES AND IF A MAGNETIC SPEAKER IS TO BE USED, IT IS CONNECTED ACROSS THE EXTREMETIES OF THE OUTPUT TRANSFORMER'S PRIMARY WINDING WITH A 2 MFD. FIXED CONDENSER IN SERIES. IN THIS WAY, THE SIGNAL VOLTAGES CAN BE IMPRESSED UPON THE SPEAKER WINDINGS AND STILL NONE OF THE POWER TUBE PLATE CURRENT WILL FLOW THROUGH THE SPEAKER WINDINGS.

IF A DYNAMIC SPEAKER IS TO BE USED, THEN ITS VOICE COIL SHOULD BE CONNECTED ACROSS THE ENDS OF THE OUTPUT TRANSFORMER'S SECONDARY WINDING. SINCE THIS RECEIVER IS BATTERY OPERATED, A PERMANENT MAGNET TYPE DYNAMIC SPEAKER SHOULD BE USED. THE OPERATING PRINCIPLES OF THIS SPEAKER ARE IDENTICAL TO THE DYNAMIC SPEAKERS ABOUT WHICH YOU ALREADY STUDIED, WITH THE EXCEPTION THAT THE FIELD IS ENERGIZED BY A PERMANENT MAGNET INSTEAD OF BY A DIRECT CURRENT. THE OUTPUT TRANSFORMER SHOULD BE ESPECIALLY DESIGNED TO MATCH TWO TYPE -31 PUSH-PULL TUBES TO THE VOICE COIL OF THE

SPEAKER IN QUESTION. SUCH TRANSFORMERS ARE COMMERCIALLY AVAILABLE AND CAN BE OBTAINED FROM ANY GOOD RADIO SUPPLY HOUSE UPON REQUEST OR ELSE CAN BE SUPPLIED DIRECT WITH THE SPEAKER UNIT IF SO SPECIFIED.

THE DIAL LIGHT IS SIMPLY A SMALL INCANDESCENT LAMP USED TO ILLUMINATE THE TUNING DIAL AND IT IS CONNECTED ACROSS THE FILAMENT CIRCUIT AS SHOWN IN THE DIAGRAM OF FIG. 9. A LAMP HAVING A FILAMENT RATING OF 2 VOLTS AND .06 AMP. WILL BE SUITABLE FOR THIS PURPOSE.

THE REST OF THE CIRCUIT DETAILS OF THIS SIX-TUBE RECEIVER ARE AN OLD STORY TO YOU BY THIS TIME AND THERE WILL THEREFORE BE NO NEED FOR DISCUSSING IT ANY FURTHER WITH YOU NOW. BE SURE HOWEVER, TO STUDY THIS DIAGRAM WITH UTMOST CARE SO THAT YOU WILL HAVE A CLEAR MENTAL PICTURE OF THE CIRCUIT.

SHIELDING

COMPLETE SHIELDING IS A CHARACTERISTIC OF THE WELL DESIGNED RECEIVER EMPLOYING SCREEN GRID TUBES AND THIS WILL BECOME APPARENT UPON INSPECTING THE RECEIVER ILLUSTRATED IN FIG. 10. AS YOU WILL OBSERVE, THIS ENTIRE RECEIVER IS BUILT UPON A METALLIC CHASSIS BASE AND EACH OF THE SCREEN GRID TUBES, AS WELL AS EACH OF THE R.F. TRANSFORMERS, IS HOUSED WITHIN AN INDIVIDUAL SHIELD CAN.

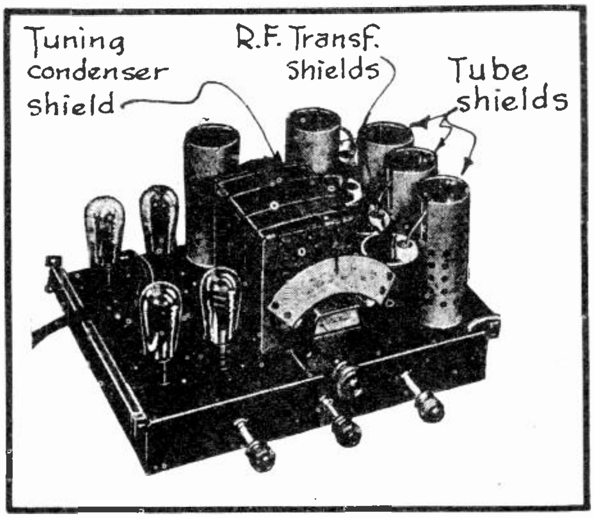

FIG. 10
A Shielded Receiver.

THESE SHIELD CANS ARE GENERALLY MADE OF ALUMINUM. THE CHASSIS BASE MAY BE MADE OF SHEET ALUMINUM OR STEEL, HOWEVER, IT IS NOW A COMMON PRACTICE TO MAKE THESE CHASSIS BASES FROM SHEET STEEL PLATED WITH CADMIUM. THE CADMIUM PLATING OFFERS A BRIGHT SURFACE WHILE AT THE SAME TIME SUPPLYING A SURFACE TO WHICH SOLDER WILL STICK READILY. THE TUNING CONDENSER, IN FIG. 10, IS ALSO PARTIALLY SHIELDED.

THE MAIN PURPOSE OF THESE METAL CONTAINERS IS NOT SIMPLY TO PROTECT THE WORKING PARTS FROM DUST AND DIRT BUT THEY HAVE A DEFINITE ELECTRICAL TASK TO PERFORM. THE CHIEF REASON FOR USING THESE CANS IS TO PROVIDE A SHIELDING BETWEEN ADJACENT RADIO PARTS SO THAT THERE WILL BE NO POSSIBILITY FOR INDUCTIVE OR CAPACITIVE COUPLING BETWEEN THEM.

PRINCIPLE OF SHIELDING

YOU WILL NO DOUBT RECALL THAT IN YOUR STUDIES OF R.F. AMPLIFICATION, YOU LEARNED THAT IT IS NECESSARY TO ALWAYS ARRANGE THE R.F. COILS IN SUCH POSITIONS, SO AS TO PREVENT THEIR MAGNETIC FIELDS FROM LINKING WITH EACH OTHER.

NOW IN FIG. 11 YOU WILL SEE TWO R.F. TRANSFORMERS OR COILS, WHICH ARE PLACED QUITE CLOSE AND PARALLEL TO EACHOTHER. ORDINARILY, THIS WOULD GIVE A VERY UNDESIRABLE INDUCTIVE COUPLING BETWEEN THEM AND WHICH WOULD

SERIOUSLY AFFECT THE OPERATION OF THE RECEIVER. HOWEVER, BY PLACING A LARGE COPPER SHEET OR PLATE BETWEEN THEM AND GROUNDING THIS PLATE, WE CAN PREVENT THE UNDESIRABLE INTERACTION BETWEEN THE TWO R.F. TRANSFORMERS. NOTICE, THAT IT IS NECESSARY TO GROUND THIS PLATE, IN ORDER TO PERMIT IT TO ACT AS AN EFFECTIVE SHIELD BETWEEN THESE TWO TRANSFORMERS.

BESIDES THE MAGNETIC FIELD BETWEEN TWO SUCH COILS, WE ALSO HAVE AN ELECTROSTATIC FIELD, WHICH OFFERS CAPACITIVE FEED-BACKS LIKE A CONDENSER AND GROUNDED SHIELDING "KILLS" THIS TYPE OF COUPLING BETWEEN PARTS, AS WELL AS INDUCTIVE COUPLING.

IN PRACTICE WE DON'T GENERALLY DEPEND UPON A PLAIN PLATE OR PARTITION FOR OUR SHIELDING PROBLEMS BUT WE DO THIS JOB STILL MORE THOROUGHLY BY BUILDING AN ENCLOSURE OF METAL SHIELDING AROUND THE PARTS TO BE SHIELDED.

CONSTRUCTION METHOD USED WITH SHIELDS

WHEN ENCLOSING AN R.F. TRANSFORMER IN A SHIELDING CAN, IT IS ADVISABLE TO PROVIDE A DISTANCE OF FROM 1 TO 2 INCHES BETWEEN EITHER END OF THE TRANSFORMER AND THE ENDS OF THE SHIELD ENCLOSURE. THERE SHOULD ALSO BE A CLEARANCE OF ABOUT 3/4 TO 1 INCH BETWEEN THE TRANSFORMER'S SIDES AND THE SIDEWALL OF THE SHIELDING CAN AS SHOWN IN FIG. 12. THESE CLEARANCE DIMENSIONS ONLY HOLD GOOD FOR THE MODERN TYPE SMALL- DIAMETER R.F. TRANSFORMERS AND THE LARGER THE COIL-DIAMETER, THE GREATER WILL BE THE REQUIRED CLEARANCES. LARGE COILS WOULD THEREFORE NECESSITATE AN EXTREMELY LARGE SHIELDING CAN, WHICH WOULD NOT BE PRACTICAL.

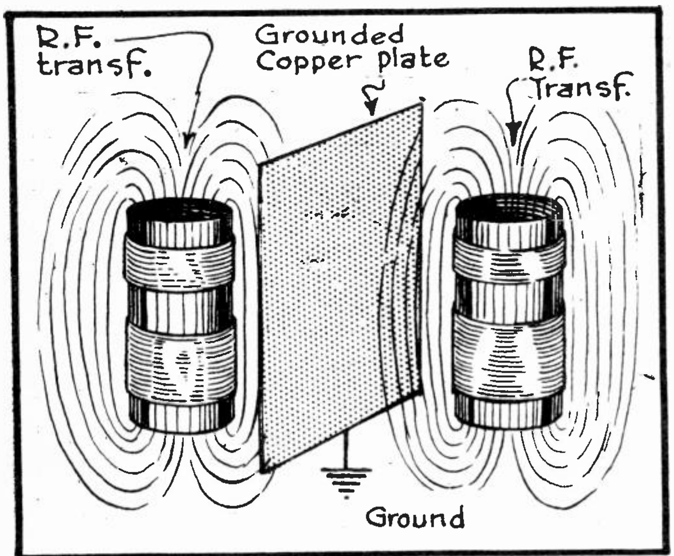

FIG. 11
Principle of shielding.

IN ORDER TO CONSTRUCT AN EFFECTIVE SHIELDING JOB, GREAT CARE MUST BE EXERCISED TO INSURE THAT ALL OF THE SHIELDING METAL IS FASTENED TOGETHER ELECTRICALLY SECURE AND THOROUGHLY GROUNDED.

NATURALLY, WHEN A METAL CHASSIS BASE IS USED AND THE SHIELDING METAL IS FIRMLY MOUNTED UPON IT, THEN THE ENTIRE SHIELDING CAN BE GROUNDED SIMULTANEOUSLY SIMPLY BY GROUNDING THE CHASSIS-BASE. ONE MUST ALSO BEAR IN MIND THAT THE SHIELDING CANS SHOULD BE MOUNTED TO THE CHASSIS-BASE IN SUCH A WAY SO THAT THEY CAN BE REMOVED EASILY IN CASE REPAIRS ARE REQUIRED ON THE ENCLOSED RADIO UNIT.

IN FIG. 13 YOU WILL SEE A POPULAR TYPE OF SHIELD CAN FOR AN R.F. TRANSFORMER OR COIL, AS WELL AS A TUBE SHIELD. THESE UNITS CAN BE PURCHASED READY-MADE AT A REASONABLE COST.

AS YOU WILL OBSERVE, THESE COMMERCIAL SHIELDS ARE MADE IN TWO PIECES,

CONSISTING OF A BASE AND COVER. THE SHIELD BASE IS FASTENED FIRMLY TO THE CHASSIS BASE TOGETHER WITH ITS RESPECTIVE TUBE SOCKET OR R.F. TRANSFORMER AND WITH THE TRANSFORMER OR TUBE IN PLACE, THE COVER CAN BE PLACED CONVIENTLY OVER IT AND BE PRESSED ONTO ITS BASE AND THEREBY BE HELD IN POSITION FIRMLY.

THE HOLES IN THE SIDE WALL OF THE TUBE SHIELD OFFER COOLING FASCILITIES FOR THE TUBE WHICH BECOMES HOT WHILE IN OPERATION AND THE CAN AS A WHOLE, PROVIDES A VERY EFFECTIVE MEANS FOR PREVENTING ELECTROSTATIC COUPLING BETWEEN THE ENCLOSED TUBE AND ANY SURROUNDING PARTS.

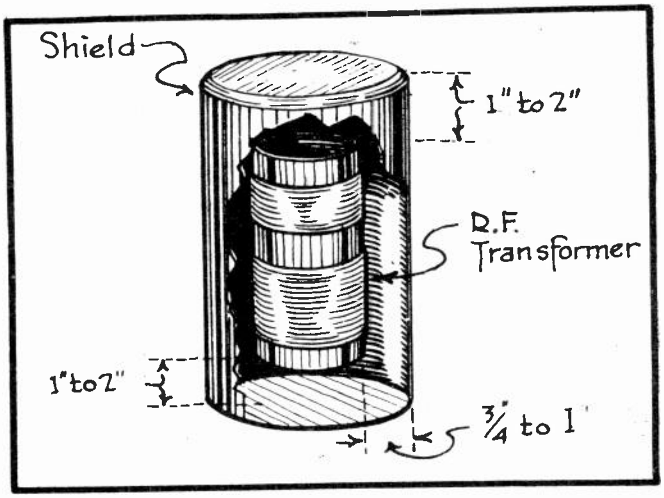

FIG. 12
R. F. Transformer in shield.

THE CONTROL GRID CAP OF THE SCREEN GRID TUBE CAN PROJECT THROUGH THE LARGE HOLE WHICH IS SUPPLIED IN THE TOP OF THE SHIELD CAN SO THAT THE CONTROL GRID WIRE CAN BE ATTACHED TO IT CONVENIENTLY. IT IS A COMMON PRACTICE TO RUN THIS CONTROL GRID WIRE FROM THE R.F. TRANSFORMER THROUGH THE HOLE PROVIDED IN THE TOP OF ITS SHIELD CAN AND THEN TO CONNECT IT TO THE CONTROL GRID CAP OF THE TUBE BY MEANS OF A SPECIAL CLIP. THIS CLIP IS SHOWN SOLDERED TO THE END OF THE CONTROL GRID WIRE IN FIG. 14.

IT IS CHIEFLY THE R.F. AND DETECTOR STAGES WHICH ARE SHIELDED IN THIS MANNER, FOR ONLY THESE CIRCUITS HANDLE THE HIGH FREQUENCY CURRENTS WHICH ARE LIKELY TO CAUSE COUPLING TROUBLES IF NOT TAKEN CARE OF PROPERLY. THE AUDIO AND POWER STAGES ARE NOT FREQUENTLY SHIELDED BECAUSE THE AUDIO FREQUENCIES HANDLED BY THEM ARE COMPARATIVELY LOW. YOU WILL, HOWEVER, COME ACROSS A.C. RECEIVERS WHERE THE PARTS OF THE POWER PACK ARE SHIELDED SO AS TO AVOID HUM INDUCTION BUT THIS WILL ALL BE EXPLAINED TO YOU LATER.

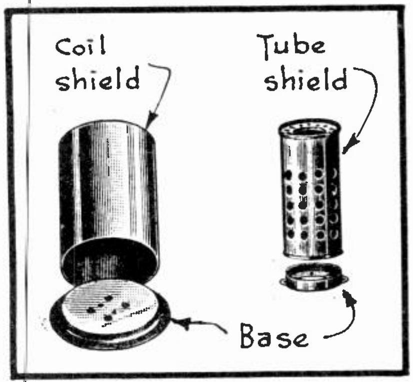

FIG. 13
A Typical Coil and Tube Shield.

ANOTHER METHOD OF SHIELDING, WHICH IS SOMETIMES USED, IS ILLUSTRATED IN FIG. 15 AND IN THIS CASE ALL OF THE PARTS CONSTITUTING A SINGLE STAGE ARE TOGETHER ENCLOSED IN A SHIELD CAN. HERE, OF COURSE, A RATHER LARGE SHIELD CAN IS REQUIRED AND IT IS INDICATED ON THE DIAGRAM BY THE ENCLOSURE WHICH IS DRAWN WITH BROKEN LINES AND DESIGNATED AS BEING GROUNDED.

BY HAVING EACH STAGE INDIVIDUALLY SHIELDED IN THIS WAY, THERE WILL BE NO POSSIBILITY OF UNDESIRABLE COUPLING BETWEEN STAGES. A SHIELD CAN AS THIS WOULD APPEAR AS THE ONE SHOWN IN FIG. 16.

USE OF THE SCREEN GRID TUBE AS A SPACE CHARGE AMPLIFIER

IN FIG. 17 YOU WILL SEE ANOTHER APPLICATION OF THE SCREEN GRID TUBE

ILLUSTRATED. WHEN USED IN THIS WAY, WE SPEAK OF THE ARRANGEMENT AS BEING A "SPACE CHARGE" AMPLIFIER, HOWEVER, THIS USE OF THE SCREEN GRID TUBE IS BY NO MEANS AS POPULAR AS ALREADY SHOWN YOU IN RESPECT TO THE USE OF THE TUBE AS AN R.F. AMPLIFIER.

NOTICE IN FIG. 17 THAT THE REGULAR CONTROL GRID IS BEING USED AS THE SCREEN GRID AND A POSITIVE POTENTIAL OF 22½ VOLTS IS BEING APPLIED TO IT. THE REGULAR SCREEN GRID IS CONNECTED TO THE CIRCUIT, SO THAT IT WILL TAKE THE PLACE OF THE CONVENTIONAL CONTROL GRID AND THE ACTION OF THE TUBE IS NOW AS FOLLOWS: THE HEATED FILAMENT IS THROWING OFF MILLIONS OF ELECTRONS, ALL OF WHICH ARE NEGATIVELY CHARGED. THEN AS THE FILAMENT LOOSES MORE AND MORE ELECTRONS IN THIS WAY, IT HAS A TENDENCY TO GRADUALLY BECOME MORE POSITIVE. NOW SINCE LIKE ELECTRICAL CHARGES REPEL EACHOTHER AND UNLIKE CHARGES ATTRACT EACHOTHER, WE FIND THAT MANY OF THE NEGATIVELY CHARGED ELECTRONS, WHICH ARE AT THE TIME IN THE SPACE BETWEEN THE FILAMENT AND PLATE, HAVE A TENDENCY TO PUSH BACK OR REPEL ANY ADDITIONAL ELECTRONS WHICH ARE FLEEING FROM THE FILAMENT AND IN THIS WAY, THE ELECTRONS THEMSELVES ARE ACTUALLY TRYING TO FORCE OTHER ELECTRONS BACK TOWARDS THE FILAMENT. THIS "FIGHT" BETWEEN THE ELECTRONS TAKES PLACE IN THE SPACE BETWEEN THE PLATE AND FILAMENT, BUT CLOSER TO THE FILAMENT AND THE RESULT IS THAT AT THIS POINT, A DENSE CLOUD OF ELECTRONS DEVELOPES AND WE CALL THIS ELECTRONIC CLOUD THE "SPACE CHARGE".

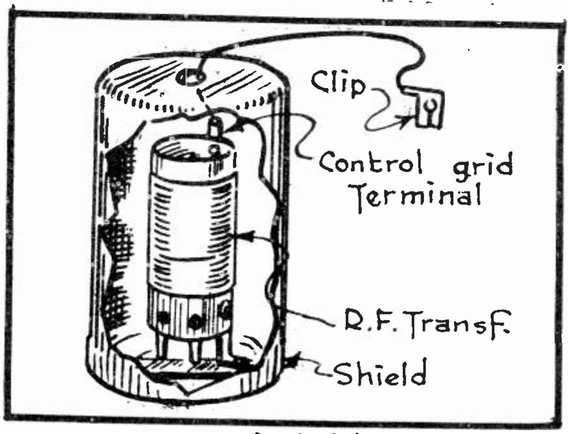

FIG. 14
The Shielded Transformer With Control Grid Connection.

THIS SPACE CHARGE HAS A TENDENCY TO RETARD THE FLOW OF ELECTRONS BETWEEN THE FILAMENT AND PLATE AND THEREBY LIMITS THE FLOW OF PLATE CURRENT. SO BY APPLYING A POSITIVE POTENTIAL TO THE GRID, WHICH IS NEAR THE FILAMENT AS SHOWN IN FIG. 17, THIS CONTINUALLY POSITIVELY CHARGED GRID WILL ATTRACT THE ELECTRONS FROM THE FILAMENT, SPEED THEM UP ON THEIR WAY OVER TO THE PLATE AND THEREBY BREAK UP THE SPACE CHARGE.

THEN BY HAVING THE CONTROL GRID (SCREEN GRID IN THIS CASE) SURROUNDING THE PLATE, THE SIGNAL VOLTAGE CHANGES UPON IT WILL CONTROL THE AMOUNT OF ELECTRONS WHICH ACTUALLY GET TO THE PLATE AND THEREBY GIVES US A CONVENTIONAL PLATE CURRENT CONTROL. THIS PROCESS, HOWEVER GIVES US A MARKED INCREASE IN THE

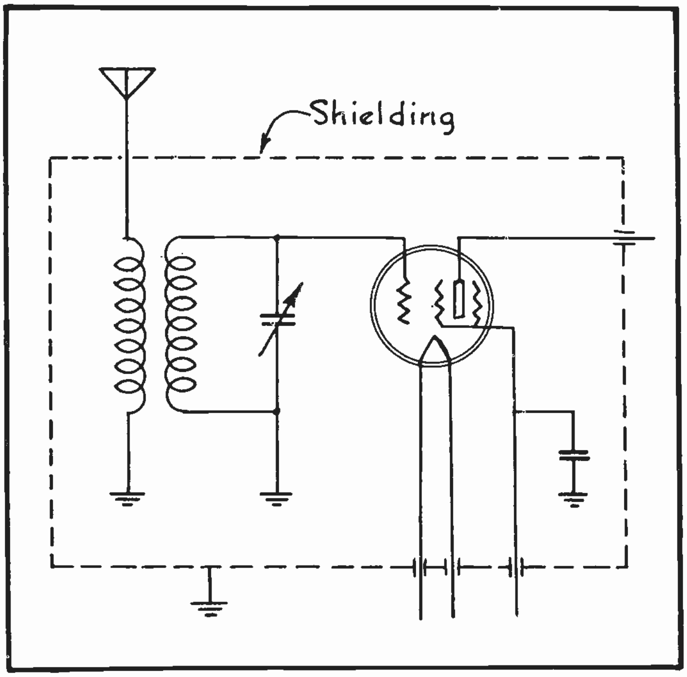

FIG. 15
A Shielded R.F. Stage.

FLOW OF THE PLATE CURRENT FOR A GIVEN APPLIED PLATE VOLTAGE AND BY USING THIS ARRANGEMENT IN A STAGE OF AUDIO FREQUENCY AMPLIFICATION FOLLOWING THE DETECTOR, TREMENDOUS SIGNAL STRENGTH CAN BE OBTAINED. IN FACT, ONE STAGE OF SPACE CHARGE A.F. AMPLIFICATION, IN ADDITION TO AN OUTPUT TUBE, WILL IN MOST CASES BE SUFFICIENT.

BY USING THIS TUBE AS A SPACE CHARGE AMPLIFIER, THE GRID-PLATE CAPACITY HAS AGAIN RE-APPEARED AND THEREFORE, THIS CONNECTION WOULD BE OF NO VALUE WHEN USED IN THE R.F. STAGES WHERE WE HANDLE HIGH RADIO FREQUENCIES.

THE POWER PENTODE

FROM THE PRECEDING EXPLANATION OF THE SCREEN GRID TUBE, WHEN USED AS A SPACE-CHARGE AMPLIFIER, YOU WILL RECALL THAT BY CONNECTING THE CONTROL GRID TO A B+ POTENTIAL, WE ARE ABLE TO REDUCE THE SPACE CHARGE SURROUNDING THE FILAMENT AND THAT THIS WILL INCREASE THE FLOW OF PLATE CURRENT CONSIDERABLY AT A GIVEN APPLIED PLATE VOLTAGE. ALTHOUGH THIS RESULT INCREASES THE TUBE'S ABILITY AS A VOLTAGE AMPLIFIER, YET IT DOESN'T OFFER ANY ADVANTAGE IN POWER AMPLIFIER CIRCUITS BECAUSE OF THE HIGH VALUE OF "SECONDARY EMISSION" WHICH IS ENCOUNTERED, DUE TO THE GREAT SPEED AT WHICH THE FILAMENT ELECTRONS TRAVEL OVER TO THE PLATE.

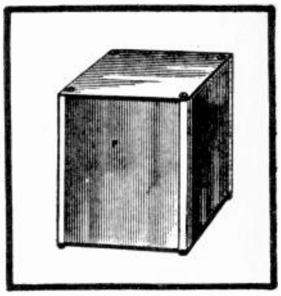

FIG.16
A large shield can.

AS THESE ELECTRONS STRIKE THE PLATE AT A TREMENDOUS SPEED, THEY KNOCK OUT OF IT ADDITIONAL ELECTRONS WHICH ARE ATTRACTED BACK TOWARDS THE GRID. WE CALL THIS THE "SECONDARY EMISSION" AND SINCE IT OPPOSES THE REGULAR FLOW OF ELECTRONS FROM FILAMENT TO PLATE, IT MATERIALLY REDUCES THE REGULAR FLOW OF ELECTRONS AND LOWERS THE PLATE CURRENT TO WHAT ITS VALUE WOULD BE IF THIS SECONDARY EMISSION COULD BE PREVENTED.

HERE IS WHERE THE PENTODE POWER AMPLIFIER CAME INTO THE PICTURE, FOR ITS CONSTRUCTION IS SUCH THAT IT REDUCES THE SPACE CHARGE, AS WELL AS TO REDUCE THE UNDESIRABLE EFFECTS OF SECONDARY EMISSION. THE PLATE CURRENT THROUGH THIS TUBE AND ITS ABILITY TO FUNCTION AS A POWER AMPLIFIER ARE THEREFORE INCREASED ACCORDINGLY.

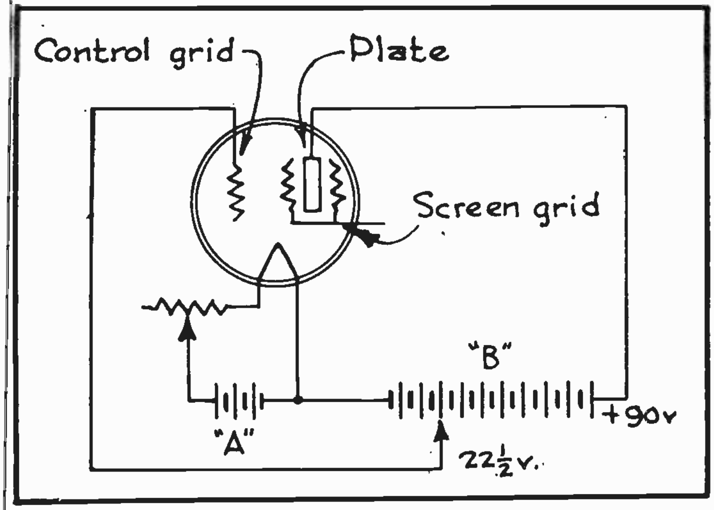

FIG.17
Screen Grid Tube used as Space-charge Amplifier.

THE ARRANGEMENT OF THE ELEMENTS WITHIN THIS TUBE, WHEN VIEWED FROM ABOVE, WILL APPEAR AS SHOWN IN THE UPPER PORTION OF FIG. 18, WHEREAS THE SYMBOL FOR THIS TUBE IS SHOWN YOU IN THE LOWER SECTION OF THIS SAME ILLUSTRATION.

UPON STUDYING FIG. 18 VERY CAREFULLY, YOU WILL OBSERVE THAT THE FILAMENT IS MOUNTED AT THE CENTER OF

THE ASSEMBLY AND IS SURROUNDED BY THE CONTROL GRID. THE SCREEN GRID SURROUNDS THE CONTROL GRID AND A THIRD GRID, WHICH WE CALL A SUPPRESSOR GRID, IS PLACED BETWEEN THE SCREEN GRID AND THE PLATE.

THE SUPPRESSOR GRID IS PERMANENTLY CONNECTED TO THE FILAMENT WITHIN THE TUBE ITSELF BUT THE OTHER ELEMENTS ALL HAVE THEIR RESPECTIVE EXTERNAL CONNECTIONS.

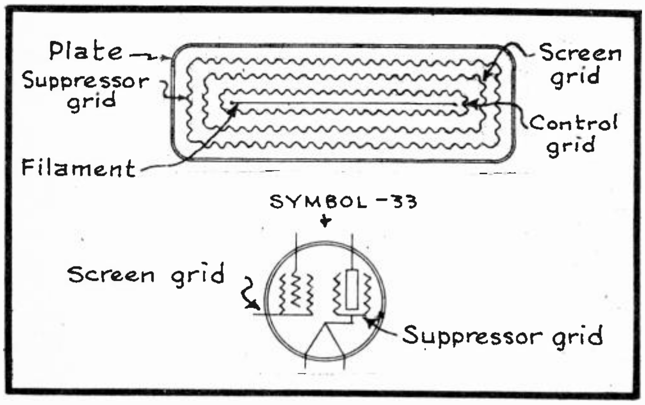

FIG. 18
Construction & Symbol of the Power Pentode.

THE SCREEN GRID OF THE PENTODE, WHICH IS LOCATED RELATIVELY CLOSE TO THE FILAMENT, IS CONNECTED TO A B+ POTENTIAL AND THEREFORE ASSISTS IN SPEEDING THE ELECTRONS ON THEIR WAY OVER TO THE PLATE AND REDUCES THE SPACE CHARGE. THEN SINCE THE SUPPRESSOR GRID IS CONNECTED DIRECTLY TO THE FILAMENT, IT REMAINS AT THE SAME AVERAGE POTENTIAL AS THE FILAMENT AND THE SUPPRESSOR GRID THEREFORE HAS PRACTICALLY NO EFFECT UPON THE FLOW OF ELECTRONS FROM THE FILAMENT TO THE PLATE; IT IS, HOWEVER, NEGATIVE IN RESPECT TO THE PLATE. THIS POTENTIAL DIFFERENCE BETWEEN THE SUPPRESSOR GRID AND THE PLATE IS EQUAL TO THE INSTANTANEOUS PLATE POTENTIAL AND THEREFORE THE SECONDARY EMISSION ELECTRONS WHICH LEAVE THE PLATE DUE TO THE BOMBARDMENT OF THE FILAMENT ELECTRONS, FIND THE PATH TO THE FILAMENT THROUGH THE SUPPRESSOR GRID A DIFFICULT ONE. THEREFORE, THE GREATER PORTION OF THESE SECONDARY EMISSION ELECTRONS RETURN TO THE PLATE AND THEREBY ASSIST IN INCREASING THE PLATE CURRENT.

THE TYPE -33 PENTODE

THE PENTODE POWER AMPLIFIER, WHICH IS NOW BEING EXTENSIVELY USED IN BATTERY OPERATED RECEIVERS, IS KNOWN AS THE -33. THIS TUBE OPERATES WITH A FILAMENT VOLTAGE OF 2 VOLTS AND DRAWS A FILAMENT CURRENT OF 0.26 AMP. THIS BEING THE CASE, YOU WILL READILY NOTICE THAT IT IS ADAPTABLE TO BEING USED AS A POWER TUBE IN BATTERY OPERATED RECEIVERS WHICH EMPLOY TYPE-30 AND 32-TUBES IN THE OTHER STAGES.

THIS TUBE AND ITS SOCKET CONNECTIONS ARE ILLUSTRATED FOR YOU IN FIG. 19. AS YOU WILL OBSERVE, IT IS EQUIPPED WITH FIVE BASE PRONGS—TWO OF WHICH SERVE FOR THE FILAMENT CONNECTIONS, ONE FOR THE CONTROL GRID, ONE FOR THE PLATE AND ONE FOR THE SCREEN GRID. THE SUPPRESSOR GRID IS CONNECTED TO THE FILAMENT WITHIN THE TUBE STRUCTURE AS AL-

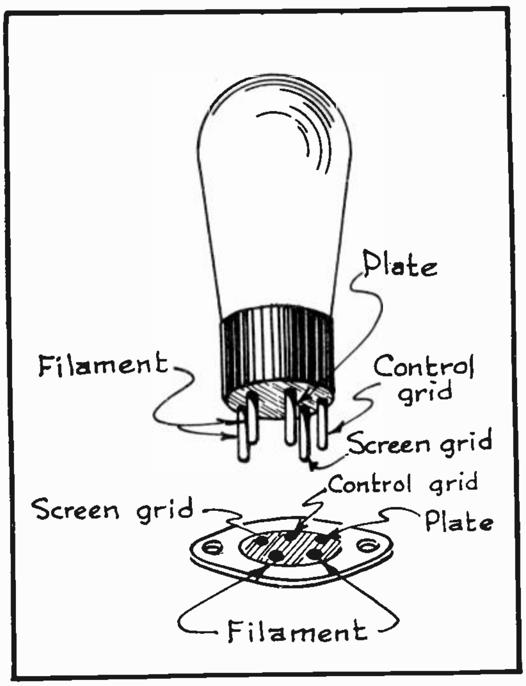

FIG. 19
The -33 Type Tube.

READY MENTIONED.

FOR THE BEST RESULTS, THIS TUBE SHOULD BE OPERATED WITH A PLATE VOLTAGE OF +135 VOLTS AND A SCREEN GRID VOLTAGE OF +135 VOLTS. A BIAS OF -13.5 VOLTS SHOULD BE IMPRESSED UPON THE CONTROL GRID AND THE TUBE WILL THEN DRAW A NORMAL PLATE CURRENT OF 14 MILLIAMPERES. ITS AMPLIFICATION FACTOR IS 75 AND IT HAS A RATED POWER OUTPUT OF 700 MILLIWATTS. (ONE MILLIWATT IS EQUIVALENT TO THE ONE-THOUSANDTH PART OF ONE WATT).

IN FIG. 20 YOU WILL SEE A CIRCUIT DIAGRAM WHICH ILLUSTRATES HOW A SINGLE TYPE-33 TUBE MAY BE USED IN THE POWER STAGE OF A RECEIVER. DUE TO THE SENSITIVITY AND HIGH AMPLIFICATION OF THIS TUBE, IT CAN BE USED SATISFACTORILY IMMEDIATELY FOLLOWING THE DETECTOR. IN THE CASE OF FIG. 20,

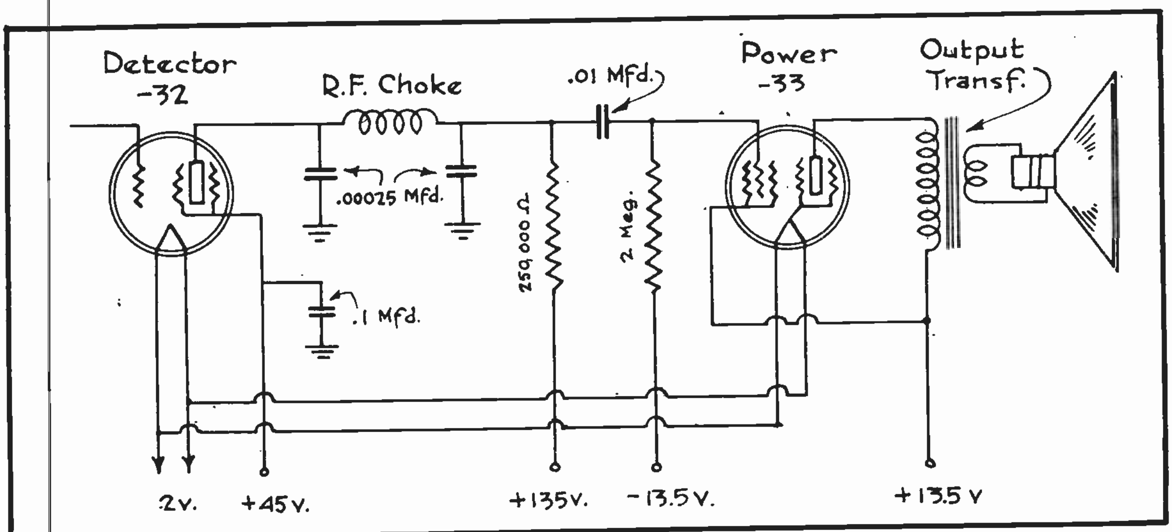

FIG. 20
Application of a -33 Tube In the Power Stage.

A TYPE-32 TUBE IS BEING USED AS A POWER DETECTOR.

THE SPEAKER WHICH IS BEING USED WITH THIS SAME CIRCUIT IS OF THE PERMANENT MAGNET, DYNAMIC TYPE AND THE OUTPUT TRANSFORMER IS DESIGNED TO MATCH A SINGLE -33 TUBE INTO THE SPEAKER VOICE COIL.

HAVING COMPLETED THIS LESSON, WE SHALL LEAVE BATTERY-TYPE RECEIVERS FOR A WHILE AND TURN OUR ATTENTION TO THE CONSTRUCTION AND OPERATING PRINCIPLES OF A.C. RECEIVERS. ALTHOUGH IT IS TRUE THAT WE HAVE SPENT A CONSIDERABLE TIME WITH THE BATTERY SETS, YOU MAY REST ASSURED THAT THIS WAS WELL WORTH WHILE. THIS IS LARGELY DUE TO THE FACT THAT MOST OF THE RADIO PRINCIPLES WHICH YOU HAVE SO FAR LEARNED CONCERNING BATTERY OPERATED RECEIVERS, WILL APPLY EQUALLY AS WELL TO THE A.C. SETS. THIS NATURALLY MEANS THAT YOU WILL BE ABLE TO PROGRESS THROUGH YOUR STUDIES OF A.C. RECEIVERS QUITE RAPIDLY.

IN THE NEXT LESSON, YOU ARE GOING TO LEARN ABOUT THE TUBES WHICH ARE DESIGNED ESPECIALLY TO BE USED IN THE A.C. SETS AND THEN WE WILL GO INTO AN INTENSE INVESTIGATION OF THE RECEIVER CIRCUITS THEMSELVES.

EXAMINATION QUESTIONS

LESSON NO. 14

1. - WHAT ARE THE MOST OUTSTANDING REASONS FOR USING SCREEN GRID TUBES IN THE R.F. STAGES OF A RECEIVER?

2. - DESCRIBE BRIEFLY THE CONSTRUCTION OF A SCREEN GRID VACUUM TUBE.

3. - WHAT ARE THE OPERATING CHARACTERISTICS OF THE TYPE -32 TUBE WHEN IT IS TO BE USED AS AN R.F. AMPLIFIER?

4. - WHY IS SHIELDING EMPLOYED IN MODERN RECEIVERS?

5. - DESCRIBE BRIEFLY HOW A SCREEN GRID TUBE MAY BE USED AS A "SPACE-CHARGE" AMPLIFIER.

6. - DESCRIBE THE CONSTRUCTION OF THE PENTODE TUBE.

7. - WHAT ARE THE OPERATING CHARACTERISTICS OF THE TYPE -33 PENTODE?

8. - WHAT CHIEF ADVANTAGES DOES THE -33 TUBE HAVE TO OFFER AS COMPARED TO THE -31?

9. - DRAW A DIAGRAM, SHOWING HOW A SINGLE TYPE -33 TUBE SHOULD BE CONNECTED IN THE CIRCUIT OF A RECEIVER.

10.- HOW WOULD YOU USE A TYPE -32 TUBE AS A POWER DETECTOR?

DEAR STUDENT

THOROUGHNESS IS ONE OF THE CORNERSTONES OF SUCCESS. LET US, THEREFORE, NOT SLIGHT OUR WORK. WE MUST KEEP IN MIND THAT EVERYTHING THAT IS WORTHWHILE DOING IS IMPORTANT, AND NOTHING THAT IS IMPORTANT CAN WE AFFORD TO NEGLECT, OR TO DO IN A SLIPSHOD MANNER.

WE MUST BE THOROUGH IF WE WANT TO BE SUCCESSFUL.

J.A.R.

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LESSON NO. 15

VACUUM TUBES FOR A.C. RECEIVERS

ALL OF THE TUBES, WHICH WE HAVE MADE USE OF SO FAR IN OUR STUDIES, REQUIRED THAT A DIRECT CURRENT BE SENT THROUGH THEIR FILAMENT IN ORDER FOR THE FILAMENT TO EMIT ELECTRONS.

NOW THE ONLY THING THAT THIS FILAMENT CURRENT IS EXPECTED TO DO IS TO HEAT THE FILAMENT AND AS FAR AS THIS HEATING EFFECT IS CONCERNED, ALTERNATING CURRENT CAN ACCOMPLISH IT AS WELL AS A DIRECT CURRENT. THIS BEING THE CASE, ONE MIGHT AT FIRST SUPPOSE THAT WE COULD USE A CONVENTIONAL DIRECT CURRENT TYPE TUBE, SUCH AS THE -01 A, FOR EXAMPLE, PERMIT AN ALTERNATING CURRENT TO FLOW THROUGH ITS FILAMENT AND THEREBY OBTAIN THE NECESSARY ELECTRON EMISSION SO THAT THE TUBE COULD OPERATE JUST AS EFFICIENTLY AS IF A D.C. SUPPLY WERE USED TO HEAT THE FILAMENT.

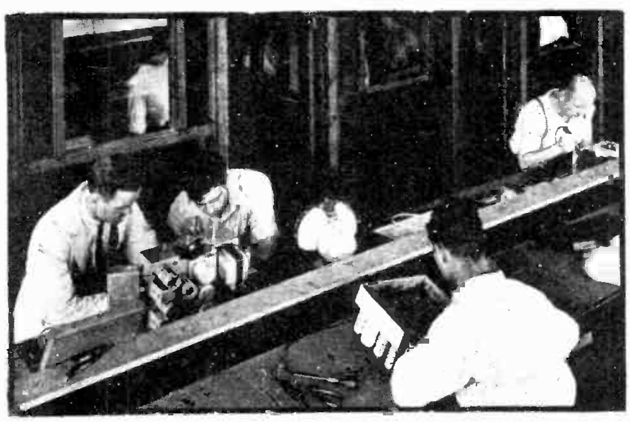
Fig. 1
Partial View Of National's Radio Service Department

THIS ALL SOUNDS QUITE LOGICAL UP TO A CERTAIN POINT BUT IF WE SHOULD CARRY OUR INVESTIGATION STILL FARTHER AND ACTUALLY EXPERIMENT TO SEE WHAT HAPPENS IF AN -01 A TUBE IS USED AS A DETECTOR, WHILE BEING FURNISHED WITH AN A.C. FILAMENT SUPPLY, WE WOULD FIND THAT A VERY DISAGREEABLE HUM WOULD BE EMITTED FROM THE HEADPHONES OR SPEAKER.

THE REASON FOR HUM WHEN A.C. FILAMENT SUPPLY IS USED

THE REASON FOR THIS HUM, WHEN USING THE -01 A WITH AN A.C. FILAMENT SUPPLY, IS THAT AS THE 50 OR 60 CYCLE ALTERNATING CURRENT CHANGES ITS DIRECTION OF FLOW THROUGH THE FILAMENT, IT IS CONTINUALLY INCREASING AND DECREASING IN ITS INTENSITY AND AT CERTAIN INTERVALS NO CURRENT IS FLOWING AT ALL. THIS WILL NATURALLY MEAN THAT THE TEMPERATURE OF THE FILAMENT

WILL NOT BE UNIFORM AND IN BETWEEN ALTERNATIONS OF THIS FILAMENT CURRENT, THE FILAMENT WILL COOL OFF SOMEWHAT. THEN SINCE THE EMISSION OF ELECTRONS DEPENDS UPON THE TEMPERATURE OF THE FILAMENT, IT IS OBVIOUS THAT THIS VARYING FILAMENT TEMPERATURE WILL CAUSE A VARYING ELECTRON EMISSION, SO THAT THE PLATE CURRENT CHANGES WILL VARY ACCORDINGLY, AND THUS PRODUCE THE AUDIBLE HUM IN THE SPEAKER.

ALTHOUGH SOME OF THE EARLIER A.C. RECEIVERS DID ACTUALLY EMPLOY TYPE-01 A TUBES, YET THEY WERE NOT REALLY PRACTICAL FOR THIS PURPOSE. FOR BETTER PERFORMANCE, IT WAS NECESSARY TO DESIGN SPECIAL TUBES WHICH ARE ESPECIALLY ADAPTABLE TO OPERATE WITH AN A.C. FILAMENT SUPPLY.

IT IS WITH THESE SPECIAL A.C. TUBES THAT WE ARE GOING TO CONCERN OURSELVES IN THIS LESSON AND THE FIRST OF THESE, WHICH YOU ARE GOING TO BE TOLD ABOUT, IS THE TYPE-26, ILLUSTRATED IN FIG. 2.

THE -26

THIS -26 TUBE IS IDENTICAL IN SIZE AND SHAPE TO THE -01 A, WHICH YOU HAVE ALREADY HEARD SO MUCH ABOUT. THE ELEMENTS WITHIN THIS TUBE ARE ALSO PLACED IN THE SAME POSITIONS AS IN THE -01 A BUT IN ORDER TO MAINTAIN A UNIFORM FILAMENT TEMPERATURE WITH AN A.C. SUPPLY, THE FILAMENT OF THE -26 IS MUCH THICKER THAN THAT IN THE -01 A. IN FACT, THE FILAMENT OF THE -26 IS RIBBON SHAPED, PROVIDED WITH AN OXIDE COATING TO GIVE A GOOD ELECTRON EMISSION AND IT IS INSTALLED IN THE TUBE SO AS TO TAKE THE FORM OF AN INVERTED "V".

DUE TO THE USE OF THIS HEAVIER FILAMENT, THE RESISTANCE OF THE FILAMENT WILL BE LOWERED, SO THAT CONSIDERABLE CURRENT WILL FLOW THRU IT WITH A COMPARATIVELY LOW IMPRESSED VOLTAGE. FURTHERMORE, THE HEAVY FILAMENT WILL HOLD HEAT MORE SO THAN A THIN FILAMENT AND FOR THIS REASON, ITS TEMPERATURE WILL NOT VARY SO VERY MUCH, EVEN THOUGH AN A.C. SUPPLY IS BEING USED. THE TENDENCY FOR THIS FILAMENT TO HOLD HEAT ADDS GREATLY TOWARDS REDUCING THE HUM.

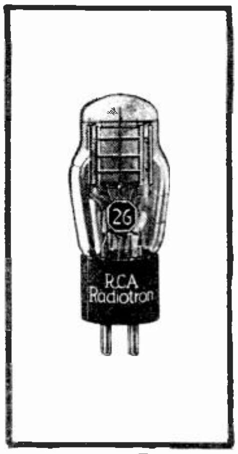

FIG. 2
The -26

THIS TUBE IS, HOWEVER, NOT SUITABLE FOR USE AS A DETECTOR BUT ONLY AS AN R.F. AMPLIFIER AND FOR THE FIRST STAGE OF A.F. AMPLIFICATION. THE RECOMMENDED FILAMENT VOLTAGE FOR THE -26 TUBE IS 1.5 VOLTS AND THE CURRENT DRAWN BY THE FILAMENT WITH THIS VOLTAGE IS 1.05 AMPERES.

THE MAXIMUM PLATE VOLTAGE ALLOWED FOR THIS TUBE IS 180 VOLTS BUT AN AVERAGE OF 135 VOLTS IS ONLY RECOMMENDED. WITH A PLATE VOLTAGE OF 135 VOLTS, A GRID BIAS OF FROM -9 TO -12 VOLTS SHOULD BE USED. IT HAS AN AMPLIFICATION FACTOR OF 8.3. AND ITS AVERAGE PLATE CURRENT IS 6.3 MA.

THE TYPE - 27 TUBE

THE DETECTOR STAGE IS THE MOST SENSITIVE STAGE OF ALL AND ANY HUM WHICH IS SET UP IN IT, WILL BE GREATLY MAGNIFIED BY THE TIME IT COMES OUT OF THE SPEAKER. THEREFORE, ENGINEERS DECIDED TO CONSTRUCT A TUBE IN WHICH THE FILAMENT ITSELF DOES NOT EMIT THE ELECTRONS AND A SEPARATE ELECTRODE, WHICH HAS NO A.C. FLOWING THROUGH IT, IS USED AS THE ELECTRON EMITTER.

TUBES OF THIS TYPE ARE GENERALLY SPOKEN OF AS HEATER TYPE TUBES AND IN FIG. 3 YOU ARE SHOWN A TUBE OF THIS CLASS WHICH IS KNOWN AS THE -27. THIS TUBE IS ENTIRELY DIFFERENT IN CONSTRUCTION FROM ANY WHICH WE HAVE SO FAR DISCUSSED AND IN FIG. 4, YOU WILL SEE A PHOTOGRAPH OF A CUT-AWAY SECTION OF THE -27 TUBE, SHOWING YOU HOW THE ELEMENTS ARE ARRANGED.

FIG. 3
The -27

NOTICE IN FIG. 4 THAT A REGULAR INVERTED "V" SHAPED FILAMENT RUNS STRAIGHT UP THROUGH THE CENTER OF THE TUBE AND IT IS IMBEDDED INSIDE OF A ROD-SHAPED INSULATOR, WHICH LOOKS LIKE PORCELAIN. A METAL SLEEVE SURROUNDS THIS INSULATOR ROD AND THIS SLEEVE IS COATED WITH BARIUM OR STRONTIUM OXIDES, SO THAT IT WILL EMIT ELECTRONS READILY WHEN HEATED. WE CALL THIS OXIDE COATED SLEEVE THE CATHODE.

NOW IF WE SHOULD PASS AN ALTERNATING CURRENT THRU THIS FILAMENT, IT WILL HEAT UP THE FILAMENT AND THIS IN TURN WILL HEAT UP THE INSULATOR AND CATHODE, THE LATTER BECOMING RED HOT. THE CATHODE, WHEN HEATED SUFFICIENTLY WILL THEN EMIT ELECTRONS, THE SAME AS ANY OTHER HOT BODY, AND BY HAVING THE CATHODE PROPERLY COATED WITH THE NECESSARY OXIDES, A HEAVY STREAM OF ELECTRONS WILL BE LIBERATED FROM ITS SURFACE.

THE PERFORATED PLATE, IN THIS CASE, IS CYLINDRICAL IN SHAPE, SO THAT IT COMPLETELY SURROUNDS THE CATHODE. THE GRID CONSISTS OF A THIN WIRE WOUND INTO THE FORM OF A SPIRAL, WHICH IS SUSPENDED IN THE SPACE BETWEEN THE CATHODE AND PLATE AND IN THIS WAY, IT CAN CONTROL THE FLOW OF ELECTRONS FROM THE CATHODE OVER TO THE PLATE.

THE INSULATOR BETWEEN THE FILAMENT AND THE CATHODE DOES NOT READILY RESPOND TO A CHANGE IN TEMPERATURE AND THEREFORE, IT TAKES AROUND 20 SECONDS AFTER FIRST TURNING ON THE RECEIVER, FOR THE FILAMENT TO HEAT UP THE CATHODE SUFFICIENTLY TO ENABLE THIS LATTER ELECTRODE TO EMIT THE REQUIRED NUMBER OF ELECTRONS SO AS TO BRING IT UP TO A STATE OF EFFICIENT OPERATION. THEN TOO, WE FIND THAT EVEN AFTER THE FILAMENT SUPPLY IS CUT-OFF, THE CATHODE WILL REMAIN SUFFICIENTLY HOT FOR A FEW SECONDS SO AS TO CONTINUE LIBERATING ELECTRONS AND THEREFORE, THE SPEAKER SOUNDS

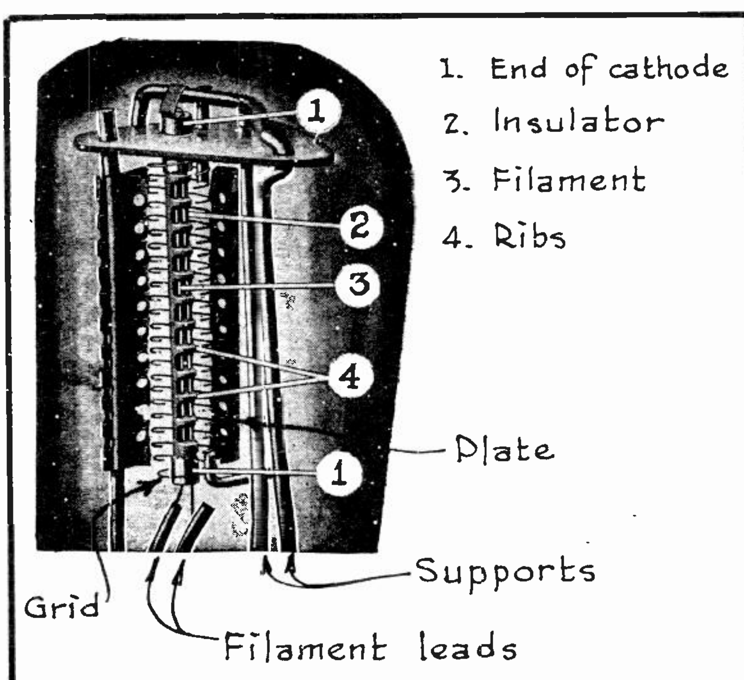

FIG. 4
Construction of the -27.

WILL DIE DOWN GRADUALLY, AFTER THE RECEIVER IS TURNED OFF.

DUE TO THIS SLUGGISH RESPONSE TO TEMPERATURE CHANGES, OR THE THERMAL INERTIA OF THE INSULATOR TUBE, AS THE ENGINEER WOULD SAY, IT CAN READILY BE SEEN THAT ALTHOUGH THE CURRENT FLOW THROUGH THE FILAMENT VARIES IN INTENSITY WITH THE ALTERNATING CURRENT REVERSALS, THE INDIRECTLY HEATED CATHODE WILL REMAIN AT A PRACTICALLY CONSTANT TEMPERATURE, SO AS TO DELIVER A UNIFORM ELECTRON EMISSION. THEREFORE, PRACTICALLY NO HUM AT ALL WILL BE NOTICED.

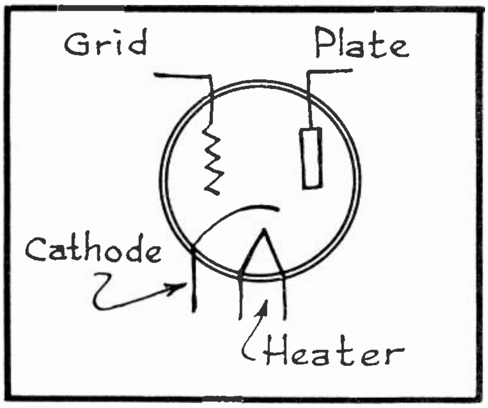

FIG. 5.
Symbol for the heater type tube.

IN FIG. 5, YOU WILL SEE THE SYMBOL USED FOR THE -27 TYPE HEATER TUBE. OBSERVE THAT WE HAVE ALTOGETHER FOUR ELEMENTS WITHIN THIS TUBE, CONSISTING OF THE HEATER, CATHODE, GRID AND PLATE.THIS IN TURN MEANS THAT YOU WILL FIND FIVE PRONGS AT THE BOTTOM OF THIS TUBE'S BASE INSTEAD OF ONLY FOUR. TWO OF THESE PRONGS WILL BE FOR THE FILAMENT OR HEATER, ONE FOR THE PLATE, ONE FOR THE GRID AND THE OTHER FOR THE CATHODE.

THE HOLES IN THE SOCKET FOR THIS TUBE WILL BE LAID-OUT AS PICTURED IN FIG. 6 AND A FIVE-PRONG SOCKET AS THIS IS GENERALLY CLASSIFIED AS A "U Y" SOCKET.THE SOCKET IS HERE BEING VIEWED FROM ABOVE.

THIS TUBE WAS SPECIALLY DESIGNED FOR USE AS A DETECTOR IN CONJUNCTION WITH THE -26, WHICH WAS USED IN THE R.F. AND FIRST AUDIO STAGES.NEVERTHELESS, THIS -27 CAN ALSO BE USED IN ALL R.F. STAGES, AUDIO STAGES,AS WELL AS FOR A DETECTOR. IT IS NOT, HOWEVER SUITABLE FOR USE IN THE POWER STAGE.

THE -27 REQUIRES A FILAMENT OR HEATER VOLTAGE OF 2.5 VOLTS AND THE CURRENT DRAWN BY THE FILAMENT IS 1.75 AMPERES. IT HAS AN AMPLIFICATION FACTOR OF ABOUT 8 AND THE REQUIRED PLATE VOLTAGE,WHEN USING THIS TUBE AS A GRID CONDENSER AND LEAK DETECTOR, IS 45 VOLTS. THE GRID CONDENSER SHOULD THEN HAVE A CAPACITY RATING OF .00025 MFD.AND THE LEAK SHOULD HAVE A RESISTANCE OF 2 MEGOHMS. THE GRID BIAS SHOULD BE ZERO.

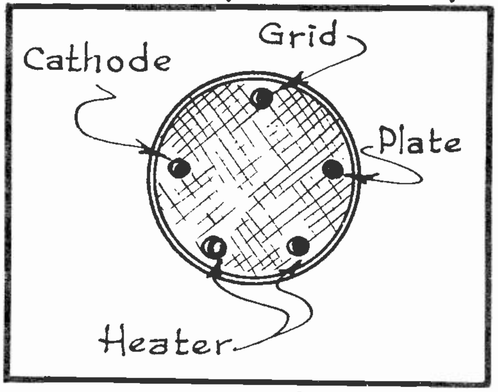

FIG. 6
Socket Arrangement for -27 Tube.

FOR POWER DETECTION THE -27 TUBE SHOULD BE OPERATED WITH A GRID BIAS OF -25 TO -28 VOLTS AND WITH A PLATE POTENTIAL OF +180 TO +250 VOLTS. THERE ARE, HOWEVER, SOME EXCEPTIONS TO THESE AVERAGE OPERATING VOLTAGES, AS YOU SHALL LEARN DURING YOUR PROGRESS THROUGH THE LESSONS TO FOLLOW.

AS AN AMPLIFIER, IT MAY BE OPERATED AT A PLATE VOLTAGE OF +135 VOLTS, TOGETHER WITH A GRID BIAS VOLTAGE OF -9 OR AT A PLATE VOLTAGE OF +180 VOLTS, TOGETHER WITH A GRID BIAS VOLTAGE OF -13.5 VOLTS. IT DRAWS AN AVERAGE PLATE CURRENT OF 5 MILLIAMPERES.

THE -56 TUBE

NEW TUBES ARE CONSTANTLY APPEARING ON THE MARKET TO REPLACE THE OLD

ER TYPES AND AMONG THESE NEWER TUBES WE FIND THE -56 WHICH WAS PRODUCED TO REPLACE THE -27. THE -56 IS SUPERIOR TO THE -27 IN MANY RESPECTS--ITS MOST IMPORTANT IMPROVEMENTS ARE THAT ITS FILAMENT CURRENT HAS BEEN REDUCED TO 1 AMPERE WITH THE SAME APPLIED VOLTAGE OF 2.5 VOLTS; THE AMPLIFICATION FACTOR HAS BEEN INCREASED TO 13.5 AND ITS OVER-ALL SIZE IS SMALLER THAN THAT OF THE -27. THE TONE QUALITY OFFERED BY THE -27, HOWEVER, IS IN SOME CASES BETTER.

A PHOTOGRAPH OF THE -56 APPEARS IN FIG. 7 AND ALTHOUGH SMALLER IN SIZE THAN THE -27, IT IS CONSTRUCTED ALONG THE SAME LINES AS ITS PREDECESSOR, CONSISTING OF A HEATER OR FILAMENT, CATHODE, CONTROL GRID AND A PLATE. THE SYMBOL, BASE AND SOCKET CONNECTIONS FOR THE -56 ARE IDENTICAL TO THOSE OF THE -27.

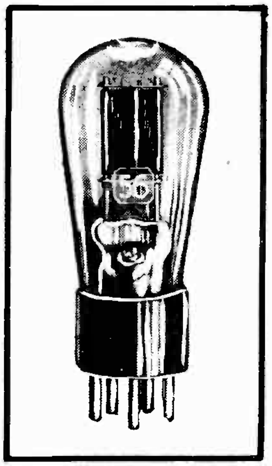

FIG.7
The -56 Tube.

WHEN USED AS A GRID CONDENSER AND LEAK TYPE DETECTOR, THE -56 SHOULD BE OPERATED WITH A PLATE VOLTAGE OF +45 VOLTS AND A GRID BIAS OF ZERO VOLTS. THE GRID CONDENSER MAY HAVE A VALUE OF .00025 MFD. AND THE GRID LEAK VALUE MAY RANGE FROM 1 TO 5 MEGOHMS.

FOR POWER DETECTION, THE PLATE VOLTAGE SHOULD BE 250 VOLTS AND THE GRID BIAS -20 VOLTS. THE PLATE CURRENT UNDER THESE CONDITIONS WILL BE ABOUT 0.2 MA. WITH NO A.C. SIGNAL INPUT.

THE TYPE -56 TUBE OPERATES BEST AS AN A.F. AMPLIFIER WITH A PLATE POTENTIAL OF +250 VOLTS AND A GRID BIAS OF -13.5 VOLTS. THE PLATE CURRENT UNDER THESE CONDITIONS WILL BE 5 MA.

THE TYPE -10 TUBE

FIG. 8
The -10 Tube.

THE NEXT TUBE TO BE BROUGHT TO YOUR ATTENTION IS THE TYPE -10. THIS IS A POWER AMPLIFIER WHOSE FILAMENT MAY BE FURNISHED WITH EITHER A D.C. OR A.C. 7.5 VOLT SUPPLY. IT DRAWS A NORMAL FILAMENT CURRENT OF 1.25 AMP.

THE -10 IS A TRIODE WITH A BASE OF CONVENTIONAL UX DESIGN. IT HAS A RATED AMPLIFICATION FACTOR OF 8 AND WHEN OPERATED WITH A PLATE VOLTAGE OF +250 VOLTS AND A GRID BIAS OF -22 VOLTS, IT WILL DRAW 10 MA. OF PLATE CURRENT AND FURNISH A POWER OUTPUT OF 400 MILLIWATTS. WITH A PLATE VOLTAGE OF +350 VOLTS AND A GRID BIAS OF -31 VOLTS, ITS NORMAL PLATE CURRENT IS INCREASED TO A VALUE OF 16 MA. AND ITS RATED OUTPUT POWER TO 900 MILLIWATTS. IF THE PLATE VOLTAGE IS RAISED TO A VALUE OF 425 VOLTS, AND ITS GRID BIAS TO -39 VOLTS, THEN ITS PLATE CURRENT BECOMES 18 MA. AND ITS RATED OUTPUT POWER 1600 MILLIWATTS. A PICTURE OF THE TYPE -10 TUBE APPEARS IN FIG. 8.

THE TYPE -45 TUBE

THE -45 TUBE WAS THE MOST POPULAR A.C. POWER TUBE FOR RECEIVER PURPOSES OVER A CONSIDERABLE PERIOD OF TIME. IT IS A REGULAR FILAMENT--TYPE TRIODE, HAVING FOUR BASE PRONGS IN THE STANDARD UX ARRANGEMENT. THIS TUBE ONLY HAS AN AMPLIFICATION FACTOR OF 3.5 BUT IT WILL HANDLE LARGE AMOUNTS

OF POWER WITHOUT DISTORTION.

THE THICK FILAMENT, WHICH CARRIES A.C. AND AT THE SAME TIME ACTS AS THE ELECTRON EMITTER, REQUIRES A VOLTAGE OF 2.5 VOLTS AND THE CURRENT DRAWN BY IT IS 1.5 AMPERES. THE PLATE VOLTAGE USED WITH THIS TUBE CAN BE FROM ABOUT 90 UP TO 250 VOLTS AND THE NEGATIVE C BIAS VOLTAGE WILL BE ANYWHERE BETWEEN 15 AND 50 VOLTS.

THE RELATIONS BETWEEN VARIOUS OF THESE PLATE VOLTAGES, GRID BIAS VOLTAGES AND PLATE CURRENTS ARE AS FOLLOWS:

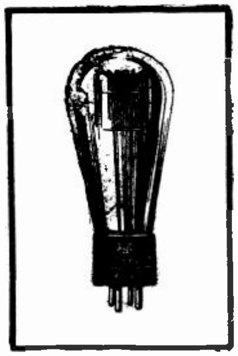

FIG. 9
The -50

PLATE VOLTAGE	GRID BIAS VOLTAGE	PLATE CURRENT
90	-15	14 MA.
120	-21.0	19 "
150	-27.5	23 "
180	-34.0	26 "
250	-50.0	32 "

IT IS MOST COMMON TO OPERATE THE -45 AS A POWER AMPLIFIER WITH A PLATE VOLTAGE OF 250 VOLTS AND A GRID BIAS OF -50 VOLTS. OPERATING UNDER THESE CONDITIONS, THE RATED POWER OUTPUT OF THE TUBE IS 1600 MILLIWATTS OR SLIGHTLY BETTER THAN 1 1/2 WATTS.

THE TYPE -50 POWER AMPLIFIER

THE TYPE -50 POWER AMPLIFIER WHICH IS ILLUSTRATED FOR YOU IN FIG. 9 IS ALSO OF THE CONVENTIONAL TRIODE DESIGN, CONTAINING A FILAMENT, GRID AND PLATE, TOGETHER WITH A STANDARD FOUR-PRONG BASE ARRANGEMENT. ITS AMPLIFICATION FACTOR IS 3.8 OR ONLY SLIGHTLY GREATER THAN THAT OF THE -45, HOWEVER, IT IS CAPABLE OF DELIVERING A POWER OUTPUT OF NEARLY THREE TIMES THAT OF THE -45 AND THIS IS WHY IT MET WITH SUCH POPULARITY IN PUBLIC ADDRESS EQUIPMENT, ETC., WHERE CONSIDERABLE SIGNAL POWER IS TO BE HANDLED.

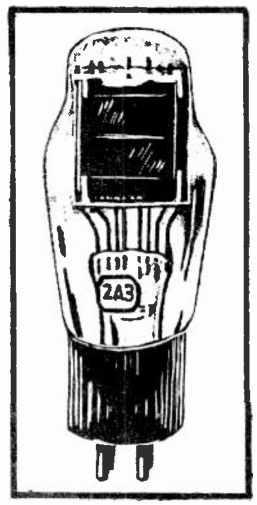

FIG. 10
The 2A3

THE -50 REQUIRES A FILAMENT VOLTAGE OF 7.5 VOLTS AND DRAWS A FILAMENT CURRENT OF 1.25 AMP WITH AN APPLIED PLATE VOLTAGE OF +250 VOLTS AND A GRID BIAS OF -45 VOLTS, IT WILL DRAW A NORMAL PLATE CURRENT OF 28 MILLIAMPERES AND DELIVERS A POWER OUTPUT OF 1000 MILLIWATTS.

BY USING A PLATE VOLTAGE OF 450 VOLTS AND A GRID BIAS OF -84 VOLTS, THE PLATE CURRENT BECOMES 55 MILLIAMPERES AND THE OUTPUT POWER 4600 MILLIWATTS.

THE 2A3

THE 2A3, WHICH IS ILLUSTRATED IN FIG. 10, IS A TRIODE-TYPE POWER AMPLIFIER OF NEW DESIGN WHICH IS CAPABLE OF HANDLING A RATHER LARGE OUTPUT POWER. ALTHOUGH THIS TUBE HAS A STANDARD UX BASE TO WHICH ITS ELEMENTS ARE CONNECTED IN THE CONVENTIONAL TRIODE ARRANGEMENT, YET ITS FIL-

AMENT CONSTRUCTION IS SOMEWHAT OUT OF THE ORDINARY. THIS DIFFERENCE IN FILAMENT CONSTRUCTION LIES IN THE FACT THAT THE FILAMENT IS COMPOSED OF A LARGE NUMBER OF COATED FILAMENTS ARRANGED IN A SERIES-PARALLEL COMBINATION SO AS TO PROVIDE A VERY LARGE ELECTRON EMITTING AREA. THE FILAMENT AS A WHOLE, HOWEVER, HAS ITS EXTREMITIES CONNECTED TO TWO OF THE BASE PRONGS IN THE REGULAR WAY.

THE FILAMENT OF THE 2A3 IS RATED AT 2.5 VOLTS. WHEN USED SINGLY, IT SHOULD BE OPERATED WITH A PLATE VOLTAGE +250 VOLTS AND A GRID BIAS OF -42 VOLTS. THE PLATE CURRENT WILL THEN BE 60 MA. AND THE UNDISTORTED POWER OUTPUT 3.5 WATTS.

WHEN USED IN PUSH-PULL, TWO OF THESE TUBES WILL TOGETHER HANDLE AN OUTPUT POWER OF 15 WATTS. TO REALIZE THIS OUTPUT UNDER THESE CONDITIONS, THE PLATE VOLTAGE SHOULD BE 300 VOLTS PER TUBE AND A GRID BIAS OF -62 VOLTS PER TUBE. THE PLATE CURRENT PER TUBE WILL THEN BE 40 MA.

FIG. 11
The -47 Pentode

THE -47 POWER PENTODE

YOU ARE ALREADY FAMILIAR WITH THE CONSTRUCTIONAL PRINCIPLES, OPERATION AND ADVANTAGES DERIVED THRU THE USE OF THE PENTODE TYPE POWER AMPLIFIER IN BATTERY OPERATED RECEIVERS. ALL THAT WAS MENTIONED CONCERNING BATTERY-TYPE POWER PENTODES APPLIES EQUALLY WELL TO POWER PENTODES IN GENERAL AS USED IN A.C. RECEIVERS, WITH THE EXCEPTION OF THE OPERATING CHARACTERISTICS OF THE TUBES THEMSELVES AND SOME MINOR DIFFERENCES IN CONSTRUCTION SO AS TO ADAPT THEM TO THE PARTICULAR A.C. CIRCUIT REQUIREMENTS.

THE TYPE -47 A.C. POWER PENTODE IS SHOWN YOU IN FIG. 11 AND ITS SYMBOL APPEARS IN FIG. 12 TOGETHER WITH THE CORRESPONDING SOCKET ARRANGEMENT AS VIEWED FROM ABOVE. NOTICE THAT THE SYMBOL FOR THE -47 IS THE SAME AS THAT FOR THE -33 BATTERY TYPE POWER PENTODE. THE SAME IS TRUE IN RESPECT TO THE BASE PRONG AND SOCKET ARRANGEMENT.

THE OPERATING CHARACTERISTICS OF THE -47 ARE AS FOLLOWS:

FILAMENT	1.5 AMPERES AT 2.5 VOLTS
PLATE VOLTAGE	250 VOLTS (MAXIMUM)
SCREEN GRID VOLTAGE	250 " "
CONTROL GRID BIAS VOLTAGE	-16.5 "
PLATE CURRENT	32 MA.
SCREEN GRID CURRENT	7.5 MA.
AMPLIFICATION FACTOR	90
POWER OUTPUT	2500 MILLIWATTS.

FROM THE PRECEDING SPECIFICATIONS OF THE -47, YOU WILL NOTE THAT THIS TUBE OFFERS A HIGH AMPLIFICATION FACTOR IN ADDITION TO GOOD POWER HANDLING ABILITY. BECAUSE OF THESE TWO QUALITIES, IT IS COMMON TO FIND A TUBE OF THIS TYPE IMMEDIATELY FOLLOWING THE DETECTOR, THUS DOING AWAY WITH THE NEED FOR A STAGE OF A.F. AMPLIFICATION BETWEEN THE DETECTOR AND POWER STAGES. THIS IS ESPECIALLY TRUE IN RECEIVERS OF MIDGET DESIGN, AS YOU SHALL LEARN IN LATER LESSONS.

THE -46 POWER AMPLIFIER

THE -46 IS A POWER AMPLIFIER TUBE OF SPECIAL CONSTRUCTION WHICH WAS DESIGNED PRIMARILY FOR USE IN WHAT ARE KNOWN AS CLASS "B" A.F. AMPLIFIERS AND WHICH WILL BE EXPLAINED TO YOU IN DETAIL A LITTLE LATER ON. IN GENERAL OUTWARD APPEARANCE, THIS TUBE IS NOT UNLIKE THE CONVENTIONAL TYPE AS CAN BE READILY SEEN UPON INSPECTING FIG. 13.

THE SYMBOL FOR THE -46 IS SHOWN YOU IN FIG. 14 AND YOU WILL NO DOUBT IMMEDIATELY RECOGNIZE IT AS BEING THE SAME AS THAT OF THE TYPE -32 SCREEN GRID TUBE. THIS TUBE HAS A FIVE PRONG STANDARD BASE AND WILL BE ACCOMMODATED BY THE SAME SOCKET ARRANGEMENT AS ALREADY SHOWN YOU IN THIS LESSON IN RESPECT TO THE -47 TUBE.

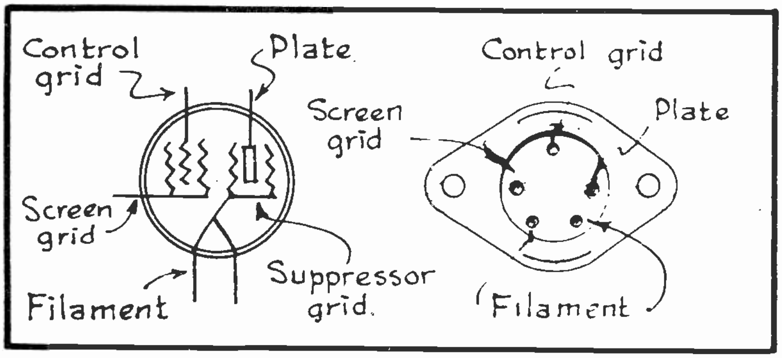

FIG. 12
Symbol and Socket Lay-out for -47 Pentode.

FOR CLASS "B" OPERATION, THE SCREEN GRID TERMINAL IS CONNECTED TO THE CONTROL GRID TERMINAL AT THE SOCKET AND NO BIAS VOLTAGE IS EMPLOYED. THE FILAMENT OF THE TUBE DRAWS 1.75 AMPERES AT 2.5 VOLTS.

WHEN OPERATED WITH A PLATE VOLTAGE OF 300 VOLTS, THE PLATE CURRENT REACHES A VALUE 4 MA. AND THE OUTPUT POWER IS 8000 MILLIWATTS. WITH 400 VOLTS APPLIED TO THE PLATE, THE PLATE CURRENT BECOMES 6 MA. AND THE OUTPUT POWER 10000 MILLIWATTS.

POWER TUBES WITH INDIRECT HEATERS

IN ALL OF THE A.C. POWER AMPLIFIER TUBES WHICH WERE DESCRIBED TO YOU SO FAR IN THIS LESSON, THE FILAMENT ITSELF SERVED TO EMIT THE ELECTRONS. ALTHOUGH THIS PRACTICE IS NOT ADVISABLE IN TUBES PRECEDING THE POWER STAGE ON ACCOUNT OF THE ABILITY OF THE FOLLOWING STAGES TO AMPLIFY ANY HUM INTRODUCED INTO ANY OF THE EARLIER STAGES, YET THIS PRACTICE HAS BEEN FOLLOWED CONSIDERABLY AS REGARDS THE POWER AMPLIFIER TUBES. THIS OF COURSE IS DUE TO THE FACT THAT THE POWER TUBE IS INSTALLED IN THE FINAL AMPLIFYING STAGE AND WHAT LITTLE HUM IS INTRODUCED HERE CANNOT BE AMPLIFIED TO ANY GREAT EXTENT.

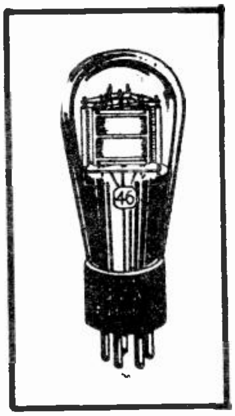

FIG. 13
The -46

THIS ALL WORKED OUT FAIRLY WELL WITH THOSE POWER TUBES HAVING A LOW AMPLIFICATION FACTOR BUT THE POWER PENTODES HAVE SUCH A HIGH DEGREE OF SENSITIVITY THAT THEY AMPLIFY CONSIDERABLY THE HUM ORIGINATING FROM THE PASSAGE OF A.C. THROUGH THEIR FILAMENT. FOR THIS REASON, THE A.C. POWER PENTODES OF MORE RECENT DESIGN ARE OF THE INDIRECT HEATER TYPE IN WHICH CASE THE FILAMENT OR HEATER ELEMENT SIMPLY SERVES TO HEAT THE CATHODE ELECTRON EMITTER, THE SAME AS FOUND IN THE TYPE -27 TUBE.

THE -59 POWER AMPLIFIER

THE FIRST OF THESE INDIRECT HEATER TYPE POWER AMPLIFIERS, WHICH WE

SHALL CONSIDER, IS THE -59 PRESENTED TO YOU IN FIG. 15. THE SYMBOL FOR THIS SAME TUBE IS SHOWN IN FIG. 16 AS IS ALSO THE SOCKET ARRANGEMENT AS VIEWED FROM ABOVE.

THE -59, YOU WILL NOTE, IS EQUIPPED WITH A HEATER (FILAMENT), CATHODE, CONTROL GRID, SCREEN GRID, SUPPRESSOR GRID AND A PLATE. THE ENDS OF THE HEATER ARE CONNECTED TO THE TWO BASE PRONGS HAVING THE GREATEST DIAMETER AND THE CATHODE, CONTROL GRID, SCREEN GRID, SUPPRESSOR GRID AND PLATE THEN EACH HAVE THEIR INDIVIDUAL BASE PRONG CONNECTION AS HERE SHOWN, THUS ACCOUNTING FOR THE SEVEN BASE PRONGS.

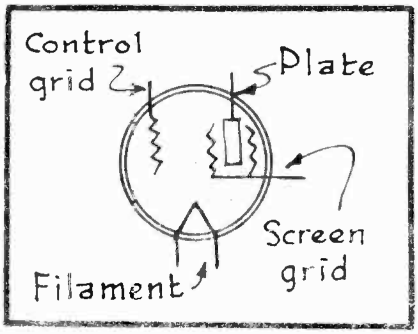

FIG. 14
Symbol of the -46.

BY AVOIDING INTER-ELEMENT CONNECTIONS WITHIN THE TUBE AND SUPPLYING ALL OF THESE CONNECTION FASCILITIES EXTERNALLY, THE TUBE CAN BE ADAPTED TO A VARIETY OF PURPOSES. FOR EXAMPLE, TO OPERATE THE TUBE AS A TRIODE, THE SUPRESSOR AND SCREEN GRIDS ARE BOTH CONNECTED TO THE PLATE, THE PLATE VOLTAGE SHOULD THEN BE 250 VOLTS AND THE GRID BIAS -28 VOLTS. THE PLATE CURRENT WILL THEN BE 38 MA. AND THE OUTPUT POWER 1250 MILLIWATTS. TO OPERATE THE TUBE AS A PENTODE, THE SUPPRESSOR GRID SHOULD BE CONNECTED TO THE CATHODE, THE PLATE VOLTAGE AND SCREEN GRID VOLTAGE SHOULD THEN BE 250 VOLTS AND WITH -18 VOLTS OF BIAS VOLTAGE ON THE CONTROL GRID. THE NORMAL PLATE CURRENT WILL THEN BE 35 MA. AND THE OUTPUT POWER 3000 MILLIWATTS.

FOR CLASS "B" OPERATION, THE CONTROL GRID AND SCREEN GRID SHOULD BE CONNECTED TOGETHER, 400 VOLTS APPLIED TO THE PLATE AND WITH ZERO BIAS VOLTAGE. TWO TUBES ARE GENERALLY OPERATED TOGETHER FOR CLASS "B" AMPLIFICATION AND THE PLATE CURRENT PER TUBE WILL BE 15 MA. AND THE COMBINED POWER OUTPUT OF BOTH TUBES 20 WATTS.

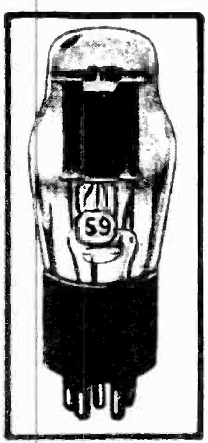
FIG. 15
The - 59

THE FILAMENT CURRENT DRAWN BY THE -59 IS 2 AMPERES AT 2.5 VOLTS.

THE 2A5

THE 2A5 WHICH IS SHOWN YOU IN FIG. 17 IS A POWER AMPLIFIER PENTODE OF THE HEATER-CATHODE OR INDIRECT HEATER TYPE. IT IS CAPABLE OF DELIVERING LARGE POWER OUTPUTS WITH RELATIVELY SMALL SIGNAL VOLTAGES, WHILE AT THE SAME TIME KEEPING HUM AT A VERY LOW LEVEL. IT HAS PRACTICALLY THE SAME POWER HANDLING ABILITY AS THE -59 WHEN USED AS A PENTODE.

THE SYMBOL AND SOCKET ARRANGEMENT FOR THE 2 A 5, AS VIEWED FROM ABOVE, IS SHOWN YOU IN FIG. 18. BY STUDYING THIS SYMBOL, YOU WILL READILY NOTE THAT THE CONSTRUCTION OF THIS TUBE IS QUITE SIMILAR TO THAT OF THE -59, WITH THE EXCEPTION THAT THE SUPPRESSOR GRID IS CONNECTED TO THE CATHODE WITHIN THE TUBE ITSELF, THUS ELIMINATING ONE OF THE BASE PRONGS. CONSEQUENTLY, THE 2A5 HAS SIX BASE PRONGS WHICH ARE ARRANGED TO CORRESPOND WITH THE ILLUSTRATION AT THE RIGHT OF FIG. 18.

THE HEATER BASE PRONGS AND THE CORRESPONDING HOLES OF THE SOCKET

CAN READILY BE DETERMINED BY THE FACT THAT THEY ARE OF LARGEST DIAMETER. THE RELATIVE POSITIONS OF THE REMAINING PRONGS TO THOSE OF THE HEATER WILL THEN BE AS HERE ILLUSTRATED.

THE OPERATING CHARACTERISTICS OF THE 2A5 ARE AS FOLLOWS:

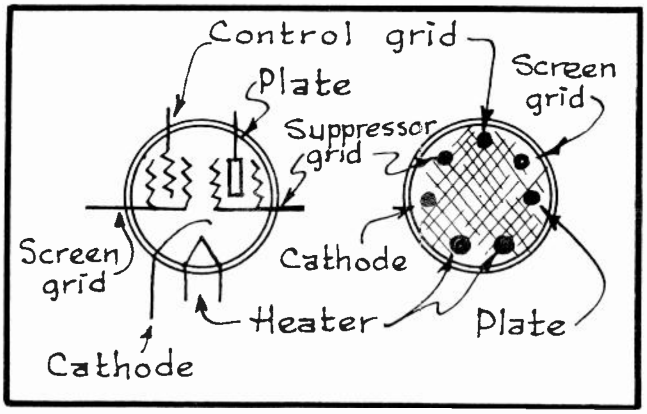

FIG. 16
Symbol and Connections of the -59

HEATER VOLTAGE......	2.5	VOLTS
HEATER CURRENT.....	1.75	AMP.
PLATE VOLTAGE.......	250	VOLTS
SCREEN VOLTAGE......	250	"
GRID BIAS..........	-16.5	"
PLATE CURRENT........	34	MA.
SCREEN CURRENT......	6.5	"
OUTPUT POWER..........	3	WATTS

THE -24

THE -24 IS A HEATER-CATHODE TYPE SCREEN GRID TUBE WHICH IS INTENDED FOR USE PRIMARILY IN THE R.F. AND DETECTOR STAGES OF A.C. RECEIVERS ALTHOUGH IT CAN BE USED AS AN A.F. AMPLIFIER ALSO. ITS INTERNAL CONSTRUCTION IS ILLUSTRATED FOR YOU IN FIG. 19 AND FROM WHICH YOU WILL NOTE THAT IN ITS FUNDAMENTAL CONSTRUCTION, IT IS QUITE SIMILAR TO THE -27 WITH THE EXCEPTION THAT THE CONVENTIONAL SCREEN GRID PRINCIPLES ARE INCORPORATED IN IT.

IN OTHER WORDS, THE -24 CONSISTS OF A HEATER, CATHODE, CONTROL GRID, SCREEN GRID AND PLATE -- ALL ARRANGED IN THE RELATIVE POSITIONS AS SHOWN IN FIG. 19. THE CATHODE IS OF COURSE THE ELECTRON EMITTER IN THIS CASE, BEING HEATED BY THE FILAMENT THE SAME AS IN THE -27 TUBE. THE OTHER OPERATING PRINCIPLES ARE ALL THE SAME AS ALREADY EXPLAINED TO YOU REGARDING BATTERY-TYPE SCREEN GRID TUBES.

THE SYMBOL FOR THE -24 IS SHOWN YOU IN FIG. 20 WHILE ITS SOCKET ARRANGEMENT AS VIEWED FROM ABOVE IS ILLUSTRATED IN FIG. 21. NOTICE THAT THIS IS A STANDARD UY OR FIVE PRONG SOCKET THE SAME AS THAT USED IN CONJUNCTION WITH THE -27, ONLY THAT THE TERMINAL WHICH IS USED FOR THE CONTROL GRID CONNECTION WITH THE -27 TUBE IS USED AS THE SCREEN GRID CONNECTION WITH THE -24.

FIG. 17
The 2A5

THE CONTROL GRID CONNECTION FOR THE -24 TUBE IS MADE AT THE METAL CAP TERMINAL ON TOP OF ITS GLASS BULB THE SAME AS FOR THE -32 AND THE TUBE SHOULD BE HOUSED WITHIN A METAL SHIELD CAN IN ORDER TO REALIZE ITS BEST PERFORMANCE.

THE HEATER OF THE -24 DRAWS 1.75 AMP AT 2.5 VOLTS. TO OPERATE IT AS AN R.F. AMPLIFIER, THE PLATE VOLTAGE SHOULD BE +180 VOLTS, THE SCREEN VOLTAGE +75 VOLTS AND THE GRID BIAS -1.5 VOLTS. THE TUBE WILL THEN DRAW AN AVERAGE PLATE CURRENT OF 4 MA. AND OFFERS A RATED AMPLIFICATION FACTOR OF 420. THIS FULL AMPLIFICATION FACTOR, HOWEVER, IS NOT REALIZED IN ACTUAL PRACTICE.

TO OPERATE THE -24 AS A POWER DETECTOR, USE A PLATE VOLTAGE OF +250 TO +275 VOLTS, A SCREEN VOLTAGE OF +30 TO +45 VOLTS AND A GRID BIAS OF -5 VOLTS. THE PLATE CURRENT WILL THEN BE APPROXIMATELY 0.1 MA.

AS A GENERAL RULE, THE SCREEN CURRENT OF SCREEN GRID TUBES IS ABOUT 1/3 THAT OF THE NORMAL PLATE CURRENT.

THE -24 A

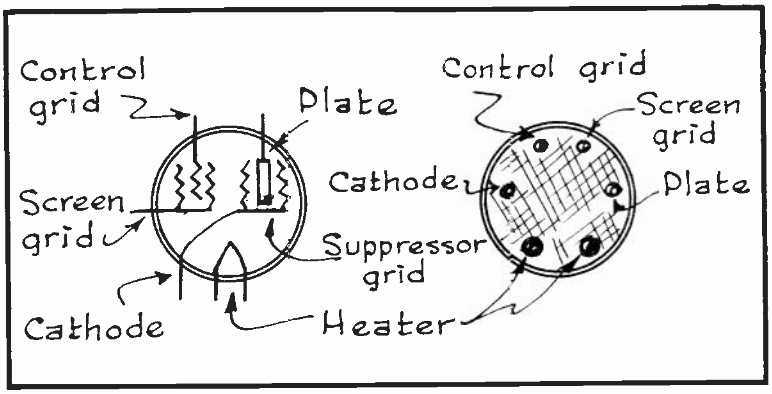

FIG. 18
Symbol and Socket Arrangement of the 2A5.

IN GENERAL CONSTRUCTION THE -24A IS IDENTICAL TO THE -24 WITH A FEW MINOR REFINEMENTS WHICH MAKE IT ESPECIALLY ADAPTABLE FOR USE AS A POWER DETECTOR OR A.F. AMPLIFIER. TO OPERATE IT AS A POWER DETECTOR, OR R.F. AMPLIFIER, THE SAME OPERATING CHARACTERISTICS APPLY AS ALREADY GIVEN FOR THIS SAME PURPOSE IN RESPECT TO THE -24. AS AN A.F. AMPLIFIER, THE PLATE VOLTAGE SHOULD BE 250 VOLTS, THE SCREEN GRID VOLTAGE 25 VOLTS AND THE GRID BIAS -1 VOLT. THE NORMAL PLATE CURRENT WITH NO SIGNAL WILL THEN BE 0.5 MA. AND ITS RATED AMPLIFICATION FACTOR 1000.

THE -35 AND -51

THE TYPE -35 AND -51 ARE BOTH SCREEN GRID TUBES OF THE HEATER-CATHODE TYPE THE SAME AS THE -24. HOWEVER, THE ARRANGEMENT OF THE CONTROL GRID IS SUCH THAT THE AMPLIFICATION FACTOR OF THE TUBE VARIES IN RELATION WITH THE VALUE OF THE GRID BIAS VOLTAGE. IN OTHER WORDS, BY MAKING THE GRID BIAS VOLTAGE MORE NEGATIVE, THE AMPLIFICATION FACTOR OF THE TUBE IS LOWERED. THEREFORE, BY CONTROLLING THE BIAS VOLTAGE, WE HAVE IN EFFECT AN EFFICIENT MEANS FOR CONTROLLING THE VOLUME. SINCE THE GREEK LETTER "MU" IS USED TO DESIGNATE A TUBE'S AMPLIFICATION FACTOR, THE TYPE -35 AND -51 TUBES ARE CLASSIFIED AS VARIABLE -MU TUBES. THE -35 AND -51 TUBES ARE IDENTICAL AND THEREFORE CAN BE REPLACED BY EACH OTHER -- IT IS SIMPLY A CASE OF SOME MANUFACTURERS USING A DIFFERENT NUMBERING CODE FOR THE SAME TUBE.

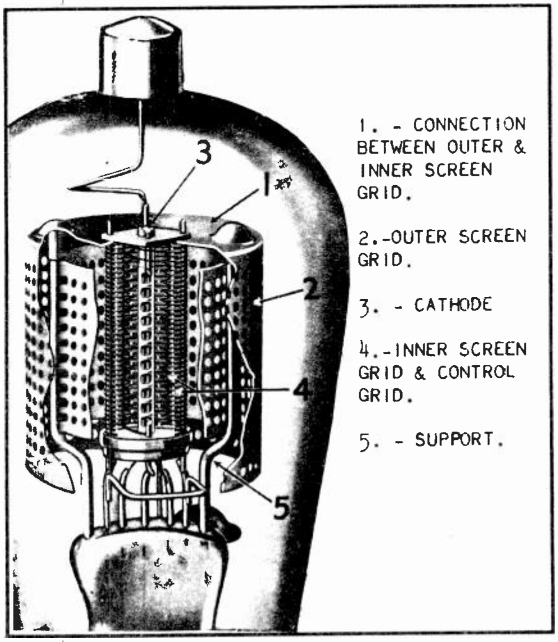

FIG. 19
Construction of the -24 Tube.

THE TUBE ITSELF IS SHOWN YOU IN FIG. 22, WHEREAS ITS SYMBOL APPEARS IN FIG. 23. OBSERVE THE CLOSE RESEMBLANCE TO THE -24 AS

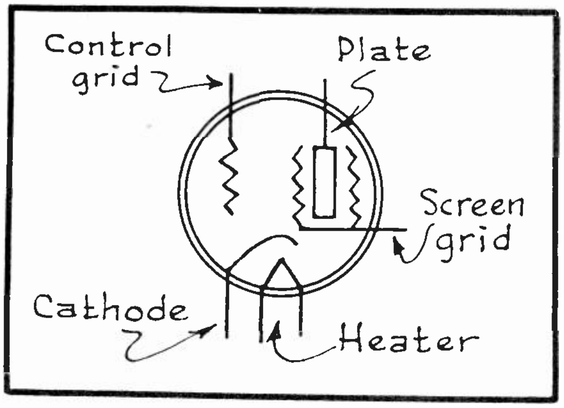

FIG. 20
Symbol of the -24.

REGARDS BOTH THE ACTUAL APPEARANCE AND SYMBOL OF THE TUBE. THE SMALL ARROW WHICH IS INCORPORATED IN THE CONTROL GRID ELEMENT OF THE SYMBOL INDICATES THE FACT THAT THE TUBE HAS VARIABLE-MU CHARACTERISTICS.

THE SOCKET ARRANGEMENT AND CONNECTIONS FOR THE -35 AND -51 ARE EXACTLY THE SAME AS USED FOR THE -24.

THIS VARIABLE-MU TUBE IS STRICTLY AN R.F. AMPLIFIER AND ITS OPERATING CHARACTERISTICS ARE AS FOLLOWS:

HEATER VOLTAGE	2.5 VOLTS
" CURRENT	1.75 AMP.
PLATE VOLTAGE	250 VOLTS
SCREEN GRID VOLTAGE	90 "
GRID BIAS VOLTAGE	-3 TO -50 VOLTS (VARIABLE WITHIN THESE LIMITS.)
PLATE CURRENT	6.5 MA.
SCREEN "	2 "
AMPLIFICATION FACTOR	370 (APPROXIMATELY.)

R.F. PENTODES

IN ADDITION TO THE USE OF PENTODE AMPLIFIER TUBES IN THE POWER STAGE, PENTODES OF SPECIAL DESIGN ARE ALSO NOW BEING USED IN THE R.F., DETECTOR, OR INTERMEDIATE A.F. STAGES. AMONG THESE SO-CALLED R.F. PENTODES, WE FIND THE TYPE -57 AND -58 TUBES EXTENSIVELY USED. THESE TWO TUBES ARE ALSO KNOWN AS "TRIPLE - GRID AMPLIFIERS".

THE -57

THIS TUBE IS A GENERAL-PURPOSE PENTODE. IT INCLUDES MANY IMPROVEMENTS AND IS ADAPTED TO A WIDE VARIETY OF USES. FOR EXAMPLE, IT IS IDEALLY SUITED FOR OPERATION, AS A POWER DETECTOR, AS A SCREEN-GRID R.F. OR A.F. AMPLIFIER, OR ELSE IT CAN BE USED AS AN AUTOMATIC VOLUME CONTROL TUBE. IN GENERAL, IT IS REPLACING THE -24 AND -24A IN RECEIVERS OF MORE MODERN DESIGN.

IN ORDER THAT YOU MAY GAIN A CLEARER UNDERSTANDING OF THE GENERAL CONSTRUCTIONAL FEATURES OF THE NEW -57 TUBE, THE ILLUSTRATION OF FIG. 25 HAS BEEN PREPARED FOR YOU.

AT THE LEFT OF FIG. 25, YOU ARE LOOKING AT THE SYMBOL OF THIS TUBE. AS YOU WILL OBSERVE, THE HEATER AND CATHODE ARRANGEMENT ARE CONVENTIONAL. THE SCREEN GRID SURROUNDS THE CONTROL GRID AND THE SUPPRESSOR GRID SURROUNDS THE PLATE.

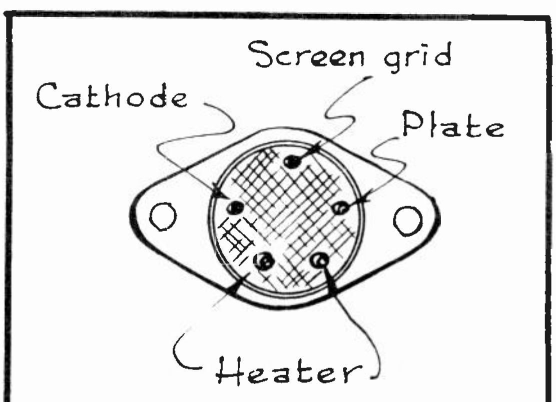

FIG. 21
Socket Arrangement for the -24.

THE CONTROL GRID CONNECTION FOR THIS TUBE IS MADE TO THE CAP ON TOP OF THE GLASS BULB, WHILE THE OTHER TUBE ELEMENTS ARE EACH CONNECTED INDIVIDUALLY TO THE SIX PRONGS PROVIDED ON THE TUBE BASE. THE SIX PRONG BASE ARRANGEMENT FOR THE TYPE -57 TUBE IS ILLUSTRATED FOR YOU AT THE RIGHT OF FIG. 25 AND THE DOTTED CIRCLE AT THE CENTER REPRESENTS THE CONTROL-GRID CONNECTION CAP AT THE TOP OF THE GLASS BULB.

FIG. 22
The -35

BY HAVING THE SUPPRESSOR GRID CONNECTED TO AN INDIVIDUAL BASE PRONG, THE TUBE IS MADE MORE FLEXIBLE IN ITS APPLICATION TO SPECIAL CIRCUIT DESIGNS. FOR EXAMPLE, BY CONNECTING THE SUPPRESSOR GRID PRONG TO THE CATHODE PRONG, THE TUBE CAN BE MADE TO FUNCTION AS A CUSTOMARY PENTODE, YET THIS SUPPRESSOR GRID TERMINAL IS SEPARATE FROM ALL OTHERS, SO THAT IT CAN BE CONNECTED TO ANY OTHER POINT WHICH MAY BE DESIRABLE FOR ANY PARTICULAR CIRCUIT.

A TUBE OF SUCH AN ENORMOUS AMPLIFYING POWER, AS OFFERED BY THIS -57, NEEDS PERFECT SHIELDING. THEREFORE, THE TOP OF THE GLASS BULB IS ESPECIALLY DESIGNED TO ACCOMMODATE A SPECIAL INTERNAL SHIELD. AS MAY BE SEEN FROM THE ILLUSTRATION IN FIG. 24, THIS INTERNAL SHIELD IS PLACED WITHIN THE BULB DOME, DIRECTLY ABOVE THE ELEMENT ASSEMBLY AND IT IS CONNECTED WITHIN THE BULB TO THE CATHODE.

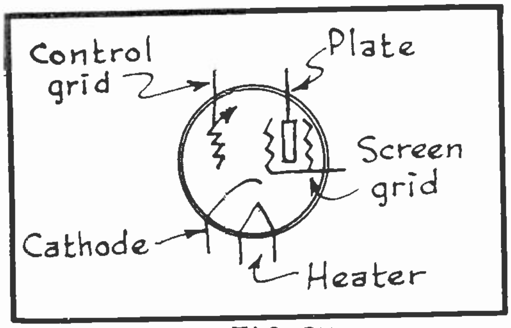

FIG. 23
Symbol of the -35 and -51.

THIS DOME-TOP BULB MAKES POSSIBLE THE CLOSE PROXIMITY OF THE EXTERNAL AND INTERNAL SHIELDS, THE CLOSE SPACING OF WHICH MAKES AVAILABLE A LOW EFFECTIVE PLATE-GRID CAPACITY, WHICH IN TURN IS ALL IMPORTANT TO PREVENT OSCILLATION IN A CIRCUIT OF EXCEPTIONALLY HIGH GAIN.

THE EXTERNAL SHIELD CAN FOR THIS TYPE OF TUBE SHOULD BE SHAPED TO CONFORM WITH THE CONTOUR OF THE TUBE BULB.

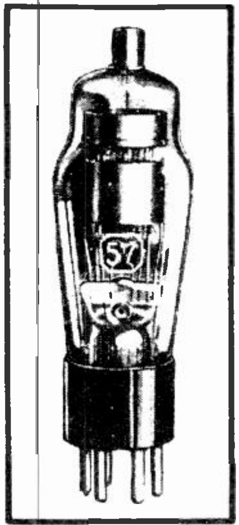

FIG. 24
The - 57.

THE HEATER VOLTAGE FOR THE -57 TUBE SHOULD BE 2.5 VOLTS A.C. AND UNDER THESE CONDITIONS, THE FILAMENT WILL DRAW BUT 1 AMPERE OF CURRENT.

AS AN R.F. AMPLIFIER, THE OPERATING CHARACTERISTICS OF THIS TUBE ARE AS FOLLOWS:

PLATE VOLTAGE = 250 VOLTS; SCREEN-GRID VOLTAGE = 100 VOLTS; CONTROL-GRID BIAS = -3 VOLTS; PLATE CURRENT = 2 MILLIAMPERES; SCREEN CURRENT = 1 MA; AMPLIFICATION FACTOR = 1500.

AS A DETECTOR, THE GRID-BIAS OR POWER DETECTION METHOD IS RECOMMENDED. UNDER THESE CONDITIONS, ALL APPLIED VOLTAGES REMAIN THE SAME AS SPECIFIED FOR ITS USE AS AN R.F. AMPLIFIER, WITH THE EXCEPTION OF THE GRID BIAS, WHICH SHOULD BE CHANGED TO -6 VOLTS. THE PLATE LOAD FOR OPERATING THIS TUBE AS A POWER DETECTOR SHOULD BE EQUIVALENT TO A 250,000 OHM RESISTOR. THE PLATE CURRENT OF THE -57 TUBE IN A POWER

DETECTION CIRCUIT WILL BE APPROXIMATELY .1 MILLIAMPERE.

THE TYPE -58 TUBE

THIS TUBE IS SHOWN YOU IN FIG. 26 AND FROM GENERAL APPEARANCE, IT IS IDENTICAL TO THE -57. IN FACT, THE SOCKET CONNECTIONS FOR BOTH THE -57 AND -58 TUBES ARE ALIKE.

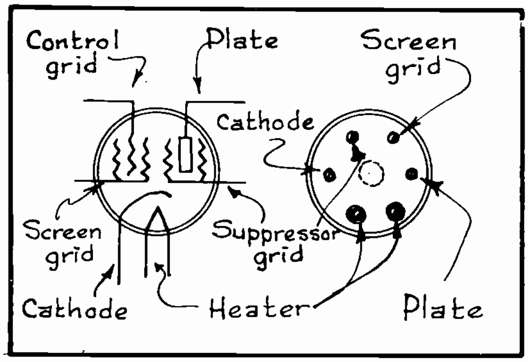

FIG. 25
Arrangement of elements and Connections for -57 Tube.

THE MAJOR DIFFERENCE BETWEEN THESE TWO TUBES IS THAT THE -58 HAS "VARIABLE-MU" CHARACTERISTICS, IN THIS WAY BEING ADAPTABLE TO REPLACING THE TYPE -35 AND -51 SCREEN GRID VARIABLE-MU TUBES. DUE TO THE "VARIABLE-MU" CHARACTERISTICS OF THE -58 TUBE, IT OFFERS AN OPPORTUNITY FOR VOLUME CONTROL BY VARYING ITS GRID BIAS VOLTAGE. THIS, IS THE SMOOTHEST TYPE OF RECEIVER VOLUME CONTROL WHICH IS AVAILABLE AT THE PRESENT TIME.

ANOTHER ADVANTAGE OF THE -58 TUBE OVER THE -57 IS THAT THE -58 IS CAPABLE OF HANDLING GREATER SIGNAL VOLTAGES WITHOUT DISTORTION AS IS THE -57.

SINCE THE SAME GROUP OF ELEMENTS ARE FOUND IN THE -58 AS IN THE -57, THE BASE PRONG ARRANGEMENT FOR BOTH TYPES ARE ALIKE.

FIG. 26
The -58.

THE OPERATING CHARACTERISTIC FOR THE -58 TUBE ARE AS FOLLOWS: HEATER VOLTAGE = 2.5 VOLTS; HEATER CURRENT = 1 AMPERE; PLATE VOLTAGE = 250 VOLTS; SCREEN VOLTAGE = 100 VOLTS; GRID BIAS = -3 TO -50 VOLTS; AMPLIFICATION FACTOR = 1280; PLATE CURRENT = 8.2 MILLIAMPERES; SCREEN CURRENT = 3 MILLIAMPERES.

THE -58 ALSO USES THE SAME SHIELDING AS RECOMMENDED FOR THE -57 AND ALSO EMPLOYS THE INNER SHIELD IN THE DOME OF THE GLASS BULB. THE -58 IS NOT SUITABLE FOR USE AS A DETECTOR.

RECTIFIER TUBES

ALL OF THE TUBES WHICH WE HAVE INVESTIGATED SO FAR IN THIS LESSON UTILIZE AN A.C. SUPPLY FOR THEIR FILAMENT OR HEATER SO AS TO BE ESPECIALLY ADAPTABLE FOR A.C. RECEIVERS. NOW ALTHOUGH ALTERNATING CURRENT CAN BE SATISFACTORILY USED FOR THIS PURPOSE, A DIRECT CURRENT IS STILL NECESSARY TO MEET THE "B" AND "C" REQUIREMENTS OF THE A.C. TYPE RECEIVERS.

THIS "B" AND "C" SUPPLY IS OBTAINED BY UTILIZING THE A.C. AS FURNISHED BY THE LIGHTING CIRCUIT OF THE BUILDING, THEN BOOSTING THE VOLTAGE TO A HIGHER VALUE AND RECTIFYING THE A.C. SO THAT A HIGH VOLTAGE D.C. SUPPLY WILL BE AVAILABLE FOR "B" AND "C" USE. WE EMPLOY SPECIAL RECTIFYING TUBES IN ORDER TO OBTAIN THIS RESULT AND IT IS TO THESE TUBES THAT WE

DIRECT YOUR SPECIAL ATTENTION, IN ORDER THAT YOU MAY BE ABLE TO MAKE THE PROPER APPLICATIONS.

THE -81

THE -81 IS A FILAMENT TYPE RECTIFYING TUBE, WHICH OFFERS HALF-WAVE RECTIFICATION AND IT CONSISTS OF A FILAMENT SUPPORTED IN THE SPACE WITHIN A RECTANGULAR BOX-SHAPED PLATE. FOUR PRONGS PROTRUDE FROM THE BASE OF THIS TUBE AND THE TWO LARGEST ONES HAVE THE ENDS OF THE FILAMENT CONNECTED TO THEM, WHILE THE PLATE IS CONNECTED TO ONE OF THE SMALLER PRONGS. THE REMAINING SMALL PRONG, HOWEVER, IS ONLY A "DUMMY" AND HAS NO ELECTRICAL CONNECTION WHATEVER MADE TO IT.

FIG. 27
The -81 Tube.

THIS PRONG AND SOCKET ARRANGEMENT IS CLEARLY SHOWN IN FIG. 28 AND ALTHOUGH FOUR HOLES ARE PROVIDED IN THE STANDARD UX SOCKET, YET THE CIRCUIT CONNECTIONS ARE ONLY MADE TO THREE OF THEM.

IN FIG. 29 YOU WILL SEE THE SYMBOL FOR THIS -81 HALF-WAVE RECTIFYING TUBE. NOTICE THAT THIS SYMBOL INDICATES THAT THIS TUBE IS ONLY PROVIDED WITH TWO ELEMENTS, THE FILAMENT AND PLATE.

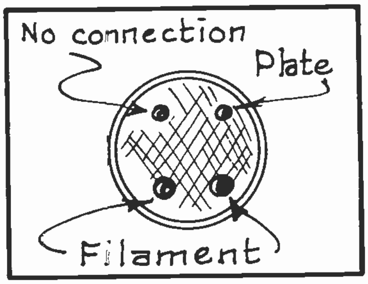

FIG. 28
Socket lay-out for -81

THE FILAMENT OF THIS TUBE REQUIRES THAT A VOLTAGE OF 7.5 VOLTS BE IMPRESSED ACROSS IT AND THE CURRENT DRAWN BY THE FILAMENT UNDER THESE CONDITIONS WILL BE 1.25 AMPERES. THE A.C. VOLTAGE IMPRESSED UPON THE PLATE OF THIS TUBE SHOULD NOT EXCEED 750 VOLTS AND ONLY 650 TO 700 VOLTS IS RECOMMENDED.

THE -81 WILL DELIVER A DIRECT CURRENT OF ABOUT 85 MILLIAMPERES WHEN A PLATE VOLTAGE OF 700 VOLTS IS BEING USED. IT IS, HOWEVER, ALSO POSSIBLE TO USE TWO OF THESE TUBES IN PARALLEL SO THAT FULL-WAVE RECTIFICATION WILL BE OBTAINED WITH A MAXIMUM D. C. LOAD CURRENT OF 130 MILLIAMPERES. YOU WILL SEE HOW THIS IS DONE IN A LATER LESSON.

THE TYPE -80 TUBE

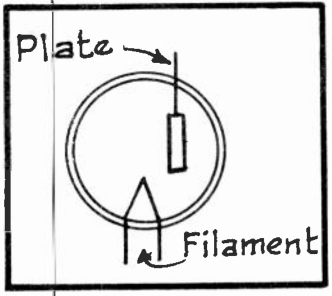

FIG. 29
Symbol for -81

WE ALSO MAKE USE OF THE -80 TYPE TUBE, WHICH IS A FULL-WAVE RECTIFYING TUBE, (SEE FIG. 30). THE INTERNAL CONSTRUCTION OF THIS TUBE IS SHOWN IN FIGURE 31 AND HERE YOU WILL SEE THAT THIS TUBE HAS TWO BOX-SHAPED PLATE ELEMENTS, WITH A FILAMENT SUPPORTED WITHIN THE SPACE OF EACH OF THEM. THESE TWO FILAMENTS ARE INTERNALLY CONNECTED IN SERIES WITH EACH OTHER, SO THAT BOTH OF THEM MAKE USE OF THE SAME TWO FILAMENT PRONGS AT THE BASE OF THE TUBE. EACH OF THE PLATES, HOWEVER, HAS ITS INDIVIDUAL TUBE PRONG.

IN FIG. 32, YOU WILL SEE HOW THE TUBE PRONG AND SOCKET CONNECTIONS ARE MADE, WHEREAS FIG. 33 SHOWS YOU HOW THIS TYPE OF TUBE IS INDICATED IN THE FORM OF A SYMBOL. NOTICE THAT ALL CONNECTIONS AND TERMINALS ARE BEING

USED AND THAT THE SYMBOL INDICATES THE FACT THAT THIS TUBE IS EQUIPPED WITH A FIALMENT AND TWO PLATES.

THE TYPE -80 TUBE REQUIRES A FILAMENT VOLTAGE OF 5 VOLTS AND THE CURRENT DRAWN BY THE FILAMENT WITH THIS APPLIED VOLTAGE IS 2 AMPERES.

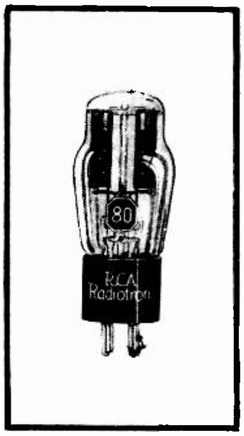

FIG. 30
The -80.

EACH PLATE WILL WITHSTAND A MAXIMUM A.C. VOLTAGE OF ABOUT 350 VOLTS AND THE MAXIMUM OUTPUT OR LOAD CURRENT UNDER THESE CONDITIONS IS 125 MILLIAMPERES.

THE -82

THE -82 IS ALSO A FULL-WAVE RECTIFIER AND HAS A DOUBLE SECTION FILAMENT AND TWO PLATES THE SAME AS THE -80 BUT INSTEAD OF THE GLASS BULB BEING TOTALLY EVACUATED, A QUANTITY OF MERCURY VAPOR IS CONTAINED WITHIN THE BULB. THUS THIS TUBE IS ALSO SPOKEN OF AS BEING A MERCURY-VAPOR RECTIFIER.

THE PURPOSE OF THIS MERCURY VAPOR WITHIN THE TUBE IS TO REDUCE THE D.C. VOLTAGE LOSS DUE TO THE HIGH INTERNAL RESISTANCE GENERALLY ENCOUNTERED IN EVACUATED TUBES AND CAN BE EXPLAINED IN THE FOLLOWING MANNER:

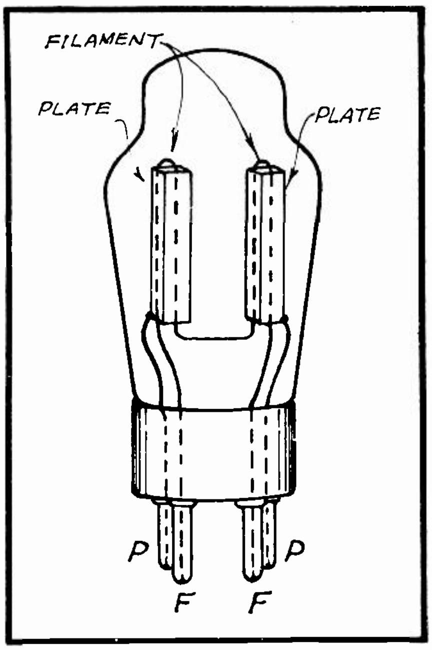

FIG. 31
Construction of the -80

THE HEATED FILAMENT EMITS ELECTRONS WHICH ARE ATTRACTED TOWARDS WHICHEVER OF THE PLATES HAPPENS TO BE POSITIVELY CHARGED AT ANY ONE PARTICULAR INSTANT. THESE ELECTRONS, HOWEVER, ESTABLISH A CLOUD OR SPACE-CHARGE NEAR THE FILAMENT AND THUS OPPOSE THE PASSAGE OF ANY FURTHER ELECTRON FLOW, AS YOU ALREADY KNOW. SUCH AN ACTICN WOULD INCREASE THE INTERNAL RESISTANCE OF THE TUBE BETWEEN THE FILAMENT AND PLATE VERY MATERIALLY AND THEREBY RESULT IN A CONSIDERABLE VOLTAGE DROP WITHIN THE TUBE.

BY INJECTING A CERTAIN QUANTITY OF MERCURY VAPOR INTO THE BULB, THE ELECTRONS WHICH ARE EMITTED BY THE FILAMENT, STRIKE THE ATOMS OF MERCURY VAPOR AND BY COLLISION BREAK UP THE ATOMS OF MERCURY VAPOR INTO THE POSITIVE AND NEGATIVE CHARGES OR PROTONS AND ELECTRONS OF WHICH IT IS COMPOSED. THE ADDITIONAL FREE ELECTRONS OBTAINED IN THIS MANNER ARE ATTRACTED TOWARD THE POSITIVELY CHARGED PLATE TOGETHER WITH THE FILAMENT ELECTRONS, THEREBY INCREASING THE TOTAL PASSAGE OF ELECTRONS IN THE SPACE BETWEEN THE FILAMENT AND PLATE. AT THE SAME TIME, THE REMAINING POSITIVE CHARGES FROM THE DISASSOCIATED MERCURY VAPOR ATOMS NEUTRALIZE THE NEGATIVE SPACE CHARGE AROUND THE FILAMENT. SO ALTOGETHER THEN, THERE IS A COMPARITIVELY FREE PASSAGE OF ELECTRONS FROM THE FILAMENT TO THE POSITIVE PLATE AND THE INTERNAL RESIS-

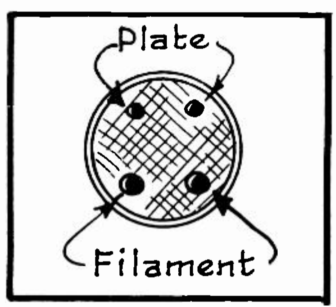

FIG. 32
Socket lay-out for the -80.

tance of the tube is in this way decreased considerably. The D.C. voltage loss within the tube will then be reduced accordingly.

The operating characteristics of the -82 are as follows:

Filament voltage	2.5 Volts
Filament current	3 Amps.
Maximum A.C. voltage per plate	500 Volts
Maximum D.C. output current	125 Ma.

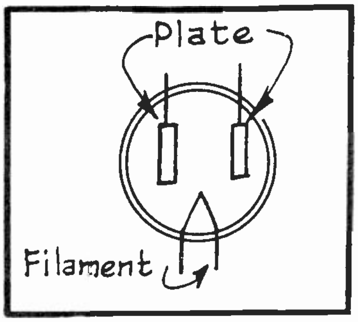

FIG. 33
Symbol of the -80.

THE 83

The type 83 tube is also a full-wave mercury-vapor rectifier the same as the 82, with the exception that it is intended for supplying large amounts of D.C. power to receivers and amplifiers whose requirements are in excess of the rating of the 82. Also the 83 is recommended for heavy-drain receivers and amplifiers in which the direct-current requirements cause considerable variation in the load impressed on the rectifier tube.

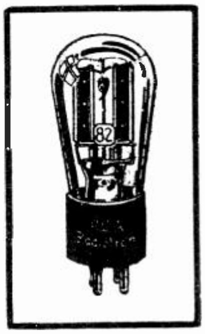

FIG. 34
The -82

The excellent voltage regulation characteristic of the 83 is due to its low and practically constant tube voltage drop of about only 15 volts for any current drain up to the full emission of its filaments.

The symbol of the 83 tube appears in Fig. 35 and as you will observe it is of the four base-prong type containing a double section filament (both sections being connected in series) and two plates.

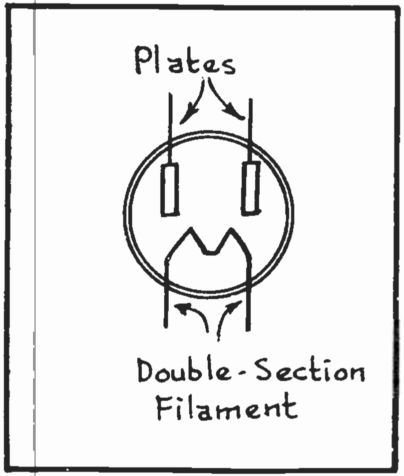

FIG. 35
Symbol of the 83 Tube.

The operating characteristics of the 83 tube are as follows:

Filament voltage (A.C.)...	5 Volts
Filament current	3 Amps.
A.C. voltage per plate ..	500 Volts (max.)
D.C. output current (continuous)........	250 Ma. (max.)
Peak plate current	800 Ma. (max.)
Tube voltage drop	15 Volts (app.)

VARIATIONS IN TUBE SYMBOLS

Tube and receiver manufacturers sometimes differ as to the manner in which they represent the various tube types by means of symbols. Therefore, when checking the circuit diagrams of commercial receivers you will find quite a variety of symbol styles used.

FIG. 36 HAS BEEN PREPARED TO ILLUSTRATE ANOTHER POPULAR STYLE FOR DRAWING THE SYMBOLS OF THE VARIOUS TYPES APPEARING IN THIS LESSON. IT IS ADVISABLE THAT YOU ALSO STUDY THE DESIGNS IN FIG. 36 CAREFULLY SO AS TO BECOME INTIMATELY ACQUAINTED WITH THEM.

AS YOU PROGRESS WITH YOUR STUDIES YOU WILL BE INTRODUCED TO STILL OTHER TYPES OF GLASS TUBES. THESE ADDITIONAL TUBES WILL BE DISCUSSED AS WE HAVE NEED FOR THEM DURING THE EXPLANATIONS OF THE CIRCUITS TO WHICH THEY ARE PARTICULARLY ADAPTED. YOUR PRESENT KNOWLEDGE OF A.C. TUBES IS NOW SUFFICIENT SO THAT YOU CAN INTELLIGENTLY UNDERTAKE THE STUDY OF A.C. RECEIVER CIRCUITS AS IT APPEARS IN THE NEXT LESSON.

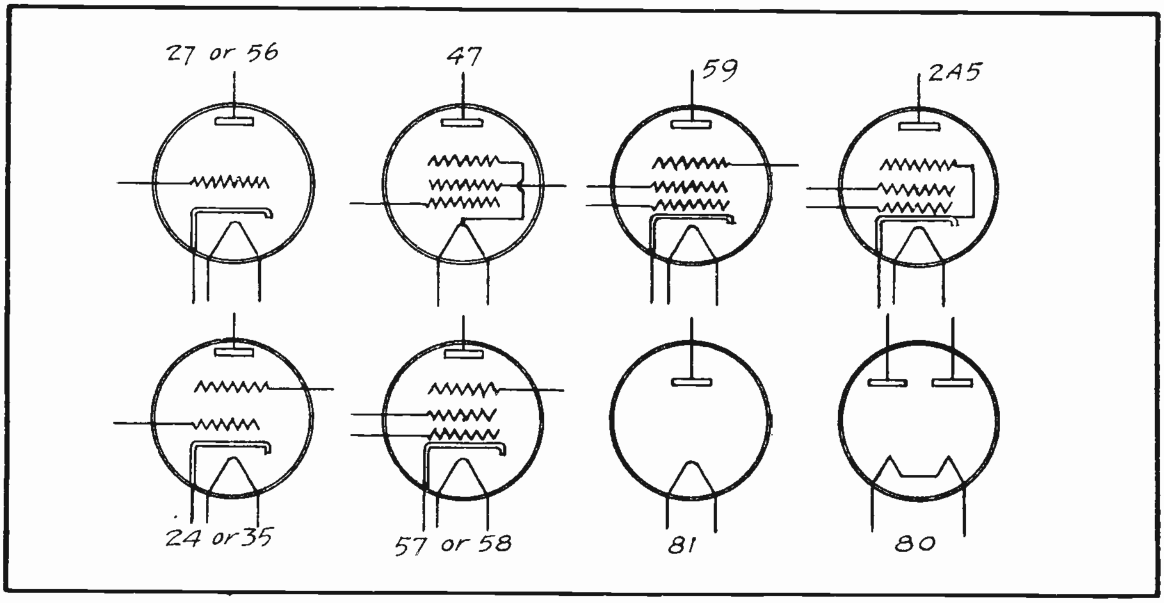

FIG.36
Popular Method of Drawing Tube Symbols.

IT IS NOT ESSENTIAL FOR YOU TO MEMORIZE ALL OF THE MANY TUBE SPECIFICATIONS GIVEN IN THIS LESSON BUT RATHER TO USE THIS LESSON AS A SOURCE OF REFERENCE WHEN YOU HAVE NEED FOR THIS KIND OF INFORMATION. YOU WILL ALSO RECEIVE FROM US A LITTLE LATER ON A COMPLETE TUBE CHART FURNISHING IN COMPACT FORM THE CHARACTERISTICS FOR ALL POPULAR TUBES.

IMPORTANT NOTICE CONCERNING METAL TUBES

YOUR PRESENT STUDIES PERTAINING TO VACUUM TUBES AND THEIR RELATED CIRCUITS ARE CONFINED SOLELY TO THE GLASS TUBES OF BASIC DESIGN. HOWEVER, LATER IN THE COURSE, YOU WILL RECEIVE COMPLETE INFORMATION CONCERNING THE CONSTRUCTION, OPERATING CHARACTERISTICS, AND APPLICATIONS OF ALL TYPES OF GLASS-"METAL", METAL-GLASS, AND ALL-METAL TUBES.

FOR INSTRUCTION PURPOSES, IT IS NOT ADVISABLE TO DISCUSS BOTH THE GLASS AND METAL TUBES WITH YOU AT THE SAME TIME. THE REASON FOR THIS IS THAT THE MORE RECENT METAL TUBES EMPLOY AN ENTIRELY DIFFERENT BASE TERMINAL ARRANGEMENT THAN THE CONVENTIONAL GLASS TUBES AND CONSEQUENTLY IF YOU SHOULD TRY TO FAMILIARIZE YOURSELF WITH ALL OF THESE VARIATIONS AT ONE TIME, THERE IS A POSSIBILITY OF YOUR BECOMING CONFUSED. FROM A

TEACHING STANDPOINT, YOU CAN READILY SEE THAT SUCH A CONDITION WOULD BE ENTIRELY UNSATISFACTORY.

YOU WILL NO DOUBT BE INTERESTED TO KNOW, HOWEVER, THAT AS FAR AS THE INTERNAL ELEMENTS OF THE METAL TUBES ARE CONCERNED, THEY ARE VERY SIMILAR TO THOSE USED IN STANDARD GLASS TUBES. THIS MEANS THAT ALL OF THE TECHNICAL KNOWLEDGE WHICH YOU ARE NOW ACQUIRING RELATIVE TO GLASS TUBES CAN ALSO BE APPLIED DIRECTLY TO METAL TUBES LATER ON.

ANOTHER LOGICAL REASON FOR FAMILIARIZING YOURSELF WITH THE GLASS TUBES FIRST, IS THAT THE GREATEST PERCENTAGE OF RECEIVERS NOW IN USE, WHICH REQUIRE THE MOST ATTENTION OF THE SERVICE MAN, STILL USE GLASS TUBES. THIS IS OBVIOUS IN THAT THE METAL TUBE SETS ARE STILL SO NEW THAT THEY HAVEN'T AS YET BEEN SUBJECTED TO PROLONGED USAGE AS HAVE THE GLASS TUBE SETS. THIS BEING TRUE, YOU WILL AGREE THAT YOUR GREATEST OPPORTUNITIES FOR EARNING MONEY THROUGH SPARE-TIME RADIO SERVICE WORK IS AT THE PRESENT TIME STILL IN THE FIELD OF RECEIVERS EQUIPPED WITH GLASS TUBES.

YOU MUST ALSO CONSIDER THE FACT THAT METAL TUBES HAVE NOT REPLACED THE GLASS TUBES IN ALL CASES AND THAT GLASS TUBES ARE STILL BEING INSTALLED IN SOME OF THE LATEST RADIO EQUIPMENT AND NO DOUBT WILL STILL BE USED TO A CONSIDERABLE EXTENT IN CIRCUITS OF THE FUTURE.

IT IS OF THE UTMOST IMPORTANCE THAT YOU DIRECT YOUR ATTENTION AT THE PRESENT TIME TO THE INSTRUCTION MATERIAL WHICH HAS BEEN PREPARED FOR YOU RELATIVE TO GLASS TUBES. ALSO BEAR IN MIND THAT AT THE PROPER TIME, LATER IN THE COURSE, COMPLETE INFORMATION WILL BE BROUGHT TO YOU CONCERNING METAL TUBES OF ALL TYPES, AS WELL AS OTHER TYPES OF TUBES OF MORE COMPLEX DESIGN AND WHICH DO NOT APPEAR IN THIS PRESENT STUDY OF VACUUM TUBE CIRCUITS.

EXAMINATION QUESTIONS

LESSON NO. 15

1. - WHY IS IT NOT ADVISABLE TO PASS AN ALTERNATING CURRENT THROUGH AN ELECTRON EMITTER OF A TUBE PRECEDING THE POWER STAGE OF A RECEIVER?

2. - WHAT IS THE CHIEF ADVANTAGE DERIVED FROM USING A CATHODE IN CONJUNCTION WITH A FILAMENT OR HEATER IN THE CONSTRUCTION OF A.C. TUBES?

3. - WHAT FILAMENT, PLATE AND GRID BIAS VOLTAGE WOULD YOU EMPLOY TO OPERATE A TYPE -27 TUBE AS AN AMPLIFIER?

4. - WHAT FILAMENT, PLATE AND GRID BIAS VOLTAGE WOULD YOU EMPLOY TO OPERATE A TYPE -56 TUBE AS AN AMPLIFIER?

5. - WHAT FILAMENT, PLATE AND GRID BIAS VOLTAGE WOULD YOU EMPLOY TO OPERATE A TYPE -47 POWER PENTODE?

6. - HOW MUCH PLATE CURRENT DOES A TYPE 2A5 TUBE DRAW?

7. - DESCRIBE BRIEFLY THE CONSTRUCTION OF THE TYPE -24 TUBE.

8. - WHAT IS THE OUTSTANDING DIFFERENCE IN THE CONSTRUCTIONAL AND OPERATING FEATURES BETWEEN THE TYPE -24, -35 AND -57 TUBES?

9. - DESCRIBE BRIEFLY THE CONSTRUCTION OF THE TYPE -58 TUBE.

10. - FOR WHAT PURPOSE IS THE TYPE -80 TUBE INTENDED?

11. - DESCRIBE BRIEFLY THE CONSTRUCTIONAL FEATURES OF THE TYPE -82 TUBE.

DEAR STUDENT

A DAY WITHOUT SOME COURAGE SPRINKLED INTO IT, IS A DAY LITTLE WORTH WHILE, FOR COURAGE MAKES THE MAN. THERE NEVER WAS A REAL MAN WHO DIDN'T HAVE COURAGE.

WE CAN NEVER FAIL IF WE HAVE COURAGE -- BUT WILL SELDOM EVER WIN WITHOUT IT. SO, LET'S HAVE COURAGE.

JAR

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NATIONAL SCHOOLS

Established 1905

Los Angeles, California

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LESSON NO. 16

A. C. RECEIVERS

ALTHOUGH HAVING COMPLETED ONLY FIFTEEN LESSONS, YOU SHOULD NOW BE FAMILIAR WITH A GREAT MANY RADIO PRINCIPLES RELATED TO BATTERY-OPERATED RECEIVER CIRCUITS, BATTERY ELIMINATORS, ETC. YOU CAN NOW EXPAND YOUR

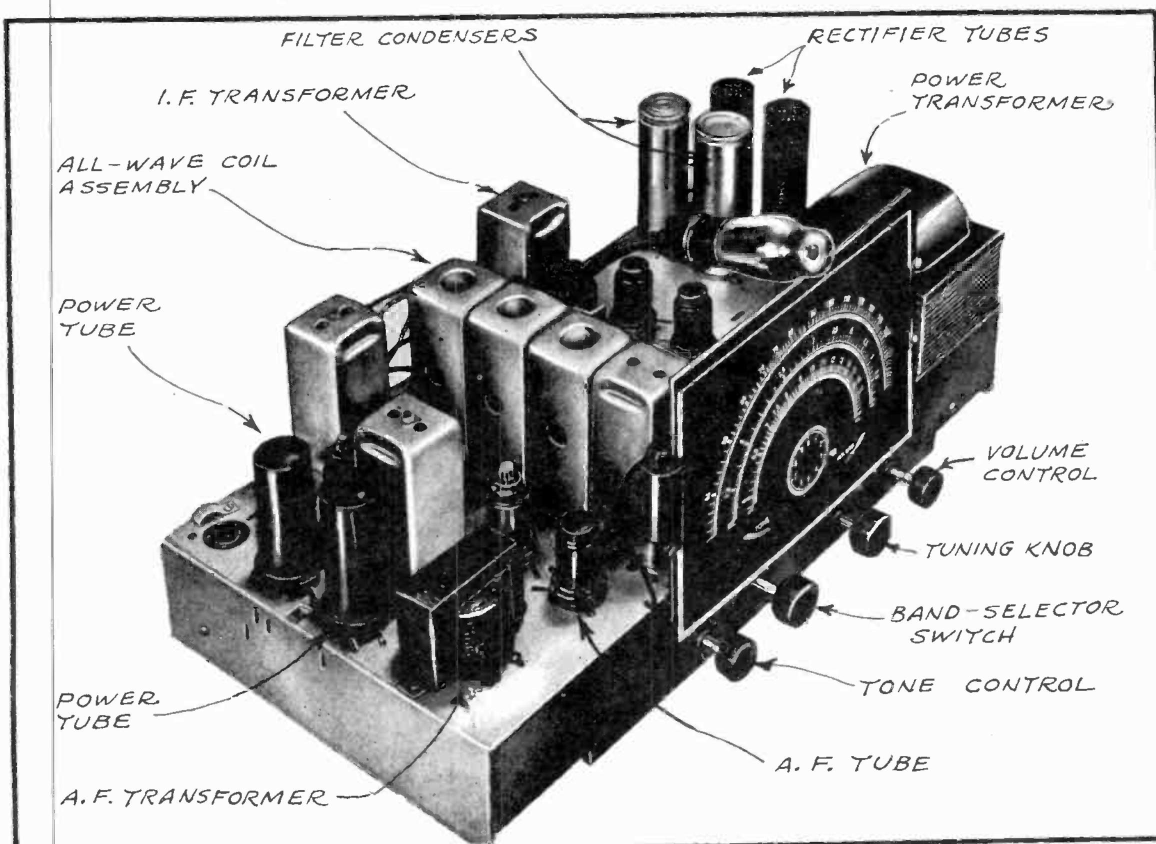

FIG. 1
MODERN METAL-TUBE A.C. RECEIVER

KNOWLEDGE BY LEARNING THE PRINCIPLES UPON WHICH THE SO-CALLED A-C RECEIVERS OPERATE. YOU WILL FIND THE LESSONS TO FOLLOW AS INTERESTING AND INSTRUCTIVE AS THOSE WHICH YOU HAVE ALREADY COMPLETED.

SO FAR AS PERFORMANCE IS CONCERNED, THE BATTERY-OPERATED RECEIVER OF MODERN DESIGN IS REALLY BETTER THAN THE A-C RECEIVER, BECAUSE BATTERIES PRODUCE A SMOOTH AND UNIFORM FLOW OF ELECTRICAL ENERGY THAT IS IDEAL FOR RADIO USE. THE A-C RECEIVER, HOWEVER, IS THE MOST CONVENIENT FROM

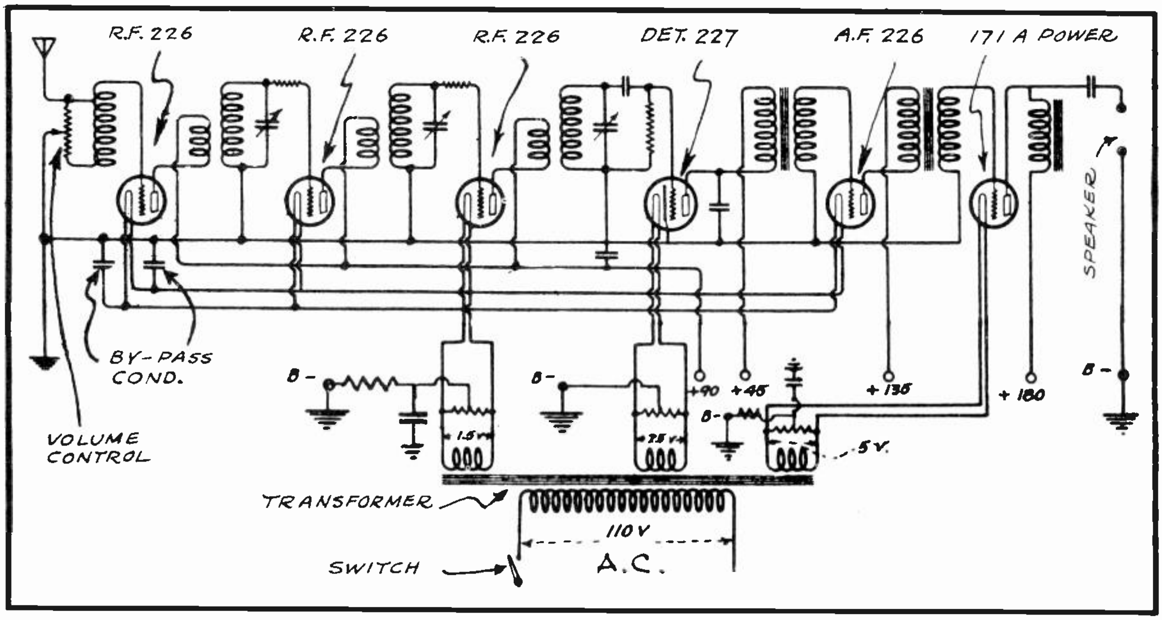

FIG. 2
EARLY SIX-TUBE A.C. RECEIVER CIRCUIT

THE SET-OWNER'S VIEWPOINT, BECAUSE HE HAS ONLY TO PLUG A CONNECTION INTO A LIGHTING CIRCUIT OUTLET, AND IS NEVER TROUBLED BY HAVING TO ADD WATER TO A STORAGE BATTERY, OR PURCHASE A NEW SET OF "B" BATTERIES.

NEARLY EVERYTHING THAT YOU HAVE LEARNED IN YOUR PREVIOUS STUDIES OF BATTERY-TYPE RECEIVERS WILL APPLY EQUALLY TO A-C RECEIVERS, BECAUSE THE FUNDAMENTAL PRINCIPLES SUCH AS TUNING, AMPLIFICATION, DETECTION, ETC., ARE IDENTICAL IN BOTH BASES. THEREFORE, IT IS UNNECESSARY TO GO OVER THE GROUND ALREADY THOROUGHLY COVERED, AND WE CAN PROCEED TO STUDY THOSE FEATURES OF A-C RECEIVERS WHICH WERE NOT FOUND IN THE BATTERY TYPES.

THE LOGICAL ORDER IN WHICH TO STUDY THE VARIOUS FEATURES OF A-C RECEIVERS IS TO COMMENCE WITH THE EARLIER AND EASIER CIRCUITS, AND GRADUALLY ADVANCE, STEP-BY-STEP, TO AND THROUGH CIRCUITS OF RECENT DESIGN. IN THIS WAY YOU WILL HAVE AN OPPORTUNITY TO FAMILIARIZE YOURSELF WITH THE IMPROVEMENTS WHICH HAVE BEEN MADE DURING THE DEVELOPMENT PERIOD OF A-C RECEIVERS, AND IN ADDITION, YOUR STUDY OF THE SUBJECT WILL BE GREATLY SIMPLIFIED.

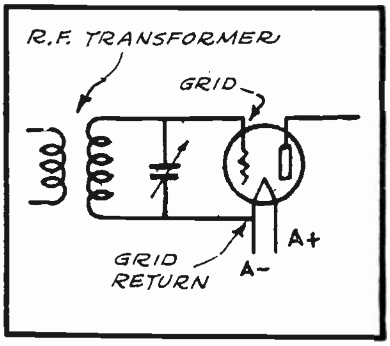

FIG. 3
GRID RETURN CONNECTION

AN EARLY A-C RECEIVER

IN FIG.2 IS SHOWN THE DIAGRAM OF AN EARLY

SIX-TUBE A-C RECEIVER IN WHICH THREE TYPE 26 TUBES ARE USED IN THE R.F. AMPLIFYING STAGES, ONE 26 IN THE A.F. STAGE, A 27 AS DETECTOR, AND A 71A AS THE POWER AMPLIFIER.

THE FIRST CONCERN WILL BE TO PROVIDE A SUITABLE FILAMENT SUPPLY FOR THE TUBES. SINCE ALL OF THE TUBES IN THIS CIRCUIT ARE DESIGNED TO UTILIZE AN A-C FILAMENT SUPPLY OF LOW VOLTAGE, THIS ENERGY CAN BE OBTAINED CONVENIENTLY FROM THE 110-VOLT LIGHTING CIRCUIT OF THE BUILDING, AIDED BY A SPECIAL TRANSFORMER WITHIN THE RADIO RECEIVER. THIS PARTICULAR TRANSFORMER IS OF THE STEP-DOWN TYPE, MEANING THAT WHEN ITS PRIMARY WINDING IS CONNECTED TO THE 110-VOLT A-C CIRCUIT, LOWER VOLTAGES WILL BE AVAILABLE ACROSS THE EXTREMITIES OF ITS SECONDARY WINDINGS. TO MEET THE FILAMENT REQUIREMENTS OF THE TUBES USED IN FIG. 2, FILAMENT VOLTAGES OF 1.5, 2.5, AND 5 VOLTS ARE NECESSARY, AND THEREFORE THREE SEPARATE WINDINGS ARE PROVIDED ON THE TRANSFORMER, EACH DESIGNED TO FURNISH ONE OF THE LOW-VOLTAGE VALUES SPECIFIED, WHEN 110 VOLTS A-C IS IMPRESSED ACROSS THE SINGLE PRIMARY WINDING WHICH IS COMMON TO ALL OF THE SECONDARY WINDINGS. ALL WINDINGS ARE WOUND ON THE SAME IRON CORE, SO THAT THE PRIMARY WINDING SIMULTANEOUSLY INDUCES THE VARIOUS LOW A-C VOLTAGES IN EACH OF THE SECONDARY WINDINGS.

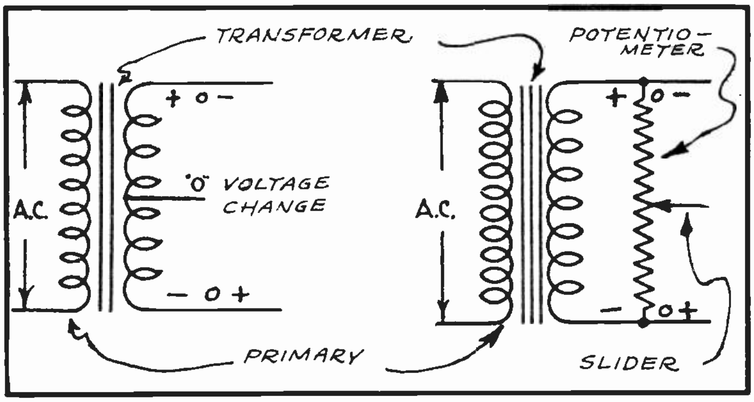

FIG. 4
ELECTRICAL CENTER OF A TRANSFORMER WINDING

AS THE TRANSFORMER NOW UNDER CONSIDERATION SUPPLIES ONLY THE VOLTAGES FOR THE FILAMENTS OF THE TUBES, WE CLASSIFY IT AS A FILAMENT TRANSFORMER. IN THE NEXT LESSON YOU WILL BE TOLD MORE ABOUT THE CONSTRUCTION OF SUCH TRANSFORMERS -- FOR THE PRESENT YOU ARE INTERESTED ONLY IN THEIR USE.

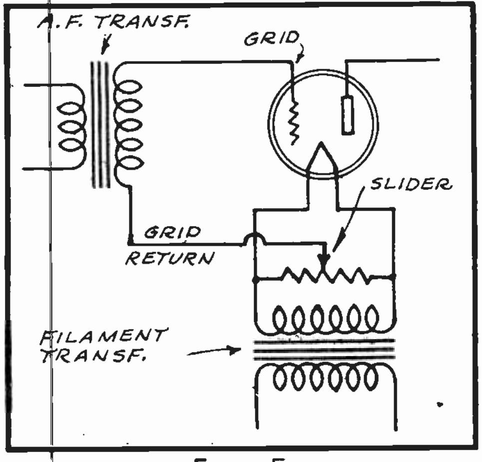

FIG. 5
GRID RETURN FOR FILAMENT TYPE A.C. TUBE

ALL OF THE 26 TUBES REQUIRE AN A-C FILAMENT VOLTAGE OF 1.5 VOLTS, SO WE CONNECT THESE TUBE FILAMENTS IN PARALLEL, AND THEN CONNECT THIS PARALLEL GROUP ACROSS THE 1.5 VOLT WINDING OF THE FILAMENT TRANSFORMER. IN THIS WAY, ALL OF THE 26 TUBES WILL RECEIVE THEIR FILAMENT SUPPLY FROM THE SAME SOURCE.

THE 27 DETECTOR TUBE, HOWEVER, REQUIRES 2.5 VOLTS, HENCE ITS FILAMENT IS CONNECTED ACROSS THE 2.5-VOLT SECONDARY WINDING OF THE TRANSFORMER, AND AS THE 71A POWER TUBE REQUIRES A FILAMENT VOLTAGE OF 5 VOLTS, IT IS CONNECTED ACROSS THE ENDS OF THE 5-VOLT SECONDARY WINDING

OF THE TRANSFORMER. THIS COMPLETES THE FILAMENT SUPPLY FOR ALL OF THE TUBES IN A SIMPLE MANNER.

THE NEXT IMPORTANT FEATURE TO OBSERVE IN FIG. 2 IS THAT THE NEGATIVE END OF THE "B" SUPPLY TO THIS RECEIVER IS GROUNDED, AND THAT THE GRID-RETURNS OF ALL TUBES ARE CONNECTED TO THIS COMMON GROUND OR "B-". A RESISTOR, WHOSE CENTER POINT IS CONNECTED TO GROUND, IS CONNECTED ACROSS EACH OF THE TRANSFORMER FILAMENT WINDINGS. THE FOLLOWING EXPLANATION AND ILLUSTRATIONS WILL SHOW YOU WHY THE CONNECTIONS ARE SO MADE.

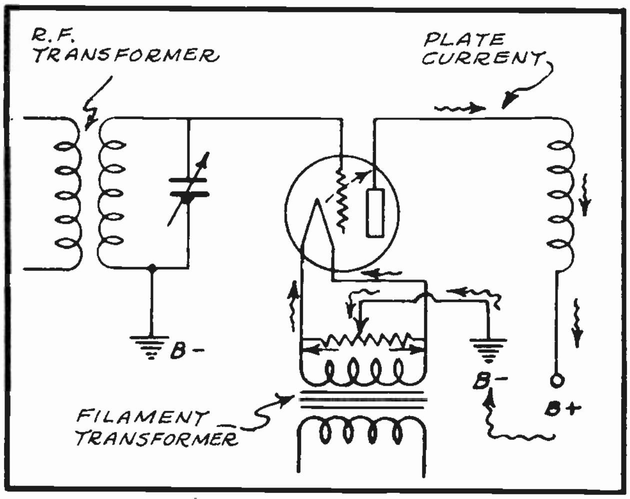

FIG. 6
USE OF GROUND RETURN FOR "B" LINE

GRID-RETURN CONNECTIONS

YOU WILL REMEMBER THAT IN BATTERY-OPERATED RECEIVERS, THE GRID RETURN IS USUALLY CONNECTED TO THE NEGATIVE SIDE OF THE FILAMENT, AS SHOWN IN FIG. 3. IN THIS CASE, THE FILAMENT SUPPLY DOES NOT ALTER THE POLARITY OF THE GRID; ONLY THE SIGNAL VOLTAGES APPLIED TO THE GRID WILL AFFECT THE POLARITY OF THIS ELEMENT.

SHOULD WE CONNECT THE GRID RETURN OF AN A-C RECEIVER TO ONE SIDE OF THE TUBE'S FILAMENT, AS PICTURED IN FIG. 3, THE POLARITY AT THIS CONNECTION WOULD NOT REMAIN UNIFORM, ON ACCOUNT OF THE A-C REVERSALS THRU THE FILAMENT. THIS CONDITION WOULD CAUSE THE TUBE'S GRID TO HAVE ITS POTENTIAL VARIED IN STEP WITH THESE VOLTAGE CHANGES TAKING PLACE AT THE GRID-RETURN CONNECTION, AND WOULD RESULT IN AN UNDESIRABLE HUM BEING EMITTED FROM THE SPEAKER.

NOW LOOK AT FIG. 4; AT THE LEFT IS SHOWN A TRANSFORMER IN WHICH AN A-C VOLTAGE IS BEING IMPRESSED ACROSS ITS PRIMARY WINDING. AS THESE A-C CURRENT REVERSALS FLOW THROUGH THIS WINDING THE TOP END OF THE SECONDARY WILL BE MADE POSITIVE AT ONE INSTANT AND THE BOTTOM END NEGATIVE AT THE SAME TIME. THEN DURING THE NEXT REVERSAL OF A-C THRU THE PRIMARY WINDING, THE ENDS OF THE SECONDARY WILL ALSO REVERSE POLARITY, SO THAT THE TOP END WILL BECOME NEGATIVE AND THE BOTTOM POSITIVE.

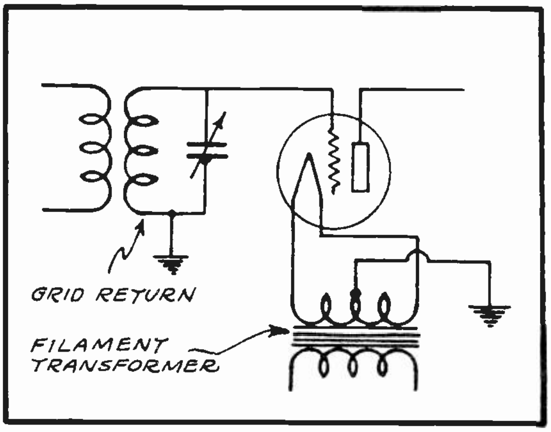

FIG. 7
USE OF CENTER-TAPPED FILAMENT TRANSFORMER WINDING

THE REVERSAL IN THE POLARITY OF THE SECONDARY IS REPEATED CONTINUOUSLY, BUT THERE IS ONE POINT NEAR THE CENTER OF THE SECONDARY WINDING WHICH REMAINS AT A CONSTANT VOLTAGE, OR AT THE AVERAGE OF THAT OF THE TWO

ENDS. WE CALL THIS THE ELECTRICAL CENTER OF THE WINDING, AND IT IS TO THIS "ZERO POINT" THAT THE GRID OF THE TUBE IS TO BE CONNECTED.

THE ELECTRICAL CENTER OF A WINDING IS NOT NECESSARILY AT ITS MIDDLE TURN. TO LOCATE IT IN AN EASY AND PRACTICAL MANNER, A POTENTIOMETER MAY BE CONNECTED ACROSS THE ENDS OF THE WINDING, AND A SLIDER OR ARM MOVED ALONG THIS RESISTANCE SO AS TO MAKE CONTACT WITH ANY DESIRED POINT. THE SAME VOLTAGE CHANGES OCCUR AT THE ENDS OF THIS RESISTANCE ELEMENT AS ARE

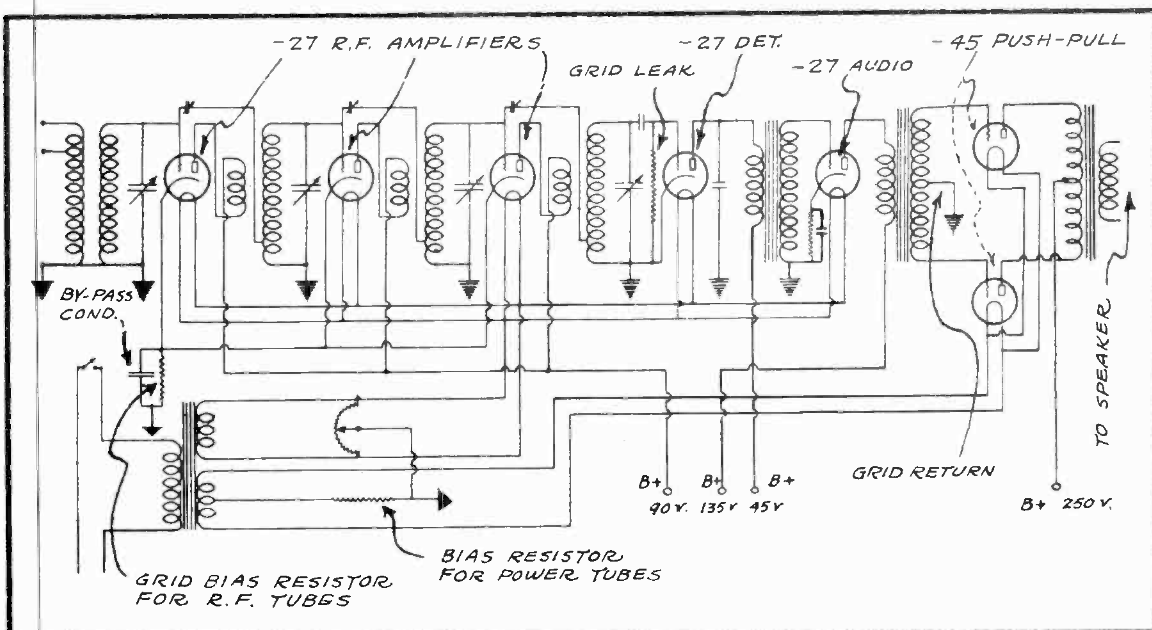

FIG. 8
A.C. RECEIVER CIRCUIT USING -27 TUBES IN ALL BUT THE POWER STAGE

TAKING PLACE ACROSS THE ENDS OF THE SECONDARY WINDING, AND CONSEQUENTLY, THERE IS SOME POINT NEAR THE CENTER OF THIS RESISTANCE WHICH REMAINS AT AN AVERAGE POTENTIAL. WE CAN CONNECT THE GRID RETURN TO THIS POINT AS SHOWN IN FIG. 5. IN SOME A-C RECEIVERS YOU WILL FIND THAT THE POSITION OF THE SLIDER ON THIS POTENTIOMETER IS CONTROLLED BY A SCREW-DRIVER ADJUSTMENT.

WHEN MAKING THIS ADJUSTMENT IN PRACTICE, ROTATE THE ADJUSTING SCREW SLOWLY UNTIL A SETTING IS FOUND WHERE THE SPEAKER HUM IS LEAST; THE ARM WILL THEN BE MAKING CONTACT WITH THE ELECTRICAL CENTER OF THE RESISTOR. THIS UNIT IS USUALLY REFERRED TO AS THE HUM ADJUSTER.

YOU WILL QUITE OFTEN FIND THAT INSTEAD OF THIS CENTER TAP BEING ADJUSTABLE, THE RESISTANCE ELEMENT HAS A FIXED CENTER TAP WHOSE POSITION HAS BEEN PERMANENTLY SET AT THE CORRECT POINT.

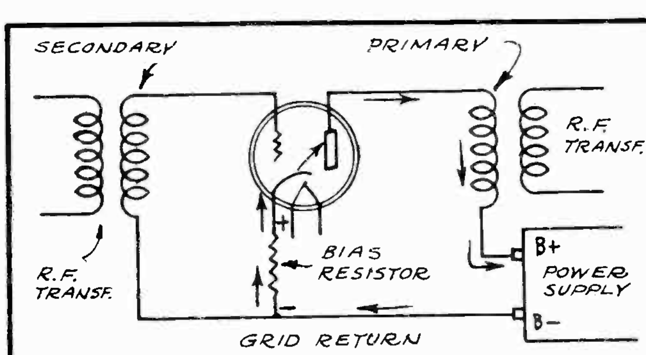

FIG. 9
PRINCIPLE OF AUTOMATIC BIAS

GROUNDING THE "B-" SIDE OF THE CIRCUIT TO THE METAL CHASSIS MAKES IT POSSIBLE TO SIMPLIFY THE CIRCUIT WIRING GREATLY, AND THIS IS THE SYSTEM MOST USED IN PRACTICE. FIG. 6 SHOWS HOW THE GRID-RETURN OF THE TUBE, AND ITS PLATE CIRCUIT, CAN BOTH BE COMPLETED AT ONE TIME BY THIS SYSTEM OF GROUNDING. FIG. 7 ALSO SHOWS HOW IT IS POSSIBLE TO PROVIDE A GRID-RETURN TO A CENTER-TAPPED FILAMENT TRANSFORMER WINDING WITHOUT THE USE OF A POTENTIOMETER OR CENTER-TAPPED RESISTOR. THIS METHOD IS ALSO EXTENSIVELY USED, BUT SHOULD NO B-GROUNDING SYSTEM BE USED, THE GRID-RETURN MAY BE CONNECTED DIRECTLY TO THE ELECTRICAL CENTER OF THE TRANSFORMER WINDING.

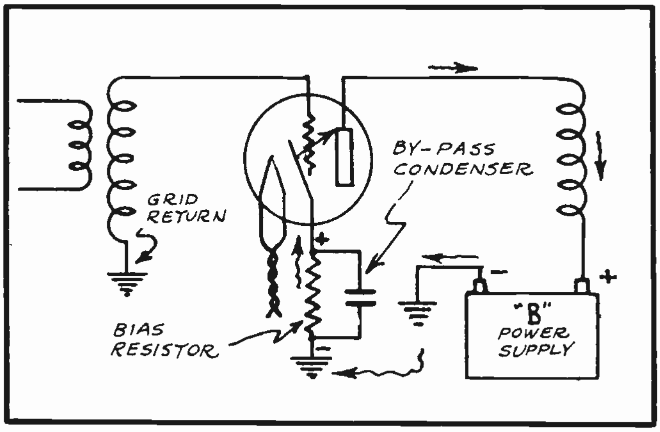

FIG. 10
AUTOMATIC BIAS WITH GROUND RETURN

IN FIG. 8 YOU WILL SEE AN A-C RECEIVER CIRCUIT IN WHICH 27 TUBES ARE USED IN ALL STAGES EXCEPT THE POWER STAGE, WHERE A PAIR OF 45'S ARE IN PUSH-PULL ARRANGEMENT. OBSERVE THAT THE CATHODES OF ALL OF THE 27 TUBES ARE CONNECTED TO GROUND, AND THAT THE GRID-RETURN CIRCUITS OF ALL STAGES EMPLOYING 27 TUBES ARE ALSO GROUNDED. THIS MEANS THAT WHEN USING THE HEATER TYPE TUBE, THE GRID-RETURN IS CONNECTED TO THE CATHODE OR ELECTRON EMITTER AND NOT TO THE FILAMENT. THE BYPASS CONDENSER IN THE PLATE CIRCUIT OF THE DETECTOR IS CONNECTED BETWEEN THE PLATE AND GROUND.

GRID BIAS IN A-C RECEIVERS

NOTICE THAT A FIXED RESISTOR IS CONNECTED BETWEEN GROUND AND THE CATHODES OF THE R.F. AND AUDIO TUBES. THESE ARE BIAS RESISTORS, WHICH FURNISH THE AFORE-MENTIONED TUBES WITH THE NECESSARY NEGATIVE GRID BIAS VOLTAGE. THE ACTION OF THE GRID BIAS RESISTOR WILL BECOME CLEARER TO YOU BY STUDYING FIG. 9, WHERE YOU WILL SEE THAT WE CONSIDER THE ELECTRON FLOW (PLATE CURRENT) THRU THE 27 TUBE AS BEING FROM THE CATHODE TO THE PLATE, COMPLETING ITS ROUND-TRIP BY PASSING FROM THE PLATE INTO THE B+ LINE AND THENCE BACK TO THE "B" POWER SUPPLY.

BY INSERTING A RESISTANCE BETWEEN THE CATHODE AND THE B- LINE, ALL OF THE PLATE CURRENT WHICH FLOWS THROUGH THIS TUBE MUST ALSO FLOW THRU THE RESISTOR. FROM OHM'S LAW YOU LEARNED THAT WHENEVER A DIRECT CURRENT FLOWS THRU A RESISTANCE, A VOLTAGE WILL BE DEVELOPED ACROSS THAT RESISTANCF, WHICH IS EXACTLY WHAT HAPPENS AT THE BIAS RESISTOR

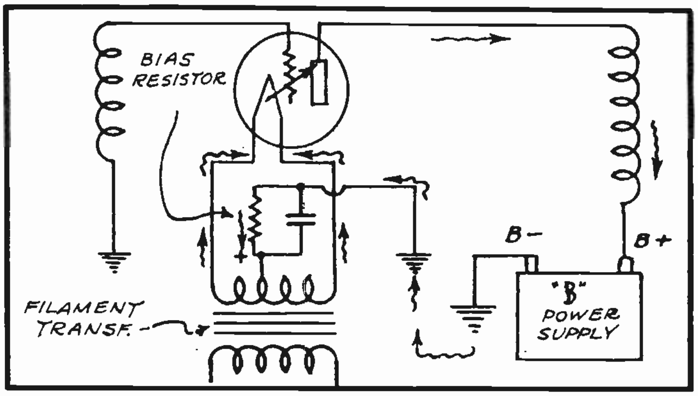

FIG. 11
PROCURING BIAS WITH FILAMENT TYPE TUBE

shown in Fig. 9. That is, the d-c plate current (electrons) which flows thru this tube and bias resistor will produce a voltage across its ends, giving the upper end of the resistor a positive polarity, and the lower end, negative. Then, by connecting the grid-return of this tube to the lower or negative end of the bias resistor, it is obvious that the grid will be maintained at a negative potential with respect to the cathode, thus providing the "C" bias.

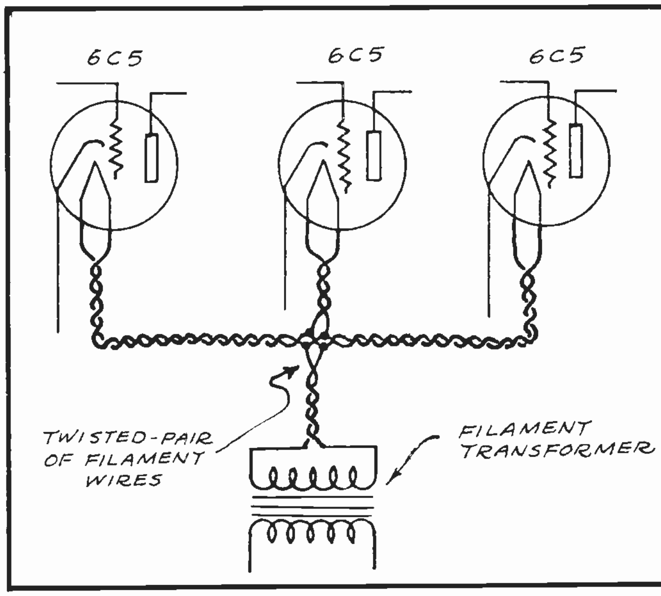

Fig. 12
Wiring The Filament Circuit

In Fig. 10 you will see how the plate current flows thru the bias resistor when the B- side of the circuit is grounded. This means that the grounded end of the bias resistor is NEGATIVE, so that by also grounding the grid-return of this tube, a negative "C" bias will be impressed upon the tube's grid. Also notice in Fig. 10 that a bypass condenser is connected across the ends of the bias resistor. This condenser should have a capacity of .1 to .5 mfd for the R.F. stages, and up to 2 mfd for the A.F. stages. Its purpose is to offer free passage to the flow of R.F. or A.F. currents so that these higher frequencies will not be forced thru the bias resistor, thus improving tone quality.

A typical method of using the bias resistor with the filament-type a-c tubes is shown in Fig. 11, where the bias resistor is connected between ground and the center-tap of the filament transformer winding. Therefore, the plate current will divide thru the tube's filament circuit as shown, thence passing to ground and back to its source. Since both the negative end of the bias resistor and the grid-return of the tube are grounded, it is clear that a negative bias voltage will be impressed upon the tube's grid.

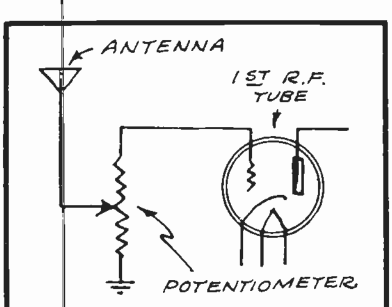

Fig. 13
Simple Volume Control

It is a simple matter to determine the value of grid bias resistor necessary to obtain a certain bias voltage. All that must be done is to apply Ohm's Law in the following way: For example, if a 6C5 is used, with 250 volts applied to its plate, and a negative bias of minus 8 volts is required on the grid of this tube when operating under these conditions (as stated by the tube manufacturer) then by ascertaining the operating characteristics of the 6C5 tube, we find that this tube, when operating at the above values, will draw an average plate current of about 8 milliamperes which will flow thru the bias resistor. To produce a voltage-drop of 8 volts

ACROSS THE RESISTOR, FOR USE AS A BIAS, THE VALUE OF THIS RESISTOR (IN OHMS) WILL BE DETERMINED AS FOLLOWS:

$R = \frac{E}{I}$; SINCE "I" MUST BE EXPRESSED IN AMPERES, WE CONVERT THE 8 MA. OF PLATE CURRENT TO ITS EQUIVALENT, .008 MA. THEN $R = \frac{8}{.008} = 1000$ OHMS.

IF A SINGLE BIAS RESISTOR IS USED FOR MORE THAN ONE TUBE, THE PLATE CURRENT DRAWN THRU THE RESISTOR WILL BE EQUAL TO THE SUM OF THE SEVERAL PLATE CURRENTS. THAT IS, IF THREE TUBES ARE CONNECTED IN PARALLEL AND 250 VOLTS APPLIED TO THE PLATE OF EACH, AS IN THE CASE OF THE PREVIOUS EXAMPLE, THEN 3 TIMES 8 MILLIAMPERES OR 24 MILLIAMPERES WILL FLOW THROUGH THE SINGLE BIAS RESISTOR. THEREFORE, TO PRODUCE THE REQUIRED 8 VOLT BIAS, ONLY $\frac{8}{.024}$ OR $333.\overline{3}$ OHMS WILL BE NEEDED FOR THE BIAS RESISTOR. (NOTICE THAT 24 MA. IS EQUIVALENT TO .024 AMP.) THIS IS A GOOD METHOD OF OBTAINING AUTOMATICALLY-CONTROLLED BIAS VOLTAGE, FOR IF THE PLATE VOLTAGE BECOMES HIGH, MORE PLATE CURRENT WILL FLOW THRU THE BIAS RESISTOR, CAUSING A GREATER VOLT-DROP AND GREATER NEGATIVE GRID BIAS. THIS, IN TURN, WILL REDUCE PLATE CURRENT. IF PLATE VOLTAGE BECOMES LOW, LESS VOLTAGE ACROSS THE BIAS RESISTOR WILL RESULT, SO THAT THE BIAS VOLTAGE WILL AUTOMATICALLY BE INCREASED TO COMPENSATE FOR THE LOW PLATE VOLTAGE.

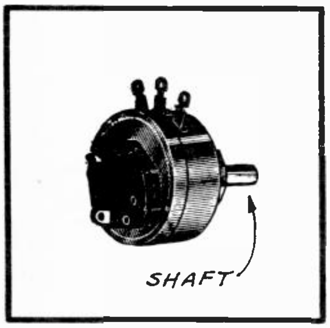

FIG. 14
A POTENTIOMETER

TWISTING THE FILAMENT WIRES

ANOTHER IMPORTANT FEATURE TO NOTICE ABOUT A-C RECEIVER CONSTRUCTION IS ILLUSTRATED IN FIG. 12. OBSERVE THAT THE FILAMENT WIRES ARE ALWAYS TWISTED TOGETHER THROUGHOUT THEIR ENTIRE LENGTH. EACH WIRE IS, OF COURSE, THOROUGHLY INSULATED, SO THAT NO ELECTRICAL CONTACT BETWEEN THEM WILL BE POSSIBLE. THIS ARRANGEMENT OF FILAMENT OR HEATER WIRES AIDS MATERIALLY IN REDUCING THE A-C HUM IN THE RECEIVER, BECAUSE THE MAGNETIC FIELDS PRODUCED AROUND THESE CONDUCTORS ARE NEUTRALIZED WHEN THE WIRES ARE THUS TWISTED TOGETHER.

VOLUME CONTROL

THE NEXT PROBLEM FOR CONSIDERATION IS HOW TO CONTROL THE SOUND VOLUME IN A-C RECEIVERS. THE MOST SIMPLE AND MOST USED METHODS ARE TO CONTROL THE AMOUNT OF SIGNAL ENERGY FED INTO THE SET, OR TO CONTROL THE RECEIVER'S AMPLIFYING ABILITY. FIG. 13 SHOWS AN EASY MEANS OF ACCOMPLISHING CONTROL BY THE FIRST METHOD. HERE YOU WILL SEE A POTENTIOMETER CONNECTED IN THE ANTENNA CIRCUIT.

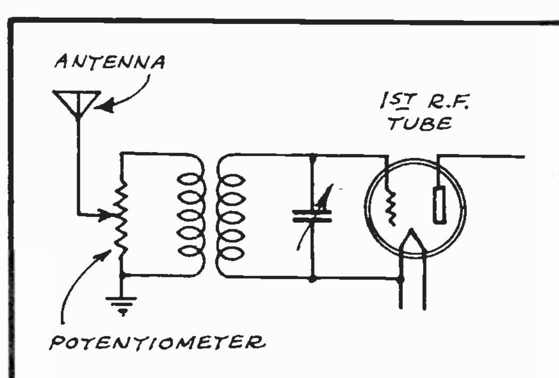

FIG. 15
CONTROLLING SIGNAL ENERGY

IN GENERAL CONSTRUCTION, A POTENTIOMETER IS QUITE SIMILAR TO A RHEOSTAT, AS YOU WILL READILY NOTICE UPON INSPECTING FIG. 14. THE ESSENTIAL DIFFERENCE BETWEEN THEM IS THAT THE RHEOSTAT HAS TWO CONNECTION TERMINALS, WHEREAS THE POTENTIOMETER HAS THREE. THE CENTER TERMINAL IN FIG. 14 IS CONNECTED TO THE CONTACT ARM; EACH OF THE OTHER TWO TERMINALS IS CONNECTED TO AN END OF THE RESISTANCE ELEMENT.

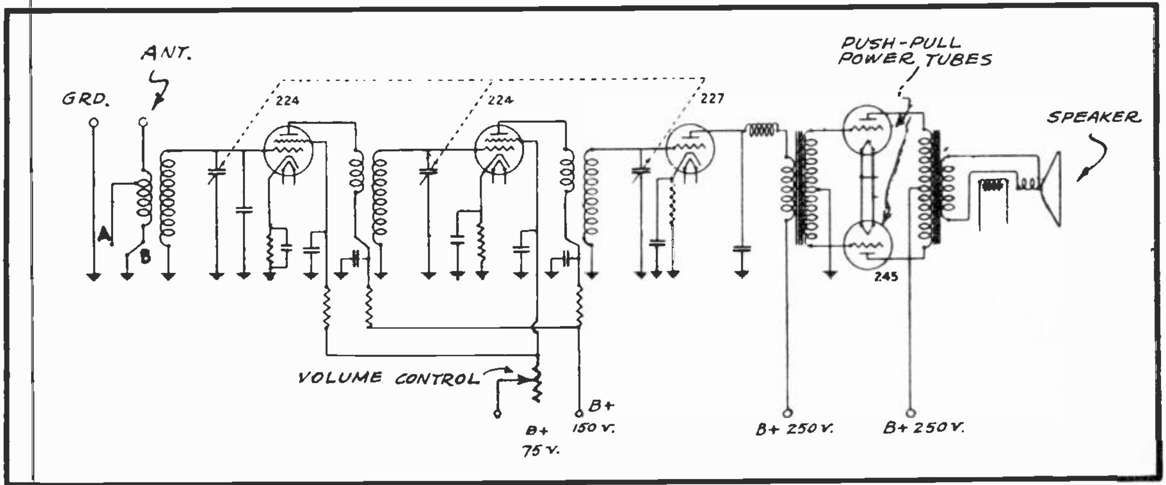

FIG. 16
FIVE-TUBE A.C. RECEIVER USING SCREEN GRID R.F. TUBES

AS SHOWN IN FIG. 13, ONE END OF THIS POTENTIOMETER'S RESISTANCE UNIT IS CONNECTED TO THE TUBE'S GRID, AND THE OTHER END TO GROUND. BY MOVING THE ARM SO THAT IT MAKES CONTACT WITH THE RESISTANCE CLOSER TO THE UPPER END, MOST OF THE SIGNAL ENERGY WILL BE IMPRESSED UPON THE TUBE'S GRID, AND THE VOLUME OF SOUND WILL BE INCREASED. SHOULD THE ARM BE MOVED SO THAT IT MAKES CONTACT CLOSER TO THE LOWER END OF THE RESISTANCE ELEMENT, THERE WILL THEN BE LESS RESISTANCE BETWEEN THE ANTENNA AND THE TUBE'S GRID, AND THEREFORE, MOST OF THE SIGNAL ENERGY WILL PASS TO GROUND INSTEAD OF TO GRID, THEREBY REDUCING THE SOUND VOLUME.

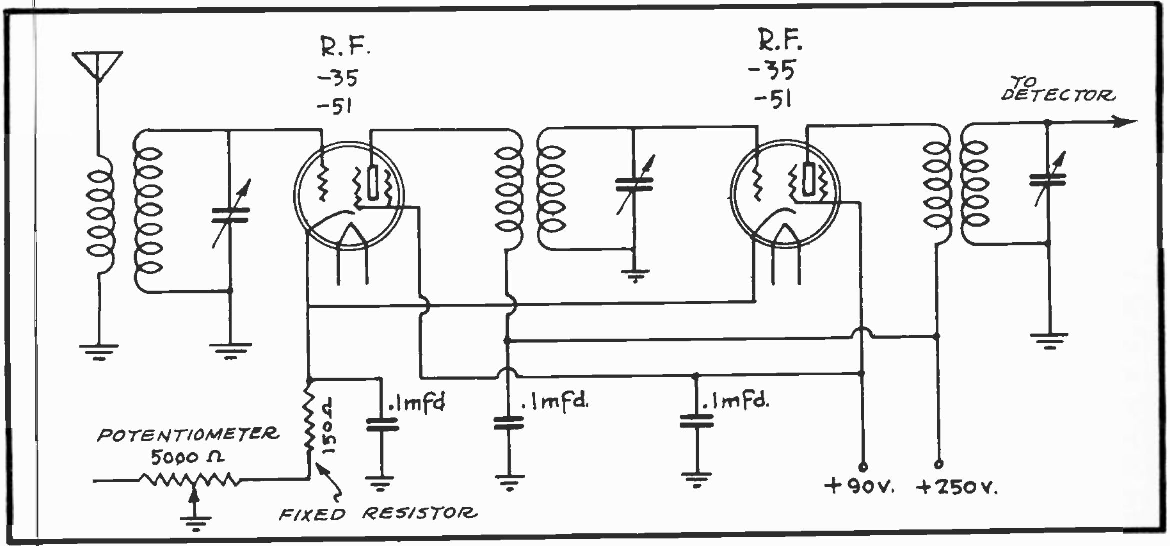

FIG. 17
USING TYPE -35 OR -51 TUBES IN AN R.F. AMPLIFIER

In Fig. 15 you will see how the volume can be controlled by a potentiometer connected across the primary winding of the 1st R.F. transformer. By moving the arm toward the upper part of the resistance element, most of the signal energy from the antenna will flow to ground by way of the R.F. transformer's primary winding, and thus act more strongly upon the tube's grid. This position will give greatest volume. If the arm is moved farther downward, the path of least resistance will then be for the signal energy to pass from the antenna directly to ground, instead of through the primary winding, which will bring about a decrease in volume.

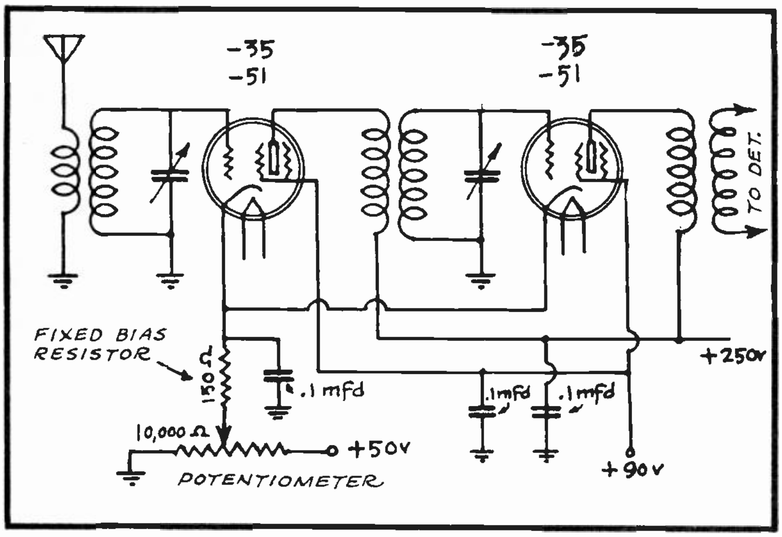

Fig. 18
Another Bias Voltage Volume Control

VOLUME CONTROL IN SCREEN-GRID RECEIVERS

In the earlier types of screen grid receiver that used type 24 tubes, it was a common practice to control the volume by means of a potentiometer or rheostat connected in the screen grid circuits, in some such manner as illustrated in Fig.16. By adjusting this unit the screen grid voltage on the 24 tubes may be either increased or decreased, resulting respectively in increase or decrease in volume. Screen grid tubes with a variable-mu characteristic soon replaced the type 24 tubes, and made possible greater operating efficiency and a smoother control of volume.

VARIABLE MU PRINCIPLES

An R.F. amplifier using type 35 or 51 variable-mu screen grid tubes is illustrated in Fig. 17. You will observe that the circuit is quite similar to those in which type 24 tubes are used -- the chief difference being the method of controlling the volume.

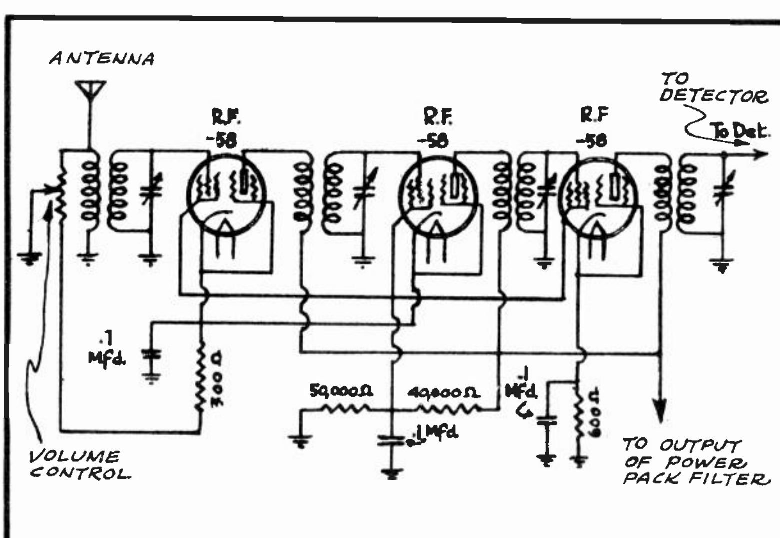

Fig. 19
Three Tuned R.F. Stages With Type -58 Tubes

In the case of Fig. 17, the cathodes of the two R.F. tubes are connected together and a fixed resistor is installed between this common connection and one end of the resistance element of a potentiometer. The arm of the potentiometer is grounded to the chassis base. All of the plate current of these two R.F. tubes must flow thru the fixed bias resistor and potentiometer arm, in order to reach the grounded B- side of the circuit. If the potentiometer arm is moved to the extreme right, the lower end of the fixed bias resistor will then be grounded direct and all of the plate current will pass thru the fixed resistor to ground, without flowing thru any portion of the potentiometer's resistance element. This current flow will cause a definite voltage to be developed across the extremities of this resistor, which will be impressed upon the control grids of the two R.F. tubes in the form of a grid bias voltage.

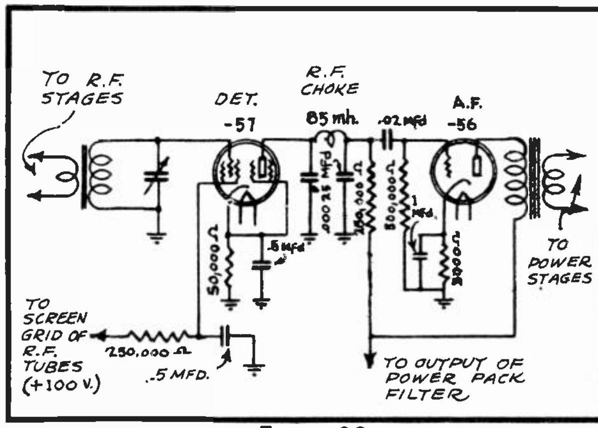

Fig. 20
Power Detector Stage With A -57 Tube

Now, if the potentiometer arm should be moved farther toward the left, the plate current must flow thru a portion of the potentiometer's resistance element in addition to the fixed bias resistor, before it can reach B- potential or ground. By increasing the resistance of the cathode circuit in this manner a greater voltage-drop will be effective across this combined resistance, and the grid bias voltage will therefore be increased still further in negative value.

Whenever the bias voltage is made MORE NEGATIVE, the amplification factor of the tube is reduced, and the signal volume is reduced accordingly. By making the grid bias voltage LESS NEGATIVE, the amplification factor of the tube is raised and the signal volume increased, thus providing a satisfactory control of volume.

You will observe that the fixed bias resistor sets a limit as to the least bias voltage which can be applied to the R.F. tubes. In other words, even with the potentio-

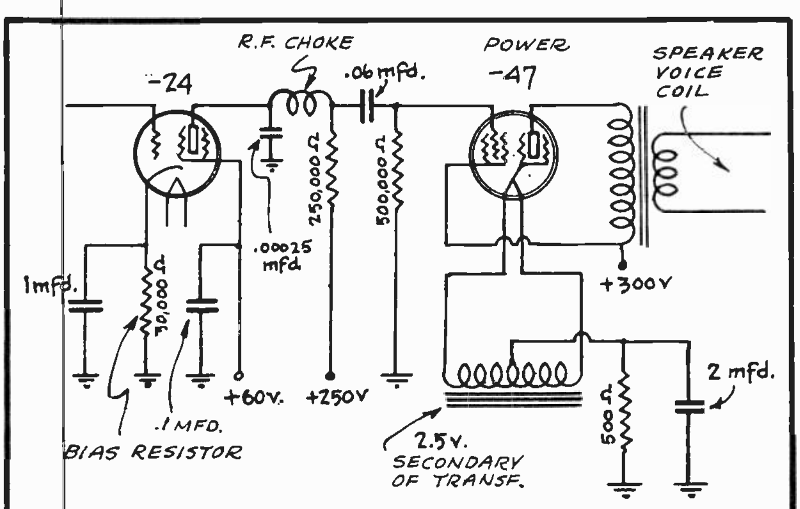

Fig. 21
Power Stage Connection Using One -47 Pentode

METER ARM SET FOR MAXIMUM VOLUME, THE R.F. TUBES WILL NOT BE DEPRIVED OF ALL BIAS VOLTAGE. ALSO NOTICE THE EXTENSIVE USE OF THE .1 MFD. BYPASS CONDENSERS IN THE CIRCUIT OF FIG. 17. ONE IS USED TO BYPASS ALL RADIO FREQUENCY ENERGY AROUND THE BIAS RESISTOR. ANOTHER BYPASSES TO GROUND ALL R.F. ENERGY IN THE SCREEN-GRID CIRCUITS, AND THE THIRD CONDENSER BYPASSES TO GROUND THE R.F. ENERGY IN THE PLATE CIRCUITS.

ANOTHER METHOD OF CONTROLLING THE GRID BIAS VOLTAGE IN A CIRCUIT CONTAINING VARIABLE-MU TUBES IN THE R.F.STAGES IS ILLUSTRATED IN FIG. 18, WHERE YOU WILL OBSERVE THAT A FIXED BIAS RESISTOR IS AGAIN INSTALLED IN THE CATHODE CIRCUIT. THE CONNECTION TO THE POTENTIOMETER, HOWEVER, IS DIFFERENT FROM THAT IN FIG. 17. THAT IS, IN FIG. 18 THE LOWER END OF THE FIXED BIAS RESISTOR IS CONNECTED TO THE ARM OF THE POTENTIOMETER,ONE END OF THE POTENTIOMETER'S RESISTANCE ELEMENT IS GROUNDED, AND THE OTHER END IS CONNECTED TO A +50 VOLT POTENTIAL.

BY MOVING THE ARM OF THE POTENTIOMETER ALONG ITS RESISTANCE ELEMENT TO THE EXTREME LEFT, THE LOWER END OF THE FIXED BIAS RESISTOR WILL BE GROUNDED DIRECT; THE BIAS VOLTAGE WILL THEN HAVE A VALUE OF ABOUT -3 VOLTS, AND THE SOUND VOLUME WILL BE MAXIMUM. AS THE POTENTIOMETER ARM IS MOVED FARTHER TOWARD THE RIGHT THE GRID BIAS VOLTAGE BECOMES MORE AND MORE NEGATIVE, DUE TO THE INCREASED AMOUNT OF POTENTIOMETER RESISTANCE WHICH IS INCLUDED BETWEEN GROUND AND THE LOWER END OF THE FIXED BIAS RESISTOR. THE SOUND VOLUME WILL THEN DECREASE.

APPLICATION OF TYPE 58 TUBES

FIG. 19 SHOWS HOW TYPE 58 TUBES ARE USED IN THE R.F. STAGE OF A RECEIVER. IN THIS PARTICULAR CASE THERE ARE THREE STAGES OF R.F. AMPLIFICATION. OBSERVE THAT THE SUPPRESSOR GRID OF EACH TUBE IS CONNECTED TO

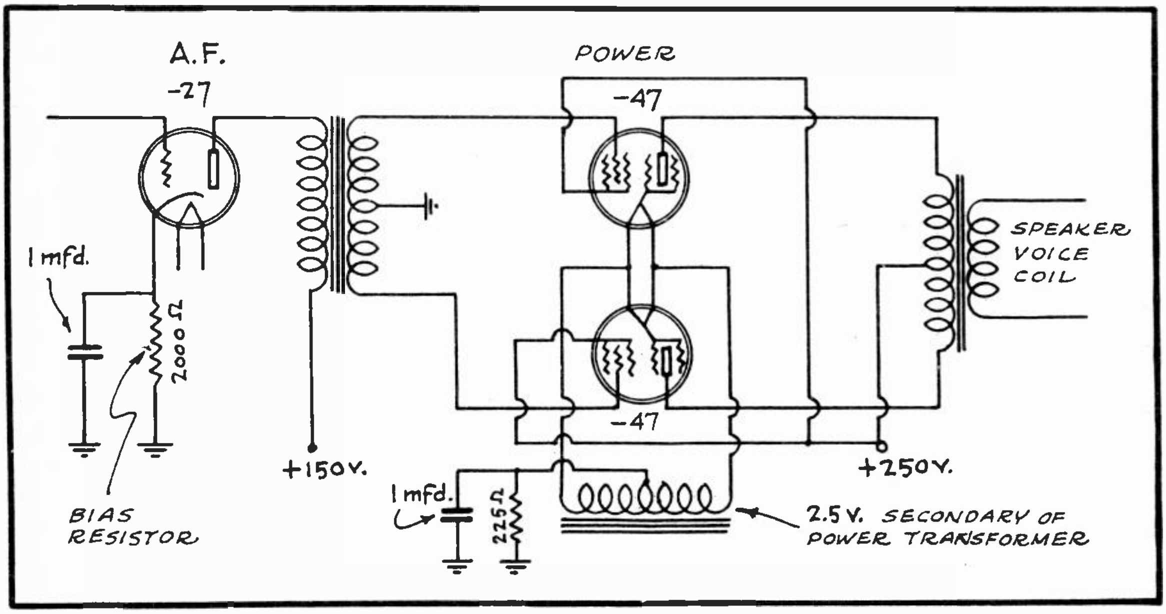

FIG. 22
POWER STAGE WITH TWO -47'S IN PUSH-PULL

THE CATHODE OF THE SAME TUBE. THE CONTROL GRID, SCREEN GRID, AND PLATE CONNECTIONS ARE ALL MADE IN THE CONVENTIONAL MANNER WITH WHICH YOU ARE ALREADY FAMILIAR.

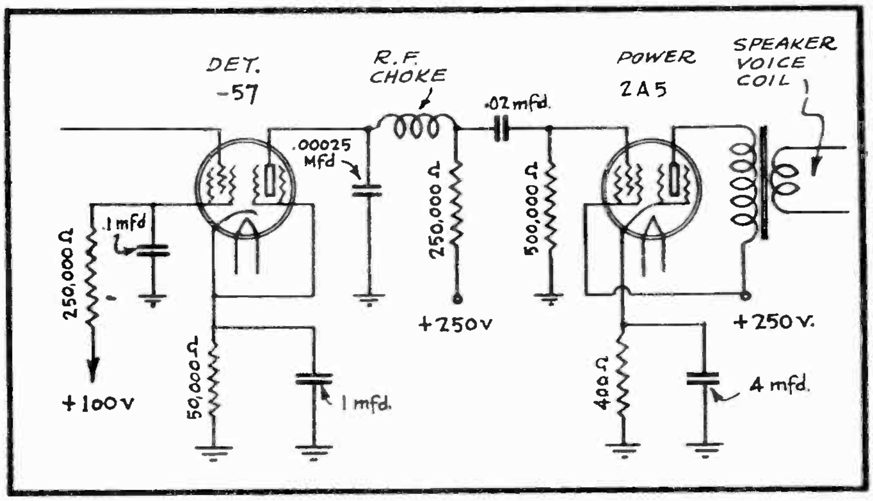

FIG. 23
A SINGLE 2A5 USED IN THE POWER STAGE

THE CATHODES OF THE FIRST TWO R.F. TUBES ARE TOGETHER CONNECTED TO GROUND THRU A 300-OHM FIXED BIAS RESISTOR, AND A POTENTIOMETER-TYPE VOLUME CONTROL, SO THAT THE GRID-BIAS VOLTAGE OF THESE SAME TWO TUBES CAN THEREBY BE REGULATED TO CONTROL THE AMPLIFICATION OFFERED BY THESE SAME TWO TUBES, AND THUS PROVIDE A MEANS FOR CONTROLLING SOUND VOLUME. THE 58 TUBE, YOU WILL RECALL, HAS "VARIABLE-MU" CHARACTERISTICS, SO THAT THIS TYPE OF VOLUME CONTROL CAN BE APPLIED VERY EFFECTIVELY.

THE THIRD R.F. TUBE HAS ITS INDIVIDUAL BIAS RESISTOR OF 600 OHMS. THEREFORE, THE BIAS VOLTAGE AND AMPLIFYING ABILITY OF THIS TUBE REMAINS FIXED, REGARDLESS OF THE VOLUME-CONTROL SETTING.

THE PLATE CIRCUITS OF ALL THREE TUBES ARE CONNECTED IN PARALLEL, SO THAT A PLATE VOLTAGE OF 250 VOLTS CAN BE IMPRESSED UPON EACH OF THESE TUBES. THE RESISTOR OF 40,000 OHMS SERVES TO REDUCE THE HIGH "B" VOLTAGE TO ABOUT 100 VOLTS, WHICH IS APPLIED TO THE SCREEN GRIDS OF THESE TUBES. THE 50,000-OHM FIXED RESISTOR SERVES AS A "BLEEDER RESISTOR" WHOSE PURPOSE WILL BE EXPLAINED IN THE NEXT LESSON. ALSO, NOTE PARTICULARLY THAT THE .1 MFD. CONDENSERS ARE USED TO BY-PASS THE VARIOUS RESISTORS IN THIS CIRCUIT.

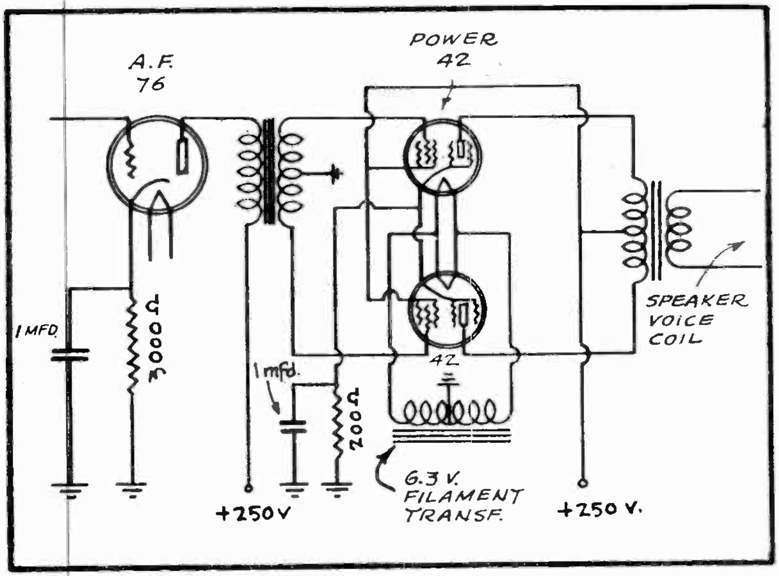

FIG. 24
CIRCUIT EMPLOYING A PAIR OF 42'S IN PUSH-PULL

APPLICATION OF THE 56 AND 57 TUBES

FIG. 20 ILLUSTRATES

A TYPICAL METHOD OF USING A 57 TUBE AS A POWER DETECTOR, COUPLING IT TO A 56 A.F. TUBE BY MEANS OF RESISTANCE-CAPACITY COUPLING. HERE TOO, THE SUPPRESSOR GRID OF THE 57 IS CONNECTED TO THE CATHODE, AND A 50,000-OHM RESISTOR BETWEEN CATHODE AND GROUND SERVES AS THE BIAS RESISTOR. A 3000-OHM FIXED RESISTOR IS CONNECTED BETWEEN THE CATHODE OF THE 56 TUBE AND GROUND TO FURNISH THE BIAS VOLTAGE FOR THIS SAME TUBE. OTHER THAN THESE POINTS, THE CIRCUIT IS NO DIFFERENT FROM THOSE WITH WHICH YOU ARE ALREADY FAMILIAR.

APPLICATION OF THE 47 TUBE

FIG. 21 SHOWS THE CIRCUIT ARRANGEMENTS USING A TYPE 47 PENTODE AS THE POWER TUBE, WITH A 24 POWER DETECTOR RESISTANCE-CAPACITY COUPLED TO THE POWER STAGE. NOTICE ESPECIALLY THAT THE SUPPRESSOR GRID OF THE 47 IS ALREADY CONNECTED TO THE FILAMENT, INSIDE OF THE TUBE. THE PLATE AND SCREEN GRID ARE BOTH CONNECTED TO THE POINT OF MAXIMUM "B" VOLTAGE.

NOTICE THAT ALTHOUGH THE PLATE AND SCREEN GRID OF THE 47 TUBE ARE CONNECTED TO A B+ VOLTAGE VALUE OF 300 VOLTS, THE ACTUAL EFFECTIVE PLATE AND SCREEN GRID VOLTAGE FOR THIS TUBE IS NOT 300 VOLTS, BUT ONLY 300 MINUS THE BIAS VOLTAGE OF 16.5 OR APPROXIMATELY 283.5 VOLTS. THE LATTER VALUE WOULD BE OBTAINED UPON MEASURING THE VOLTAGE FROM THE PLATE OR SCREEN GRID TO THE FILAMENT OF THIS TUBE. IN COMMERCIAL RECEIVER CIRCUITS YOU WILL FIND THE TUBE VOLTAGE VALUES TO VARY FROM THOSE SPECIFIED.

THE 2.5-VOLT SECONDARY WINDING OF THE TRANSFORMER WHICH SUPPLIES

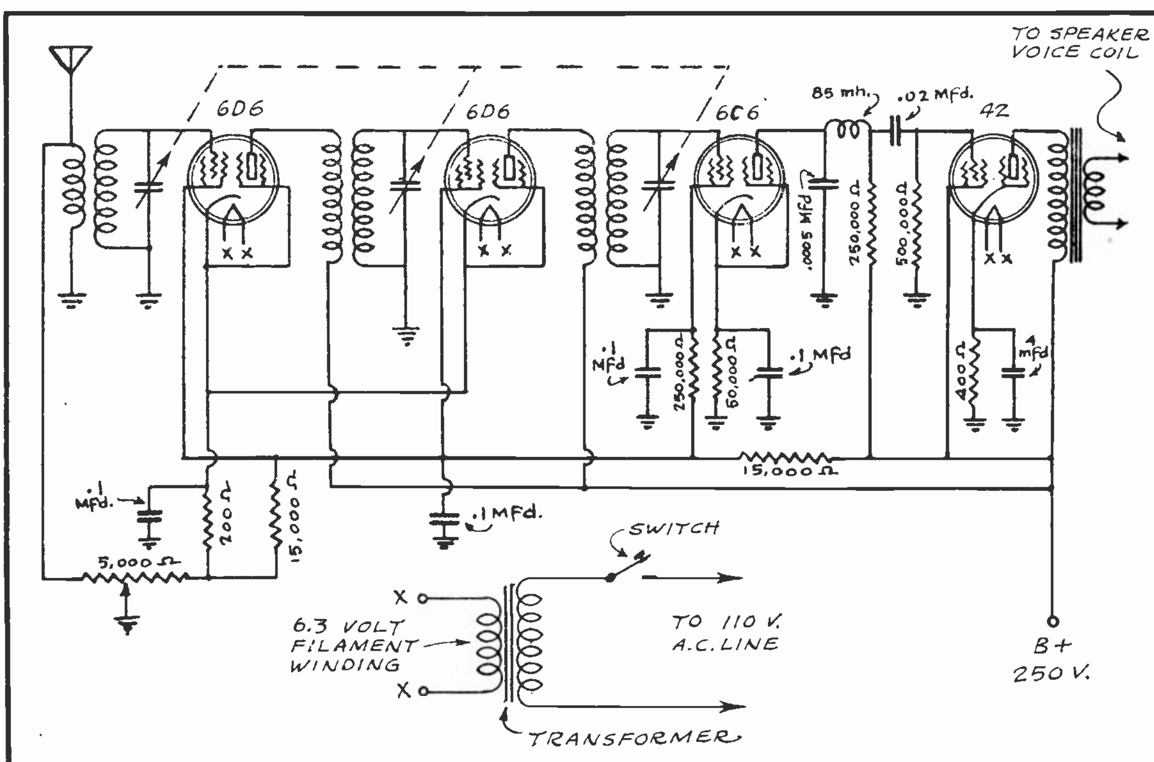

FIG. 25
FOUR-TUBE RECEIVER CIRCUIT

THE FILAMENT VOLTAGE FOR THE 47 IS CENTER-TAPPED, AND A BIAS RESISTOR OF 500 OHMS IS CONNECTED BETWEEN THIS CENTER AND GROUND. A 2 MFD BYPASS CONDENSER IS CONNECTED IN PARALLEL WITH, OR SHUNTED ACROSS THIS BIAS RESISTOR, SO THAT ALL A.F. CURRENTS CAN PASS THRU THE CONDENSER TO GROUND, INSTEAD OF FLOWING THRU THE BIAS RESISTOR. ONLY THE D-C PORTION OF THE PLATE CURRENT FLOWS THRU THE RESISTOR AND PRODUCES THE NEGATIVE BIAS VOLTAGE.

TWO 47'S IN PUSH-PULL

FIG. 22 SHOWS A PUSH-PULL POWER STAGE WITH A PAIR OF 47'S COUPLED TO AN A.F. STAGE IN WHICH A 27 IS USED. THE FILAMENTS OF THE TWO 47'S ARE CONNECTED IN PARALLEL, AND THEN CONNECTED ACROSS THE ENDS OF A 2.5 VOLT TRANSFORMER FILAMENT WINDING. A 225-OHM RESISTOR IS CONNECTED BETWEEN THE CENTER-TAP OF THIS TRANSFORMER WINDING AND GROUND, TO FURNISH THE BIAS VOLTAGE FOR BOTH POWER TUBES.

IT IS NOT ALTOGETHER NECESSARY TO SHUNT THE BIAS RESISTOR WITH A BYPASS CONDENSER WHEN USING TUBES IN PUSH-PULL, AND WHEN BOTH TUBES HAVE IDENTICAL INTER-ELEMENT CAPACITIES. HOWEVER, IF THESE CHARACTERISTICS ARE NOT PRECISELY THE SAME, THE USE OF A BYPASS CONDENSER WILL PREVENT TROUBLE WHICH IS LIKELY TO BE CAUSED BY THESE CONDITIONS OF THE CIRCUIT -- AND WILL PRESERVE TONE QUALITY.

THE GRIDS OF THESE TWO TUBES ARE CONNECTED TO THE ENDS OF THE INPUT PUSH-PULL TRANSFORMER'S SECONDARY WINDING, WHILE THE CENTER-TAP OF THIS SAME WINDING IS GROUNDED. EACH OF THE PLATES IS CONNECTED TO AN END OF THE OUTPUT PUSH-PULL TRANSFORMER'S PRIMARY WINDING, AND THE CENTER-TAP OF THIS WINDING IS CONNECTED TO A 250-VOLT "B" SOURCE. THE SCREEN GRIDS OF BOTH TUBES ARE TOGETHER CONNECTED TO THIS SAME 250-VOLT POINT OF THE CIRCUIT.

APPLICATION OF 2A5 TUBE

FIG. 23 SHOWS HOW TO CONNECT A SINGLE 2A5 PENTODE IN THE POWER STAGE OF A RECEIVER IN WHICH THE POWER STAGE IMMEDIATELY FOLLOWS THE DETECTOR. NOTE THAT RESISTANCE-CAPACITY COUPLING IS USED BETWEEN THE TWO-STAGES, AND THAT A TYPE 57 TUBE IS THE POWER DETECTOR. STUDY THE POWER-STAGE CIRCUIT WITH SPECIAL CARE, OBSERVING THAT THE SUPPRESSOR GRID IS CONNECTED TO THE CATHODE WITHIN THE TUBE STRUCTURE, AND THAT A 400-OHM FIXED RESISTOR IS CONNECTED BETWEEN CATHODE AND GROUND TO FURNISH THE GRID BIAS. THE 4 MFD BYPASS CONDENSER, SHUNTING THIS BIAS RESISTOR, OFFERS COMPARATIVELY FREE PASSAGE FOR THE A.F. CURRENT COMPONENT, SO THAT THESE FLUCTUATING CURRENTS WILL NOT FLOW THRU THE 400-OHM RESISTOR. THIS AIDS TONE QUALITY. THE TRANSFORMER WINDING WHICH SUPPLIES THE FILAMENT VOLTAGE TO THE 2A5 SHOULD PREFERABLY HAVE ITS CENTER TAP GROUNDED TO THE CHASSIS, TO AVOID HUM.

THE SCREEN GRID IS CONNECTED TO A POTENTIAL OF 250 VOLTS, LIKE THE PLATE CIRCUIT OF THE TUBE, AND THE CONTROL GRID IS CONNECTED TO THE INPUT CIRCUIT OF THE TUBE IN THE USUAL WAY. THE OUTPUT TRANSFORMER SHOULD BE DESIGNED TO MATCH A SINGLE 2A5, AND FEEDING INTO THE VOICE COIL OF THE SPEAKER IN QUESTION.

TWO 42's IN PUSH-PULL

The conventional method of connecting a pair of 42's in a push-pull power stage is illustrated in Fig. 24. The two cathodes are interconnected, and together are grounded through a 200-ohm bias resistor. The screen grids are together connected to a potential of 250 volts, and each of the control grids is connected to an end of the input push-pull transformer's secondary winding.

The center-tap of the 6.3 volt winding of the transformer supplying the filament voltage for the 42's is grounded. In all other respects the circuit is similar to those which you have already studied.

Now that you are familiar with the various sections of typical A-C receivers, your next step will be to study several complete circuits

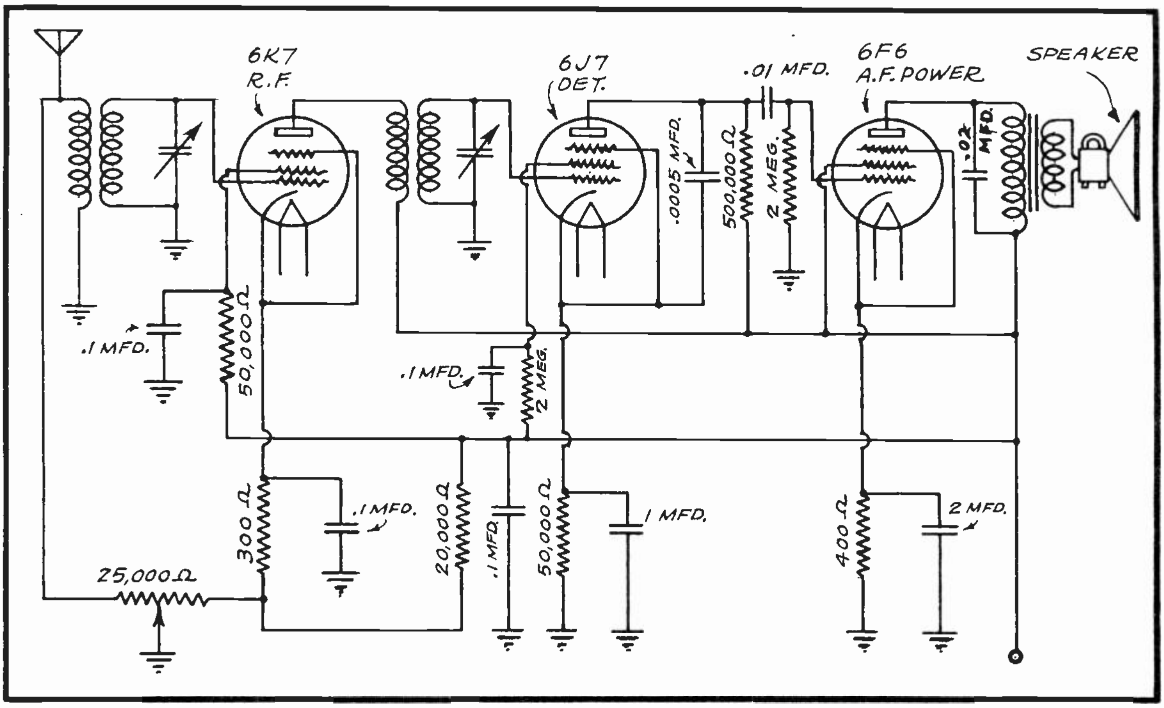

Fig. 26
Simple Metal-Tube Circuit

wherein the features thus far considered are used in combination. To simplify matters for you, the B power supply has been left out of these circuits, but you will find this part of the system fully explained in the next lesson.

You will also find that the circuits herein presented demonstrate clearly the close relation between the application of both the older tube types thus far described, and the tubes of more recent design. Complete operating characteristics for the tubes used in these more modern circuits are given in Job Sheet #14.

FOUR-TUBE CIRCUIT

In Fig. 25 is shown a circuit diagram of a four-tube A-C receiver

EMPLOYING TUBES WHOSE FILAMENTS ARE DESIGNED FOR OPERATION FROM A 6.3 VOLT CIRCUIT. WITH THIS EXCEPTION, THE 6D6, 6C6, AND 42 TUBES ARE VERY SIMILAR TO THE 58, 57 AND 2A5, RESPECTIVELY. THE FILAMENTS OF THE TUBES USED IN FIG. 25 ARE ALL CONNECTED TO TERMINALS X OF THE TRANSFORMER'S 6.3 VOLT WINDING.

METAL TUBE CIRCUIT

FIGURE 26 ILLUSTRATES THE CIRCUIT CONNECTIONS AS USED IN A THREE-TUBE RECEIVER, EMPLOYING THE METAL-TUBE EQUIVALENTS FOR THE 6D6, 6C6, AND 42. THESE METAL-TUBE EQUIVALENTS ARE KNOWN AS THE 6K7, 6J7, AND 6F6. NOTICE PARTICULARLY IN FIG. 26 THAT THE FUNDAMENTAL CIRCUIT REMAINS THE SAME WHETHER GLASS OR METAL TUBES ARE EMPLOYED. THE CHIEF DIFFERENCE LIES IN THE CONNECTIONS MADE AT THE SOCKETS OF THE TUBES.

METAL TUBE CONSTRUCTION

A GREAT MANY REFINEMENTS HAVE BEEN MADE FROM YEAR TO YEAR IN THE DESIGN OF VACUUM TUBES. THE MOST RECENT REVOLUTIONARY CHANGE CONSISTED OF REPLACING THE CUSTOMARY GLASS BULB OR ENCLOSURE WITH A METAL CONTAINER. TUBES OF THIS LATTER DESIGN ARE KNOWN AS THE METAL TUBES AND THEY ARE BEING USED EXTENSIVELY IN RECEIVERS OF RECENT DESIGN.

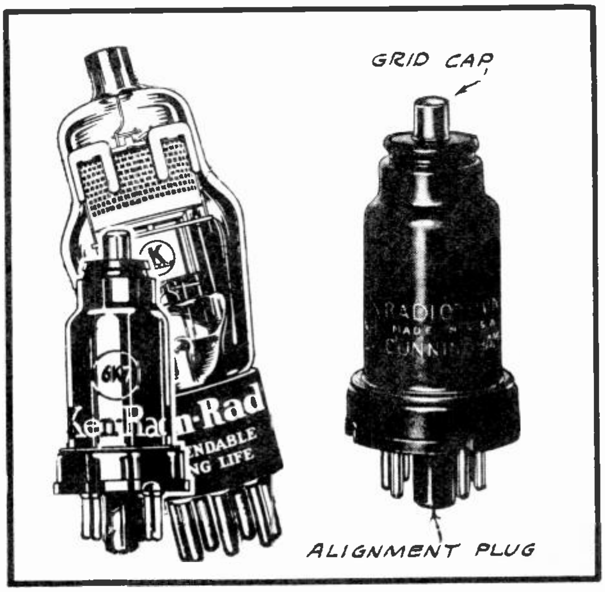

FIG. 27
TUBE COMPARISON

IN FIG. 1 YOU ARE SHOWN THE CHASSIS OF A MODERN RECEIVER EQUIPPED WITH METAL TUBES. BY STUDYING THIS ILLUSTRATION CAREFULLY, YOU WILL OBSERVE HOW TUBES OF THIS TYPE APPEAR WHEN INSTALLED IN A TYPICAL RECEIVER.

AT THE LEFT OF FIG. 27 YOU ARE SHOWN A COMPARISON OF SIZE AND APPEARANCE BETWEEN A TYPICAL GLASS AND METAL TUBE, WHILE AT THE RIGHT OF FIG. 27 ONE TYPE OF METAL TUBE IS SHOWN IN GREATER DETAIL.

ASIDE FROM THE METAL ENCLOSURE, THE MAJORITY OF METAL TUBES ARE SMALLER BOTH IN DIAMETER AND HEIGHT THAN THE CORRESPONDING GLASS TUBE. ANOTHER GREAT DIFFERENCE FROM THE STANDPOINT OF APPEARANCE IS THAT THE METAL TUBES ARE EQUIPPED WITH 8-PRONG BASES WHICH ARE KNOWN AS OCTAL BASES. IN ADDITION, THE OCTAL BASE IS FITTED WITH AN ALIGNING PLUG.

YOU WILL ACQUIRE A STILL CLEARER UNDERSTANDING OF THE INTERNAL CONSTRUCTION OF THE ALL-METAL TUBE BY REFERRING TO THE CUT-AWAY SECTION OF THE TUBE WHICH APPEARS IN FIG. 28. STUDY THIS ILLUSTRATION CAREFULLY AND NOTE THAT THE INDEX NUMBERS, WHICH APPEAR ON THIS UNIT, CORRESPOND WITH THE PARTS-NAMES ALSO APPEARING IN THIS SAME ILLUSTRATION IN TABULAR FORM.

THE OCTAL BASE

THE ARRANGEMENT AND DIMENSIONS OF THE SMALL OCTAL 8-PIN BASE, AS USED WITH THESE METAL TUBES, IS SUCH AS TO CORRESPOND WITH THE SOCKET ILLUSTRATED IN FIG. 29.

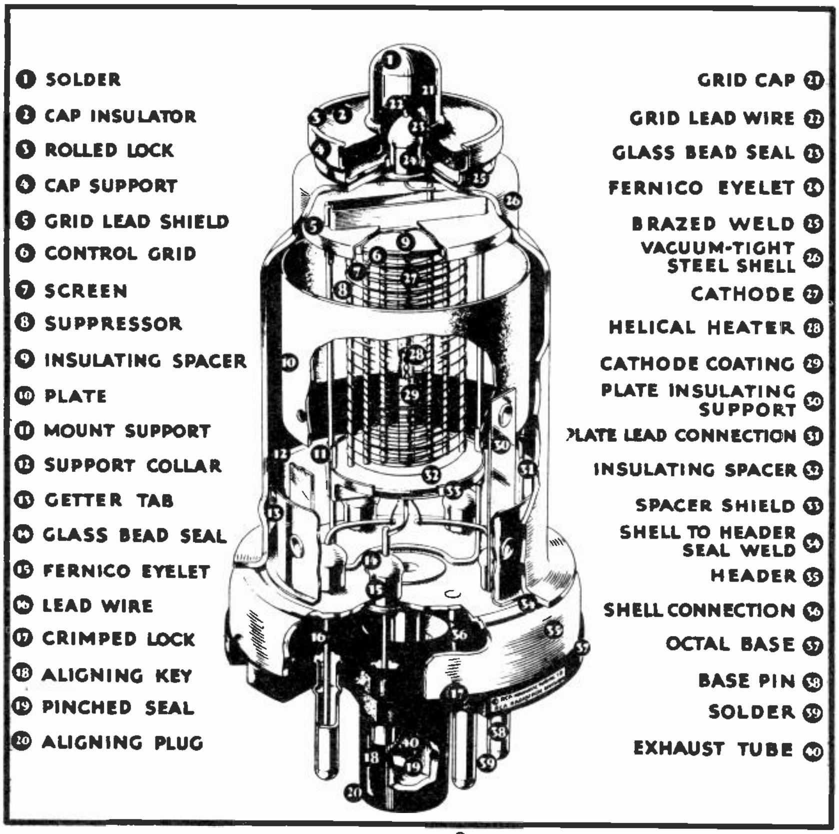

FIG. 28
INTERNAL STRUCTURE OF AN ALL-METAL TUBE

WHEN A TOTAL OF EIGHT PRONGS ARE MOUNTED ON THE BASE, THEY ARE SPACED EQUI-DISTANT, APART AND NUMBERED TO CORRESPOND WITH THE SOCKET TERMINAL NUMBERS DESIGNATED IN FIG. 29.

THESE PRONGS ARE ALL EQUAL IN DIAMETER AND LENGTH, AND IF THE PARTICULAR TUBE TYPE HAPPENS TO BE SUCH THAT ALL 8 PRONGS ARE NOT REQUIRED, THEN THE SURPLUS PRONGS ARE SIMPLY OMITTED FROM THE BASE BY THE MANUFACTURER. REGARDLESS OF THE NUMBER OF BASE PRONGS USED, HOWEVER, THE SPACING OF THE PRONGS USED STILL REMAINS THE SAME AS THOUGH ALL EIGHT PRONGS WERE INSTALLED, AND AT THESE POINTS ON THE BASE WHERE NO PRONGS ARE REQUIRED, THEY ARE SIMPLY OMITTED AT THAT PARTICULAR POINT.

WITH THE STANDARD BASE ARRANGEMENT AS THIS FOR ALL METAL TUBES, IT IS CLEAR THAT THE SAME SIZE AND TYPE OF SOCKET CAN BE USED FOR ANY OF THESE TUBES, AND CIRCUIT CONNECTIONS ONLY MADE AT THOSE POINTS WHERE NECESSARY.

IN FIG. 29 YOU WILL NOTE THAT EIGHT HOLES ARE ARRANGED IN A CIRCULAR PATH AROUND THE SOCKET TO ACCOMMODATE THE PRONGS OF THE TUBE BASE. A ROUND HOLE IS PROVIDED AT THE CENTER OF THE SOCKET THRU WHICH THE ALIGNING PLUG OF THE TUBE BASE CAN BE INSERTED.

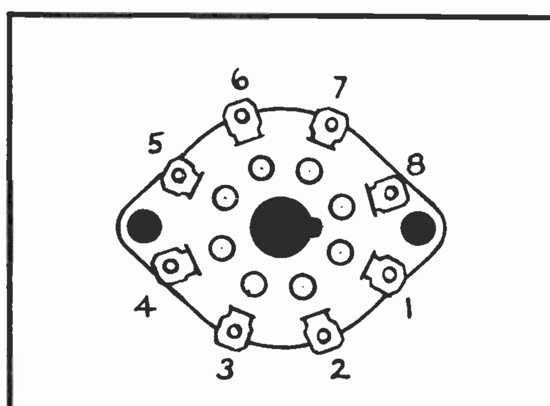

FIG. 29
THE OCTAL SOCKET

A SLOT IN THE ALIGNING HOLE TAKES CARE OF THE KEY PROJECTION ON THE ALIGNING PLUG OF THE TUBE BASE AND THUS PERMITS THE TUBE TO BE INSTALLED INTO THE SOCKET IN ONE POSITION ONLY, IN SPITE OF THE FACT THAT ALL OF THE PRONG HOLES OF THE SOCKETS ARE OF THE SAME SIZE AND EQUALLY SPACED.

THE NUMBERING OF THE BASE PRONGS, AS WILL BE NOTED IN FIG. 29, ALWAYS STARTS FROM THE SHELL CONNECTION OF THE TUBE AND WHICH IS THE FIRST PIN TO THE LEFT OF THE LOCATING KEY ON THE ALIGNING PLUG WHEN THE BASE IS VIEWED FROM THE BOTTOM, AND WITH THE KEY TOWARD THE OBSERVER. FROM THIS FIRST PIN, THE OTHERS ARE ALL NUMBERED IN A CONSECUTIVE ORDER AND IN A CLOCKWISE DIRECTION.

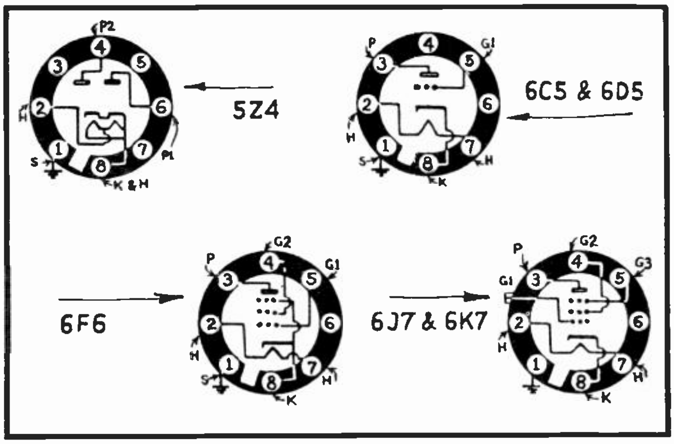

FIG. 30
METAL-TUBE BASE CONNECTIONS

SOCKET CONNECTIONS

IN FIG. 30 YOU ARE SHOWN THE BASE CONNECTIONS FOR THE FOUR TYPES OF METAL TUBES IN WHICH WE ARE AT THE PRESENT TIME INTERESTED. LATER IN THE COURSE YOU WILL RECEIVE THE COMPLETE OPERATING CHARACTERISTICS OF THESE TUBES AS WELL AS MANY OTHERS WHICH ARE INCLUDED IN THE METAL-TUBE FAMILY.

IN EACH OF THESE SYMBOLS THE FOLLOWING ABBREVIATIONS ARE USED: S = THE METAL SHELL OF THE TUBE WHICH IS ALWAYS CONNECTED TO PIN #1 OF THE BASE. THIS PIN CONNECTION IS THEN GROUNDED WHEN WIRING THE CIRCUITS, AND THE METAL SHELL THEN SERVES AS A SHIELD FOR THE TUBE, THEREBY DOING AWAY WITH THE NEED FOR A SHIELD AS REQUIRED BY GLASS TUBES; H = HEATER CONNECTION; K = CATHODE CONNECTIONS; P -P_1 AND P_2 = PLATE CONNECTIONS; G-G -G_2 AND G_3 = GRID CONNECTIONS.

EXAMINATION QUESTIONS

LESSON NO. 16

1. - WHAT METHOD IS GENERALLY EMPLOYED FOR SUPPLYING THE REQUIRED FILAMENT VOLTAGE TO THE TUBES IN A.C. RECEIVERS?

2. - HOW IS THE GRID-BIAS VOLTAGE GENERALLY OBTAINED IN A.C. RECEIVERS THAT EMPLOY TUBES HAVING INDIRECTLY HEATED CATHODES?

3. - FOR WHAT REASON IS A BYPASS CONDENSER GENERALLY CONNECTED ACROSS A BIAS RESISTOR?

4. - IN A.C. RECEIVERS, WHY IS IT ADVISABLE TO TWIST THE FILAMENT CIRCUIT WIRES TOGETHER THROUGHOUT THEIR ENTIRE LENGTH?

5. - DRAW A CIRCUIT DIAGRAM SHOWING THREE TYPE 58 TUBES CONNECTED IN THE CIRCUITS OF AN R.F. AMPLIFIER.

6. - DRAW A CIRCUIT DIAGRAM SHOWING A SINGLE 2A5 TUBE IN THE POWER STAGE OF AN A.F. AMPLIFIER.

7. - DRAW A CIRCUIT DIAGRAM SHOWING HOW A PAIR OF TYPE 42 TUBES MAY BE USED IN A PUSH-PULL POWER STAGE.

8. - DRAW A BASIC DIAGRAM OF A METAL-TUBE RECEIVER, USING ONE 6K7, ONE 6J7 AND ONE 6F6 TUBE.

9. - DRAW A DIAGRAM OF AN A.C. RECEIVER USING TWO 6D6 TUBES, ONE 6C6 TUBE, AND ONE 42 TUBE.

10. - WHAT IS THE CONVENTIONAL METHOD FOR CONTROLLING THE VOLUME IN RECEIVERS USING VARIABLE-MU TUBES IN THE R.F. STAGES?

simultaneously

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LESSON NO. 17

POWER SUPPLY FOR A.C. RECEIVERS

Since you are now familiar with the general operation of A-C receivers, your next step will be to acquaint yourself thoroughly with the POWER SUPPLY used with this type of receiver. This should be rather easy for you, because your present understanding of "A" and "B" eliminators will help you to grasp the various principles employed in A-C power supply operation, most of which are exactly the same as those used in the battery eliminators.

In Fig. 2 the various units which together form the complete power supply are all laid out in diagram form. Above each unit you will see a graphical representation of what is going on within it.

THE POWER TRANSFORMER

Starting at the left of Fig.2, we have first the POWER TRANSFORMER, which receives an A-C supply from the house lighting lines. This particular transformer does the following two important things: (1) It steps-up some of the lighting supply current to a high A-C voltage which is delivered to the rectifier for "B" use; (2) It also steps-down the A-C lighting voltage to the various A-C voltages required by the tube filaments.

Fig. 1
National Instructor Describing Speakers

As shown in Fig.2,

THESE LOW-VOLTAGE ALTERNATING CURRENTS ARE DELIVERED DIRECTLY TO THE FILAMENT CIRCUITS OF THE RECEIVER, AND THEY DO NOT PASS THROUGH THE RECTIFIER.

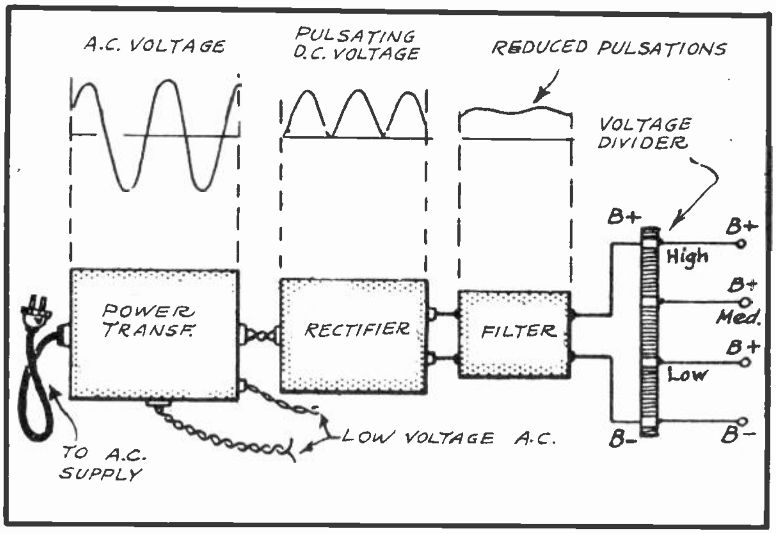

FIG. 2
UNITS OF POWER PACK AND THEIR ACTION

THE FILTER

THE HIGH A-C VOLTAGES DELIVERED BY THE POWER TRANSFORMER TO THE RECTIFIER ARE CONVERTED BY IT INTO A PULSATING CURRENT, WHICH IS A DIRECT CURRENT THAT FLOWS IN DISCONNECTED "SPURTS". THIS PULSATING DIRECT CURRENT IS NOT SUITABLE FOR USE IN THE PLATE CIRCUITS OF THE RECEIVER, FOR IT WOULD CAUSE HUM. TO SMOOTH OUT THESE PULSATIONS, THIS "ROUGH" D-C IS PASSED THROUGH A FILTER WHEREIN THE PULSATIONS ARE "IRONED OUT", SO TO SPEAK, AND THE CURRENT DELIVERED BY THE FILTER IS QUITE SMOOTH, APPROACHING THE UNIFORMITY IN FLOW THAT IS CHARACTERISTIC OF BATTERY CURRENT.

B-VOLTAGE DISTRIBUTION

THE VOLTAGE ACROSS THE POSITIVE AND NEGATIVE SIDES OF THE "B" LINES AS THEY COME OUT OF THE FILTER WILL BE QUITE HIGH; FOR EXAMPLE, 300 VOLTS WHICH IS SUITABLE FOR THE PLATE CIRCUIT OF MOST POWER STAGES, BUT TOO HIGH FOR USE ON THE PLATES AND SCREEN GRIDS OF THE OTHER TUBES OF THE RECEIVER. THEREFORE, WE MAY CONNECT A TAPPED RESISTOR ACROSS THE B+ AND B- LINES, AT THE OUTPUT OF THE FILTER. THIS IS CALLED THE VOLTAGE-DIVIDER.

ONE END OF THIS VOLTAGE-DIVIDER IS B-, AND THE OTHER EXTREMITY GIVES THE MAXIMUM B+ VALUE. THE INTERMEDIATE TAPS, OR THOSE BETWEEN B+ AND B-, FURNISH THE LOWER B+ VALUES FOR THE VARIOUS PLATE AND SCREEN-GRID CIRCUIT CONNECTIONS. THE VOLTAGE-DI-

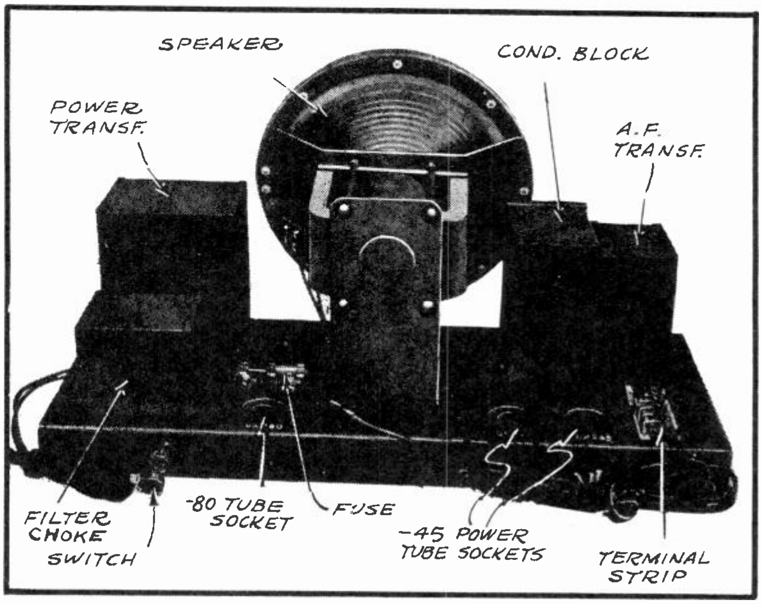

FIG. 3
A.C. POWER PACK

VIDER DOES JUST WHAT ITS NAME INDICATES; IT PROVIDES THE RECEIVER WITH THE REQUIRED VARIETY OF "B" VOLTAGES WHICH ARE NECESSARY FOR THE DIFFERENT STAGES.

THE MORE MODERN PRACTICE IS TO REPLACE THE VOLTAGE-DIVIDER RESISTOR WITH A NETWORK OF INDIVIDUAL RESISTORS PLACED AT THE MOST CONVENIENT POINTS IN THE RECEIVER CIRCUIT, AS EXPLAINED AND ILLUSTRATED LATER IN THIS LESSON. IT IS ALSO WELL TO POINT OUT THAT SOME YEARS AGO IT WAS CUSTOMARY TO INCORPORATE THE SPEAKER, POWER SUPPLY, AND THE POWER STAGE OF THE AUDIO AMPLIFIER INTO ONE INTEGRAL UNIT APART FROM THE RECEIVER PROPER, AS SHOWN IN FIG. 3, BUT THE MODERN PRACTICE IS TO MOUNT ALL UNITS OF THE POWER SUPPLY SYSTEM ON THE RECEIVER CHASSIS, AS SHOWN IN FIG. 4.

NOW THAT YOU ARE FAMILIAR WITH THE GENERAL SET-UP OF THE POWER SUPPLY SYSTEM, WE SHALL CONTINUE WITH A MORE DETAILED EXPLANATION OF THE VARIOUS PARTS.

DETAILS OF THE POWER TRANSFORMER

A TYPICAL POWER TRANSFORMER IS SHOWN IN FIG. 5. IN THIS ILLUSTRATION YOU ARE ABLE TO SEE THE SOLDERING LUGS AT THE TERMINALS OF THE VARIOUS WINDINGS; THE EXPRESSION "C.T.", AS HERE USED, DESIGNATES THE CENTER-

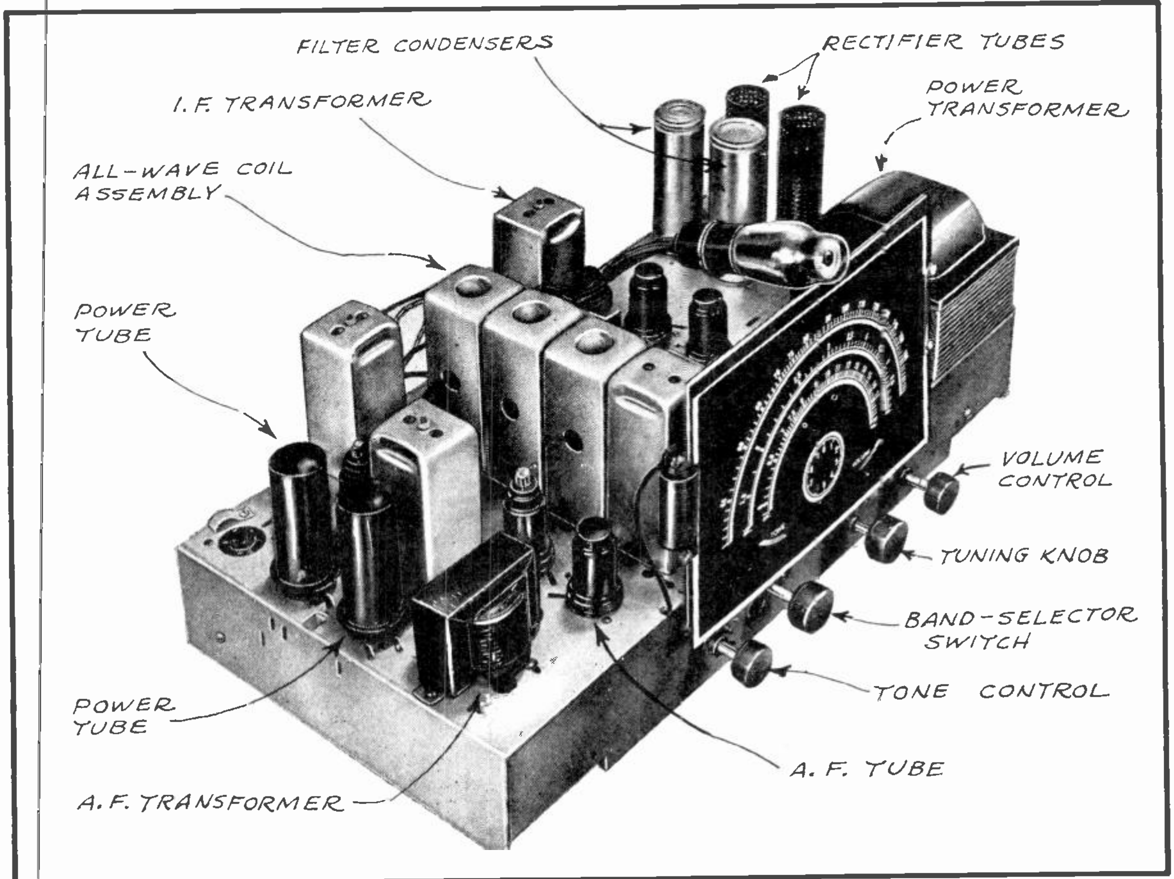

FIG. 4
MODERN METAL-TUBE RECEIVER

TAP TERMINAL OF A WINDING, AND "H.T." REFERS TO THE HIGH-TENSION OR HIGH VOLTAGE WINDING.

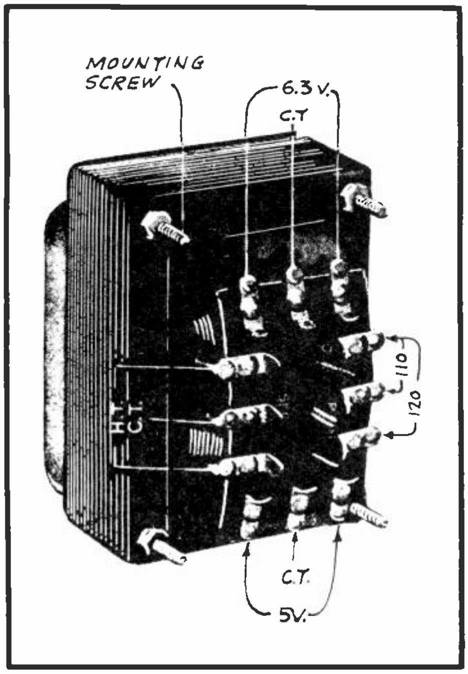

FIG. 5
DETAILS OF POWER TRANSFORMER

THIS PARTICULAR TRANSFORMER HAS A PRIMARY WINDING SUITABLE FOR CONNECTION TO A LIGHTING CIRCUIT OPERATING AT 110 OR 120 VOLTS. IN ADDITION, IT HAS A HIGH-VOLTAGE CENTER-TAPPED SECONDARY WINDING FOR "B" USE, A 5-VOLT CENTER-TAPPED SECONDARY FOR THE FILAMENT OF A TYPE 80 TUBE, A 6.3-VOLT CENTER-TAPPED SECONDARY FOR POWER TUBE FILAMENTS, AND THE THREE WIRES PROJECTING FROM THE CENTRAL PORTION OF THE TERMINAL STRIP ARE THE ENDS AND CENTER-TAP OF ANOTHER 6.3-VOLT SECONDARY FURNISHING THE FILAMENT SUPPLY FOR THE REMAINDER OF THE RECEIVER TUBES.

THE FOUR SCREW-ENDS AT THE FOUR CORNERS OF THIS TRANSFORMER'S CORE ARE USED IN FASTENING THE UNIT TO THE CHASSIS BASE.

ANOTHER POPULAR TRANSFORMER CONSTRUCTION IS TO USE WIRE LEADS FOR THE WINDING CONNECTIONS, INSTEAD OF THE TERMINAL ARRANGEMENT OF FIG. 5. SUCH A TRANSFORMER IS USUALLY ENCASED IN A METAL SHIELD.

FIG.6 DIAGRAMS THE INTERNAL CONSTRUCTION OF A TYPICAL POWER TRANSFORMER, CONSISTING OF A LAMINATED IRON CORE, AROUND WHICH ARE WOUND A PRIMARY AND SEVERAL SECONDARY WINDINGS. THE PRIMARY IS CONNECTED ACROSS THE A-C LIGHTING CIRCUIT AND THE HIGH-VOLTAGE WINDING BUILDS UP THE VOLTAGE FOR THE "B" SUPPLY. THE LOW-VOLTAGE SECONDARIES PROVIDE THE PROPER VOLTAGES FOR THE VARIOUS TUBE FILAMENTS.

THE HALF-WAVE RECTIFIER

IN FIG. 7 IS ILLUSTRATED A TYPICAL HALF-WAVE RECTIFIER CIRCUIT, IN WHICH THE 81 FILAMENT-TYPE RECTIFYING TUBE IS USED. THE PRIMARY WINDING OF THE POWER TRANSFORMER IS PROVIDED WITH 110-VOLT A-C VOLTAGE FROM THE LIGHTING LINES, AND IT BUILDS UP AN A-C VOLTAGE OF 650 VOLTS ACROSS THE HIGH-VOLTAGE SECONDARY, AND 7½ VOLTS ACROSS THE FILAMENT WINDING. THE ENDS OF THIS 7½ VOLT TRANSFORMER WINDING ARE CONNECTED ACROSS THE FILAMENT OF THE 81 TUBE, AND THE CURRENT FLOW THRU THE FILAMENT OF THIS TUBE HEATS IT SO THAT IT EMITS ELECTRONS.

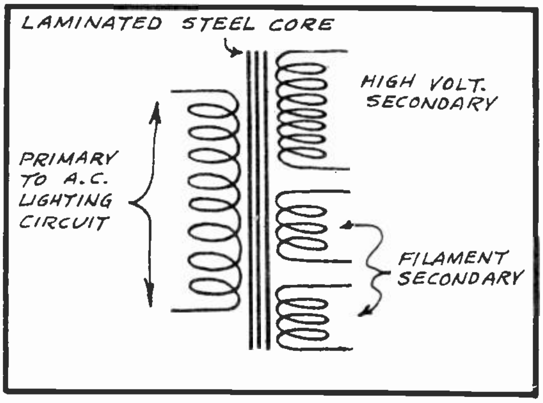

FIG. 6
DIAGRAM OF THE POWER TRANSFORMER

THE ENDS OF THE HIGH-VOLTAGE SECONDARY WINDING ARE ALTERNATELY POS-

ITIVE AND NEGATIVE BECAUSE OF THE A-C REVERSALS THRU IT, AND WHENEVER THE END WHICH IS CONNECTED TO THE TUBE'S PLATE BECOMES POSITIVE, A STREAM OF ELECTRONS IS ATTRACTED FROM THE FILAMENT OVER TO THE PLATE, AS IN ORDINARY RADIO TUBES. THESE ELECTRONS FLOW OUT OF THE HIGH-VOLTAGE SECONDARY WINDING INTO A NEGATIVE SIDE OF THE RECTIFIER'S OUTPUT CIRCUIT, TO BE DISTRIBUTED TO THE VARIOUS RECEIVER CIRCUITS. THIS SAME FLOW OF ELECTRONS RETURNS FROM THE RECEIVER CIRCUITS THRU THE POSITIVE SIDE OF THE RECTIFIER CIRCUIT, PASSING INTO THE CENTER TAP OF THE $7\frac{1}{2}$-VOLT WINDING, AND THENCE RETURNING TO THE TUBE FILAMENT TO COMPLETE THE CIRCUIT.

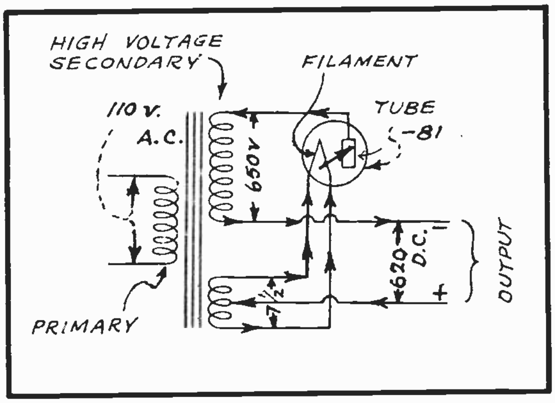

FIG. 7
HALF-WAVE RECTIFIER CIRCUIT

DURING THOSE INTERVALS WHEN THE GENERATED A-C IN THE HIGH-VOLTAGE SECONDARY WINDING CAUSES THE PLATE END OF THIS WINDING TO BECOME NEGATIVE, THE PLATE WILL NOT ATTRACT ELECTRONS FROM THE FILAMENT AND NO CURRENT WILL FLOW THRU THE TUBE. THUS, ONLY ONE-HALF OF THE LINE'S A-C WAVE IS USED, AND SINCE THE CURRENT FLOWS THRU THE RECTIFIER TUBE IN ONLY ONE DIRECTION, IT IS CLEAR THAT THE OUTPUT CURRENT WILL CONSIST OF SUCCESSIVE "SHOTS" OF CURRENT, ALL FLOWING IN THE SAME DIRECTION. THIS GIVES A PULSATING D-C PLATE SUPPLY FOR THE RECEIVER.

FIG. 8 ILLUSTRATES GRAPHICALLY THE NATURE OF THE PULSATING DIRECT CURRENT AS OBTAINED FROM A HALF-WAVE RECTIFIER SUCH AS SHOWN IN FIG. 7. THE HEAVY HORIZONTAL LINE REPRESENTS ZERO CURRENT. YOU WILL NOTE THAT EACH TIME THE RECTIFIER TUBE'S PLATE BECOMES NEGATIVE, NO CURRENT FLOWS THROUGH THE EXTERNAL CIRCUIT. THE TUBE THUS FUNCTIONS SOMEWHAT AS A ONE-WAY VALVE, PERMITTING CURRENT TO FLOW THROUGH THE CIRCUIT INTERMITTENTLY, IN ONE DIRECTION ONLY. THE FACT THAT ALL OF THE CURRENT CURVES IN FIG. 8 ARE ABOVE THE HORIZONTAL OR ZERO REFERENCE LINE INDICATES THAT THE CURRENT ALWAYS FLOWS IN THE SAME DIRECTION.

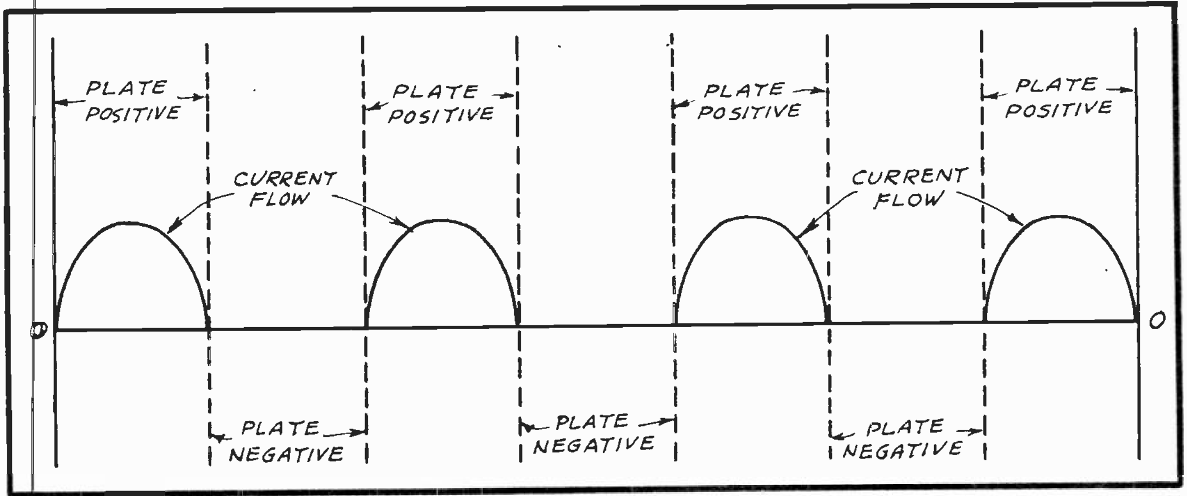

FIG. 8
CURRENT RESULTING FROM HALF-WAVE RECTIFICATION

FULL-WAVE RECTIFICATION

A FULL-WAVE RECTIFIER CIRCUIT USING THE 80 TYPE TUBE IS SHOWN IN FIG. 9. IN THIS CASE, 350 VOLTS IS GENERATED BETWEEN THE CENTER-TAP AND EACH END OF THE HIGH-VOLTAGE TRANSFORMER SECONDARY, SO THAT THERE WILL BE 350 VOLTS IMPRESSED UPON EACH PLATE OF THE 80 TUBE. THIS TUBE REQUIRES A FILAMENT VOLTAGE OF 5 VOLTS, WHICH IS PROVIDED BY THE 5-VOLT FILAMENT WINDING OF THE POWER TRANSFORMER.

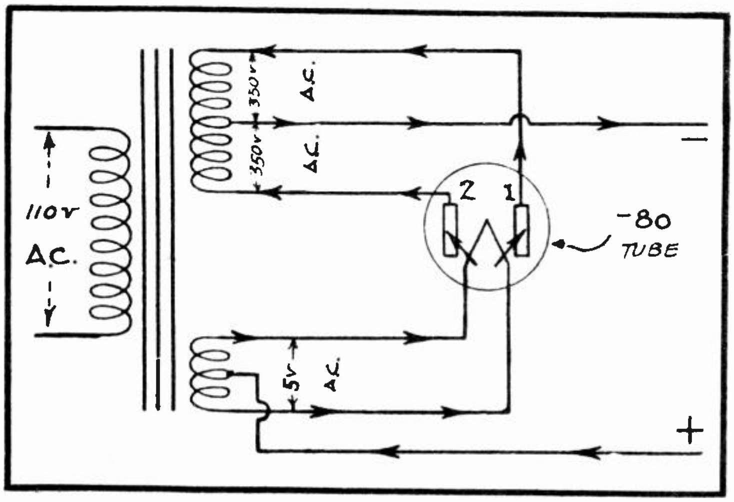

FIG. 9
FULL-WAVE RECTIFIER CIRCUIT

REGARDLESS OF WHICH WAY THE CURRENT IS FLOWING THRU THE HIGH-VOLTAGE SECONDARY, ONE OF ITS ENDS WILL ALWAYS BE POSITIVE, SO THAT PLATES #1 AND #2 OF THE 80 TUBE WILL BECOME POSITIVE IN ALTERNATION. THIS MEANS THAT DURING ONE ALTERNATION OF THE A-C, PLATE #1 WILL HAVE A POSITIVE POTENTIAL IMPRESSED UPON IT AND WILL ATTRACT ELECTRONS FROM THE FILAMENT. DURING THE NEXT REVERSAL OF THE A-C, PLATE #2 WILL BECOME POSITIVELY CHARGED, SO THAT THE ELECTRONS WILL THEN FLOW THROUGH THE TUBE FROM THE FILAMENT TO PLATE #2. IT MAKES NO DIFFERENCE WHICH OF THESE PLATES IS POSITIVE AT ANY ONE INSTANT, FOR THE ELECTRON FLOW THRU THE TUBE ALWAYS FLOWS INTO ONE OF THE PLATES AND THENCE TO THE OUTER CIRCUIT. THIS SAME FLOW OF ELECTRONS RETURNS TO THE RECTIFIER TUBE'S FILAMENT THRU THE CENTER-TAP OF THE FILAMENT WINDING.

NOTICE IN FIG. 9 THAT THE POINT AT WHICH THE ELECTRON-FLOW LEAVES THE RECTIFIER SERVES AS THE NEGATIVE SIDE OF THE RECTIFIER OUTPUT, WHILE THE RETURN SIDE OF THE CIRCUIT SERVES AS THE POSITIVE LEG OF THE RECTIFIER CIRCUIT. IT IS ALSO IMPORTANT TO NOTE THAT THE CIRCUIT ARRANGEMENT ILLUSTRATED IN FIG. 9 MAKES IT POSSIBLE TO USE BOTH HALVES OF THE A-C WAVE, THEREBY PROVIDING FULL-WAVE RECTIFICATION.

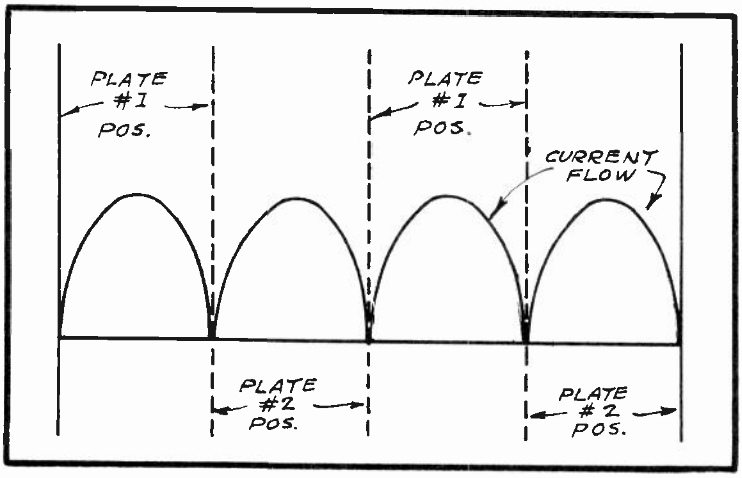

FIG. 10
CURRENT RESULTING FROM FULL-WAVE RECTIFICATION

THE WAVE-FORM OF SUCH A RECTIFIER IS SIMILAR TO THAT ILLUSTRATED IN

FIG. 10. THIS GRAPHIC ILLUSTRATION SHOWS THAT WHEN FULL-WAVE RECTIFICATION IS EMPLOYED, THE SURGES OF DIRECT CURRENT OCCUR IN A MORE CONTINUOUS SEQUENCE THAN WHEN HALF-WAVE RECTIFICATION IS USED, AND FOR THIS REASON NO INTERVALS OF ZERO CURRENT APPEAR IN FIG. 10.

THE USE OF PARALLEL RECTIFYING TUBES

THE 81 TUBE IN FIG. 7 PROVIDES AN OUTPUT OF ABOUT 620 VOLTS D-C; THE 80 TUBE DELIVERS A MAXIMUM D-C OUTPUT OF ONLY ABOUT 300 VOLTS, OR APPROXIMATELY ONE-HALF THAT OF THE 81; EACH HAS ITS PARTICULAR ADVANTAGE IN THIS RESPECT. A SINGLE 80 TUBE WILL FURNISH ENOUGH D-C VOLTAGE TO HANDLE MOST RECEIVER-TYPE POWER TUBES SATISFACTORILY, BECAUSE FOR THE MAJORITY THE MAXIMUM PLATE VOLTAGE REQUIRED WILL BE 250 VOLTS. TO HANDLE LARGER POWER TUBES, THE HIGHER D-C OUTPUT VOLTAGE OF THE 81 TUBE IS SOMETIMES NEEDED.

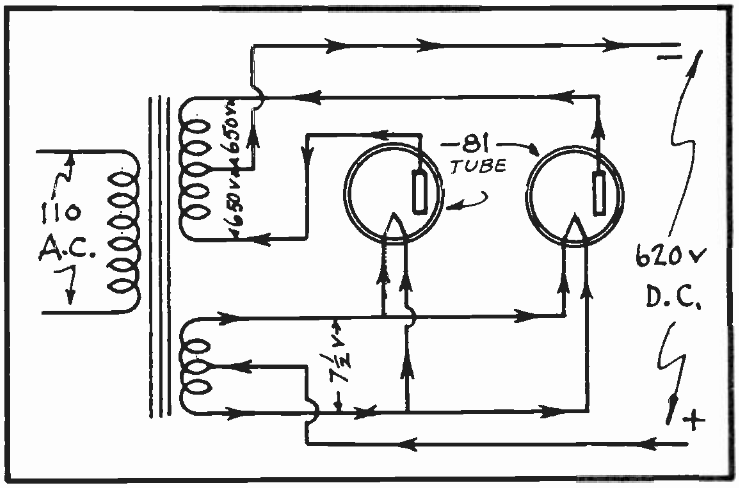

FIG. 11
FULL-WAVE RECTIFICATION WITH TWO -81 TUBES

TO USE THE 81 FOR THIS PURPOSE, AND TO BE ABLE TO OBTAIN THE REQUIRED D-C CURRENT OUTPUT TO HANDLE THE LARGER POWER TUBES IN ADDITION TO THE STANDARD TUBES IN THE RECEIVER OR AMPLIFIER, TWO 81 TUBES MAY BE CONNECTED IN A PARALLEL ARRANGEMENT, AS ILLUSTRATED IN FIG. 11, WHICH GIVES AN OUTPUT OF ABOUT 620 VOLTS D-C, AND A CURRENT OF FROM ABOUT 130 MILLIAMPERES TO 150 MILLIAMPERES MAXIMUM. IN FIG. 11 YOU WILL NOTICE THAT BY HAVING A TUBE PLATE CONNECTED IN PARALLEL, THE SAME OPERATING PRINCIPLES WILL APPLY AS OUTLINED RELATIVE TO THE 80 TUBE. THAT IS, THE CIRCUIT IN FIG. 11 GIVES FULL-WAVE RECTIFICATION, WITH THE CENTER-TAP OF THE RECTIFIER TUBE FILAMENT TRANSFORMER WINDING BEING THE POSITIVE (+) END OF THE D-C OUTPUT, WHILE THE CENTER-TAP CONNECTION OF THE HIGH-VOLTAGE SECONDARY IS THE NEGATIVE (-) END OF THE D-C OUTPUT. THE SAME PRINCIPLES EXPLAINED IN CONNECTION WITH THE 80 AND 81 TUBES MAY BE APPLIED IN LIKE MANNER TO ALL OF THE OTHER FULL-WAVE AND HALF-WAVE RECTIFIER TUBES.

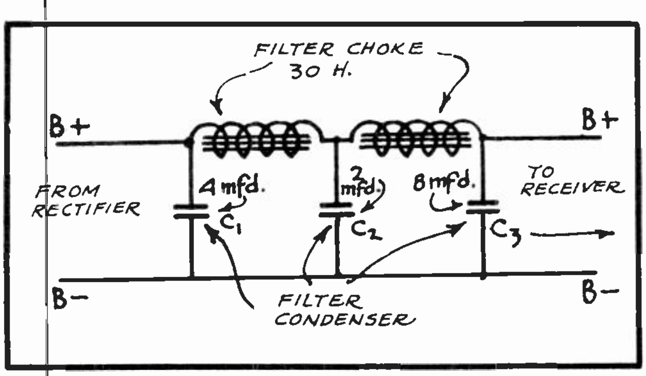

FIG. 12
TYPICAL FILTER CIRCUIT

FILTER CIRCUITS

THE NEXT PROBLEM IS TO REMOVE OR GREATLY REDUCE THE PULSATION IN THE D-C OUTPUT OF THE RECTIFIER, BY MEANS OF FILTERING. IN A PREVIOUS LESSON YOU WERE INTRODUCED TO TYPICAL FILTER CIRCUITS, AND WILL NO

DOUBT RECALL THAT THEY WERE SOMETHING LIKE THAT PICTURED IN FIG. 12; THAT IS, CONSISTING OF A CHOKE COIL AND CONDENSER COMBINATION.

YOU WILL NOT FIND THE VALUES DESIGNATED IN FIG. 12 TO HOLD GOOD IN ALL CASES; THE VARIOUS MANUFACTURERS MAY HAVE OTHER SPECIFICATIONS. HOWEVER, THE VALUES IN FIG. 12 WILL GIVE YOU AN IDEA OF WHAT FILTER CIRCUIT SPECIFICATIONS ARE LIKE.

YOU WILL VERY OFTEN FIND ALL OF THE FILTER CONDENSERS WITH THE SAME CAPACITY, GENERALLY FROM 2 MFD. TO 8 MFD., BUT USUALLY THE CONDENSER AT THE OUTPUT OF THE FILTER (C_3) HAS THE LARGEST CAPACITY, AND A LARGE CAPACITY AT THIS POINT AIDS GREATLY IN REDUCING HUM AND IMPROVING THE TONE QUALITY OF THE RECEIVER.

IT IS NOT ESSENTIAL IN ALL CASES TO HAVE EXACTLY TWO CHOKE COILS AND THREE FILTER CONDENSERS; FURTHERMORE, YOU WILL ALSO FIND CASES WHERE A CHOKE COIL PRECEDES THE FIRST FILTER CONDENSER, INSTEAD OF HAVING A FILTER CONDENSER CONNECTED DIRECTLY ACROSS THE RECTIFIER OUTPUT AS IN FIG. 12.

THE LARGER THE CAPACITY OF (C_1), THE GREATER WILL BE THE OUTPUT VOLTAGE OF THE RECTIFIER, AND FOR THIS REASON IT IS NOT ADVISABLE TO USE TOO HIGH A CAPACITY AT THIS POINT. IN OTHER WORDS, TOO GREAT A CAPACITY HERE MAY RAISE THE VOLTAGE SUFFICIENTLY TO PRODUCE AN ABNORMAL STRAIN UPON THE POWER PACK SYSTEM, ETC., RESULTING IN SERIOUS INJURY TO THEM.

THESE CONDENSERS MAY HAVE EITHER A PAPER, WET, OR DRY ELECTROLYTIC

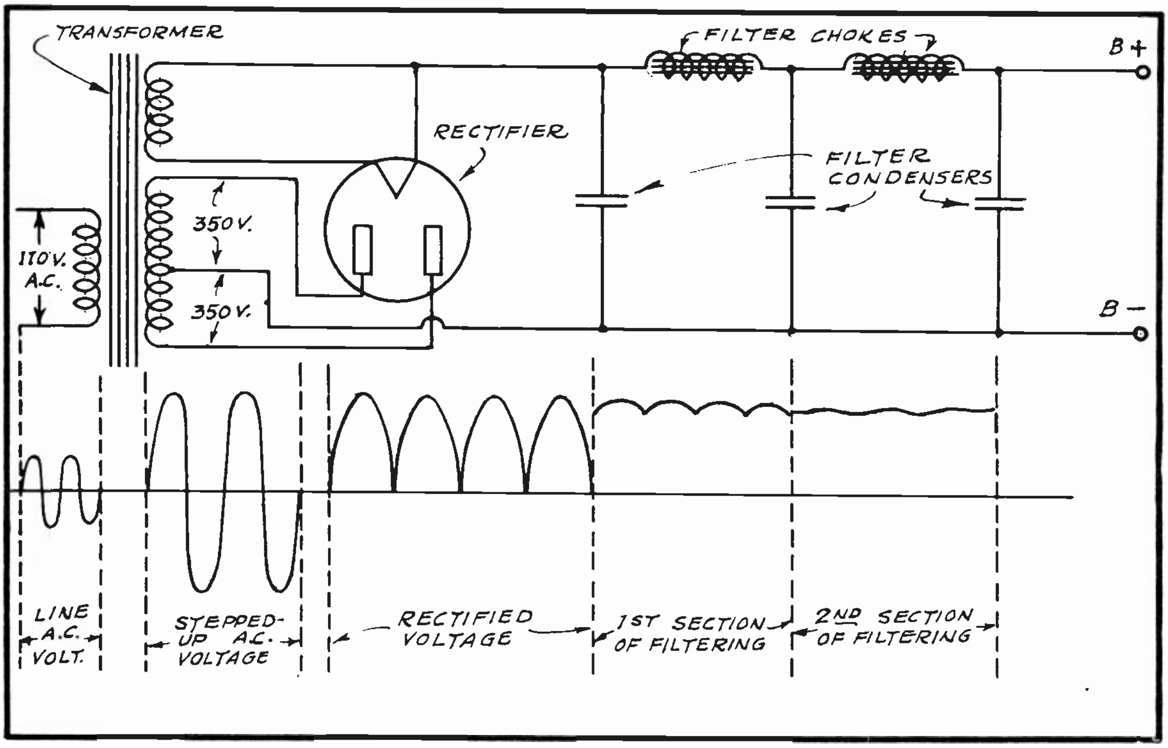

FIG. 13
ANALYSIS OF POWER SUPPLY SYSTEM

DIELECTRIC, BUT IN ALL CASES THEIR D-C VOLTAGE RATINGS MUST BE SUCH AS TO MAKE THEM CAPABLE OF STANDING UP UNDER THE MAXIMUM PEAK VOLTAGES WHICH ARE LIKELY TO BE IMPRESSED ACROSS THEM. IN ADDITION, THERE SHOULD BE A SATISFACTORY MARGIN OF SAFETY.

TO ILLUSTRATE FURTHER THE EFFECT OF A FILTER SYSTEM, YOU ARE SHOWN IN FIG. 13 A SIMPLIFIED FORM OF ELECTRICAL ANALYSIS OF A COMPLETE POWER SUPPLY SYSTEM. NOTE FIRST THAT THE A-C LINE VOLTAGE IS APPLIED ACROSS THE PRIMARY WINDING OF THE POWER TRANSFORMER, WHEREIN IT IS THEN STEPPED-UP AND APPLIED ACROSS THE PLATES OF THE RECTIFIER TUBE.

A PULSATING DIRECT CURRENT IS AVAILABLE AT THE OUTPUT OF THE RECTIFIER, AND IS PARTIALLY SMOOTHED OUT BY THE FIRST SECTION OF THE FILTER. THE SECOND SECTION OF THE FILTER MAKES THE FLOW OF RECTIFIED CURRENT STILL MORE UNIFORM, SO THAT IT VERY NEARLY APPROACHES THE UNIFORMITY OF BATTERY CURRENT.

FIG. 14
FILTER CONDENSER

FOR THE TIME BEING, THIS IS ALL YOU NEED TO KNOW CONCERNING THE OPERATING THEORY OF POWER SUPPLY SYSTEMS, BUT THIS SUBJECT WILL BE TREATED MORE TECHNICALLY IN LATER LESSONS, WHICH WILL SHOW IN DETAIL HOW ALL OF THESE VARIOUS ACTIONS ARE OBTAINED, AND WILL FAMILIARIZE YOU WITH THE DESIGN FACTORS INVOLVED.

WHILE YOUR INTEREST IS STILL CENTERED ON FIG. 13, IT IS WELL TO POINT OUT THAT IT IS NOT ESSENTIAL FOR THE B+ CONNECTION TO BE MADE AT THE CENTER-TAP OF THE RECTIFIER TUBE'S FILAMENT WINDING, BUT THAT EITHER SIDE OF THE FILAMENT CIRCUIT CAN BE USED FOR THIS PURPOSE.

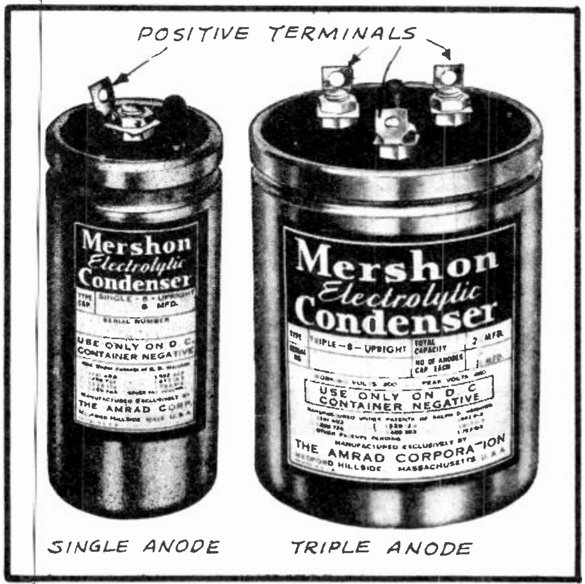

FIG. 15
ELECTROLYTIC CONDENSERS

FILTER CONDENSERS

A TYPICAL FILTER CONDENSER HAVING A PAPER DIELECTRIC IS SHOWN IN FIG. 14. THIS PARTICULAR CONDENSER HAS A CAPACITY OF 1 MFD. AND IS CAPABLE OF WITHSTANDING 1000 VOLTS (D-C) IMPRESSED ACROSS THE TERMINALS. THAT IS, ITS WORKING VOLTAGE IS RATED AT 1000 VOLTS D-C. CONDENSERS OF THIS TYPE ARE GENERALLY REFERRED TO AS "PAPER CONDENSERS," AND CAN BE OBTAINED IN A GREAT VARIETY OF CAPACITIES AND D-C VOLTAGE RATINGS.

TWO TYPICAL ELECTROLYTIC FILTER CONDENSERS ARE SHOWN IN FIG. 15. THE LARGE ONE AT THE RIGHT CONSISTS OF THREE SEPARATE CONDENSERS WITHIN A SINGLE CONTAINER OR CAN WHICH IS CONNECTED TO ONE

SIDE OR "PLATE" OF ALL THREE CONDENSERS. THE OTHER SIDE OF EACH IS CONNECTED TO ONE OF THE THREE TERMINALS AT THE CAN TOP, AND THESE MUST ALWAYS BE CONNECTED TO THE POSITIVE SIDE OF THE D-C LINE. EITHER CONNECTION OF A PAPER CONDENSER MAY BE CONNECTED TO POSITIVE OR NEGATIVE, BUT IN THE ELECTROLYTIC TYPE IT MAKES A GREAT DIFFERENCE.

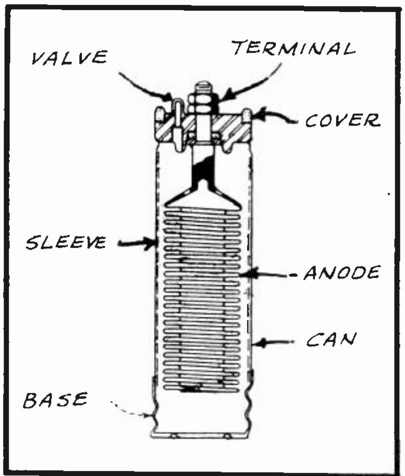

FIG. 16
INTERNAL CONSTRUCTION OF AN ELECTROLYTIC CONDENSER

THE ANODES, AS THEY ARE CALLED IN THE ELECTROLYTIC CONDENSER, MUST ALWAYS BE CONNECTED TO THE POSITIVE SIDE OF THE D-C LINE, AND FOR THAT REASON THE INDIVIDUAL POSITIVE OR ANODE TERMINALS ARE PROVIDED. THE METAL CAN, WHICH SERVES AS THE NEGATIVE OR CATHODE SIDE, MUST THEN BE CONNECTED TO THE NEGATIVE SIDE OF THE D-C LINE. DO NOT FORGET THIS, BECAUSE A REVERSED CONNECTION WILL PREVENT THE CONDENSER FROM OPERATING PROPERLY, AND IS ALMOST CERTAIN TO DAMAGE OR DESTROY IT.

EACH OF THE INDIVIDUAL CONDENSERS WITHIN THE CAN SHOWN AT THE RIGHT OF FIG. 15 HAS A CAPACITY OF 8 MFD., WHICH IS GENERALLY SPOKEN OF AS A CAPACITY OF 8 MFD. PER ANODE. THE CONDENSER AT THE LEFT IS A SINGLE UNIT HAVING BUT ONE ANODE, A CAPACITY OF 8 MFD., AND A PEAK VOLTAGE RATING OF 400 VOLTS. BUT ONE POSITIVE TERMINAL IS PROVIDED, AND THE CAN SERVES AS THE NEGATIVE TERMINAL. THE TRIPLE-ANODE CONDENSER OF FIG. 15 ALSO HAS A PEAK VOLTAGE RATING OF 400 VOLTS FOR EACH ANODE.

CONSTRUCTION OF ELECTROLYTIC CONDENSERS

THE INNER CONSTRUCTION OF A TYPICAL SINGLE-ANODE ELECTROLYTIC CONDENSER IS SHOWN IN FIG. 16. THE ANODE, WHICH CONSISTS OF A CORRUGATED TUBE OF PURE ALUMINUM, IS SUSPENDED IN THE CENTER OF THE CAN SO THAT IT CANNOT MAKE CONTACT WITH THE SIDE WALLS OF THE CAN. A HARD-RUBBER COMPOSITION COVER PREVENTS ANY POSSIBLE ELECTRICAL CONTACT BETWEEN THE ANODE AND THE CAN. A CHECK VALVE IS ALSO INSTALLED ON THIS COVER TO PERMIT THE GAS FORMED WITHIN THE CONTAINER TO ESCAPE BEFORE CREATING AN EXCESSIVE PRESSURE. AT THE SAME TIME, THIS VALVE PREVENTS DIRT FROM FINDING ITS WAY INTO THE CONDENSER, AND ALSO PREVENTS ELECTROLYTE FROM BEING SPRAYED OUT.

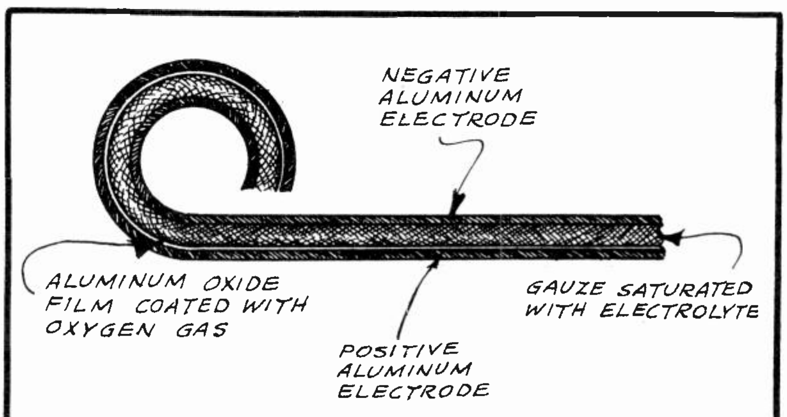

FIG. 17
CONSTRUCTIONAL FEATURES OF THE DRY ELECTROLYTIC-CONDENSER

A CRIMPED GASKET IS INSTALLED BETWEEN THE COVER AND CAN TO PROVIDE AN AIR-TIGHT

JOINT AT THIS POINT. THE LOWER END OF THE CAN HERE ILLUSTRATED IS THREADED, TO SCREW INTO A SPECIAL SOCKET AND THEREBY PROVIDE A SECURE AND CONVENIENTLY MADE CONTACT FOR THIS SIDE OF THE CIRCUIT. THE CANS FOR SUCH CONDENSERS ARE GENERALLY MADE OF COPPER, WHICH MUST BE OF UTMOST PURITY.

THE CHEMICALLY-PURE ELECTROLYTE USED IN THIS CONDENSER IS A WATER SOLUTION OF BORAX AND BORIC ACID, AND THE CAN IS FILLED WITH THIS ELECTROLYTE TO A POINT A LITTLE BELOW THE COVER. THE CONSTRUCTION THUS FAR OUTLINED DOES NOT PROVIDE A CONDENSER, BECAUSE AN IMPORTANT FORMING PROCESS MUST FIRST TAKE PLACE, WHICH PROCESS CONSISTS OF CONNECTING THE ASSEMBLED UNIT ACROSS A D-C LINE WITH THE ANODE CONNECTED TO THE POSITIVE AND THE CAN TO THE NEGATIVE SIDE. AT FIRST, CONSIDERABLE CURRENT WILL FLOW THRU THE UNIT, BUT GRADUALLY A HARD, THIN, INSOLUBLE ALUMINUM OXIDE FILM, COVERED WITH GASEOUS OXYGEN, WILL FORM OVER THE ENTIRE SURFACE OF THE ALUMINUM ANODE. THIS FILM OFFERS A GREAT DEAL OF RESISTANCE TO THE FLOW OF CURRENT, AND IS CAPABLE OF HAVING HIGH VOLTAGES IMPRESSED ACROSS IT WITHOUT CAUSING IT TO BREAK DOWN. ONLY AFTER THIS FILM HAS FORMED IS THE CONDENSER EFFECTIVE. IF 400 VOLTS D-C IS IMPRESSED ACROSS SUCH CONDENSER, HAVING A BREAK-DOWN VOLTAGE RATING OF 450 VOLTS, A LEAKAGE CURRENT OF ONLY ABOUT $\frac{1}{2}$ MILLIAMPERE WILL FLOW THROUGH IT.

FIG. 18
DRY ELECTR. CONDENSER

THE ANODE, OR ALUMINUM TUBE, SERVES AS ONE PLATE OF THE CONDENSER, AND THE ELECTROLYTE, TOGETHER WITH THE CAN, AS THE OTHER; THE FILM ON THE ALUMINUM SURFACE ACTS AS THE DIELECTRIC.

IN CASE THAT AN EXCESSIVE VOLTAGE SHOULD BE IMPRESSED ACROSS THIS CONDENSER, THE DIELECTRIC IS NOT PUNCTURED IN THE SAME SENSE AS WOULD BE THE DIELECTRIC IN A PAPER CONDENSER. THAT IS, WHEN THE DIELECTRIC IN A PAPER CONDENSER IS PUNCTURED BY EXCESSIVE VOLTAGE, THE CONDENSER BECOMES COMPLETELY SHORTED OR "BURNED OUT", SO THAT IT IS UNFIT FOR FURTHER USE.

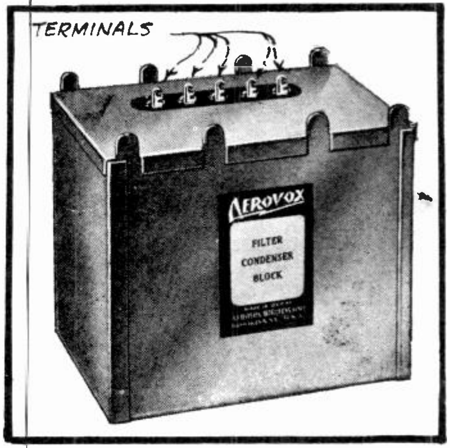

FIG. 19
CONDENSER BLOCK

WITH THE ELECTROLYTIC CONDENSER, HOWEVER, WE HAVE A DIFFERENT STATE OF AFFAIRS, FOR WHEN THE APPLIED VOLTAGE BECOMES EXCESSIVE, THE DIELECTRIC FILM ONLY "GIVES-WAY" TO PERMIT A GREATER LEAKAGE CURRENT TO PASS THRU IT, AND THE CONDENSER WILL BE ONLY TEMPORARILY INEFFECTIVE. BY REDUCING THE APPLIED VOLTAGE TO THE NORMAL VALUE, THE FILM WILL RE-BUILD TO ITS PROPER THICKNESS, ENABLING THE CONDENSER TO CONTINUE ITS WORK EFFICIENTLY. DUE TO THIS REJUVENATING PROPERTY OF THE CONDENSER, IT IS GENERALLY SPOKEN OF AS A "SELF-HEALING" OR "PUNCTURE-PROOF" CONDENSER. SHOULD THE CONNECTIONS OF THIS CONDENSER TO THE LINE BE REVERSED, A HEAVY CURRENT COULD THEN FLOW THROUGH THE CONDEN-

SER, BECAUSE THE DIELECTRIC FILM WILL THEN OFFER HARDLY ANY RESISTANCE. IN THIS RESPECT THE ELECTROLYTIC CONDENSER IS REALLY VERY MUCH LIKE A RECTIFIER, IN THAT IT OPPOSES CURRENT FLOW IN ONE DIRECTION, AND ENCOURAGES IT IN THE REVERSE DIRECTION.

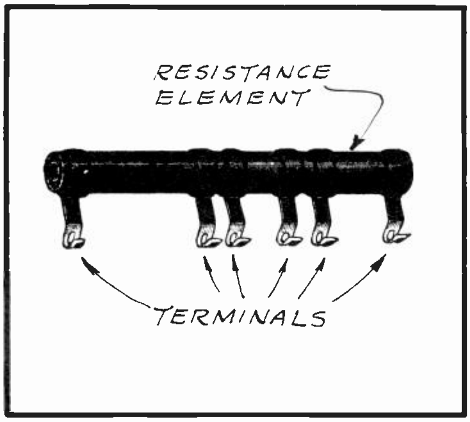

FIG. 20
VOLTAGE DIVIDER

SINCE NEITHER THE ANODE NOR THE CAN ARE CONSUMED BY THE ACTION TAKING PLACE WITHIN THIS CONDENSER, AN EXCEPTIONALLY LONG LIFE CAN BE EXPECTED. ALTHOUGH A CERTAIN AMOUNT OF WATER IN THE ELECTROLYTE IS DECOMPOSED BY THE LEAKAGE CURRENT, THE QUANTITY IS SO SMALL THAT IT HAS BEEN ESTIMATED THAT IT WOULD TAKE ABOUT 12 YEARS TO DECOMPOSE ENOUGH TO AFFECT THE CONDENSER'S CAPACITY SERIOUSLY.

MAXIMUM CAPACITY IS OBTAINED FROM THESE UNITS AT A TEMPERATURE OF 130° FAHRENHEIT, AND SINCE THE TEMPERATURE IN ORDINARY RADIO SERVICE WILL RARELY EXCEED 110° TO 115° F, VERY NEAR THE MAXIMUM CAPACITY IS OBTAINED. EXCESSIVE TEMPERATURES CAUSE GREATER LEAKAGE CURRENT AND REDUCE THE EFFICIENCY OF THE UNIT. THE CONDENSER WILL FREEZE AT APPROXIMATELY 16° F, BUT WHEN WARMED TO NORMAL TEMPERATURES IT WILL BECOME AS GOOD AS BEFORE.

ELECTROLYTIC CONDENSERS OF THE TYPES THUS FAR DESCRIBED ARE KNOWN AS THE "WET TYPES", FOR THE REASON THAT THE ELECTROLYTE IS IN A COMPLETELY LIQUIFIED STATE. BESIDE THIS FORM OF CONDENSER, THERE IS ALSO THE SO-CALLED "DRY" ELECTROLYTIC TYPE, WHICH HAS GAINED GREAT POPULARITY.

DRY ELECTROLYTIC CONDENSERS

THE DRY ELECTROLYTIC CONDENSER IS NOT AS DRY AS ITS NAME INDICATES. IN REALITY, IT IS INTERNALLY MOIST, MUCH AS THE ORDINARY "DRY CELL".

FIG. 17 DIAGRAMS THE PRINCIPLES OF CONSTRUCTION IN THE DRY ELECTROLYTIC CONDENSER, THOUGH OF COURSE THE CONSTRUCTIONAL DETAILS MAY DIFFER IN THE VARIOUS MAKES. AS YOU WILL OBSERVE, THE UNIT CONSISTS OF A POSITIVE ELECTRODE IN THE FORM OF A THIN SHEET OF PURE ALUMINUM, COATED WITH A THIN FILM OF ALUMINUM OXIDE AND OXYGEN GAS WHICH ACT AS THE DIELECTRIC. ANOTHER THIN ALUMINUM SHEET ACTS AS THE NEGATIVE ELECTRODE; THESE TWO SHEETS ARE SEPARATED FROM EACH OTHER BY ABSORBENT GAUZE SATURATED WITH A BORAX SOLUTION WHICH SERVES AS THE ELECTROLYTE. THE ALUMINUM SHEETS, TOGETHER WITH THE SATURATED GAUZE, ARE THEN

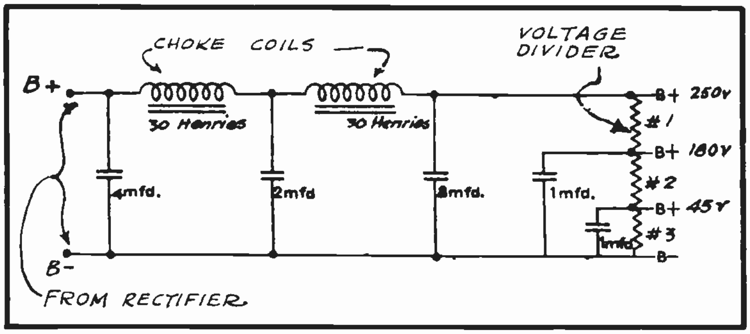

FIG. 21
INSTALLATION OF VOLTAGE DIVIDER IN CIRCUIT

ROLLED INTO A COMPACT BUNDLE AND HOUSED WITHIN AN ALUMINUM CAN, AS SHOWN. IN FIG. 18 THE POSITIVE ELECTRODE HAS A TERMINAL ATTACHED TO IT, WHILE THE NEGATIVE ALUMINUM ELECTRODE CONTACTS THE METAL CAN.

AFTER A DRY ELECTROLTYIC CONDENSER HAS BEEN CONSTRUCTED, IT MUST ALSO BE SUBJECTED TO A FORMING PROCESS AS ALREADY DESCRIBED FOR THE "WET" ELECTROLYTIC CONDENSER. THE "DRY" ELECTROLYTIC CONDENSER, HOWEVER, OFFERS CERTAIN ADVANTAGES, SUCH AS BEING ADAPTED TO MOUNTING IN ANY POSITION WITHOUT DANGER OF THE ELECTROLYTE BEING SPILLED OR SPRAYED FROM THE CAN. LIKE THE WET TYPE, IT IS SELF-HEALING.

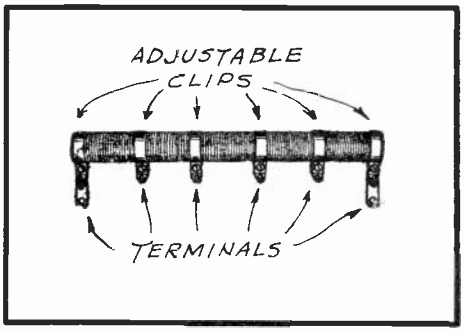

FIG. 22
ADJUSTABLE VOLTAGE DIVIDER

THE PARTICULAR DRY ELECTROLYTIC CONDENSER ILLUSTRATED IN FIG. 18 IS OF THE "INVERTED TYPE". THE TERMINAL END OF THE UNIT IS THREADED. TO INSTALL THIS CONDENSER, A HOLE IS PROVIDED ON THE CHASSIS BASE SO THAT THE THREADED TERMINAL SUPPORT CAN BE INSERTED THRU THE HOLE WITH THE TERMINAL PROJECTING UNDERNEATH. THE MOUNTING NUT IS THEN APPLIED TO FASTEN THE UNIT TO THE CHASSIS BASE IN A VERTICAL POSITION, BUT UPSIDE-DOWN OR INVERTED.

CONDENSER BLOCKS

SOMETIMES, SEVERAL DIFFERENT PAPER CONDENSERS ARE ENCLOSED WITHIN A SINGLE CONTAINER, GIVING THE ARRANGEMENT SHOWN IN FIG. 19, CALLED A "CONDENSER BLOCK". A SINGLE TERMINAL, COMMON TO ALL CONDENSERS, IS THE NEGATIVE SIDE; EACH OF THE REMAINING TERMINALS MAKES CONTACT WITH THE POSITIVE SIDE OF ONE OF THE CONDENSERS CONTAINED WITHIN THE CASE. THIS ARRANGEMENT PROVIDES A COMPACT CONDENSER ASSEMBLY.

CONDENSER REPLACEMENTS

WHEN REPLACING DEFECTIVE FILTER CONDENSERS IN COMMERCIAL RECEIVERS,

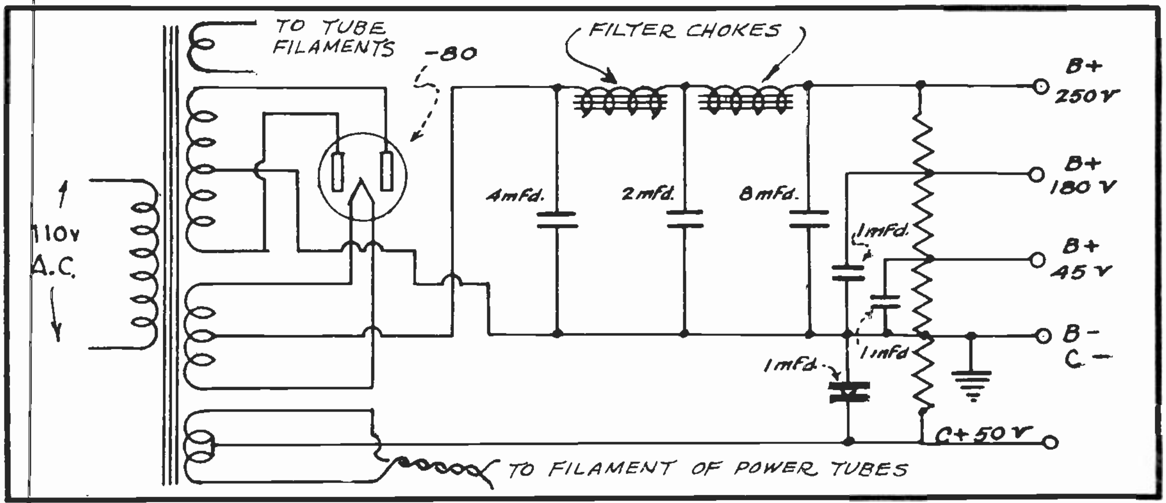

FIG. 23
"C-BIAS" VOLTAGE AT THE DIVIDER

ALWAYS MAKE IT A POINT TO PROVIDE A NEW CONDENSER OF THE SAME RATING AS THOSE ORIGINALLY USED BY THE MANUFACTURER; THIS APPLIES BOTH TO THE CAPACITY AND TO THE D-C WORKING VOLTAGE. ALSO, MAKE SURE THAT YOU CHOOSE ONE HAVING A D-C WORKING VOLTAGE RATING CONSIDERABLY GREATER THAN THE MAXIMUM D-C VOLTAGE WHICH WILL BE APPLIED ACROSS IT WHEN INSTALLED IN THE CIRCUIT IN QUESTION.

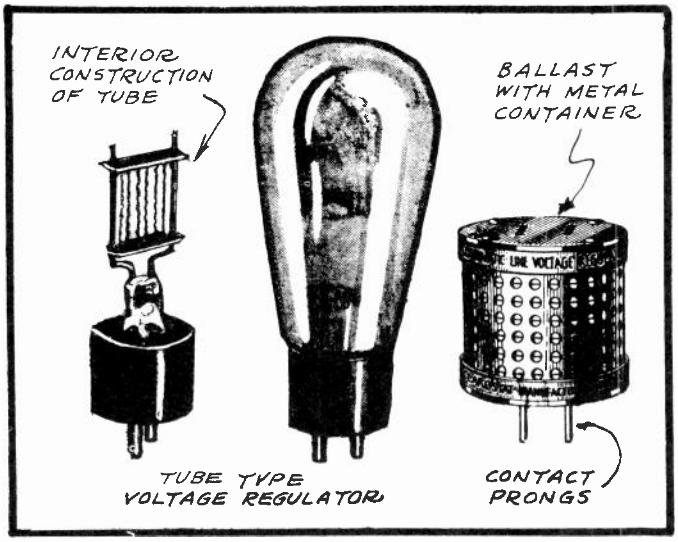

FIG. 24
TYPICAL LINE BALLASTS

FILTER CHOKE

FILTER CHOKES LOOK LIKE A.F. TRANSFORMERS. THE CHOKE COILS USED IN THE FILTER SYSTEM EACH CONSISTS OF LAMINATED IRON CORE, AROUND WHICH IS A SINGLE INSULATED WINDING. IN SOME RECEIVERS YOU WILL FIND THE CHOKE COILS CONTAINED IN A BOX, AND CONNECTIONS TO IT ARE MADE THRU LEADS OR SOLDERING LUGS PROVIDED ON THE CASE.

THE GREATER THE INDUCTANCE OF THE CHOKE COILS, AND THE GREATER THE CAPACITY OF THE FILTER CONDENSER,THE MORE UNIFORM WILL BE THE D-C OUTPUT OF THE FILTER CIRCUIT. IT IS COMMON PRACTICE TO USE FILTER CHOKES HAVING AN INDUCTANCE RATING OF FROM 15 TO 30 HENRIES, THE 30-HENRY SIZE BEING THE MOST POPULAR.

VOLTAGE DISTRIBUTION

THE FILTERED D-C OUTPUT MUST NEXT BE DIVIDED INTO THE VARIOUS VOLTAGE VALUES REQUIRED FOR THE PLATES AND SCREEN GRIDS OF THE VARIOUS TUBES,AS WELL AS FOR GRID BIAS. IN THE OLDER RECEIVERS THIS WAS ACCOMPLISHED BY MEANS OF VOLTAGE-DIVIDERS SIMILAR TO THE ONE ILLUSTRATED IN FIG. 20.

SUCH VOLTAGE-DIVIDERS CONSIST OF FIXED RESISTANCE ELEMENTS ENCLOSED WITHIN AN INSULATING SHELL OR CONTAINER,AND TAPS ARE TAKEN FROM THIS RESISTOR AT VARIOUS POINTS ALONG ITS LENGTH. FIG. 20 SHOWS THE SOLDERING LUGS WHICH ARE PROVIDED AT THE VARIOUS TAPS.

FIG.21 SHOWS HOW THE VOLTAGE-DIVIDER IS CONNECTED ACROSS THE FILTER OUTPUT, AND HOW THE VARIOUS B VOLTAGES ARE TAPPED OFF THE DIVIDER. NOTICE THAT THE B- END OF THE VOLTAGE DIVIDER SERVES AS B- FOR THE ENTIRE ARRANGEMENT. THE HIGHEST VOLTAGE, IN THIS CASE, IS OBTAINED ACROSS THE EXTREMITIES OF THE RESISTOR; IN THIS PARTICULAR ILLUSTRATION IT HAPPENS TO BE 250 VOLTS. FROM B- TO THE + 180 VOLT TAP A "B" VOLTAGE OF 180 VOLTS IS OBTAINED,

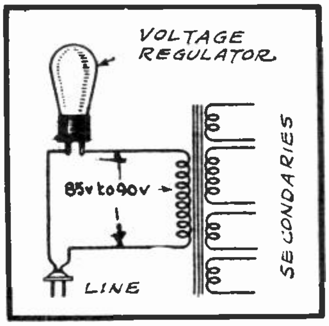

FIG. 25
INSTALLATION OF
REGULATOR

BECAUSE 70 VOLTS IS LOST IN SECTION #1 OF THE VOLTAGE DIVIDER. A VOLTAGE OF ONLY 45 VOLTS IS OBTAINED ACROSS THE TWO LOWER TERMINALS BECAUSE SECTIONS #1 AND #2 OF THE DIVIDER TOGETHER ACCOUNT FOR A LOSS OF 205 VOLTS.

ALSO, OBSERVE THAT A BYPASS CONDENSER IS CONNECTED BETWEEN THE B- SIDE OF THE LINE AND EACH B+ TAP. THE LAST FILTER CONDENSER SERVES AS THE BYPASS ACROSS THE ENTIRE VOLTAGE-DIVIDER. THE OTHER BYPASS CONDENSERS GENERALLY HAVE A CAPACITY OF ABOUT 1 MFD. EACH; THEIR PURPOSE IS TO PERMIT THE AUDIO AND RADIO FREQUENCIES TO PASS THROUGH THEM, INSTEAD OF FORCING THESE FREQUENCIES THRU THE RESISTANCE OF THE DIVIDER. THIS SCHEME ENABLES THE RECEIVER TO PERFORM BETTER, AND IMPROVES TONE QUALITY.

AS A RULE, THESE ARE PAPER CONDENSERS. IT IS NOT ABSOLUTELY NECESSARY TO INSTALL THEM DIRECTLY AT THE VOLTAGE-DIVIDER; YOU WILL OFTEN FIND THEM INSTALLED ELSEWHERE ON THE RECEIVER CHASSIS, BUT IN ALL CASES THEIR CONNECTIONS WILL BE MADE ACROSS B- AND THE PLATE OR SCREEN GRID CIRCUITS.

YOU MAY ALSO FIND VOLTAGE-DIVIDERS CONSISTING OF A RESISTANCE WOUND AROUND AN INSULATIVE SUPPORT AND EQUIPPED WITH ADJUSTABLE TAPS. IN THESE TYPES THE TAP CONNECTIONS ARE MADE IN THE FORM OF SLIDERS, AND THEIR POSITIONS CAN BE CHANGED. A LOCKING DEVICE IS PROVIDED SO THAT THE TAP CONNECTIONS CAN BE LOCKED TO THE RESISTANCE WIRE OF THE DIVIDER AT THE DESIRED POINTS. ONE OF THESE ADJUSTABLE VOLTAGE-DIVIDERS IS SHOWN IN FIG. 22.

IN FIG. 23 YOU ARE SHOWN THE DIAGRAM OF A CIRCUIT IN WHICH THE "C" BIAS VOLTAGE IS ALSO OBTAINED AT THE VOLTAGE-DIVIDER. IN THIS CASE, AN EXTRA RESISTOR IS INSERTED BETWEEN THE GROUNDED B- TAP AND THE C+TAP. THIS RESISTOR IS ALSO PROVIDED WITH A BYPASS CONDENSER.

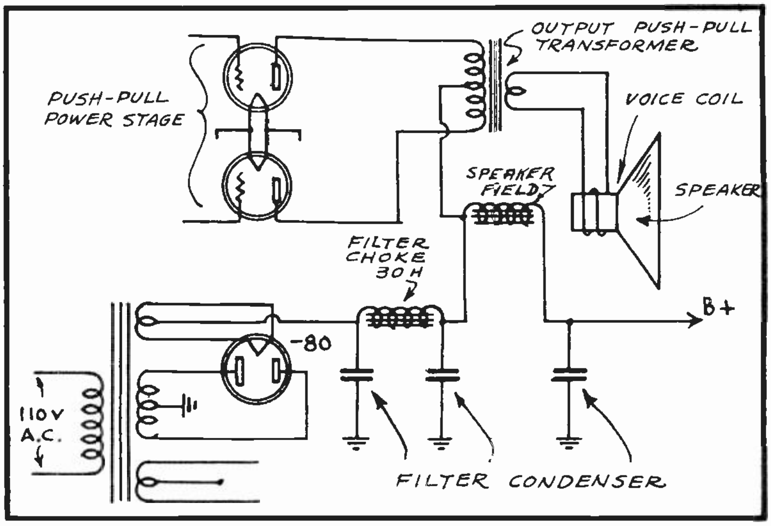

FIG. 26
USING THE SPEAKER FIELD AS A FILTER CHOKE

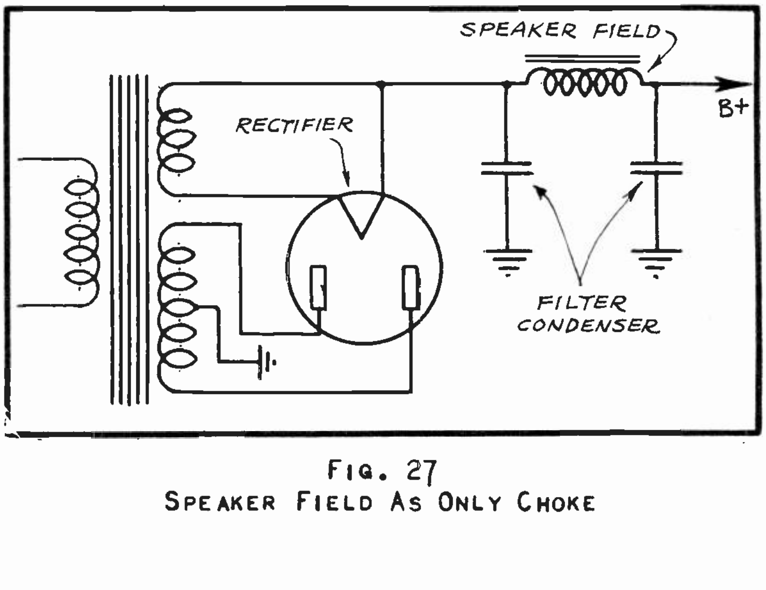

FIG. 27
SPEAKER FIELD AS ONLY CHOKE

BY CONNECTING THIS C+ TAP TO THE CENTER OF THE POWER TUBE'S FILAMENT TRANSFORMER WINDING, THE C BIAS VOLTAGE FOR THIS TUBE OR TUBES IS OBTAINED. IN FIG. 23 THIS VALUE WILL BE 50 VOLTS.

VOLTAGE REGULATORS

THERE HAVE BEEN CASES WHERE THE A-C LINE VOLTAGE HAS VARIED FROM 95 TO 125 VOLTS. TO PROVIDE A CONSTANT VOLTAGE ACROSS THE TRANSFORMER PRIMARY, REGARDLESS OF LINE VOLTAGE VARIATION, BALLASTS OR LINE VOLTAGE REGULATORS ARE SOMETIMES USED, TWO OF WHICH ARE SHOWN IN FIG.24.AT THE LEFT OF THIS ILLUSTRATION IS THE TUBE-TYPE OF REGULATOR,SHOWING BOTH ITS OUTER AND INNER APPEARANCE. AT THE RIGHT IS SHOWN A BALLAST UNIT WITH A METALLIC ENCLOSURE. EITHER TYPE MAY BE CUT IN SERIES WITH ONE PRIMARY LEAD TO THE TRANSFORMER.

IN BOTH TYPES THE RESISTANCE ELEMENT IS AN ALLOY RESISTANCE WIRE WHOSE RESISTANCE IS NOT FIXED,BUT VARIES GREATLY WITH TEMPERATURE. HENCE, EXCESS LINE VOLTAGE FORCES EXCESS CURRENT THRU THIS FILAMENT,THEREBY ALMOST INSTANTLY INCREASING ITS RESISTANCE ENOUGH TO REDUCE CURRENT FLOW TO NORMAL. CONVERSELY, IF THE LINE VOLTAGE DROPS BELOW NORMAL, THE RESISTANCE OF THE BALLAST TUBE WILL ADJUST ITSELF TO MAINTAIN NORMAL VOLTAGE AT THE TRANSFORMER. A LINE VARIATION OF 10 OR 15 VOLTS EITHER WAY FROM NORMAL CAN THUS BE NEUTRALIZED.

FIG. 25 SHOWS HOW SUCH A BALLAST IS INSTALLED IN THE CIRCUIT, AND ALSO INDICATES THE EFFECTIVE VOLTAGE MAINTAINED ACROSS THE PRIMARY WINDING OF THE TRANSFORMER. THERE ARE ALSO VOLTAGE REGULATORS AVAILABLE WHICH CAN BE INSTALLED IN THE PRIMARY CIRCUIT OF THE POWER TRANSFORMER EVEN THOUGH IT BE DESIGNED TO OPERATE AT EXACTLY 110 VOLTS.

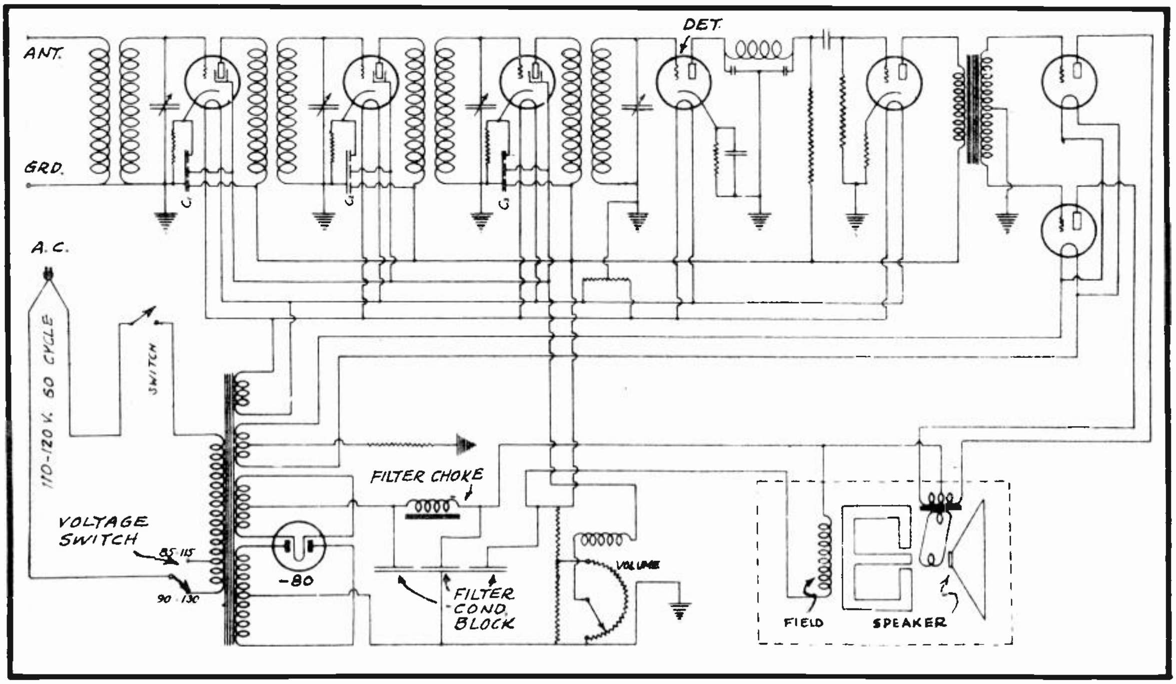

FIG. 28
EIGHT-TUBE SCREEN GRID A.C. RECEIVER WITH POWER SUPPLY

SPEAKER FIELD USED AS FILTER CHOKE

The field coil of the dynamic speaker, you will remember, consists of a winding on an iron core; therefore, this coil will in itself be an effective choke coil, and by using it as such, the expense of an extra filter choke can be saved. In Fig. 26 you will notice that the circuit connections are such as to use the speaker's field coil as the second choke of the filter. Whatever slight ripples may still be present in this current flowing thru speaker coil will not be sufficient to cause any ill effects upon the speaker's operation. Notice that the rectifier feeds into an ordinary 30-henry choke and filter-condenser combination.

By connecting the power tube plate circuit to the input end of the speaker field coil, as here illustrated, the plate current of the power tubes will not flow thru the speaker field. However, the "B" current supplying the remaining circuits must all flow thru the field coil, and it is this current which energizes the speaker field. The speaker is a D-C type dynamic unit, and has no accessory equipment separate from the receiver, with which to energize its field.

The resistance of speaker fields vary with the make and type, and it is common to find field coils having resistance ratings of 1000, 1800, and 2500 ohms. Should all of the receiver's "B" current flow thru the field coil, especially in the larger sets, excessive voltage-drop will be produced across the speaker field, thus lowering the maximum "B" voltage value available from the power supply output leading to the various receiver circuits. For this reason, the plate-circuit connection for

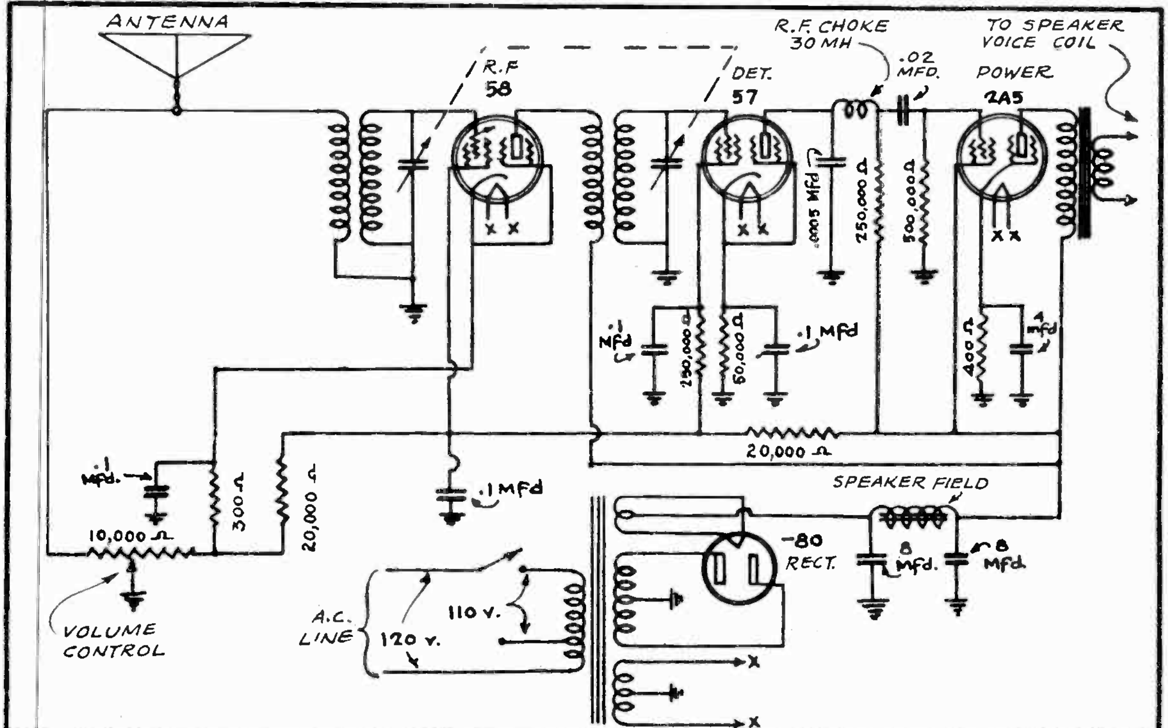

FIG. 29
FOUR-TUBE RECEIVER CIRCUIT

THE POWER STAGE SHOWN IN FIG. 26 IS MADE AT A POINT BETWEEN THE 30-HENRY CHOKE AND THE SPEAKER FIELD.

ALSO NOTICE IN FIG. 26 THAT A COMMON GROUND CONNECTION IS USED FOR THE NEGATIVE SIDE OF THE "B" CIRCUIT. IN THE SMALLER RECEIVERS, WHERE THE "B" CURRENT DRAIN IS NOT GREAT, ALL OF THIS CURRENT IS PERMITTED TO FLOW THRU THE SPEAKER FIELD, AND IN MANY CASES YOU WILL EVEN FIND THE FIELD COIL SERVING AS THE ONLY CHOKE IN THE FILTER CIRCUIT -- HAVING A FILTER CONDENSER CONNECTED BETWEEN EACH OF ITS ENDS AND THE B- SIDE OF THE CIRCUIT, AS SHOWN IN FIG. 27.

WHILE ON THE SUBJECT OF SPEAKERS, IT IS ADVISABLE TO REMIND YOU THAT WHEN USING A DYNAMIC SPEAKER IT IS IMPERATIVE THAT THE OUTPUT OF THE SPEAKER COUPLING TRANSFORMER BE DESIGNED TO MATCH CORRECTLY THE SPEAKER'S VOICE COIL IMPEDANCE RATING, WITH THE PARTICULAR TYPE AND COMBINATION OF POWER TUBES USED IN THE A.F. AMPLIFIER. BY "IMPEDANCE" WE MEAN THE TOTAL OPPOSITION OFFERED TO A FLOW OF ALTERNATING CURRENT BY THE COMBINED EFFECTS OF ORDINARY(OHMIC) RESISTANCE, CAPACITY, AND INDUCTANCE. IN A LATER LESSON YOU WILL LEARN MUCH MORE ABOUT IMPEDANCE.

A-C RECEIVER

IN FIG. 28 IS SHOWN A CIRCUIT DIAGRAM OF AN 8-TUBE A-C SCREEN-GRID RECEIVER, TOGETHER WITH ITS POWER SUPPLY.

THE R.F. CHOKE COIL AND THE TWO FIXED CONDENSERS FOLLOWING THE DETECTOR COMPRISE A TRAP WHICH FORCES ALL REMAINING RADIO FREQUENCIES OUT OF THE PLATE CIRCUIT AND INTO GROUND, SO THAT THEY WILL NOT CAUSE TROUBLE IN THE A.F. STAGES. NOTICE THAT POWER DETECTION IS USED, AND THAT THE DETECTOR FEEDS INTO THE FIRST AUDIO TUBE THRU RESISTANCE-CAPACITY COUPLING.

THIS RECEIVER'S POWER TRANSFORMER HAS A SINGLE PRIMARY WINDING WHICH FEEDS ALL OF THE SECONDARIES. IN PLACE OF A LINE BALLAST, A HIGH AND LOW-VOLTAGE SWITCH IS USED. THAT IS, THE LOWER END OF THE PRIMARY WINDING HAS TWO CONNECTIONS. IF THE LINE VOLTAGE IS KNOWN TO BE HIGH, THE CIRCUIT IS CONNECTED TO THE TERMINAL MARKED 90-130 VOLTS, BUT SHOULD THE LINE VOLTAGE BE KNOWN TO BE LOW, THEN THE CIRCUIT IS COMPLETED THRU THE TERMINAL MARKED 85-115 VOLTS, THUS CUTTING OUT A PORTION OF THE PRIMARY WINDING, AND THEREBY GIVING A GREATER TURNS-RATIO BETWEEN THE PRIMARY AND SECONDARIES.

THIS SWITCHING ARRANGEMENT CAN BE ACCOMPLISHED BY A "HIGH" AND "LOW" SWITCH, THE SWITCH BEING SET TO THE REQUIRED POSITION BY THE OPERATOR OF THE RECEIVER, OR THE SERVICEMAN. YOU WILL ALSO FIND COMMERCIAL RECEIVERS IN WHICH THIS SETTING IS MADE BY INSTALLING A FUSE IN SETS OF CLIPS WHICH ARE LABELED "HIGH" AND "LOW" VOLTAGE.

THE SPEAKER FIELD COIL IN FIG. 28 IS MADE USE OF AS A FILTER CHOKE. ALSO NOTICE THAT ON THIS DIAGRAM THE FILTER AND SEVERAL OF THE BYPASS CONDENSERS ARE INDICATED AS BEING ARRANGED IN A "CONDENSER BLOCK ASSEMBLY."

FOUR-TUBE RECEIVER

FIG. 29 ILLUSTRATES THE CIRCUITS IN A FOUR-TUBE RECEIVER, USING A 58 R.F. TUBE, A 57 POWER DETECTOR, A 2A5 POWER AMPLIFIER, AND AN 80 RECTIFIER. ALL OF THE FEATURES INCORPORATED IN THIS CIRCUIT HAVE BEEN EXPLAINED TO YOU, AND SHOULD CAUSE YOU NO DIFFICULTY IN COMBINING THEM INTO A COMPLETE RECEIVER CIRCUIT.

AN IMPORTANT POINT TO NOTICE IN THIS CIRCUIT IS THAT THE TWO SERIES-CONNECTED 20,000 OHM FIXED RESISTORS ARE CONNECTED ACROSS THE OUTPUT OF THE POWER SUPPLY FILTER THROUGH THE GROUNDED ARM OF THE VOLUME CONTROL. THIS PERMITS A SMALL FLOW OF B CURRENT THRU THE POWER SUPPLY SYSTEM BEFORE THE RECEIVER TUBES ARE SUFFICIENTLY HEATED TO DRAW PLATE AND SCREEN CURRENT, WHICH PREVENTS EXCESS VOLTAGE FROM BUILDING UP AND "PUNCTURING" THE FILTER CONDENSERS WHEN THE RECEIVER IS FIRST SWITCHED ON.

IT ALSO MAKES THE B POWER SUPPLY SYSTEM MORE STABLE IN OPERATION SO THAT ITS VOLTAGE OUTPUT WILL BE MORE UNIFORM. THE CURRENT WHICH FLOWS THRU THE B SECTION OF THE POWER SUPPLY SYSTEM, WHEN NONE OF THE RECEIVER TUBES ARE DRAWING B CURRENT, IS KNOWN AS THE BLEEDER CURRENT, AND WILL BE MORE FULLY EXPLAINED LATER IN THIS COURSE.

ALSO NOTICE THAT THE SPEAKER FIELD IS USED AS THE ONLY FILTER CHOKE IN THE POWER SUPPLY OF THIS RECEIVER.

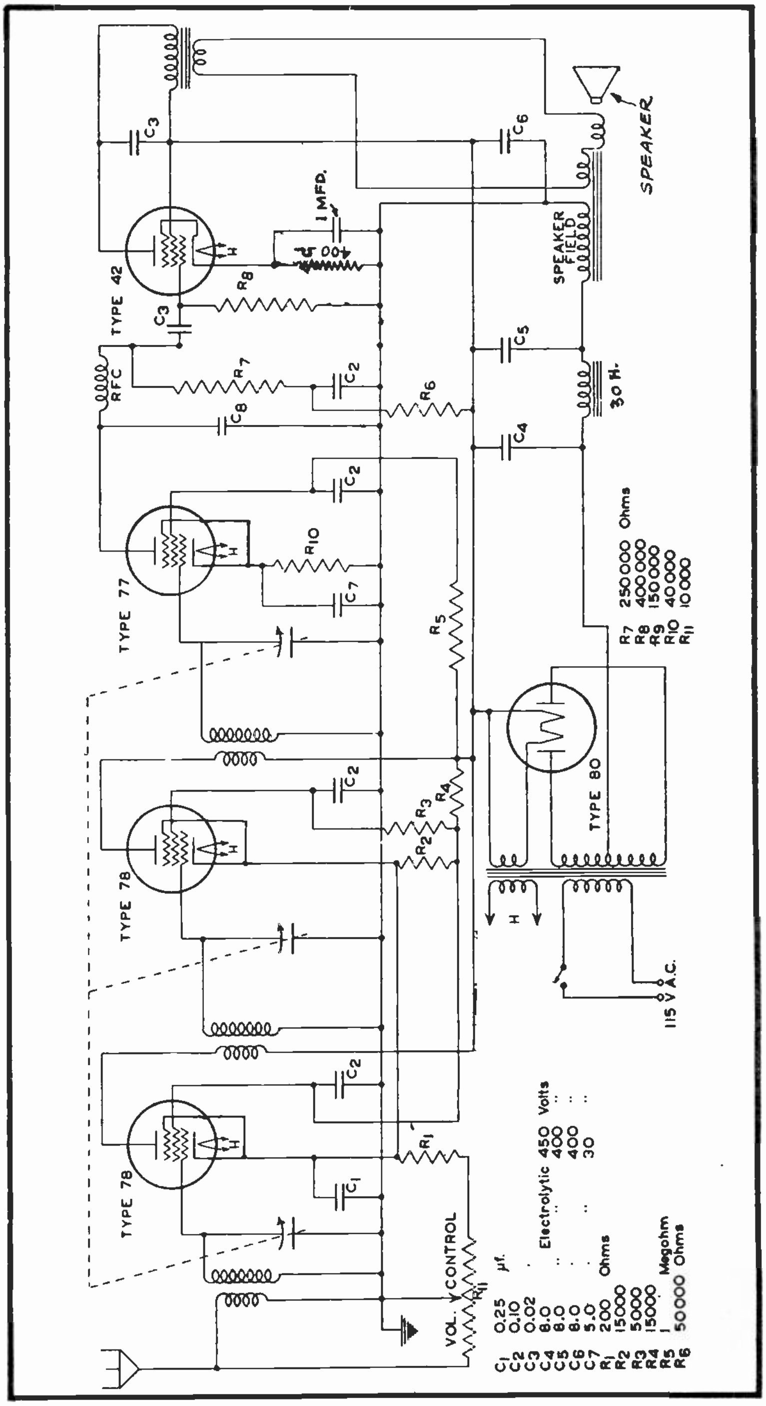

FIG. 30
FIVE-TUBE RECEIVER USING SIX-VOLT TUBES

To become certain that the connections of such a complete circuit are clearly fixed in your mind, carefully trace each of the various circuits in the diagram. Copying such diagrams on scratch paper will assist you greatly in becoming more intimately acquainted with receiver circuits, and we therefore encourage you to adopt this practice.

A-C RECEIVER WITH SIX-VOLT TUBES

In Fig. 30 is shown a circuit diagram of a five-tube receiver employing two type 78 R.F. amplifier tubes, a 77 detector, a 42 power amplifier, and an 80 rectifier.

The 78 tubes are very similar to 58 tubes, with the exception that their filaments are designed for 6.3 volts and 0.3 ampere, instead of 2.5 volts and 1 ampere. The 77 tube, when used as a power detector, has characteristics similar to the 57, except that its filament is designed for 6.3 volts and 0.3 ampere. The filament of the 42 tube is designed for 6.3 volts and 0.65 ampere, but with this exception it is in all other respects similar to the 2A5.

Another feature of this circuit is the fact that the 30-henry filter

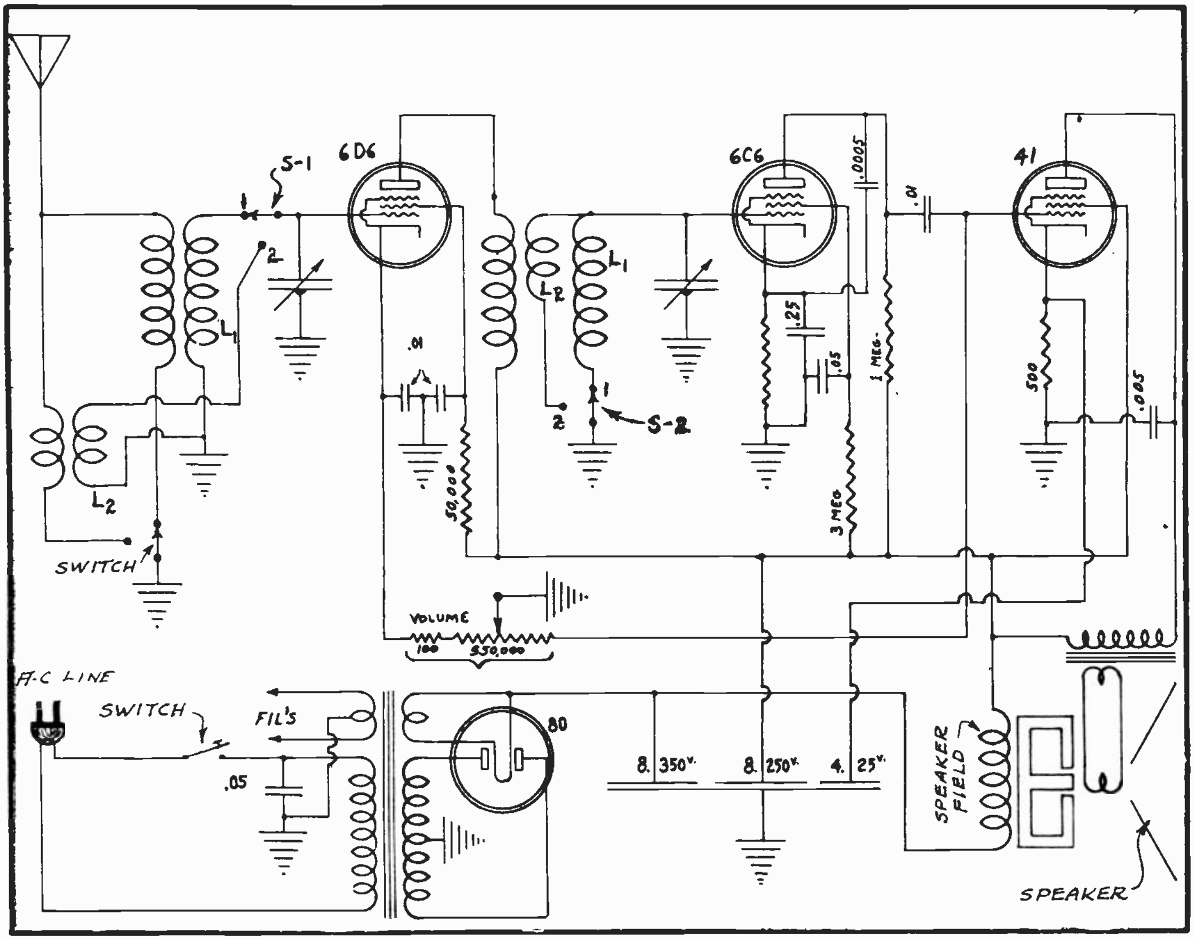

Fig. 31
Four-Tube, Two-Band Receiver

CHOKE AND THE SPEAKER FIELD ARE BOTH CONNECTED IN THE NEGATIVE SIDE OF THE B SYSTEM, RATHER THAN IN THE POSITIVE SIDE. FILTER CIRCUITS WILL OPERATE SATISFACTORILY WITH EITHER ARRANGEMENT, AND AS YOU CONTINUE YOUR STUDIES YOU WILL FIND NUMEROUS EXAMPLES OF EACH, TOGETHER WITH EXPLANATIONS REGARDING THEIR RESPECTIVE ADVANTAGES AND DISADVANTAGES.

FOUR-TUBE, TWO-BAND RECEIVER

IN FIG. 31 IS SHOWN A CIRCUIT DIAGRAM OF A FOUR-TUBE RECEIVER DESIGNED FOR THE RECEPTION OF BOTH THE BROADCAST STATIONS AND ONE BAND OF SHORT-WAVE STATIONS. THE 6D6, 6C6, AND 41 TUBES HERE USED, HAVE FILAMENTS DESIGNED FOR 6.3 VOLTS.

THE CHARACTERISTICS OF THE 6D6 AND 6C6 TUBES ARE VERY SIMILAR TO THOSE OF THE 78 AND 77, BUT THEY ARE OF A MORE MODERN DESIGN. THE 41 DIFFERS FROM THE 42 CHIEFLY IN THAT THE LATTER PROVIDES A GREATER OUTPUT. JOB SHEET #14 FURNISHES COMPLETE SPECIFICATIONS FOR THESE VARIOUS TUBE TYPES.

BY SIMULTANEOUSLY CLOSING SWITCHES S-1 AND S-2 TO POSITION #1, THE TWO COILS L_1 WILL BE CONNECTED ACROSS THEIR RESPECTIVE TUNING CONDENSER

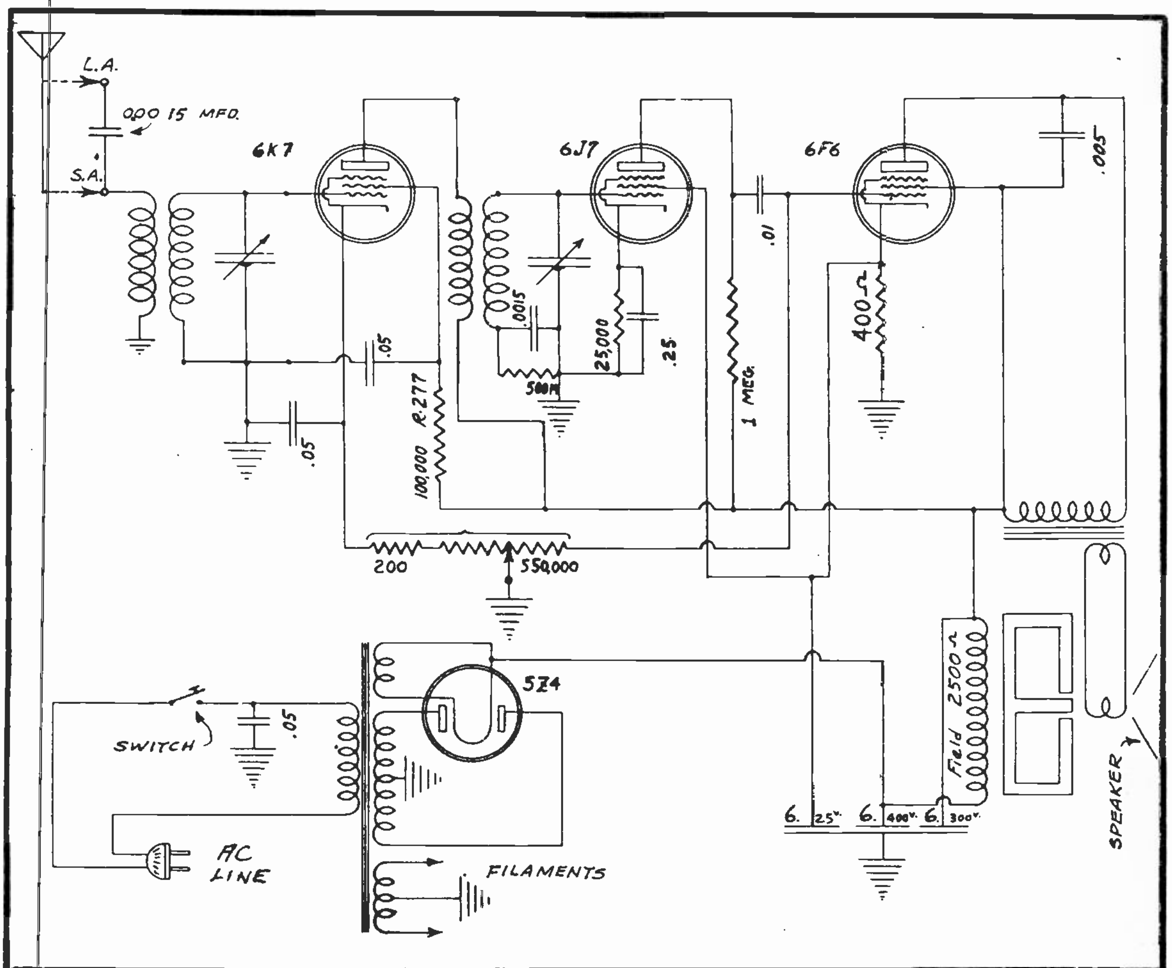

FIG. 32
METAL-TUBE RECEIVER

SECTIONS AND THEREBY MAKES STANDARD BROADCAST RECEPTION POSSIBLE.

CLOSING THESE SAME TWO SWITCHES TO POSITION #2 CONNECTS COILS L_2 ACROSS THE TUNING CONDENSERS. SINCE THESE COILS HAVE LESS TURNS AND LESS INDUCTANCE THAN COILS L_1, THE TWO CIRCUITS WILL NOW TUNE THRU A HIGHER FREQUENCY RANGE, FOR RECEPTION OF SHORT-WAVE PROGRAMS. BRIEFLY, THIS IS THE FUNDAMENTAL PRINCIPLE OF COMBINATION STANDARD BROADCAST AND SHORT-WAVE RECEIVERS, BUT LATER IN THE COURSE YOU WILL RECEIVE COMPLETE INFORMATION REGARDING THE MOST ELABORATE ALL-WAVE RECEIVER DESIGNS.

METAL-TUBE RECEIVER

THE CIRCUIT DIAGRAM OF A METAL-TUBE RECEIVER APPEARS IN FIG.32,USING A TYPE 6K7 TUBE AS THE R.F. AMPLIFIER, A 6J7 AS THE DETECTOR, A 6F6 AS THE POWER AMPLIFIER,AND A 5Z4 AS THE RECTIFIER. NOTICE THAT ALTHOUGH METAL TUBES ARE HERE USED,THE CIRCUIT REMAINS THE SAME AS FOR AN EQUIVALENT GLASS-TUBE RECEIVER. THE ESSENTIAL DIFFERENCE LIES ONLY IN THE CONSTRUCTIONAL FEATURES AND THE CONNECTIONS AT THE SOCKET, ALL OF WHICH ARE FULLY EXPLAINED IN ANOTHER LESSON, AS WELL AS IN THE JOB SHEETS.

PROVISIONS ARE ALSO MADE IN THE CIRCUIT OF FIG. 32 FOR THE USE OF EITHER A SHORT OR LONG ANTENNA. IF A SHORT ANTENNA IS USED, IT IS CONNECTED TO THE S.A. TERMINAL OF THE RECEIVER, AND THUS JOINED DIRECTLY TO THE PRIMARY WINDING OF THE R.F. TRANSFORMER. WHEN USING A LONG ANTENNA, THE LEAD-IN IS CONNECTED TO THE L.A. TERMINAL, THEREBY PLACING THE .0015 MFD. CONDENSER IN SERIES WITH THE ANTENNA AND THE PRIMARY WINDING OF THE R.F. TRANSFORMER.

THE ELECTRICAL EFFECT OF THIS CONDENSER IS SUCH AS TO REDUCE THE EFFECTIVE (ELECTRICAL) LENGTH OF THE ANTENNA, SO THAT IT BECOMES EQUIVALENT TO A SHORTER ANTENNA. BY EMPLOYING THIS METHOD, THE RECEIVER WILL OPERATE WITH EQUAL EFFICIENCY ON EITHER A LONG OR SHORT ANTENNA.

THE VOLUME CONTROL REGULATES SOUND VOLUME BY CONTROLLING BOTH THE BIAS OF THE R.F. TUBE, AND THE CONTROL-GRID RESISTOR VALUE OF THE 6F6 TUBE.

THE FIXED CONDENSER CONNECTED ACROSS THE PRIMARY WINDING OF THE OUTPUT TRANSFORMER LOWERS THE TONE PITCH SUFFICIENTLY TO PREVENT HIGH PITCHED OR SCREECHING REPRODUCTION -- THAT IS, IT MAKES A MORE MELLOW, LOW-PITCHED REPRODUCTION POSSIBLE, MORE PLEASING TO THE EAR.

HAVING COMPLETED THIS LESSON YOU SHOULD NOW HAVE A GOOD BASIC UNDERSTANDING OF THE FEATURES INCORPORATED IN WHAT ARE KNOWN AS TUNED RADIO FREQUENCY RECEIVERS. THIS KNOWLEDGE IS GOING TO ASSIST YOU GREATLY IN MASTERING THE SUPERHETERODYNE TYPE CIRCUIT WHICH IS EXPLAINED IN THE NEXT LESSON.

EXAMINATION QUESTIONS

LESSON NO. 17

1. - WHAT UNITS MAKE UP THE CONVENTIONAL TYPE OF POWER SUPPLY FOR A.C. RECEIVERS?

2. - FOR WHAT PURPOSE IS THE POWER TRANSFORMER USED?

3. - WHY DO WE USE A FILTER CIRCUIT IN THE "B" POWER SUPPLY FOR A.C. RECEIVERS?

4. - BY WHAT METHOD ARE THE VARIOUS B VOLTAGE VALUES OBTAINED AT THE OUTPUT OF THE B SUPPLY'S FILTER?

5. - DESCRIBE THE CONSTRUCTION OF A DRY ELECTROLYTIC CONDENSER.

6. - DRAW A CIRCUIT DIAGRAM OF A COMPLETE POWER SUPPLY UNIT, SHOWING ALL CONNECTIONS FOR THE POWER TRANSFORMER, RECTIFIER, FILTER AND B VOLTAGE DISTRIBUTION.

7. - WHAT ARE VOLTAGE REGULATORS USED FOR IN CONNECTION WITH THE POWER SUPPLY UNIT OF A RADIO RECEIVER?

8. - DRAW A CIRCUIT DIAGRAM WHICH ILLUSTRATES HOW THE FIELD COIL OF A D.C. TYPE DYNAMIC SPEAKER MAY BE USED AS A FILTER CHOKE FOR THE POWER SUPPLY SYSTEM.

9. - WHAT ARE SOME OF THE CHIEF ADVANTAGES OF HAVING THE POWER SUPPLY SYSTEM MADE UP OF INDIVIDUAL UNITS RATHER THAN BEING ALL COMBINED INTO ONE OR TWO COMPACT UNITS?

10. - DRAW A COMPLETE CIRCUIT DIAGRAM OF A METAL-TUBE RECEIVER USING FOUR TUBES.

· *LOYALTY* ·

"Loyalty is that quality which prompts a person to be true to the thing he undertakes. It means definite direction,fixity of purpose, steadfastness. Loyalty supplies power,poise, purpose, ballast,and works for health and success.

Nature helps the loyal man. If you are careless, slipshod, indifferent,Nature assumes that you wish to be a nobody and grants your desire.

Loyalty is the great lubricant of life. It saves the wear and tear of making daily decision as to what is best to do. It preserves balance and makes results cumulative. The man who is loyal to his work is not wrung nor preplexed by doubts -- he sticks to the ship,and if the ship founders, he goes down a hero with colors flying at the masthead and the band playing. Stick! and if you quit, quit to tackle a harder job."

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LESSON NO. 18

SUPERHETERODYNE RECEIVERS

All of the receivers which you have studied thus far are of the "tuned radio-frequency type," and are most generally referred to as "tuned r-f"or "t-r-f receivers." In this lesson, we are going to progress a step farther by discussing SUPERHETERODYNE RECEIVERS, whose operation is based on a slightly different principle.

The superheterodyne receiver has gained tremendous popularity during the past few years, and is considered as an outstanding achievement in modern radio design. The "heterodyne principle" was actually used a number of years ago, but it was only within comparatively recent years that commercial-built receivers of this type were placed on the market. Today, the majority of receivers are of the superheterodyne type.

In the study of superheterodynes, you are going to be introduced to several new principles, but everything which you have already learned relative to radio receivers in general will still apply to this type of circuit. This is one of the reasons why you are going to find the study of superheterodynes easier than you might at first have supposed.

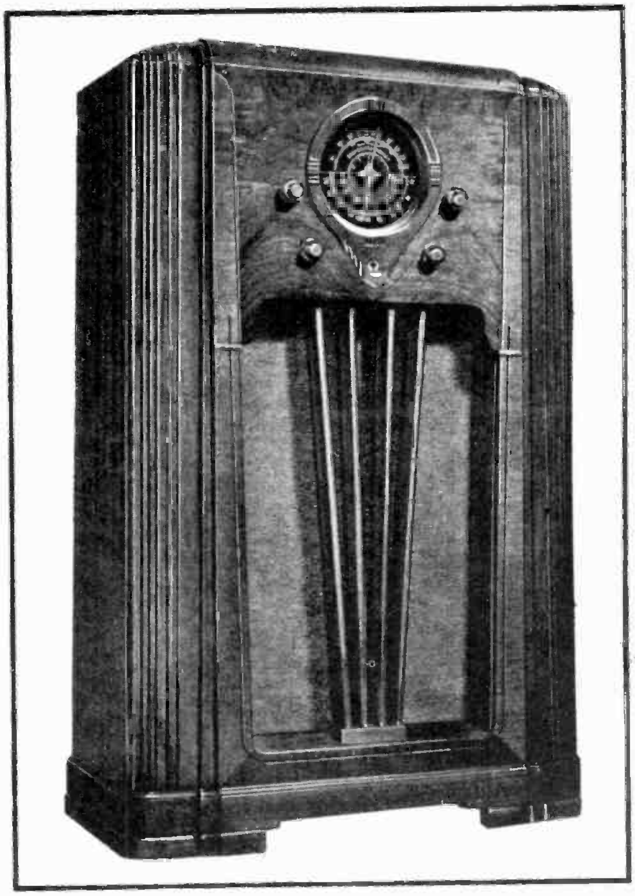

FIG. 1
CONSOLE-TYPE SUPERHETERODYNE RECEIVER

GENERAL LAY-OUT OF A SUPERHETERODYNE

The "block-diagram" in Fig.2 shows the arrangement of the various sections or units of the superheterodyne receiver. Observe in this illustration that this receiver is composed of several sections consisting of the first detector, oscillator, intermediate-frequency amplifier, second detector, audio amplifier, and speaker. That portion comprising the second detector, audio amplifier and speaker is exactly the same as in a conventional t-r-f receiver. Such being the case, you will quickly realize that the only difference between the superheterodyne and a regular t-r-f receiver exists in that portion of the circuit which precedes the second detector.

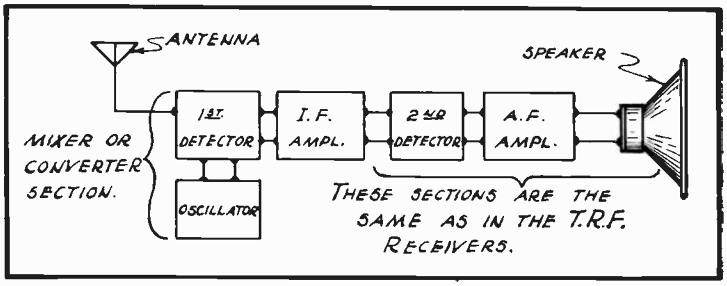

FIG. 2
SECTIONS OF THE SUPERHETERODYNE

The first section of the superheterodyne, shown in Fig. 2, is called the "frequency changer," "mixer," or "converter," and consists of two parts, known as the first detector and the oscillator.

The oscillator portion of the mixer stage is a small generator of radio-frequency energy. It consists merely of a vacuum tube in an oscillating circuit, and a tuning control whereby the operator of the receiver can adjust the oscillator to generate radio-frequency oscillations of any desired frequency.

As you will note in Fig. 2, the mixer section is connected to the intermediate-frequency amplifier. The latter is generally spoken of as the i-f amplifier.

During the operation of this receiver, the signal-energy radiated by the broadcast station will enter the first detector division of the mixer section. At the same time, the oscillator located within the receiver, will also feed radio-frequency energy into the first detector, but the frequency of the latter will be different from that of the incoming broadcast signal.

These two differing frequencies, being impressed upon the first detector simultaneously, are literally "mixed." This action causes a new frequency to be produced, which we call the INTERMEDIATE FREQUENCY, and this new or resulting frequency is fed into the intermediate-frequency amplifier where it is amplified. The intermediate-frequency is still of a radio-frequency character and is therefore inaudible; however, by passing it into the second detector, customary detection takes place and the audio component is at this point separated from the intermediate-frequency. Audio amplification then takes place in the conventional manner.

This brief explanation is intended to give you a general idea of the occurrences in the various sections of the superheterodyne receiver. No doubt, you are now wondering just how this process is actually accomplished, and why these complicated additions are made. This, however, will all be made clearer as you continue reading the following paragraphs.

REQUIREMENTS FROM A RECEIVER

1. - Selectivity is that property of a receiver which enables it to differentiate between one broadcast frequency and another. That is, a "selective receiver" tunes rather sharp and thereby prevents

interference between the various broadcast stations that are "on the air" at the same time.

2. - Sensitivity is that property of a receiver which enables it to "pick up" distant stations with ease, and with very little signal energy supplied to its antenna.

3. - Fidelity refers to the tone quality produced by the receiver. A receiver possessing good fidelity provides a rich and true reproduction of sound.

The principles used in the superheterodyne aid in obtaining all three of these desired qualities from the receiver.

THE HETERODYNE PRINCIPLE

Our next step is to investigate the "heterodyne principle" more thoroughly. Fig. 3 will serve to make this explanation clear.

In the upper portion of this illustration, you are shown a wave form that represents a frequency of 800 kc, whereas a 600 kc wave-form is shown at the center. Combining the 800 kc and the 600 kc frequencies will produce an entirely new frequency which is known as the beat frequency. This beat-frequency will no longer correspond to the 600 kc wave-form nor to the 800 kc wave-form; instead, its frequency will be equal to the arithmetical difference between the original two frequencies. That is, the beat-frequency in this particular case will be 800 kc minus 600 kc, or 200 kc. We then say that the 800 kc and 600 kc frequencies beat, combine, or "heterodyne" to produce a beat-frequency of 200 kc.

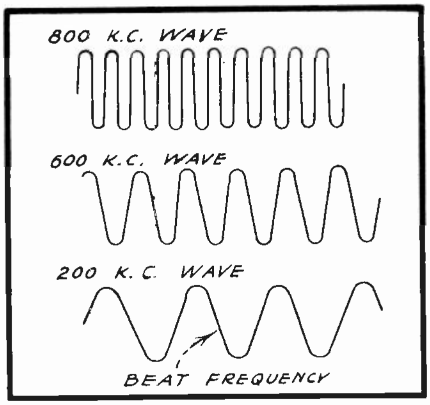

FIG. 3
THE PRINCIPLE OF BEATS

Beside this 200 kc beat-frequency, still another beat-frequency will be produced by the heterodyning of the 800 kc and 600 kc frequencies. This second beat-frequency will be equal to the sum of the original frequencies. In other words, in the particular example given, this second beat-frequency would be equal to 800 kc plus 600 kc, or 1400 kc. This latter frequency, you will note, is higher than either of the two original frequencies; however, in superheterodyne receivers we do not intentionally use this high beat-frequency. The lower one is preferable, for reasons to be explained later.

A brief consideration of the phenomena of beats as found in audio frequencies will no doubt make this important principle even more clear to you. Let us suppose, for example, that two different strings on a violin are plucked at the same time, and that the musical note produced by one of these strings has a frequency of 1000 cycles, while the note produced by the other string has a frequency of 1800 cycles.

As these two musical notes are produced simultaneously, your ear will respond not only to the 1000 cycle and 1800 cycle notes individually, but it will also detect one new note whose frequency is 1800 cycles minus 1000 cycles, or 800 cycles, and likewise another new note whose frequency is 1800 cycles plus 1000 cycles, or 2800 cycles -- the 800 and 2800-cycle frequencies are the beat-frequencies. Altogether then, an 1800, 1000, 800, and 2800 cycle tone will be impressed upon your ear at the same time.

With this principle in mind, it is obvious that if we wanted to change the frequency of a 650 kc broadcast station to a new frequency of 100 kc, all that we would have to do is to "mix" this 650 kc frequency with a frequency of 550 kc or 750 kc which is generated in the receiver. Either of the two latter frequencies will heterodyne with a 650 kc frequency to produce a 100 kc beat-frequency. This is the fundamental principle of all superheterodyne receivers.

SHORTCOMINGS OF STRAIGHT T-R-F RECEIVERS

Before investigating further the application of these principles to the superheterodyne, let us first consider briefly some of the major faults of t-r-f receivers which are overcome through the use of a superheterodyne circuit.

To begin with, the ordinary type of straight t-r-f circuit is expected to "tune in" and amplify all of the different frequencies within the broadcast band. It is physically impossible to design circuits of this type which will operate at each and everyone of these many frequencies at the same efficiency. The result is that at the higher broadcast frequencies, all straight t-r-f receivers have a natural tendency to become less selective than at the lower frequencies, and at the lower frequencies many of them are over-selective to such a degree that they eliminate some of the higher audio frequencies. Both of these extreme conditions affect the performance of the receiver in an undesirable manner.

On the other hand, if these same r-f stages are only expected to amplify but one particular frequency at all times, and no other frequency but this one, then it is a simple matter to design the amplifier to operate at maximum efficiency at this one particular frequency. This is exactly what is done in a superheterodyne receiver, for here the greater part of all r-f amplification is done at only one frequency, regardless of the received station's signal-frequency. We call this frequency, at which practically all r-f amplification takes place, the intermediate-frequency. In other words, the intermediate-frequency amplifier of the superheterodyne is permanently tuned to a chosen intermediate-frequency, so that this will be the only frequency amplified by it.

APPLICATION OF THE BEAT PRINCIPLE TO THE SUPERHETERODYNE

Now let us suppose that the intermediate-frequency amplifier of a certain superheterodyne receiver is permanently tuned to an intermediate-frequency of 100 kc. The actions taking place within this receiver are all illustrated in Fig. 4, where we assume that a 750 kc station is being received.

Since the intermediate-frequency amplifier will not amplify any frequency other than 100 kc, it will be necessary to change the 750 kc signal-frequency to 100 kc. We do this by tuning the receiver's oscillator to generate either a 650 kc or an 850 kc frequency. Let us suppose that the receiver's oscillator is tuned to produce a frequency of 850 kc. This frequency will heterodyne with the 750 kc signal-frequency to produce a 100 kc beat-frequency. This 100 kc beat-frequency will then be amplified by the intermediate-frequency amplifier, after which it acts upon the second detector, where customary detection takes place. The audio frequencies are then amplified and sent through the speaker windings in the usual way.

The 1600 kc beat-frequency, also produced by heterodyning the 750 kc signal-frequency and the 850 kc oscillator frequency, is useless because the intermediate-frequency amplifier is not tuned to amplify this higher frequency.

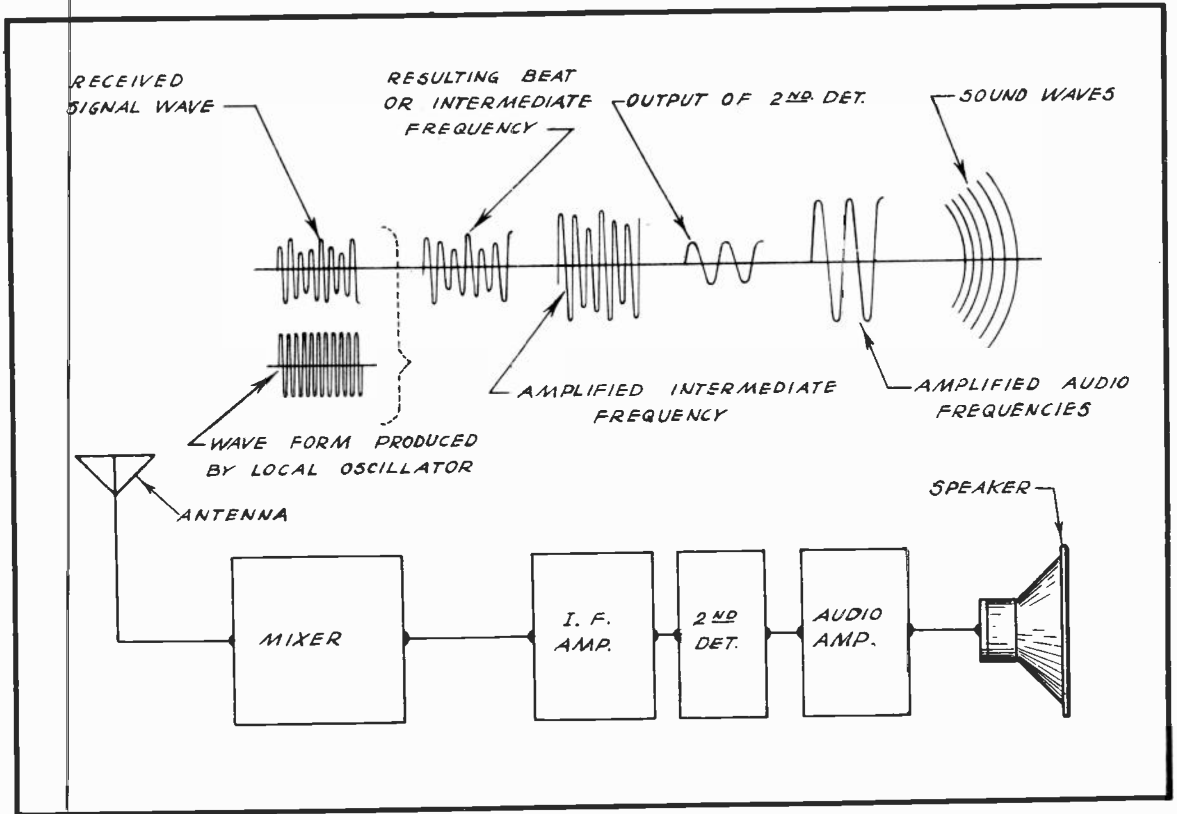

FIG. 4
FREQUENCIES HANDLED BY THE SUPERHETERODYNE

Should it be desired to tune-in a broadcast station operating at a frequency of 1250 kc, when the intermediate-frequency of the superheterodyne is adjusted for 100 kc, then the oscillator would have to be tuned to generate a frequency of either 1150 kc or 1350 kc. Either of these two oscillator frequencies will produce a beat-frequency of 100 kc when heterodyned with the 1250 kc signal-frequency.

The important fact to bear in mind at this time is that to tune in any broadcast station, we simply adjust the oscillator so that the arithmetical difference between the station and oscillator frequencies will produce a beat-frequency for which the intermediate-frequency amplifier is tuned.

Now that you are familiar with the production of beat-frequencies and how they are used in the superheterodyne, let us next investigate the circuits involved and note how these conditions are brought about within the receiver. As our first step we will study briefly a fundamental oscillator circuit, such as used in a superheterodyne receiver.

THE OSCILLATOR CIRCUIT

In Fig. 5 is shown a simple oscillator circuit for an a-c operated superheterodyne. Here you will see that one winding is connected in the plate circuit of the oscillator tube; this plate winding is placed in an inductive relationship with the tuned grid winding. This placement of the winding enables the energy in the tube's plate circuit to act upon the grid circuit in exactly the same way as in regenerative circuits described earlier in the course.

In Fig. 5, however, the coupling between the plate and grid windings is so close, and the energy-transfer from the plate winding to the grid winding is so great, that regeneration becomes excessive and the circuit commences to oscillate. That is, it commences to generate r-f energy, and continues to do so indefinitely, as long as the set is "turned on." By regulating the tuning condenser in the grid circuit of this oscillator tube, we can control the frequency at which this circuit oscillates.

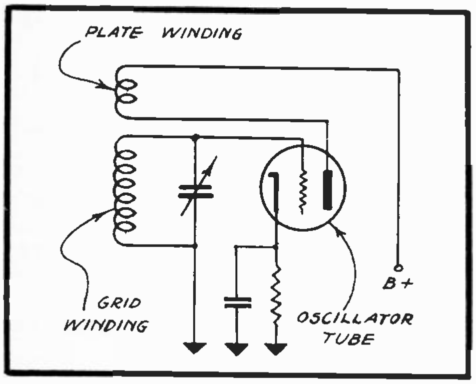

Fig. 5
Oscillator Circuit

To enable this circuit to oscillate, it is imperative to wind the plate and grid windings in the correct direction. In Fig. 6, for example, is shown the manner in which the plate and grid windings are both wound on the same bakelite tube or winding form; the ends of these windings are clearly marked.

A simple rule which will enable you to remember the proper winding direction for these coils follows: Consider both windings as a continuous or single winding which is cut in half at the center. The grid is then connected to one end and the plate to the other. Furthermore, it makes no difference which end you connect to the plate and which to the grid, so long as the windings run in the correct direction.

As a rule you will find the grid and plate windings of the oscillator wound together on the same piece of tubing, the grid winding having a sufficient number of turns to cover the required frequency band when tuned with its variable condenser. The plate winding generally consists of about 25 turns, and is wound near or directly over the top of the grid-return end of the grid winding, with adequate insulation between the two windings.

Now that we have an oscillator circuit, the next step is to provide a means whereby we can transfer the oscillator's r-f energy into the first detector tube. In Fig. 7, you will observe that we have a total of three coils or windings placed in an inductive relationship. Two of them comprise the plate and grid windings of the oscillator, whereas the third is the "pick-up" coil. The latter serves as the connecting link between the oscillator and the first detector.

When using this system, the most common practice is to wind all three of these coils on the same form, with the grid and plate windings wound as already stated; the pick-up coil is usually spaced about 1/8" from the plate winding. As far as operation is concerned, the pick-up coil could be wound either adjacent to the grid winding or adjacent to the plate winding, but a greater energy-transfer is obtained between the plate winding and pick-up coil; it is for this reason that the pick-up coil is generally

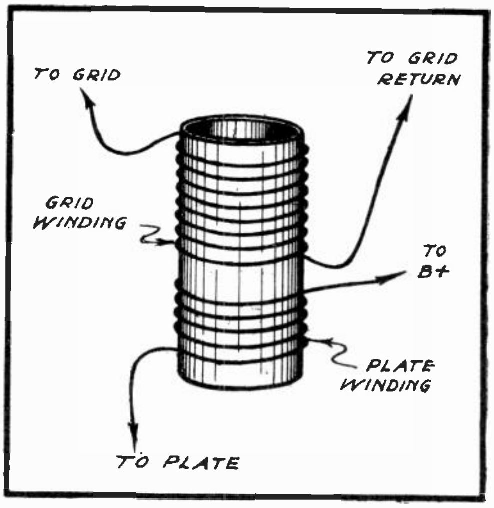

Fig. 6
Connections for Oscillator Windings

wound next to the plate winding rather than next to the grid winding. The physical relation between these three windings is illustrated in Fig. 8.

Pick-up coils generally consist of but six to ten turns of wire, and as you will note from the explanation thus far given, the coupling between the pick-up coil and plate winding of the oscillator is somewhat loose.

There is a natural tendency for a tube to draw more plate current while the circuit is oscillating than when the same tube is installed in a circuit that is not oscillating. For this reason it is advisable to use LESS plate voltage for the tube when used as an oscillator than that specified for its operation as an amplifier. In other words, if the specifications state that a certain tube, when used as an amplifier, should be operated at 135 volts plate voltage and 9 volts grid bias, this same tube when used as an oscillator, should have only about 90 volts on the plate and the bias voltage should be maintained at the same value as recommended for the higher plate voltage, that is, 9 volts. Quite often, the oscillator tube is used with no bias voltage at all. Later instruction will furnish you with more detailed information concerning this matter of voltages.

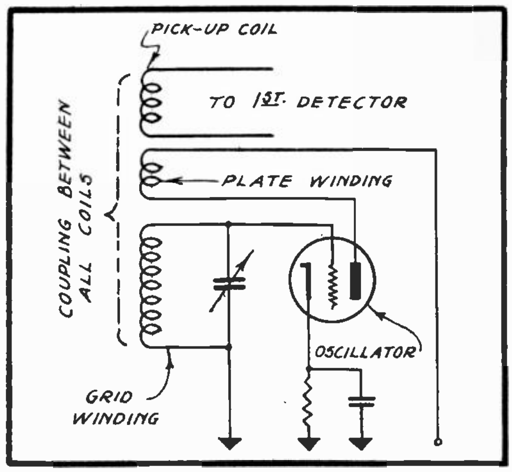

FIG. 7
RELATION BETWEEN PICK-UP AND OSCILLATOR COILS

CHANGING THE SIGNAL FREQUENCY

Leaving the subject of oscillators for the present, let us next see how we are able to "mix" the oscillator-frequency with the incoming signal-frequency.

Fig. 9 shows in diagram form a typical method of coupling the oscillator to the first detector tube. Notice that the pick-up coil is connected in the cathode circuit of the first detector, and is also inductively coupled to the oscillator coils. Such being the case, the high-frequency voltage changes in the oscillator coils will induce voltage changes of like frequency in the pick-up coil. Then, since the pick-up coil is also in effect in series with the first detector tube's grid and cathode elements, it is therefore also a part of the first detector's grid circuit. The r-f voltage changes of oscillator-frequency, induced therein, will therefore act upon the grid circuit of the first detector.

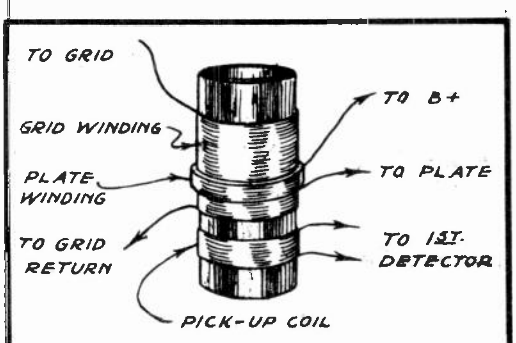

FIG. 8
OSCILLATOR AND PICK-UP COILS

Upon studying the circuit in Fig. 9 more closely, you will further note that the grid circuit of the first detector is also coupled to the antenna through an r-f transformer. Therefore, the signal-frequency and oscillator-frequency will be impressed upon the grid of the first detector simultaneously. This results in a

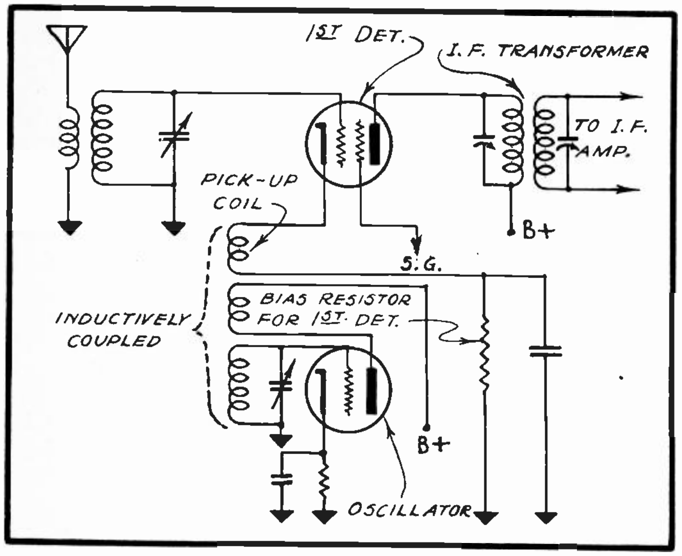

FIG. 9
COUPLING THE OSCILLATOR TO THE FIRST DETECTOR

beat-frequency which is equal to the arithmetical difference between the station signal and oscillator-frequency. This beat-frequency controls the plate current variation in the first detector tube, and also the current variation in the primary winding of the i-f transformer which is connected in the output of the first detector tube. In other words, the current flow through the primary winding of the i-f transformer varies in accordance with the beat-frequency.

In Fig. 10 is shown a schematic diagram of the circuit appearing in Fig.9. This will assist you in acquiring a clearer conception of the relation between the various parts, and you will no doubt now agree that this process of changing the signal-frequency to any desired intermediate-frequency is not so complicated after all.

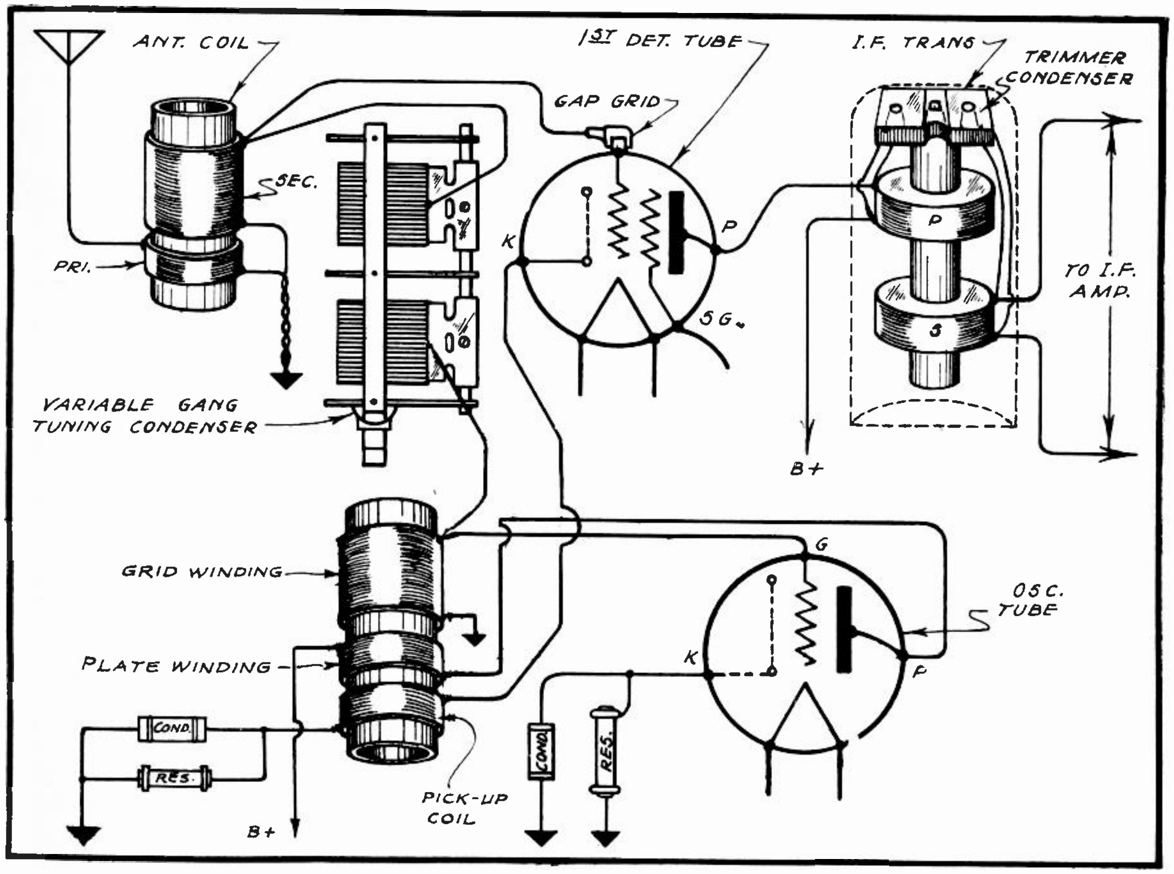

FIG. 10
SCHEMATIC DRAWING OF TYPICAL MIXER CIRCUIT

Now that we have produced our beat or intermediate-frequency, as well as having transferred it to the plate circuit of our first detector, let us next study the intermediate-frequency amplifier in greater detail.

THE INTERMEDIATE-FREQUENCY AMPLIFIER

The circuit arrangement of a typical intermediate-frequency amplifier is shown in Fig. 11. This section of the circuit is sometimes simply called the i-f amplifier, and as you will note, it consists of a chain of tuned transformers and amplifying tubes. We call these particular transformers i-f transformers; the tubes are generally referred to as i-f amplifier tubes.

The primary and secondary windings of each of the i-f transformers in this particular illustration have a small semi-variable trimmer condenser connected across their ends. Thus it is evident that these are all tuned circuits. However, the trimmer condensers in this case have no tuning control which is accessible to the radio-listener; instead, they are set only as a service adjustment by the radio service technician. All of these i-f stages are tuned to the same beat or intermediate-frequency.

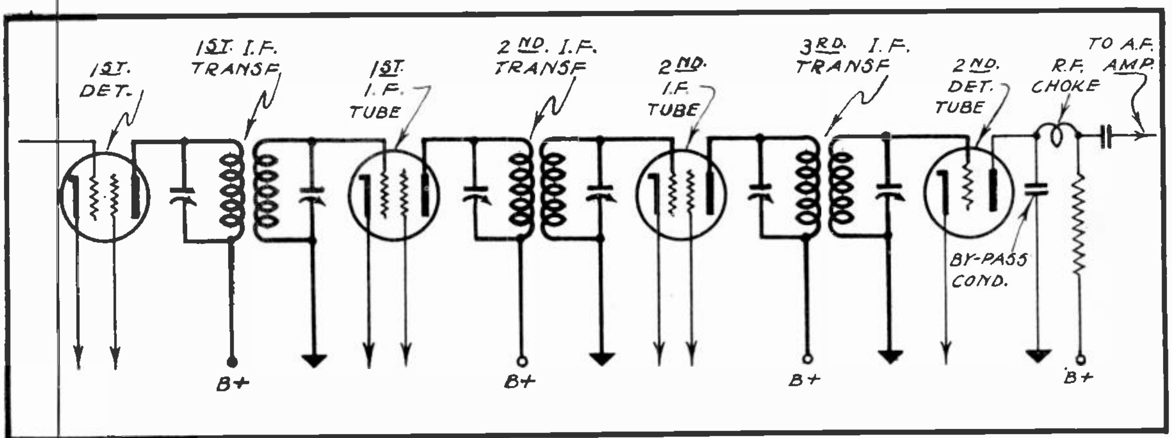

FIG. 11
CIRCUITS OF INTERMEDIATE-FREQUENCY AMPLIFIER

By again referring to Fig. 11, you will observe that while this particular i-f amplifier unit consists of three i-f transformers, it is nevertheless commonly referred to as a two-stage amplifier, irrespective of the fact that three i-f transformers are used.

Only one stage is employed in some i-f amplifiers -- more than three stages are very seldom used. The probability of r-f feed-back and undesirable oscillations limits the number of i-f stages advisable; in contrast to this, the gain and selectivity will be increased proportionately to the number of i-f stages. This subject will be more fully covered in future lessons.

The beat-frequency will be amplified by the following stages of intermediate-frequency amplification, until it is finally delivered to the second detector. Here it acts upon the grid circuit of the second detector, and this tube separates the audio frequencies from the intermediate-frequency in the same manner as the detector in a t-r-f receiver "separates"the audio frequencies from the station's broadcast frequency. The audio frequencies are then passed along through the audio section of the receiver, while the intermediate-frequency is bypassed

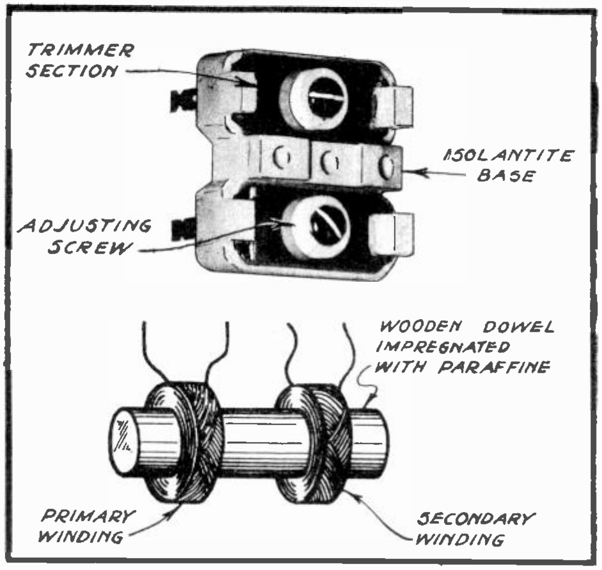

FIG. 12
COILS AND TUNING CONDENSERS OF AN I-F TRANSFORMER

to ground through the bypass condenser which is connected in the plate circuit of this tube.

In Fig. 12 are shown the essential parts of a typical intermediate-frequency transformer. The condenser section in this case consists of two semi-variable trimmer condensers mounted on a porcelain or isolantite base; one of these is used to tune the primary of the i-f transformer, the other for the secondary. The complete coil is then mounted below the condenser unit, and the assembly is housed within a metal shield can, as shown in Fig. 13.

THE QUESTION OF A LOW OR HIGH INTERMEDIATE-FREQUENCY VALUE

In early superheterodynes, the intermediate-frequency was set at a rather low value -- in some cases as low as 25 or 100 kc. Nowadays, however, we have at our disposal efficient screen grid tubes, as well as a better understanding of radio circuits and the actions of high-frequency energy. The result is that higher intermediate-frequencies are now generally employed.

A somewhat higher intermediate—frequency is really an advantage, as long as it is not too high. In fact, a higher intermediate-frequency helps us to obtain "one spot" tuning with the superheterodyne --- this means that any one station will "come in" only on one dial setting. Many of the most modern superheterodynes are, for the reasons already explained, using an intermediate-frequency of 455 kc; in fact, this particular i-f has been adopted as standard in the United States, as well as in the majority of the foreign countries.

You were told previously that to produce a given intermediate-frequency when tuning-in a certain station, the oscillator should be set to generate a frequency equal to either the intermediate-frequency plus the signal-frequency, or else the signal-frequency minus the intermediate-frequency. That is, if the intermediate-frequency is 450 kc and we want

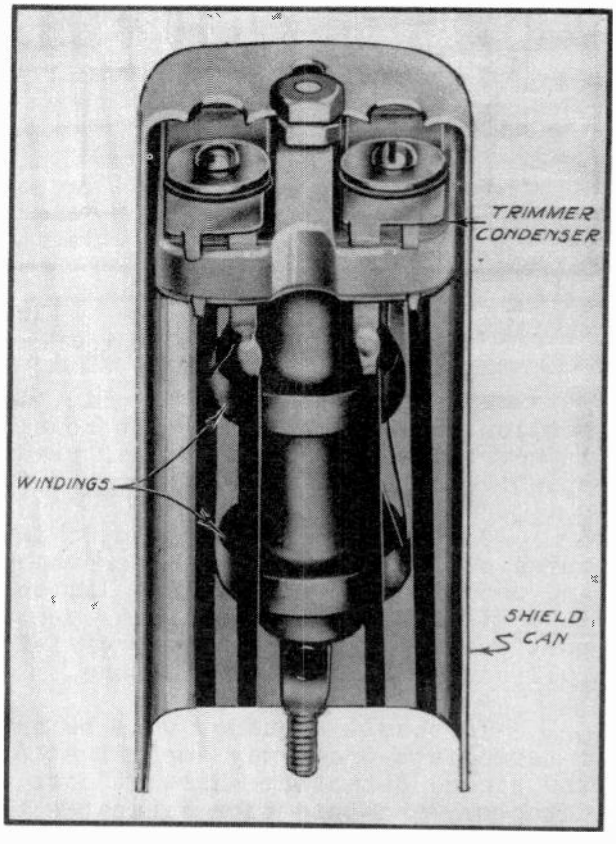

FIG. 13
COMPLETE I-F TRANSFORMER

to tune in a station whose broadcast frequency is 850 kc, then an oscillator-setting of either 1300 kc (450 + 850), or 400 kc, (850 - 450) can be used. In other words, there are two possible dial settings for any one station, but in modern broadcast practice only the higher oscillator frequencies are used.

Carrying this analysis a little farther, we find that if we have an intermediate-frequency of 500 kc, and wish to cover the broadcast band from 550 to 1500 kc with only the high setting of our oscillator, then this will require our lowest oscillator-frequency to be 1050 kc and its highest frequency 2000 kc. Therefore, all that we have to do is to build our oscillator so that it will not tune to any frequency lower than 1050 kc. In this way, together with our high intermediate-frequency, we can obtain one-spot tuning. This may also be stated in another way -- the oscillator will not now tune down to a frequency low enough to heterodyne with any broadcast station at more than one dial setting, and the intermediate-frequency can only be obtained by subtracting the signal-frequency from the oscillator-frequency. Whenever the same station is received at several dial-settings, these various positions of the dial are called repeat points.

There are different ways of looking at these various problems and an equal number of ways of arriving at a solution. For example, a high intermediate-frequency makes it easy to get one-spot tuning, but a lower intermediate-frequency makes the i-f amplifier more stable in its action, and more selective. Consequently, the logical thing to do is to compromise between these two extremes.

At the present time, an intermediate-frequency of 455 kc is most extensively used in commercial types of superheterodynes, as we have previously mentioned.

USING A T-R-F PRE-SELECTOR STAGE

To prevent more than one station at a time from heterodyning with the oscillator frequency, one or two stages of regular t-r-f circuits can be placed on front of the first detector. This is shown in Fig. 14. Let us pause for an instant and see just what effect that this arrangement produces.

The t-r-f stage, or stages, permits only one broadcast-frequency to affect the first detector, and therefore only one broadcast-frequency will be present in the grid circuit of the first detector with which the oscillator frequency can heterodyne. Actual figures will no doubt make this point more clear to you.

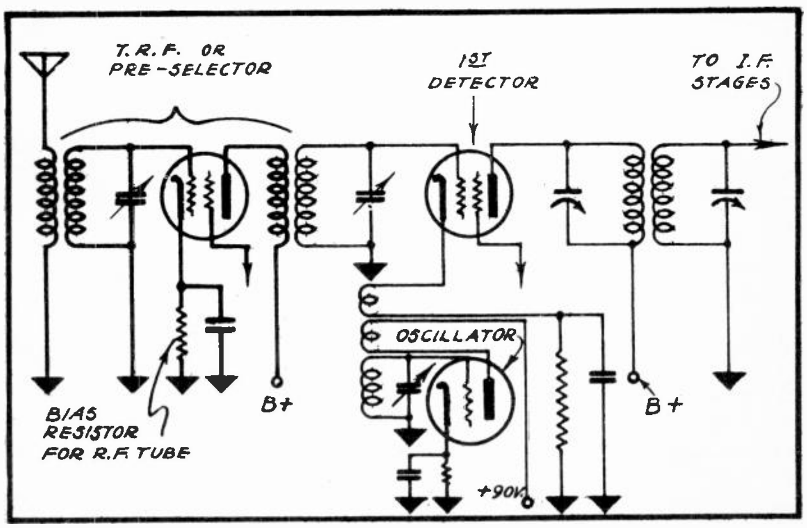

FIG. 14
APPLICATION OF PRE-SELECTOR STAGE

For example, consider two stations to be broadcasting at the same time, one of them having a frequency of 650 kc and the other a frequency of 1000 kc. Assuming the i-f to be 175 kc, we would use an oscillator frequency of 825 kc to bring in the 650 kc station.

This same oscillator-frequency would likewise heterodyne with the 1000 kc station to produce a 175 kc beat-frequency, the result being that the intermediate-frequency amplifier would amplify the signals from both these stations at the same time. This, of course, is not a desirable condition.

As will be noted from the example just given, the undesired frequency is separated from the desired frequency by the amount of twice the intermediate-frequency (2 x 175 kc = 350 kc). The undesired frequency in this case is generally referred to as the IMAGE FREQUENCY.

By placing a tuned r-f stage ahead of the first detector, we can "tune out" either of these two stations before their signal reaches the first detector and thus prevent their simultaneous amplification. However, it is not advisable to use too many tuned r-f stages ahead of the first detector as such an arrangement would cause the receiver as a whole to acquire the characteristics of the r-f stages rather than that of a superheterodyne circuit.

SINGLE TUNING-CONTROL SUPERHETERODYNE

Many of the old style superheterodynes had all kinds of controls and gadgets mounted on their panels, and for this reason considerable patience was required on the part of the operator until he finally juggled these controls around sufficiently to obtain the desired response from the receiver. In straight t-r-f circuits, it is comparatively easy to arrange things so that all of the tuning condensers can be controlled from a common shaft and still tune all of these circuits alike.

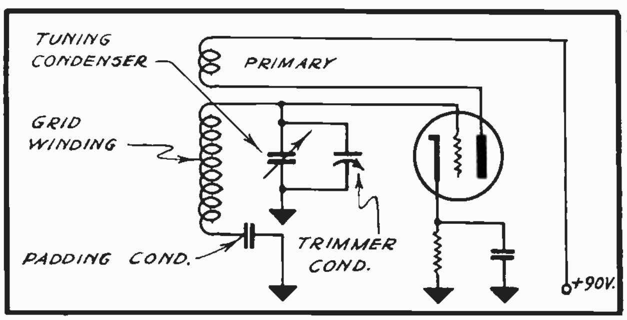

FIG. 15
OSCILLATOR CIRCUIT DESIGNED FOR SINGLE TUNING-CONTROL

In the superheterodyne, however, things are not quite so simple in this respect, because here we must consider that the first detector stage must be tuned through the broadcast frequency-band and the local oscillator through a different band of frequencies, and the relation between these two tuners must always be such as to heterodyne to a given intermediate-frequency.

To solve this problem, the most common practice is to use additional condensers in the tuned oscillator circuit,as shown in Fig. 15. Here the regular oscillator tuning condenser is connected across the grid winding of the oscillator tube, with a small fixed condenser in series. The fixed condenser is referred to as a "padding condenser." A trimmer is shunted across the oscillator section of the variable condenser, and sometimes also across the padding condenser.

These trimmer condensers are set as a service adjustment, and by properly balancing this system of condensers, the oscillator's tuning characteristics can be adjusted to such a point where its rotor plates can be rotated together with those of the first detector and pre-selector stage tuning condensers. During this simultaneous movement of the first detector and oscillator tuning condensers, they will always stay in the proper relation to each other to produce the required intermediate-frequency and for this reason they can both be controlled by a common shaft.

The design and construction of single-control tuning condensers has been simplified somewhat through the use of special types of ganged tuning condensers. One of these new condenser gangs is shown in Fig. 16, where you will observe that the oscillator section consists of specially shaped plates of smaller size, so that the capacitive relation between this and the other sections of the condenser group is such that when used with a given combination of coils, the condenser sections will maintain the proper relation to supply the correct beat-frequency without the use of a special padding circuit.

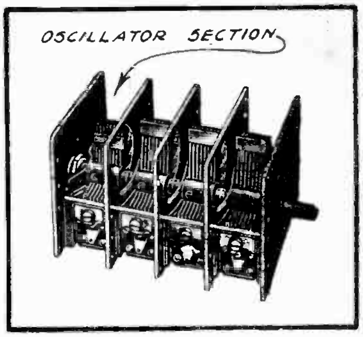

FIG. 16
SUPERHETERODYNE TUNING CONDENSER

A COMPLETE 7-TUBE SUPERHETERODYNE RECEIVER

Now that we have investigated the different sections of the superheterodyne receiver, let us next look at a complete receiver of this type. A typical superheterodyne circuit is shown in Fig. 17, and in Fig. 18 a typical arrangement of the parts on the chassis of this same receiver is shown.

Upon analyzing this circuit, you will observe that this particular receiver consists first of an r-f or pre-selector stage employing

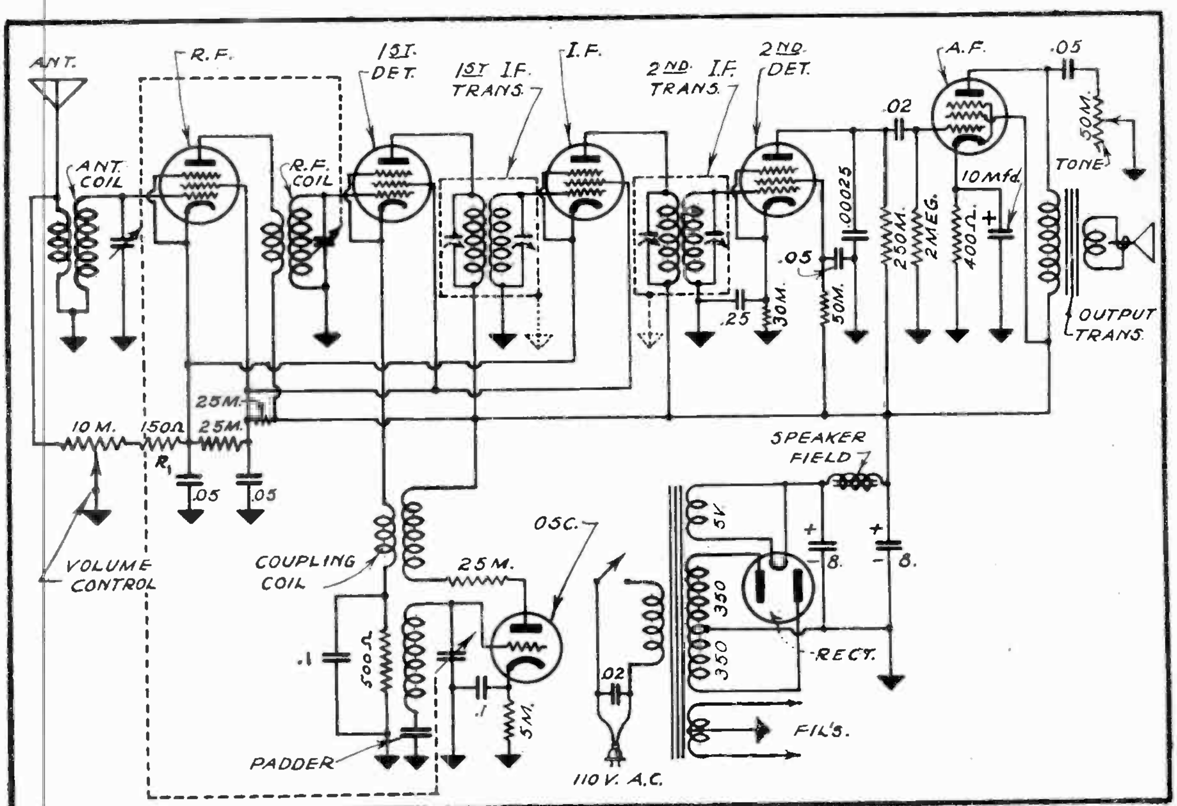

FIG. 17
CIRCUIT DIAGRAM OF SEVEN-TUBE SUPERHETERODYNE RECEIVER

a pentode-type r-f tube. This is followed by the first detector which is inductively-coupled to the oscillator and also "feeds" into the first i-f transformer. The pentode-type i-f tube passes the signal on to the second detector stage, in which an r-f pentode functions as a power detector. This stage in turn works into an audio power stage to which the speaker is coupled. The power supply is conventional.

Upon close inspection, you will no doubt now agree that the superheterodyne circuit in its entirety is really quite simple. Notice particularly that a three-gang tuning condenser is used. Resistor R_1 is connected in the cathode circuit of both the pre-selector stage and the i-f tube, so that both of these tubes will be subjected to the same bias voltage. The volume control connection is such that it will control the volume by simultaneously regulating the bias voltage for the pre-selector and i-f tube, as well as the amount of signal energy passing through the primary input of the antenna transformer.

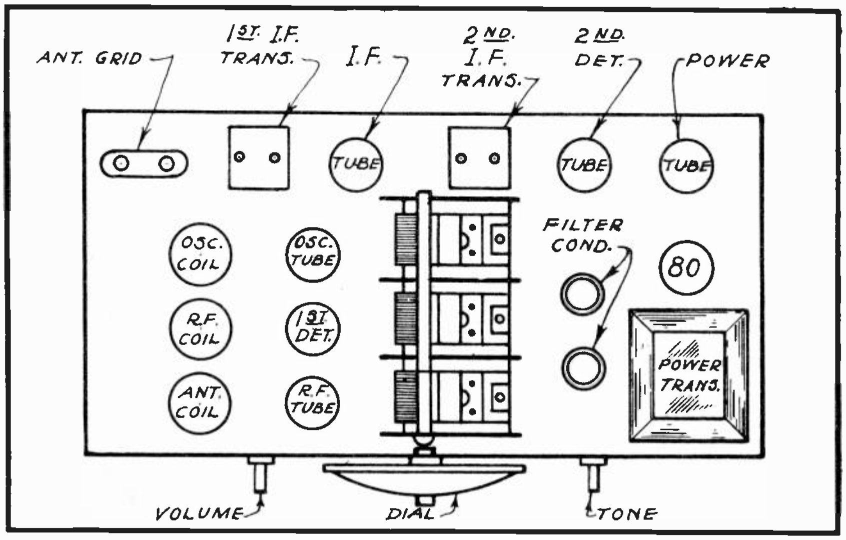

FIG. 18
TYPICAL CHASSIS ARRANGEMENT OF SEVEN-TUBE SUPERHETERODYNE RECEIVER

The parts values as given in this diagram are typical of circuits of this type, size, and arrangement. However, in later lessons you will receive more detailed information concerning this matter.

In this lesson we confined our discussions strictly to those superheterodyne circuits wherein separate first detector and oscillator tubes were used. By so doing, you were better enabled to acquire a clearer conception of the fundamental principles involved. In the next lesson, however, you will learn how the duties of the first detector and oscillator are cared for by a single tube, employing the electron-coupling principle.

We sincerely hope that this lesson has given you a good basic understanding of the constructional principles and operation of the superheterodyne receiver. As you continue with your studies, you will of course receive a great deal more valuable information concerning this type of receiver, such as the application of the newest tubes, various types of superheterodyne receivers with special features incorporated in their circuits, servicing superheterodynes, designing superheterodyne circuits, etc. In fact, the lesson immediately following is devoted exclusively to many of the modern features used in the latest model superheterodynes.

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EXAMINATION QUESTIONS

LESSON NO. 18

1. - What is the advantage of using a fairly high intermediate frequency in a superheterodyne receiver rather than a low frequency?

2. - What is meant by the expression "repeat point",as related to the tuning characteristic of a superheterodyne receiver?

3. - What advantages does a superheterodyne receiver offer over a straight t-r-f receiver?

4. - What is meant by an "image frequency" relative to a superheterodyne receiver?

5. - If the i-f amplifier of a certain superheterodyne receiver is adjusted or "peaked" to resonate at a frequency of 455 kc and you are listening to a broadcast station operating at a frequency of 800 kc, then to what frequency will the receiver's oscillator circuit be tuned during the reception of this program?

6. - Explain the heterodyne principle, as applied to superheterodyne receivers.

7. - Draw a circuit diagram showing how a pre-selector stage, first detector, and oscillator may all be inter-connected so as to produce a beat or intermediate-frequency.

8. - Explain how it is possible to maintain a constant frequency difference between the oscillator, and other tuned circuits which are all tuned by the same gang tuning condenser.

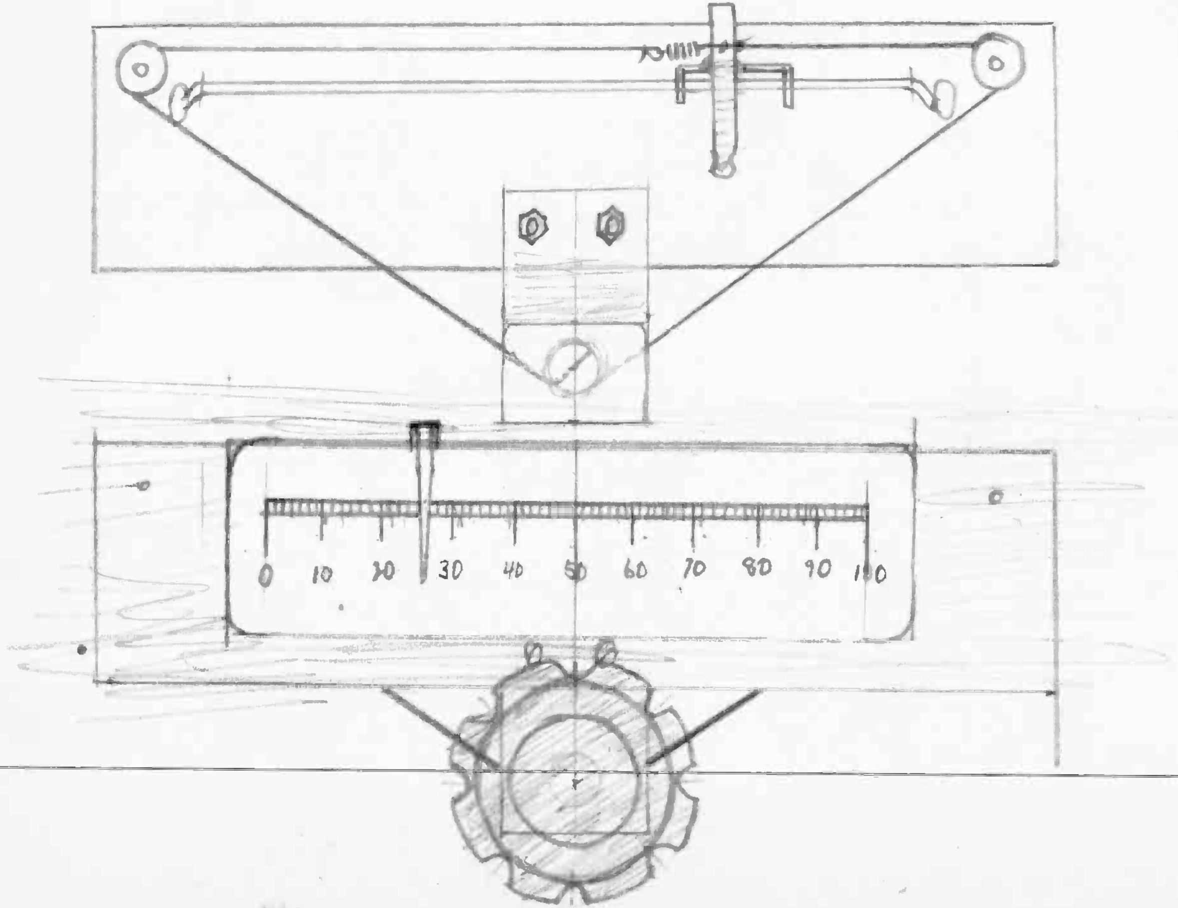
9. - Why is it advisable to use a pre-selector stage in conjunction with a superheterodyne circuit?

10. - Describe a typical i-f amplifier.

- Self Reliance -

Work is a mighty hard thing to keep track of. A man will go to an employer saying he has been looking for work everywhere, but cannot find it. The employer gets busy,finds work and gives it to him. Then the employer expects work from the employee,and when he does not get it,pays him off and starts him out looking for work again and the chances are he never finds it.

The less you require looking after, the more able you are to stand alone and complete your tasks, the greater your reward. Then if you cannot only do your work,but also intelligently and effectively direct the efforts of others, your reward is in exact ratio; and the more people you direct, and the higher the intelligence you can rightly lend, the more valuable is your life.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Practical-Technical

TRAINING IN RADIO AND TELEVISION

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LESSON NO. 19

MODERN SUPERHETERODYNE RECEIVERS

You are by this time quite familiar with the fundamental principles of superheterodyne receivers; however, there are still a number of important features applicable to this type of circuit which have up to this time not been brought to your attention. Manufacturers are continually improving the design of superheterodyne receivers -- it is the purpose of this lesson to acquaint you with the most recent of these circuit arrangements.

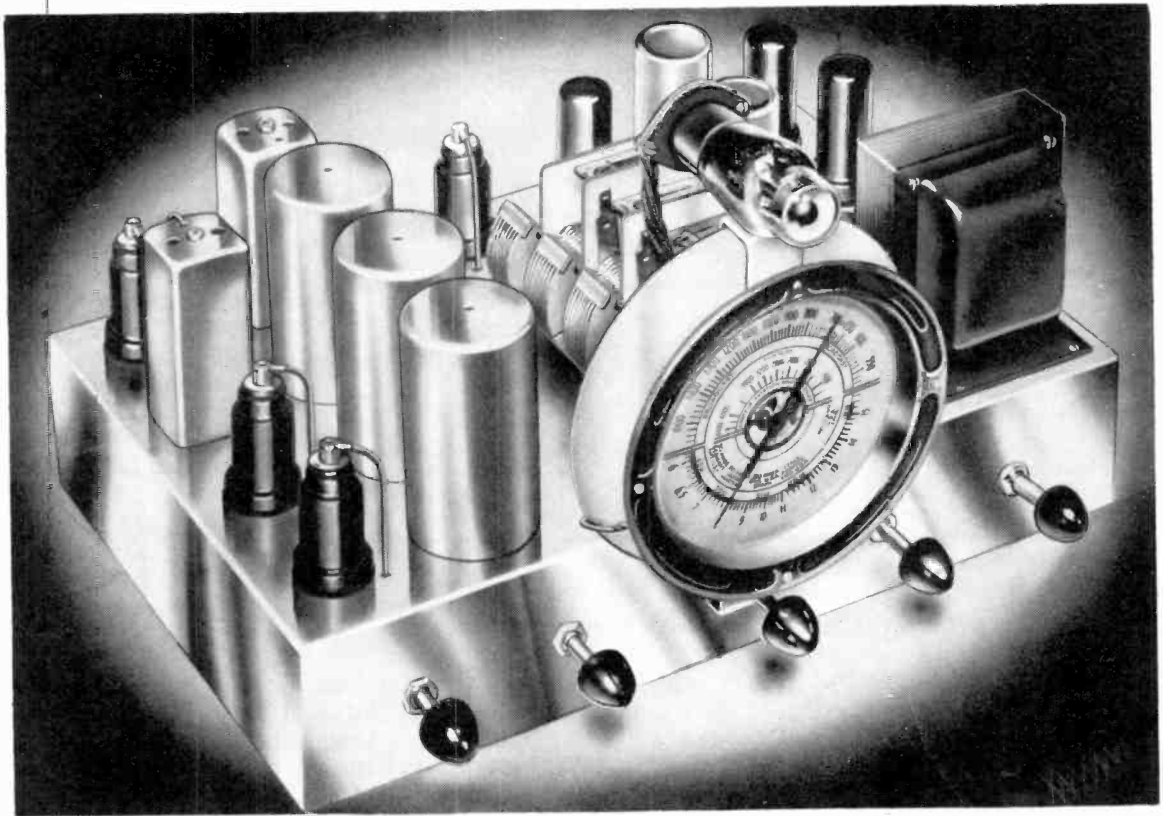

FIG. 1
MODERN SUPERHETERODYNE RECEIVER

THE AUTODYNE SYSTEM

In all of the superheterodyne receivers which you have studied thus far, two separate tubes were employed in the mixer circuit. One of these tubes functioned as the first detector and the other as the oscillator. Soon after the superheterodyne principle became popular in commercial receivers, engineers commenced devising means whereby the separate oscillator tube could be eliminated, and the process of "mixing" accomplished by a single tube.

The AUTODYNE SYSTEM provided the first successful means of accomplishing this. The autodyne system was quite popular some time ago in superheterodyne receivers of compact design, in that by eliminating the additional oscillator tube, considerable space was saved. It is of course true that the more efficient pentagrid converter tube has replaced the autodyne method of frequency conversion in superheterodynes of later design; however, we can not overlook the fact that superheterodynes employing the autodyne principle are still in use, and it is therefore advisable for you to become acquainted with them.

THE AUTODYNE CIRCUIT ARRANGEMENT

In Fig. 2 you are shown a circuit diagram of the mixer section of a superheterodyne receiver wherein the "autodyne" principle is employed. Here you will note that an ordinary r-f pentode-type tube is being used as the combination first detector and oscillator.

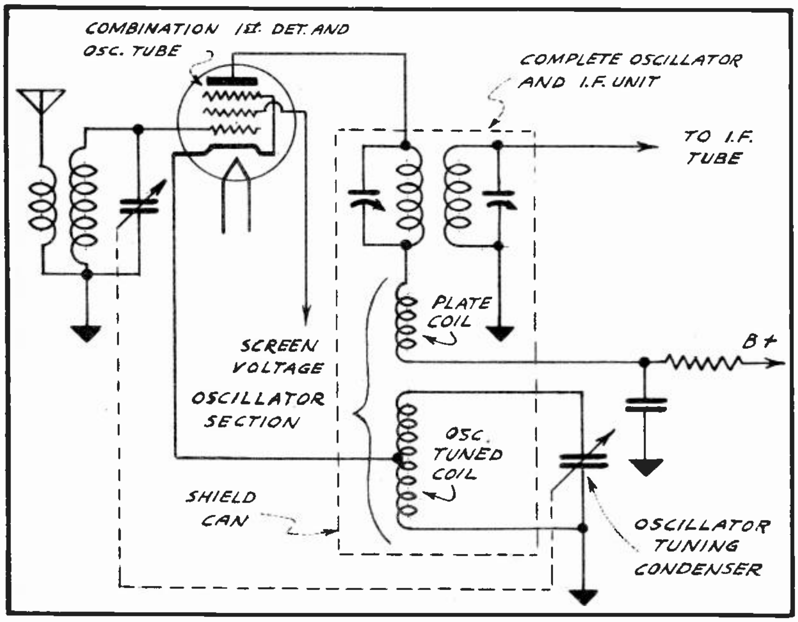

FIG. 2
AUTODYNE METHOD OF FREQUENCY CONVERSION

A common method of arranging the oscillator coil in receivers of this type was to enclose the oscillator coil assembly in the same shield can with the first i-f transformer; this is indicated in Fig. 2 by the dotted lines which form the enclosure for this coil assembly. Complete coil assemblies as this are known as "Composite oscillator--i-f units." In Fig. 3 you are shown the constructional details of such a unit.

The coils of the i-f transformer are in this case mounted on a wooden dowel, while the oscillator tuned-winding and the plate circuit winding are wound on a piece of insulative tubing surrounding the i-f coils. The plate circuit winding is wound directly over the tuned oscillator winding to provide close coupling between them. Insulating material is placed between these two windings to prevent "shorting."

The i-f trimmer condensers are mounted in the upper part of the shield can, holes being provided in the top of the can through which they can be adjusted. All winding leads are brought out through the bottom of the can.

Since part of the oscillator-tuned winding is in series with the cathode circuit of the combination first detector-oscillator tube (see Fig. 2), the oscillator coil will in effect be connected in the control grid circuit of this tube, while at the same time being inductively-coupled to the windings of the first i-f transformer. The oscillator-frequency will therefore react with the incoming signal-frequency to produce the desired beat-frequency that is to be amplified by the i-f amplifier.

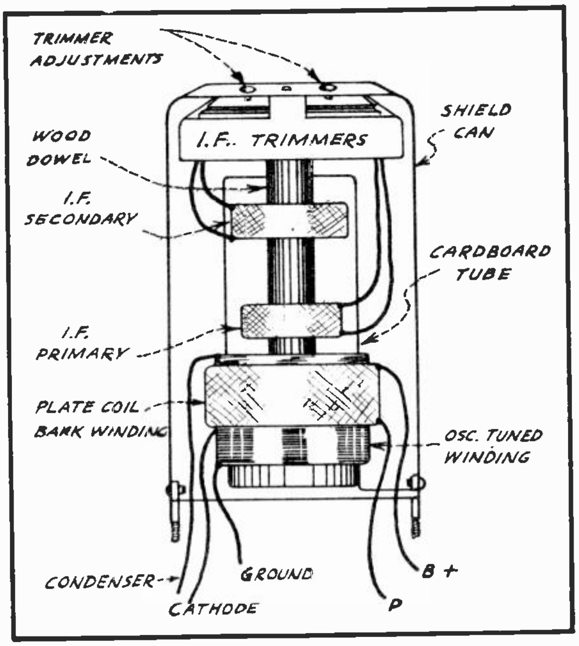

FIG. 3
COMPOSITE OSCILLATOR -- I-F UNIT

PENTAGRID CONVERTER TUBES

In superheterodyne receivers of more recent design, a special tube is used to serve as the combination first detector and oscillator. This tube is known as a PENTAGRID CONVERTER, and it is designed in such manner that the first detector and oscillator sections of the circuit are each connected to individual grids within the tube. The electron stream within the tube thus serves as the coupling medium between the first detector and oscillator sections. We call this method of uniting the first detector and oscillator sections ELECTRON COUPLING.

At this time, we will describe briefly the construction and operation of pentagrid converter tubes as applied to superheterodyne receivers. However, in later lessons other uses for this valuable tube will be brought to your attention. Later lessons will also familiarize you with other applications for electron coupling wherein the pentagrid converter tube is not used.

In Fig. 4 is shown the symbol of a pentagrid converter tube. The constructional features and operating principle of this tube can be analyzed readily by considering it as two individual tube sections, enclosed in a single glass envelope.

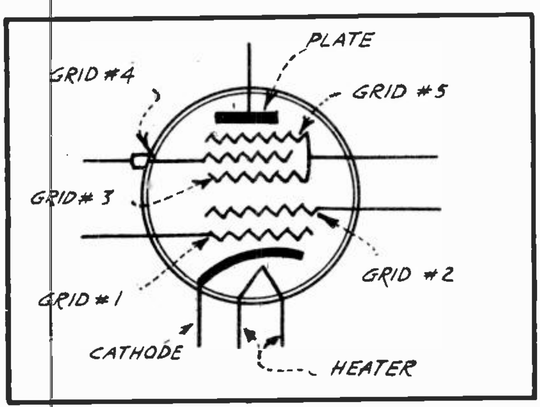

FIG. 4
SYMBOL OF PENTAGRID CONVERTER TUBE

Grid #2, in Fig. 4, instead of being constructed in the form of a conventional grid, is built in the shape of two vertical metal rods which are connected together. This grid in effect acts as a plate of the tube's triode section, and for this reason is called the ANODE GRID.

That section of the tube consisting of the heater, cathode, grid #1 and grid #2 acts as a conventional triode oscillator tube, and is connected to the circuit as shown in Fig. 5. It is well that you familiarize yourself with the circuit connections before commencing with the analysis of its operation.

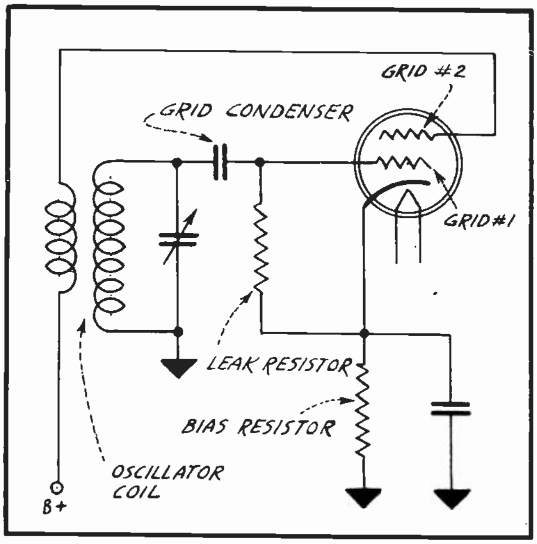

FIG. 5
THE OSCILLATOR SECTION

By studying Fig. 5 closely, you will observe that the oscillator tuning circuit is connected to grid #1 of the tube through the grid condenser, and that the plate winding of a conventional superheterodyne-type oscillator coil is connected between B+ and grid #2. With the connections thus made, the anode grid is in effect being used as the plate of a triode oscillator tube; this section of the tube therefore produces oscillations at controlled frequencies, the same as the oscillator in the older superheterodynes.

Having considered the oscillator section of the tube, let us now investigate the other element connections and analyze the operation of the system as a whole. In Fig.6 is shown the complete circuit of the pentagrid converter.

Observe in Fig. 6, that the oscillator circuit remains exactly the same as illustrated in Fig. 5. Closer inspection of Fig. 6 will reveal that grid #4 serves as the control grid, and to which the tuning circuit of a conventional first-detector is connected. The plate of this tube is connected through the primary winding of an i-f transformer to a B+ potential. Grids #3 and #5 are connected together within the tube, and serve as a shield between the control grid #4 and the plate, as well as between grid #4 and the anode grid #2. In other words, grids #3 and #5 together act as a screen-grid which is connected to a B+ potential of lower value than the plate voltage, and by-passed with a fixed condenser.

This second section of the tube may be considered together with the cathode and heater (which is common to both sections of the tube) as a screen-grid tube.

The transformer (r-f) in the first-detector circuit of Fig. 6 is exactly the same as that used in other superheterodyne circuits which you have already studied, as is also the oscillator coil. However, in the circuit design of Fig. 6, the r-f transformer of the first-detector circuit and the oscillator coils are each wound on separate forms,

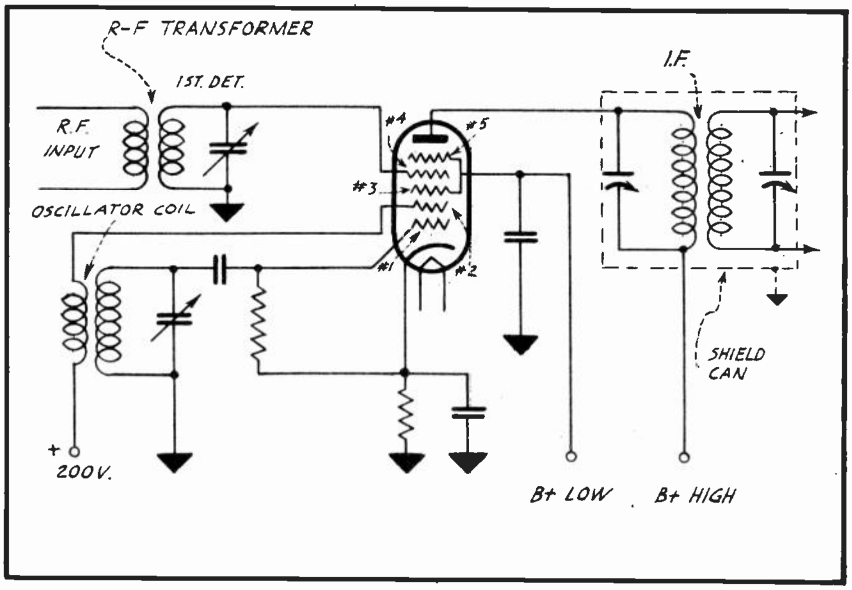

FIG. 6
MIXER CIRCUIT WITH PENTAGRID CONVERTER

so placed on the receiver chassis that there is no inductive coupling between them.

CIRCUIT OPERATION USING A PENTAGRID CONVERTER

With this circuit in mind, let us now see how the complete system operates to produce the desired intermediate-frequency.

To begin with, the heated cathode emits electrons which are attracted toward the positively-charged anode grid #2, and since grid #1 is placed between the cathode and grid #2, these electrons will be controlled in their flow by grid #1 whose potential varies at a rate determined by the frequency to which the oscillator circuit is tuned. Conditions being such, this same electron stream will be modulated (varied in intensity) at the oscillator frequency.

The anode grid is not capable of completely obstructing the flow of electrons toward the plate because it offers but little exposed surface. For this reason, the greater portion of the electron stream continues its movement toward the plate which is charged to a still higher positive potential; however,before reaching the plate, the electron stream first comes under the influence of grid #3 which is also being operated at a positive potential with respect to the cathode. Grid #3 also offers little obstruction toward the electron flow due to its construction; and being charged at a fairly high positive potential, it further accelerates the flow of electrons toward the plate. Remember, however,that the electron stream in this region of the tube is already in a modulated form, conforming to the oscillator-frequency.

The incoming signal-frequency, appearing in the tuning circuit of the first detector section, is applied to grid #4 and therefore further modulates the electron stream which has already been modulated at the oscillator frequency. This two-fold modulation creates a heterodyne effect that produces components of plate current, the frequencies of which are the various combinations of the oscillator and signal frequencies. Then, since the primary circuit of the first i-f stage is designed to resonate at the intermediate-frequency, only the desired intermediate-frequency will be present in the secondary circuit of the i-f transformer for further amplification.

The chief advantages obtained through this system of mixing or frequency conversion are the following:

(1) It simplifies the design of the oscillator circuit and at the same time eliminates one tube from the circuit.
(2) It eliminates undesired intercoupling effects between the signal, oscillator, and mixer circuits, and also its resulting detuning characteristic.
(3) It reduces local frequency radiation and is more stable in operation.

The socket connections, operating characteristics, and other specifications of individual types of pentagrid converters are given in your Job Sheets and other tube reference sources which we furnish you.

A MODERN NINE-TUBE A-C SUPERHETERODYNE

A modern superheterodyne circuit,in complete form,is illustrated in Fig.7. In this case,eight metal tubes and a glass tube are employed.

Here you will see that a tuned-radio-frequency stage precedes the first detector; this feature prevents more than one station acting upon the first-detector at the same time. The three sections of the

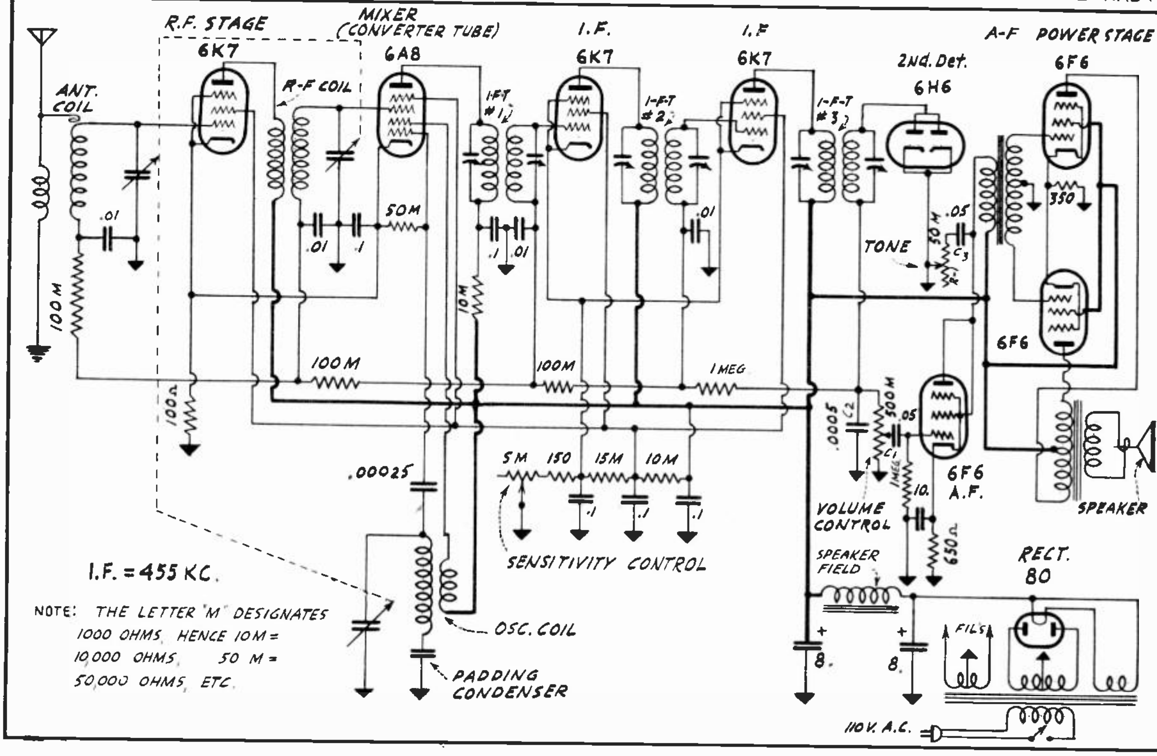

Fig. 7
Nine-tube A-C Superheterodyne Receiver

main variable tuning condenser, which are connected in these circuits as well as in the oscillator circuit, are controlled by a common shaft indicated by the dotted-line connection between them.

Two windings are included on the oscillator coil; one is connected in the anode grid circuit of the oscillator tube, and the other in the circuit of the same tube's grid #1. There is no inductive coupling between this coil and the first detector r-f coil; coupling in this new circuit is furnished by the coupling-effect provided between the different elements within the converter tube, as already explained in this lesson.

The tuning controls in Fig. 7 are so arranged that the oscillator-frequency will always differ from any signal-frequency by 455 kc, which is the intermediate-frequency used in this particular receiver. The i-f output from the converter tube (mixer) acts upon the grid circuit of the first i-f tube through the first i-f transformer which is permanently adjusted to tune this circuit to 455 kc.

The first i-f tube is coupled to the second i-f tube by means of transformer coupling. The primary and secondary windings of this transformer are both permanently tuned to the intermediate-frequency by means of trimmer condensers.

The second detector is a half-wave diode detector, which also supplied the automatic volume control action in this receiver. In later paragraphs of this lesson, you will be given an explanation of this principle.

The second detector is connected to the first a-f tube by means of resistance-capacity coupling. Audio frequencies react through this coupling condenser C-1, because the i-f currents are all bypassed to ground through condenser C-2.

The first a-f tube is in turn coupled to two power tubes connected in a push-pull arrangement. A TONE CONTROL, consisting of a condenser and variable resistor in series, is connected across the primary winding of this transformer. These parts are indicated in the circuit diagram as C-3 and R-1. The impedance of this tone control circuit may be varied by regulating the position of the adjustable resistor arm. The greater the resistance-setting, the less will be the percentage of high frequencies bypassed to ground. In this way, the operator of the receiver increases or decreases the effective range of the audio frequencies and thereby regulates the pitch of the sound produced by the speaker. This control is operated from the control panel -- you will hear more about it in later lessons.

Notice in Fig. 7 that pentode-type tubes are used in the preselector, intermediate-frequency, and audio-frequency stages, but the first a-f stage is triode-connected; the mixer section employs the converter-type tube.

WHY AUTOMATIC VOLUME CONTROL IS USED

As previously mentioned, the receiver diagrammed in Fig. 7 has automatic volume control features incorporated in its circuit. No attempt will be made at this time to explain and describe completely all of the many principles of automatic volume control, as this subject is treated thoroughly in future lessons. However, so that you will understand how automatic volume control is applied to the circuits here shown, a brief but comprehensive explanation of this system will be given at this time.

If you have listened to radio receivers in which an automatic volume control system was not employed, you have no doubt noticed that it is a common occurrence while listening to a program, or when tuning from one station to another, for the volume to suddenly increase to a blare or else decrease to such an extent that the speaker sounds are hardly audible. This condition is especially pronounced while tuning-in stations of different power and located at various distances from the receiver.

This condition is really annoying, as it makes it necessary for the operator to turn the volume control either "up" or "down", to keep the volume at a pleasing level. After all, the receiver is simply amplifying whatever signal energy reaches it and consequently, it is no more than natural that the speaker volume should increase when more signal energy is available for amplification.

Since it is impossible to control the amount of signal energy reaching the millions of listeners at all different points of the globe, the logical step for eliminating the annoyance of sudden increases or decreases in volume is to devise some means whereby the receiver automatically provides a volume of constant level when a station has been tuned-in. In the latest types of receivers, this is accomplished by means of AUTOMATIC VOLUME CONTROL -- quite often spoken of simply as "a-v-c."

Briefly, automatic volume control makes the receiver more sensitive to weak signals and less sensitive to strong signals. In this way, it serves to "fill-in" the gaps during the variation of signal strength. This is accomplished electrically by automatically controlling the grid bias voltage applied to the r-f tubes. In some of the more elaborate a-v-c systems the grid bias voltage is controlled by a separate tube; however, in the circuit of Fig. 7, the control action is furnished by the dual-purpose second detector tube. With this fundamental idea in mind, let us continue now and see just how this is all brought about.

HOW AUTOMATIC VOLUME CONTROL IS ACCOMPLISHED

In Fig. 8 you are shown the essential parts of the a-v-c circuit. This particular circuit is similar to the a-v-c portion of the superheterodyne receiver illustrated in Fig. 7. The system operates as follows:

Up to the second i-f transformer, the signal is passed through the circuit in the customary manner, but in the secondary circuit of the second i-f transformer, the signal is impressed upon the two diode plates of the combination diode detector and a-v-c tube. Both of these diode plates are connected to one side of the secondary circuit.

Since the cathodes of this tube are emitting an electron stream, while the two diode plates change their potential from positive to negative, in accordance with the signal-voltage changes, it is clear that the cathodes and the two diode plates together constitute a rectifier or detector. Both diode plates being connected together, this portion of the tube operates as a "diode" or half-wave rectifier.

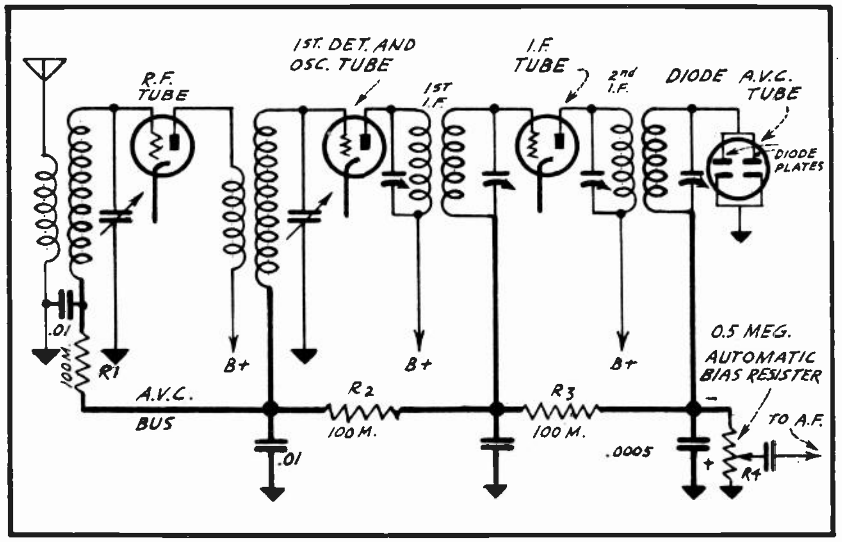

FIG. 8
DETAILS OF A-V-C CIRCUIT

The current flow, which occurs during this process of rectification, passes through the 0.5 megohm resistor, R_4 in Fig. 8, causing a corresponding voltage variation across this resistor and the .0005 mf condenser by which it is shunted.

This rectified current will also produce a corresponding audio voltage across the automatic bias resistor R_4, which is equipped with a variable control arm through which these audio variations are fed to the a-f section of the receiver.

The r-f signal current (electron flow), as it is rectified by the diode tube, will flow from this tube's cathode toward its interconnected diode plates; all of this rectified current flows through the automatic bias resistor R_4 in such a direction as to make the lower end of this resistor positive and its upper end negative.

You will observe that the grid-returns of the r-f, mixer, and i-f tubes are all connected to the a-v-c bus through their respective filters, consisting of the 0.1 megohm resistors and the 0.01 mf condensers. This combined a-v-c bus is in turn connected to the negative end of the automatic bias resistor R_4. Therefore, if the r-f signal voltage as applied to the diode plates is increased, the flow of rectified current through the automatic bias resistor will increase correspondingly; this will bring about a greater voltage drop across this resistor. In this way, the negative bias voltage on the r-f and i-f tubes is increased and the volume will therefore decrease.

In like manner, if the signal voltage acting upon the diode plates is decreased, the flow of rectified current through the automatic bias resistor will decrease, so that less bias voltage is applied to the r-f and i-f tubes; the volume therefore automatically increases. Thus we find that greater signal strengths reduce the volume and lesser signal strengths increase the volume; hence, for any one volume control setting, the volume remains practically constant.

I-F EXPANSION

All of the i-f transformers described thus far, had a fixed coupling relationship between the primary and secondary windings. Such a transformer will pass an r-f signal of a definite band-width; that is, its sharpness of tuning cannot be varied by the set-operator.

The "closer" or "tighter" the coupling, the broader will be the tuning characteristic of the transformer -- the looser the coupling, the sharper will be the tuning characteristic.

The average superheterodyne receiver, equipped with conventional i-f transformers of fixed coupling, is satisfactory under normal conditions of operation. However, there are instances where the receiver will be operated in congested areas, and where it must tune much sharper than normally in order to eliminate interference between stations. While there are many methods for increasing selectivity, the usual practice in such cases is to provide means whereby the coupling between the coils of the i-f transformer can be varied. Such practice is referred to as i-f expansion -- meaning that the broadness of tuning, and the band-width passed, can be increased or expanded, as well as being decreased.

In Fig. 9 you are shown the circuits of a typical i-f amplifier stage, employing i-f expansion. You will observe that the secondary winding of the i-f transformer is tapped at three points, which will allow three different degrees of selectivity to be employed. This arrangement varies the coupling electrically, but not physically. However, in some receivers the position of the two coils is actually changed, but this method calls for a much more costly assembly. The usual practice, therefore, is to change the coupling relation electrically.

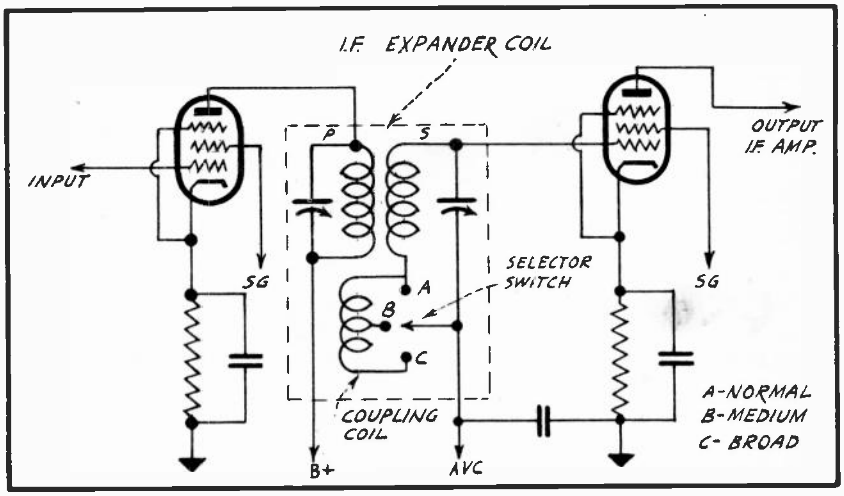

FIG. 9
I-F EXPANDER STAGE

OPERATION OF THE I-F EXPANSION CIRCUIT

In earlier lessons you learned that when two coils of like frequency characteristics are placed in an inductive relationship with each other, maximum energy-transfer between them will take place when the circuit is operated at the particular frequency to which they are tuned. Also the more exact the condition of resonance, the greater will be the amount of signal-energy transferred. You also learned that the coupling or distance between the coils affects the selectivity or band-width of the signal handled by them.

Again referring to Fig. 9, you will observe that when the selector switch is placed in position A, the secondary of the i-f transformer is tuned to exact resonance with the primary; when the switch is placed in position B, a portion of the coupling coil is connected in the circuit. Due to its close inductive relationship to the primary coil, this coil, when connected in the secondary circuit, will provide closer coupling between the primary and secondary circuits, and consequently the transformer-tuning will be more broad. The detuning effect, by adding more turns to the secondary circuit, also broadens the tuning.

Closing the switch at position C will add still more inductance to the secondary winding and at the same time will increase the coupling, so that the tuning of the transformer is even more broad.

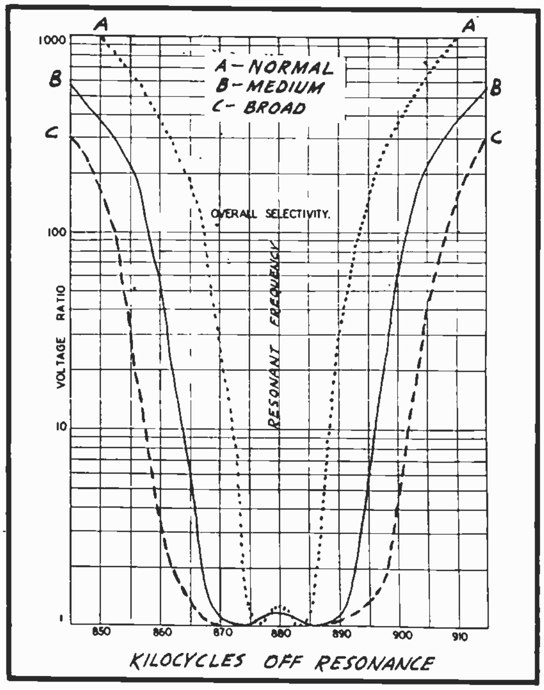

FIG. 10
HOW I-F EXPANSION VARIES THE RESONANCE CURVE

By referring to the resonance curves shown in Fig. 10, you will observe how the actual band-width will vary as the coupling is correspondingly increased or decreased from normal, to medium, to broad. The broader the tuning, the wider is the curve in Fig. 10. You will learn more about these curves in advanced lessons.

PERMEABILITY-TUNED I-F TRANSFORMERS

In the previous lesson, you were shown the constructional details of an i-f transformer that employed small compression-type trimmer condensers, shunted across the primary and secondary windings. You were also told how these trimmer condensers made it possible to properly align the transformer to the particular i-f being used.

While this method of alignment is entirely practical and widely employed in the construction of i-f transformers, there is nevertheless in existence still another very satisfactory method for trimming these windings, and which at the same time materially increased the gain and selectivity of the transformer. The latter method consists of inserting a magnetic material inside of the form on which the coils are wound, and varying the position of this core to change the tuning. An i-f transformer of this type is shown in Fig. 11, where you will observe that no variable trimmer condensers are employed.

SOME FACTS ABOUT IRON-CORE MATERIAL

The core substance now used in iron-core transformers is a magnetic material known as POLYIRON. The chief advantage offered by it is that it produces an increase in the effective inductance of a coil without increasing its effective resistance. At high frequencies, the losses introduced by ordinary iron and other previously known core materials are so high that the reverse is true; that is, the resistance increase is much greater than the inductance increase.

The outstanding properties of this new core material have permitted such remarkable improvements in the design of high-frequency inductors that a new era in radio receiver performance has been initiated. The evidence of this improvement is higher gain and greater selectivity.

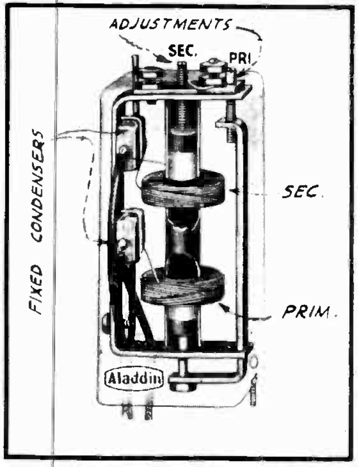

FIG. 11
IRON-CORE I-F TRANSFORMER

The inductance of any air-core coil may be increased without increasing the number of turns on the coil by merely inserting in the field of the coil a small amount of this new core material. This phenomenon can be observed readily when the end of such an iron core is inserted in a coil.

As just mentioned, when a coil is wound on an iron core made of this new material, fewer turns are necessary to secure a given inductance than if the coil did not have such a core. Since there are fewer turns, less wire is required, and the resistance of the winding is therefore reduced. Consequently, when employed in a resonant circuit, the inductor having such a core provides sharper tuning. Furthermore, these units offer remarkable freedom from frequency-drift, and eliminate difficulties previously encountered with mica trimmer condensers.

VARYING THE INDUCTANCE

From this description of the properties of iron-core or permeability-tuned i-f transformers, you can readily see that if this core substance is varied, then the inductance will be changed accordingly. Again refer to Fig. 11, and observe how the magnetic material is moved in and out of the coil-form by means of a screw adjustment. Thus, the i-f transformer can be tuned to the desired frequency.

Upon referring to Fig.12 you will note that two small fixed mica condensers are shunted across each of the windings. These fixed condensers are also shown in Fig. 11. The purpose of these condensers is to increase the tuning ratio of the coils; that is, the inductance-capacity relation is then such that the selectivity is improved to a further degree than is possible with the iron-core alone.

In some iron-core i-f transformers, the iron-core material remains in a fixed position, and the necessary tuning compensation is accomplished by means of small condensers that are connected across the coil windings. In this case these condensers are of the semi-variable type, and the tuning adjustment is then made as on i-f transformer units using compression-type trimmer condensers. Modern i-f transformers are manufactured in both the iron-core and air-core types.

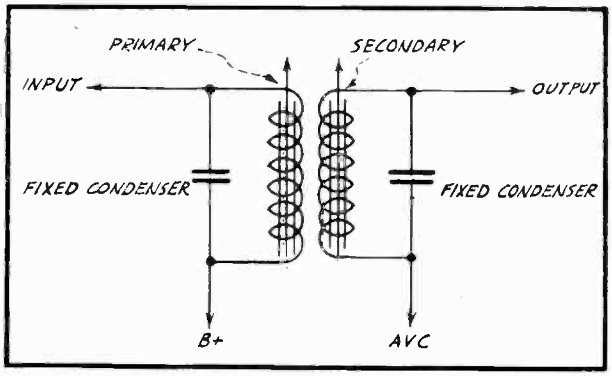

FIG. 12
I-F TRANSFORMER WITH IRON-CORE TUNING

PERMEABILITY-TUNED SUPERHETERODYNE RECEIVERS

Due to the success of iron-core i-f transformers in superheterodyne receivers, considerable effort has been expended by receiver engineers to adapt these coils to r-f circuits, whereby the tuning can be varied from one end of the broadcast band to the other, the same as is accomplished by the variable condenser. The idea in this case is to eliminate the variable tuning condenser from the circuit entirely, and to use in its place a ganged group of continuously variable iron-core tuning coils whose tuning range extends through the broadcast band. This is known as continuous permeability tuning; a modern superheterodyne tuning circuit, illustrating this feature, is presented in Fig. 13.

Upon inspection of the circuit diagram in Fig. 13, you will observe that two such coils are used, one for the antenna-detector circuit and one for the oscillator circuit. You will further notice that no main variable tuning condenser gang is employed; however, two small trimmer condensers are connected across each coil to properly align it. Fixed condensers are also shunted across each of these coils to increase the tuning ratio, as already explained relative to iron-core i-f transformers.

Continuous variable tuning of these coils throughout the standard broadcast band is accomplished by moving the iron-core material in or out of the coil forms, as illustrated in Fig. 14, where a bird's-eye-view of the tuning assembly is shown. This procedure alters the inductance values in the circuit and thereby makes tuning possible.

While the particular tuning assembly shown in Fig. 14 features a drum-type dial scale, the assembly could be adapted easily to the popular "slide rule" type dial scale, by merely mounting a pulley on

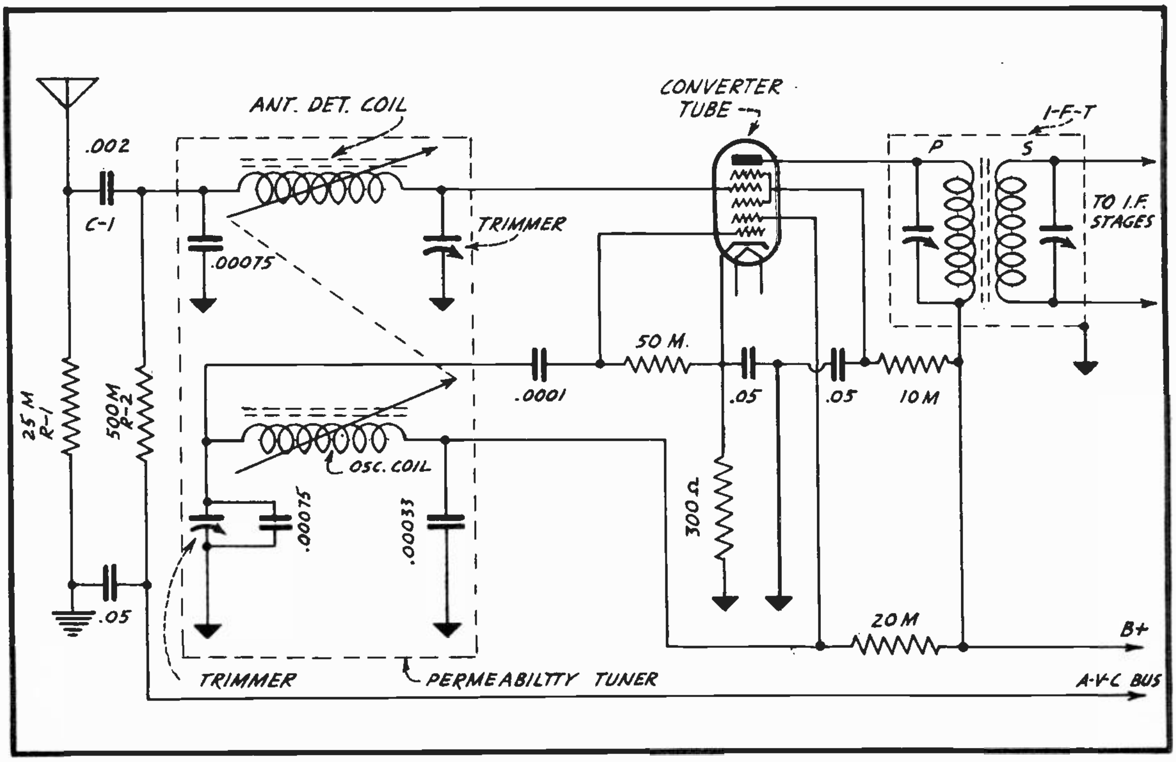

FIG. 13
PERMEABILITY-TUNED SUPERHETERODYNE TUNER CIRCUIT

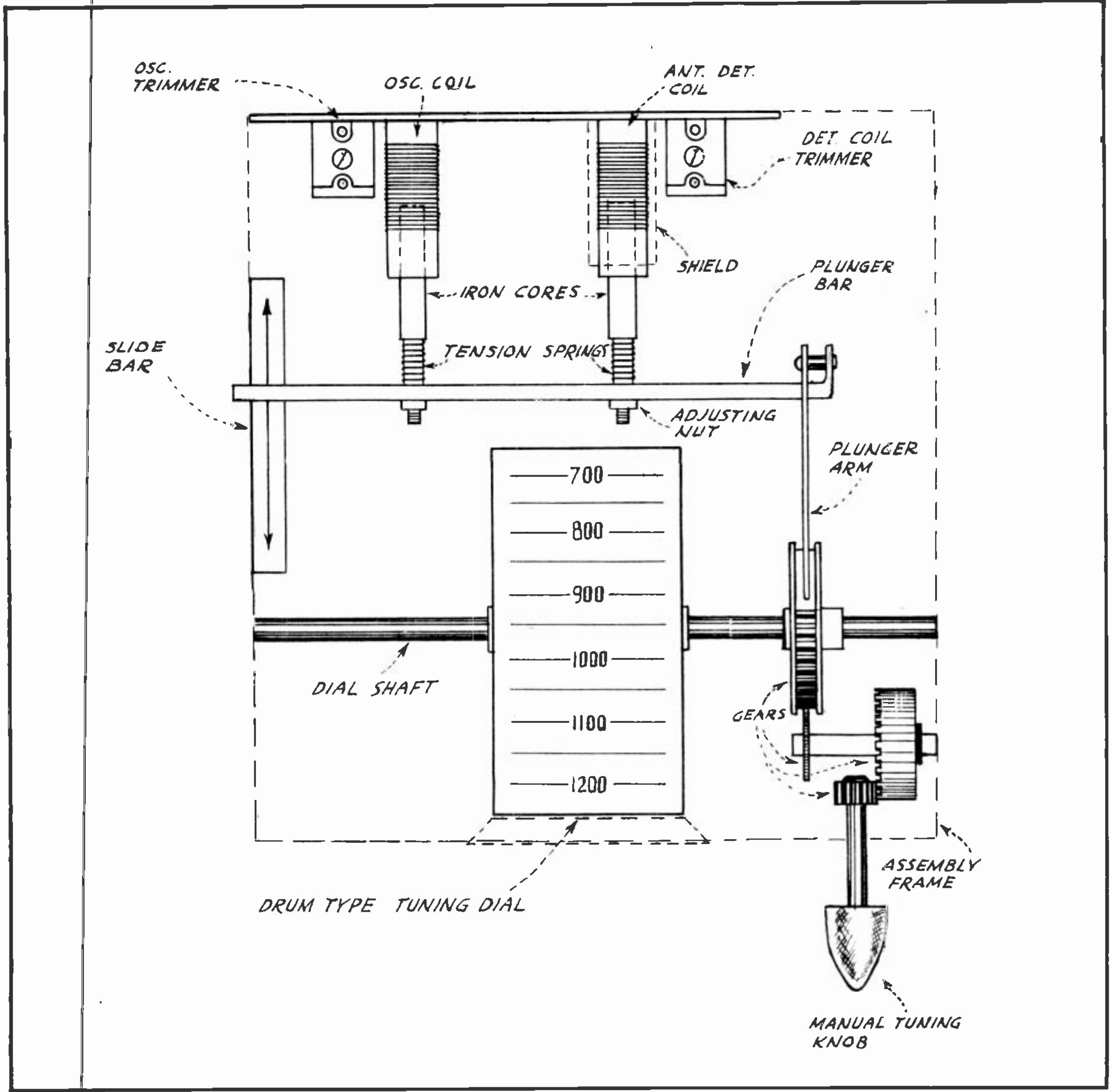

Fig. 14
Permeability Tuning Assembly

the dial shaft. A dial cable may then be used as the drive-coupling to operate a slide-rule pointer across the calibrated scale.

Upon studying Fig. 14 more closely, you will observe that rotating the manual tuning knob causes the train of gears and levers to be operated in such a manner as to move the iron-core material either in or out of the two cylindrical coil forms simultaneously. In other words, the tuning adjustments for these two coils are ganged together the same as are the various sections of a ganged variable tuning condenser. This "ganging" of the tuning controls is indicated by a dotted line in Fig. 13.

OPERATION OF THE CIRCUIT

The electrical principle of the permeability tuner shown in Fig. 13 is basically the same as the mixer circuit shown in Fig. 6 of this lesson, where a conventional type variable tuning condenser is used to tune the detector and oscillator coils.

In the circuit diagrammed in Fig. 13, all signal frequencies are received equally well by the antenna circuit, due to the aperiodic characteristic of the 25,000-ohm resistor, R_1. That is, this resistor, being non-inductive, does not possess any tuning characteristic and will therefore not resonate at any particular frequency. Instead, it will be equally receptive to currents of all frequencies that might be flowing through it.

The voltage drops developed across this resistor by the r-f signal currents flowing through it cause the signals to react through the .002 mfd coupling condenser C_1. The antenna-detector coil, being tuned, is resonated to only one frequency at any one setting and thus serves to some extent in selecting the desired signal from the unwanted ones. The desired signal is then applied to the control grid of the converter tube, at which point the incoming r-f signal will heterodyne with the steady oscillations emanating from the oscillator circuit. The resulting beat frequency will produce in the converter tube's plate circuit r-f current variations, the frequency of which will be equal to the resonant frequency of the i-f transformer. This i-f frequency, which appears in the windings of the i-f transformer, is then transferred through a conventional i-f amplifier, second detector, and audio section.

Also observe in Fig.13 that an iron-core i-f transformer is used in the output of the converter circuit so as to insure the highest possible gain from this transformer. Both the primary and secondary windings of this transformer are tuned by small trimmer condensers, and the entire assembly is housed in a shielded container to assure maximum gain and operating stability.

PADDING THE OSCILLATOR OF PERMEABILITY-TUNED CIRCUITS

From a close inspection of the oscillator circuit, you will observe that no padding condenser is employed. Instead, an ingenious method has been employed to compensate for any discrepancies that naturally arise between these two ganged circuits when varying the inductance values throughout the tuning range of the coils.

Correction for tracking is accomplished by constructing the oscillator coil's core of a slightly different grade and density of magnetic material and also by tapering the movement of the core as it is moved in or out of the coil form. This slight change in the permeability of the iron core, together with the relation of movement between the two cores, allows the oscillator to track perfectly with the detector coil.

Every modern superheterodyne receiver of good quality employs an a-v-c system, and the superheterodyne using the permeability tuner shown in Fig. 13 is no exception. In this circuit, a-v-c voltage furnished by the a-v-c system (not shown in Fig. 13) is applied to the control-grid of the pentagrid converter tube. Resistor R_2 and the antenna-detector coil serve to complete this circuit.

A BATTERY-OPERATED SUPERHETERODYNE RECEIVER

In Fig.7 of this lesson you were shown a complete circuit diagram of a modern nine-tube a-c operated superheterodyne. So that you will become intimately acquainted with battery-operated receivers of this type, we are showing you in Fig. 15 the circuit diagram of a similar receiver designed for the use of 2-volt tubes. While the battery-type receiver to be described employs only seven tubes, its performance is equivalent to the nine-tube a-c receiver referred to, because no rectifier is necessary. Upon comparing these two circuit diagrams closely, you will observe that separate push-pull audio output tubes are employed in the a-c set, while a combination type push-pull tube is used in the battery-operated receiver. This combination tube consists of two triode sections contained within a single envelope. The two grids of the tube connect to the secondary winding of the input push-pull transformer and the two plates connect to the primary winding of the output transformer. Thus this single dual-purpose tube satisfactorily serves two functions that would ordinarily have to be taken care of by two separate tubes. The operation of this dual-purpose tube is the same as if two separate tubes were connected in a push-pull arrangement.

C-BATTERY CIRCUIT DETAILS

You will also observe in Fig. 15 that the battery-type tubes in this circuit are not equipped with cathodes. Therefore, the bias voltages cannot be obtained by including bias resistors in the cathode circuits of the different tubes, as is the case in the a-c receiver.

In the battery circuit appearing in Fig. 15 the grid bias voltage is obtained by applying a negative potential directly to the grid of each tube. This bias voltage is supplied by a 9-volt "C" battery, connected across a voltage divider network consisting of the four resistors, R_1, R_2, R_3, and R_4. The voltage drops, developed across these resistors by the flow of C-battery current through them, furnish the correct bias potential required for the different tubes. An "on-off" switch is included in this C-battery circuit to break the flow of current that otherwise would be continuous whether the receiver was in operation or not. This C-battery switch is ganged with the main "on-off" switch so that these two switches can be operated simultaneously.

Since no diode-type tubes are available in the two-volt tube series, the circuit in Fig. 15 employs a type 30 triode connected as a diode. This is accomplished by connecting together the plate and grid elements of the triode --- the tube's operation is then equivalent to the 6H6 diode type tube employed in Fig. 7.

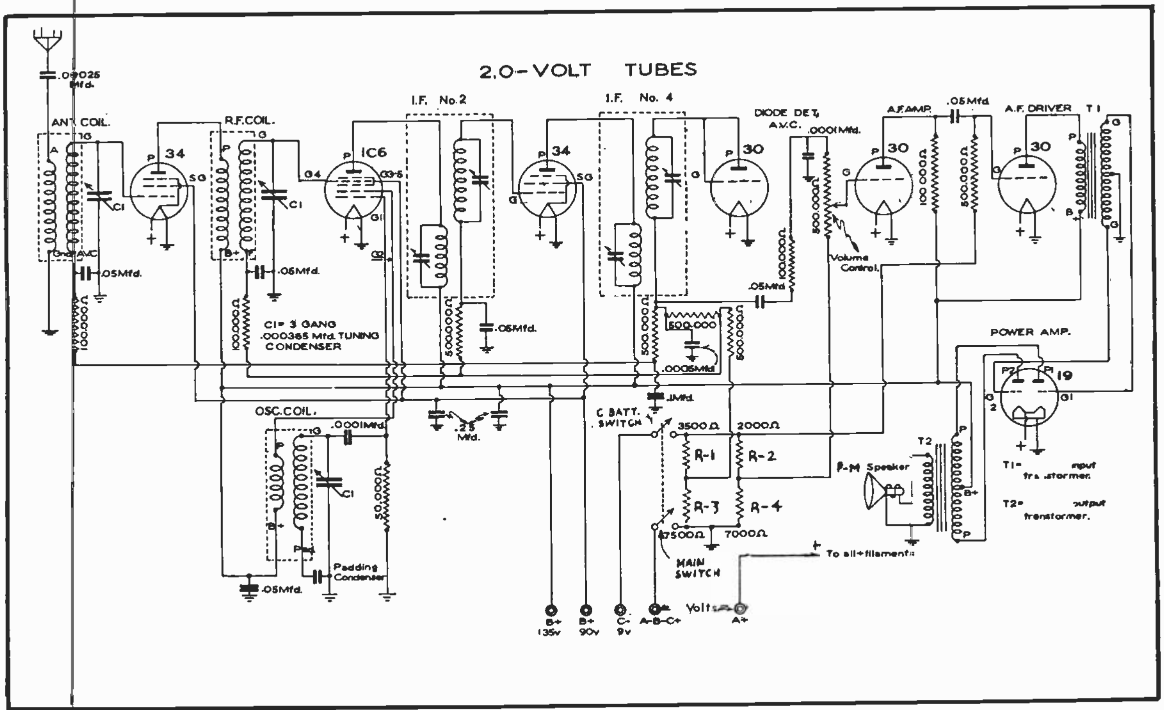

FIG. 15
SEVEN-TUBE BATTERY-OPERATED SUPERHETERODYNE RECEIVER

An electro-dynamic speaker was used in Fig. 7, its field coils serving also as the filter choke. Such a speaker would not be satisfactory in the battery-operated set diagrammed in Fig. 15, as considerable power would be consumed to excite the field. Therefore, a permanent-magnet type dynamic speaker is employed in the battery circuit. The performance of this type of dynamic speaker compares favorably with the field-coil type used in a-c sets, and is widely used in many modern battery-operated receivers.

The operating principle of the a-v-c system employed in this receiver is identical to that used in Fig. 7. Therefore, no further explanation of its circuit action need be given at this time. However, in later lessons you will receive full and complete instruction in all phases of automatic volume control systems.

New radio developments are continually being worked out, and in order for a man to rise to the top of the radio profession, he must at all times be alert and ready to learn about these new features as soon as they make their appearance in the industry.

EXAMINATION QUESTIONS

LESSON NO. 19

1. - What are the chief advantages offered by iron-core i-f transformers as compared to the conventional type air-core i-f transformers?

2. - What is meant by i-f expansion?

3. - What are the chief advantages obtained through the use of an electron-coupled oscillator as explained in this lesson regarding the application of pentagrid converter tubes to superheterodyne receivers?

4. - Why is "a-v-c" used in modern superheterodyne receivers?

5. - Describe briefly the basic principle of the autodyne system as employed in some superheterodyne receivers.

6. - Explain briefly the operating principle of the continuous permeability-tuning system.

7. - Draw a circuit diagram of only that section of a superheterodyne receiver wherein a pentagrid converter tube is used.

8. - Explain briefly how the pentagrid converter tube operates in the circuit which you have drawn in answer to Question #7.

9. - What is the basic principle whereby a-v-c action is obtained in a receiver?

10. - Describe briefly the important constructional details of a permeability-tuned i-f transformer.

RADIO - TELEVISION

Practical • J. A. ROSENKRANZ, Pres. • Training

NATIONAL SCHOOLS

Established 1905

Los Angeles, California

LESSON NO. 20

• RADIO SERVICE EQUIPMENT •

Now let us center our attention upon the SERVICE EQUIPMENT, which is required by the successful Radio Specialist. There is, of course no need of reminding you of the fact that even though a man may have a thorough knowledge of radio, yet he cannot apply this knowledge to the best advantage unless he is provided with the proper tools and testing equipment.

Probably this statement sounds somewhat harsh to you, in that it leads you into the belief that the man who is just starting out in the radio business must go to considerable expense in order to equip himself with these necessities. This, however, is far from true because you will find yourself to be able to get along splendidly with a comparatively small amount of equipment, which is surprisingly inexpensive. Then as you earn some money from your first jobs and gradually build up a profitable business, you can increase your testing equipment piece by piece as you see fit and in this way, enable these articles to pay for themselves.

FIG. 1
Checking a Receiver With an Analyzer.

As you have seen in your radio studies, remarkable progress has been made in radio construction and even though the first receivers were crude and simple looking, yet today, receivers are built with remarkable accuracy so as to enable them to offer marvelous performance.

Not only has radio itself made such tremendous progress but the radio service man and the equipment he uses, have also passed through this same stage of development. The MODERN radio service man is no longer an ordinary electrician using crude tools, guessing at troubles and working blindly in an attempt to make the necessary repairs. Conditions have changed a great

DEAL AND THE REAL RADIO MAN OF TODAY IS A PROFESSIONAL MAN, THOROUGHLY TRAINED BOTH IN MIND AND HANDS. HE NOT ONLY USES MODERN TOOLS BUT HE ALSO TRACES HIS TROUBLES WITH THE AID OF PRECISION TYPE TESTING INSTRUMENTS AS FORMERLY WERE ONLY USED BY ENGINEERS WITHIN THE ELECTRICAL LABORATORY.

BEFORE SPENDING ANY TIME WITH A DESCRIPTION OF THE MORE EXPENSIVE TESTING INSTRUMENTS, LET US FIRST CONSIDER THE ESSENTIAL EQUIPMENT WHICH YOU WILL NEED, IN ORDER TO MAKE AN ECONOMICAL START AND ESTABLISH YOURSELF IN THIS RAPIDLY PROGRESSING INDUSTRY.

RADIO SERVICE TOOLS

AT THIS TIME, WE ARE CHIEFLY INTERESTED IN THE TOOLS WHICH YOU SHOULD HAVE IN YOUR KIT, WHILE MAKING SERVICE CALLS AT THE HOMES WITHIN YOUR COMMUNITY BUT YOU WILL FIND THAT QUITE A NUMBER OF THESE TOOLS WILL "FIT IN" WITH YOUR SHOP TOOLS, AS WELL AS IN YOUR SERVICE KIT AND IN THIS WAY, THEY CAN BE MADE TO SERVE A DOUBLE PURPOSE.

THE MOST ESSENTIAL EQUIPMENT WHICH YOU SHOULD PLAN ON CARRYING WITH YOU ARE ALL INCLUDED IN THE FOLLOWING LIST:

SET OF RADIO SOCKET WRENCHES WITH A SCREW DRIVER HANDLE.
BAKELITE SCREW DRIVER OR COMBINATION NEUTRALIZER-COMPENSATOR TOOL SET.
ONE 6" DIAGONAL CUTTING PLIERS.
ONE 6" LONG NOSE PLIERS.
ONE 6" COMBINATION (SLIP JOINT) PLIERS.
ONE 6" SCREW DRIVER.
ONE MIDGET SCREW DRIVER.
SMALL FLAT FILE.
SMALL SOLDERING IRON (ELECTRIC PREFERABLE, IF USEABLE)
ROSIN-CORE SOLDER.
A FEW FEET OF #14, #16, AND #18 B&S RUBBER COVERED WIRE.
ROLL OF RADIO HOOK-UP WIRE.
1 ROLL FRICTION TAPE.
ASSORTMENT OF MACHINE SCREWS AND NUTS.
JACK KNIFE.
SOME FINE SAND PAPER.
A DENTIST'S MIRROR.
FLASHLIGHT.
SOME PIPE CLEANERS.
A SMALL CAMEL'S HAIR BRUSH (ABOUT A ½" SIZE.)
A LARGE PROTECTING CLOTH.

YOU MIGHT FIND CERTAIN CHANGES OR ADDITIONS TO MAKE TO THIS LIST BUT IT AT LEAST GIVES YOU AN IDEA UPON WHICH TO BASE YOUR EQUIPMENT. THE USES OF MOST OF THE ARTICLES IN THE ABOVE LIST ARE SELF EXPLANATORY BUT IT MIGHT BE WELL TO OFFER SOME SUGGESTIONS REGARDING SOME OF THE TOOLS WITH WHICH YOU MAY AS YET NOT BE FAMILIAR.

MOST OF THE EQUIPMENT TO BE INCLUDED IN YOUR SERVICE KIT IS ILLUSTRATED FOR YOU IN FIG. 2, SO THAT YOU MAY BE CERTAIN OF THEIR APPEARANCE IN CASE THAT YOU HAVE NEVER BEFORE HAD THE OPPORTUNITY OF WORKING WITH SOME OF THESE ITEMS.

THE SPECIAL SOCKET WRENCH SET WHICH IS ILLUSTRATED HERE HAS A SCREW driver type handle and a sturdy steel shaft to which steel sockets can be applied. The sockets illustrated with the particular set in Fig. 2 will handle hexagonal nuts of the following sizes: ¼", 5/16", 3/8" and 7/16". This handy tool permits the serviceman to remove and mount parts rapidly and with the least possible effort.

The neutralizer--compensator set, which is shown in Fig. 2, is of a fountain pen size with attached clip so that it can be carried about in the vest pocket. It is a combination multi-blade screw driver and socket wrench set made of special fibrous material offering desirable di electric properties. This tool is designed especially for adjusting the most popular types of compensator and neutralizing condensers.

The diagonal cutting pliers are exceptionally handy for cutting wire in cramped quarters around the receiver chassis in that their con-

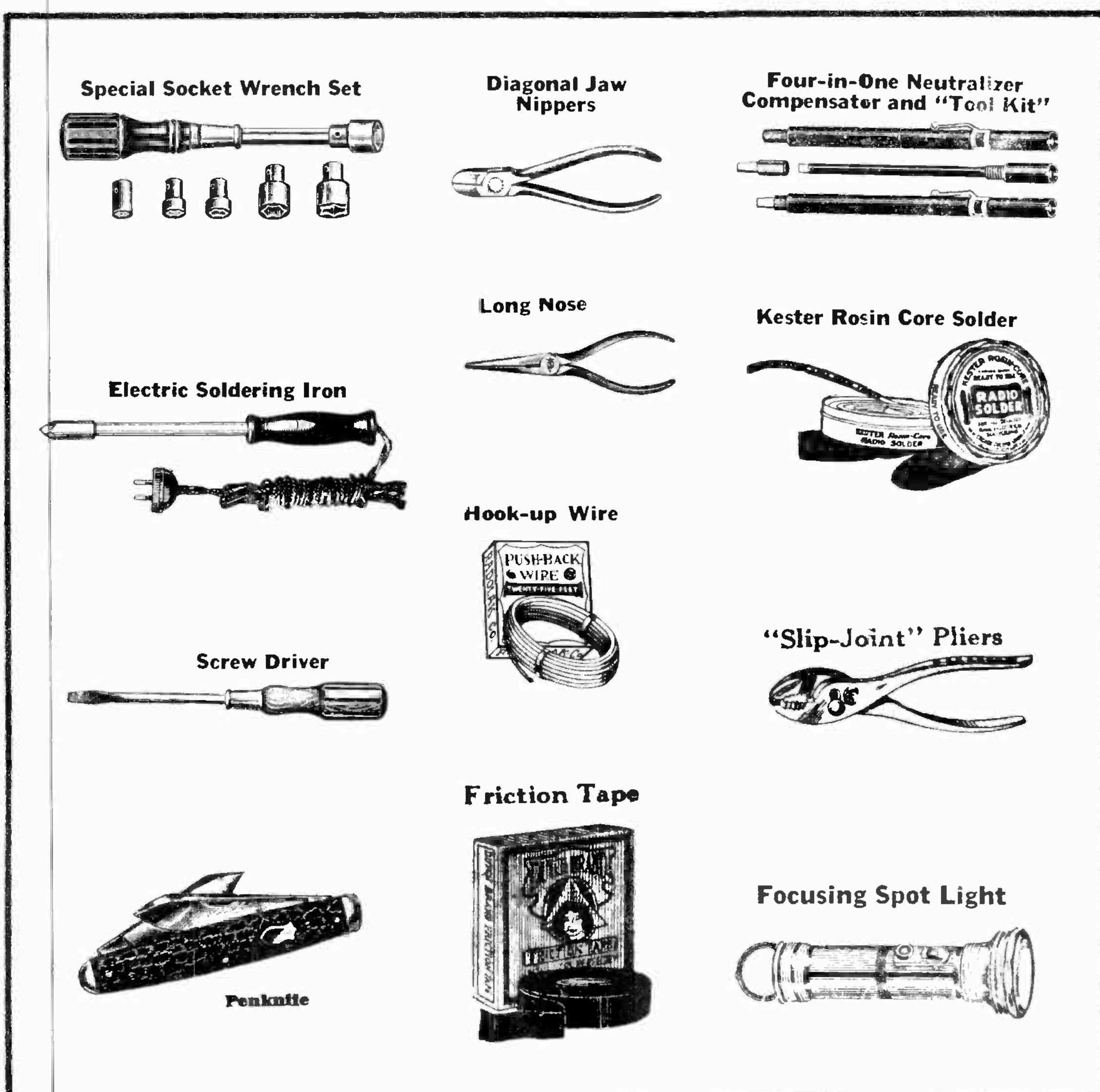

FIG. 2
Some of the Equipment You Will Use on the Service Call.

STRUCTION IS SUCH THAT YOU CAN CUT CLOSE TO ANY SOLID BODY OR OTHER WIRING.

THE LONG NOSED PLIERS ARE USEFUL FOR REACHING INTO REMOTE QUARTERS OF THE RECEIVER TO HOLD NUTS, WIRES, ETC. IN PLACE AS THEY ARE BEING FASTENED INTO POSITION OR TO REMOVE SMALL PARTS THROUGH SMALL SPACES.

THE SOLDERING IRON, OF COURSE, IS NEEDED TO SOLDER CIRCUIT CONNECTIONS ETC. AND WHEN USED IN CONJUNCTION WITH ROSIN-CORE SOLDER, IN WHICH THE FLUX OR PASTE IS ALREADY CONTAINED WITHIN THE SOLDER ITSELF, A GOOD JOB OF SOLDERING CAN BE DONE WITHOUT THE NEED OF ADDITIONAL PASTE. THIS SIMPLIFIES THE JOB OF SOLDERING CONSIDERABLY.

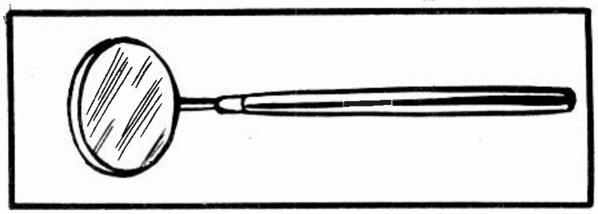

FIG. 3
Dentist Mirror.

THE SUPPLY OF WIRE WHICH IS INCLUDED IN THE LIST IS INTENDED FOR USE IN REPLACING DEFECTIVE SECTIONS OF WIRE WHEN NECESSARY ETC., WHILE THE FRICTION TAPE OFFERS A MEANS FOR INSULATING NEWLY SPLICED CONNECTIONS. THE JACK KNIFE IS ALWAYS HANDY IN STRIPPING INSULATION FROM WIRES AND OTHER MISCELLANEOUS JOBS OF THIS NATURE.

THE FILE AND SANDPAPER CAN BE USED FOR REMOVING CORROSION ETC. SO AS TO FURNISH A BRIGHT SOLDERING SURFACE.

A DENTIST'S MIRROR IS SHOWN IN FIG. 3 AND IT IS INDEED A HANDY TOOL TO HAVE WHEN IT BECOMES NECESSARY TO LOOK AROUND TIGHT CORNERS OF A RECEIVER CHASSIS, WHICH IS STILL INSTALLED WITHIN THE CABINET. VERY OFTEN, YOU WILL FIND YOURSELF IN THIS POSITION, TRYING TO LOCATE A POORLY SOLDERED JOINT IN ONE OF THESE OUT-OF THE WAY PLACES AND THE MIRROR WILL BE A GREAT AID TO YOU.

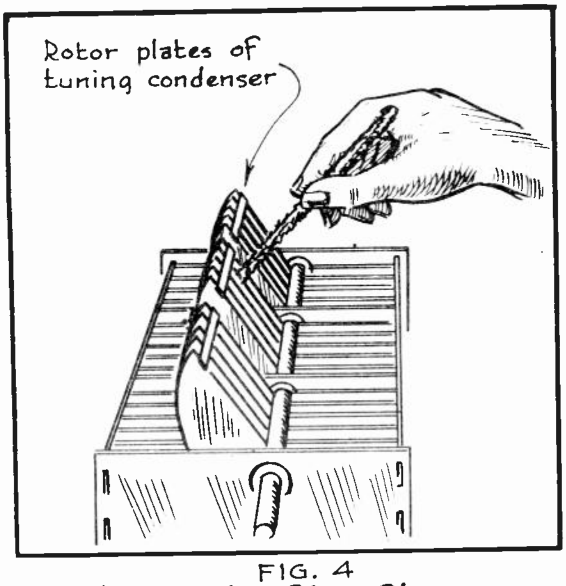

FIG. 4
Using the Pipe Cleaner.

NOT ONLY WILL THE FLASHLIGHT HELP YOU TO READ HOUSE NUMBERS WHEN LOOKING FOR THE HOME OF SOME TROUBLED RADIO OWNER, WHO HAS ASKED YOU TO MAKE A "NIGHT-CALL", IN ORDER TO REPAIR HIS RECEIVER, BUT THIS FLASHLIGHT IS ALSO GOING TO BE HELPFUL TO YOU IN LIGHTING UP THE INSIDE OF THE RECEIVER CABINET. EVEN WHEN SERVICING A RECEIVER IN A HOME IN BROAD DAYLIGHT, YOU WILL FIND THE INSIDE OF MOST RECEIVER CABINETS QUITE DARK SO THAT IT IS RATHER DIFFICULT TO LOCATE THE THINGS WHICH YOU ARE LOOKING FOR.

FIG. 4 SHOWS YOU ONE OF THE HANDY USES FOR A PIPE CLEANER AROUND RADIO EQUIPMENT, AND HERE YOU WILL SEE HOW IT CAN BE USED TO REMOVE DUST PARTICLES FROM BETWEEN TUNING CONDENSER PLATES. THE CAMEL'S HAIR BRUSH WILL BE USEFUL IN A SIMILAR WAY BECAUSE THERE IS NO DANGER IN INJURING ANY OF THE DELICATE APPARATUS WITH THEM, AS MIGHT BE EASILY DONE, WERE A

WIPING CLOTH USED FOR THIS PURPOSE.

THE PROTECTING CLOTH, WHICH WE REFER TO IN OUR LIST, SHOULD BE USED TO SPREAD OUT OVER THE CARPET OF THE HOME, DIRECTLY UNDER THE RECEIVER, SO AS TO PREVENT WIRE CLIPPING'S ETC. FROM BECOMING IMBEDDED IN THE CARPET.

PROBABLY THIS LIST OF EQUIPMENT SEEMS RATHER SMALL TO YOU BUT THEN YOU MUST REMEMBER THAT WHEN MAKING SERVICE CALLS, YOU ARE NOT EXPECTED TO CARRY OUT A COMPLETE RECONSTRUCTION JOB IN THE OWNER'S HOME. THE WORK, WHICH YOU DO THERE, CONSISTS MAINLY OF REPLACING OLD OR DEFECTIVE TUBES, SPLICING WIRES, RENEWING A CONNECTION HERE OR THERE, INSTALLING A SET OF BATTERIES, TESTING AND OTHER SUCH MINOR JOBS.

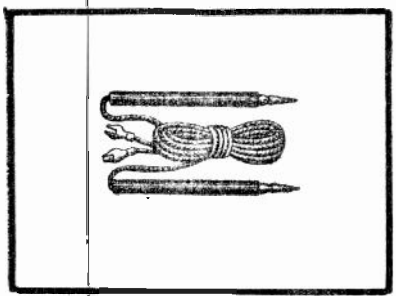

FIG. 5
A Pair of Test Leads

SHOULD THE RECEIVER REQUIRE CONSTRUCTIVE WORK WHICH MAKES IT NECESSARY TO USE ADDITIONAL TOOLS AND TO SPEND CONSIDERABLE TIME UPON THE JOB, THEN THE SENSIBLE THING TO DO IS TO REMOVE THE CHASSIS FROM THE CABINET AND TAKE IT TO YOUR SHOP WHERE YOU HAVE EVERYTHING AT HAND, SO AS TO ENABLE YOU TO DO THE WORK EFFICIENTLY. ALSO BEAR IN MIND THAT NO SET OWNER WANTS TO SEE THE VARIOUS PARTS OF HIS RECEIVER SCATTERED ALL OVER THE ROOM--THIS IS ALRIGHT IN THE SHOP BUT NOT IN THE HOME. THIS NOW, EXPLAINS THE REASON WHY IT IS NOT NECESSARY TO CARRY A WHOLE TRUNK FULL OF TOOLS WITH YOU WHEN MAKING SERVICE CALLS.

SERVICE TESTING EQUIPMENT

SO FAR, WE HAVE ONLY CONSIDERED THE TOOLS, WHICH YOU ARE LIKELY TO NEED OUT ON A SERVICE CALL BUT NOW LET US LOOK OVER THE MOST ESSENTIAL TEST EQUIPMENT, WHICH YOU SHOULD ALSO INCLUDE IN YOUR SERVICE KIT.

THE FOLLOWING LIST GIVES YOU AN OUTLINE OF THE TESTING EQUIPMENT, WHICH YOU WILL FIND MOST NECESSARY IN ORDER TO DO GOOD SERVICE WORK:

FIG. 6
Double-Range Voltmeter.

- A PAIR OF HEADPHONES.
- HYDROMETER.
- A DOUBLE OR TRIPLE-RANGE HIGH RESISTANCE D.C. VOLTMETER WITH SCALE READINGS FROM 0 TO 250 OR 750 VOLTS.
- AN A.C. TRIPLE-RANGE VOLTMETER, WITH A SCALE READING OF 0 TO 500 VOLTS.
- A MILLIAMMETER, SCALED TO READ FROM 0 TO 100 MILLIAMPERES.
- PAIR OF TEST LEADS.
- 4½ VOLT "C" BATTERY.

NOTE: IF A SET ANALYZER IS USED, THEN THE INDIVIDUAL METERS, WHICH ARE LISTED ABOVE, WILL NOT BE NECESSARY.

THE HEADPHONES WILL NOT ONLY BE HELPFUL IN ORDER TO SUBSTITUTE THEM FOR THE LOUDSPEAKER, WHEN LOOKING FOR TROUBLES IN THE RECEIVER, BUT WHEN USED IN CONJUNCTION WITH THE 4½ VOLT "C" BATTERY, THEY WILL SERVE AS AN EFFECTIVE CONTINUITY TESTER FOR TESTING TRANSFORMER WINDINGS, CONDENSERS,

CIRCUIT WIRES ETC. THE HYDROMETER WILL SERVE ITS PURPOSE IN THOSE DISTRICTS WHERE BATTERY TYPE RECEIVERS ARE STILL USED, IN THAT IT WILL ENABLE YOU TO CHECK THE SPECIFIC GRAVITY OF THE ELECTROLYTE IN THE STORAGE BATTERIES.

A TYPICAL SET OF TEST LEADS IS SHOWN YOU IN FIG. 5. AS YOU WILL OBSERVE, THEY CONSIST OF TWO SHARP POINTED PRODS PROJECTING FROM FIBER HANDLES. EACH OF THESE PRODS HAS A FLEXIBLE INSULATED WIRE ATTACHED TO IT, WITH A TERMINAL CONNECTION AT THE OTHER END.

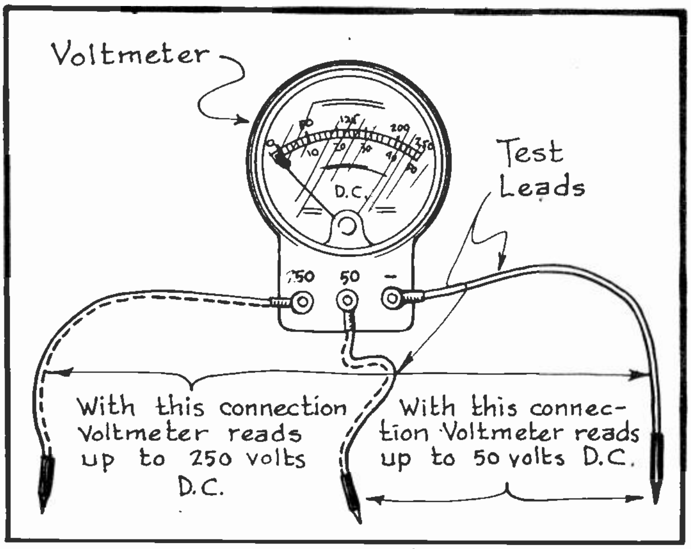

FIG. 7
Voltmeter Connections.

BY CONNECTING THESE TEST LEADS TO A SUITABLE METER, ALL FORMS OF ELECTRICAL TESTS CAN BE CARRIED OUT CONVENIENTLY. THE SHARP POINTS ON THESE LEADS, WILL PENETRATE RUST OR INSULATION, SO THAT A GOOD ELECTRICAL CONTACT CAN BE ESTABLISHED.

D.C. VOLTMETERS

IN FIG. 6, YOU WILL SEE A PORTABLE DOUBLE RANGE HIGH RESISTANCE, D.C. VOLTMETER. ONE OF ITS SCALES WILL READ VOLTAGES FROM 0 UP TO 50 VOLTS AND THE OTHER SCALE WILL TAKE CARE OF THOSE VOLTAGES BETWEEN 0 AND 250 VOLTS. REGARDLESS OF WHICH SCALE IS BEING USED, THE TEST LEAD, WHICH IS GOING TO BE CONNECTED TO THE NEGATIVE SIDE OF THE D.C. LINE, MUST BE FASTENED TO THE VOLTMETER TERMINAL WHICH IS LABELED WITH THE (-) SIGN.

IF YOU ARE GOING TO CHECK A CIRCUIT, WHOSE VOLTAGE YOU KNOW IS GOING TO BE LESS THAN 50 VOLTS, THEN CONNECT YOUR POSITIVE TEST LEAD TO THE VOLTMETER TERMINAL MARKED "50". TO READ VOLTAGES HIGHER THAN 50 BUT LESS THAN 250 VOLTS, CONNECT YOUR POSITIVE TEST LEAD TO THE "250" TERMINAL. THESE CONNECTIONS ARE SHOWN CLEARLY IN FIG. 7.

A TRIPLE-RANGE D.C. VOLTMETER IS SHOWN IN FIG. 8 AND THIS PARTICULAR VOLTMETER WILL READ D.C. VOLTAGES FROM 0 UP TO 750 VOLTS. ONE OF ITS SCALES INCLUDES READINGS BETWEEN 0 AND 10 VOLTS, ANOTHER INCLUDES 0 TO 250 VOLTS AND THE THIRD SCALE TAKES CARE OF THE VOLTAGES BETWEEN 0 AND 750 VOLTS.

FIG. 8
Triple-Range D.C. Voltmeter.

THE (-) TERMINAL OF THIS METER IS ALWAYS CONNECTED TO THE NEGATIVE SIDE OF THE D.C. LINE, REGARDLESS OF WHICH SCALE IS BEING USED. THEN TO USE THE LOW OR 10 VOLT SCALE, THE POSITIVE TEST LEAD MUST BE CONNECTED TO THE TERMINAL MARKED "LOW". SHOULD THE 250 VOLT SCALE BE REQUIRED, THEN CONNECT THE POSITIVE TEST LEAD TO THE "MEDIUM" TERMINAL AND USE THE "HIGH" TERMINAL OF THE METER FOR YOUR POSITIVE

CONNECTION WHEN TAKING READINGS BETWEEN 250 AND 750 VOLTS.

THESE D.C. METERS ALL HAVE A HIGH INTERNAL RESISTANCE AND GENERALLY, AS IN THE EXAMPLES SHOWN, THE RESISTANCE OF THESE METER WINDINGS WILL BE ABOUT 1000 OHMS PER VOLT. THEREFORE, TO USE SUCH A METER, IN ORDER TO TAKE READINGS HIGHER THAN THAT FOR WHICH THE INSTRUMENT HAPPENS TO BE CALIBRATED, YOU CAN DO THIS QUITE EASILY BY SIMPLY CONNECTING AN EXTRA RESISTANCE UNIT IN SERIES WITH THE METER. WE CALL THIS ADDITIONAL RESISTANCE A MULTIPLIER.

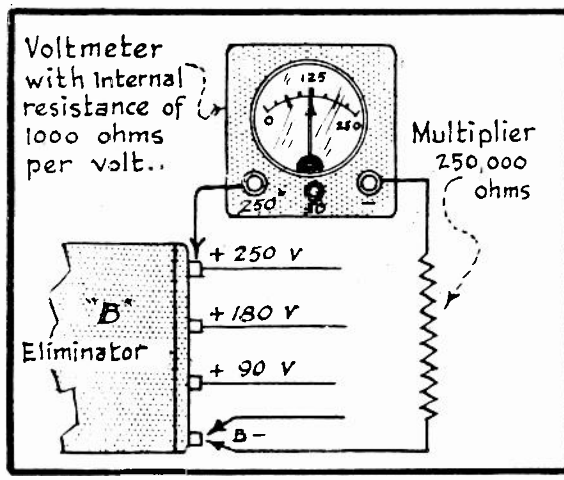

FIG. 9
Using the Multiplier to Double Voltmeter Range

USE OF THE MULTIPLIER

FIG. 9 SHOWS YOU HOW TO USE SUCH A MULTIPLIER AND IN CASE YOU SHOULD DESIRE TO DOUBLE THE RANGE OF THE METER, YOU WOULD DO IT IN THE FOLLOWING WAY: LET US SAY, FOR EXAMPLE, THAT THE METER HAS A MAXIMUM SCALE READING OF 250 VOLTS AND THE PRINTED MATTER ON THE METER DIAL STATES THAT THIS PARTICULAR METER HAS AN INTERNAL RESISTANCE OF 1000 OHMS PER VOLT. THIS WOULD MEAN THAT THE INTERNAL RESISTANCE OF THIS METER, WHEN READING A VOLTAGE OF 250 VOLTS, WILL BE 250 TIMES 1000 OHMS OR 250,000 OHMS. THEREFORE, TO DOUBLE THE POSSIBLE SCALE READING OF THIS METER, WE INSERT A MULTIPLIER OF THIS SAME INTERNAL RESISTANCE OR 250,000 OHMS IN SERIES WITH THE METER, AS SHOWN IN FIG. 9.

NOW THE METER WILL READ JUST $\frac{1}{2}$ THE ACTUAL VOLTAGE. THAT IS, WITH THE CONNECTIONS AS MADE IN FIG. 9, THE METER WILL READ 125 VOLTS WHEN THE ACTUAL VOLTAGE IS TWICE THIS AMOUNT OR 250 VOLTS, SO ONE MUST KEEP THIS IN MIND WHEN USING THE METER IN THIS WAY. WHEN THE METER READS 250 VOLTS, THE TRUE VOLTAGE WILL BE 500 VOLTS.

IF YOU WISH, YOU CAN USE A HIGH RESISTANCE RHEOSTAT AS A MULTIPLIER AND A SIMPLE METHOD OF SETTING THE RHEOSTAT ARM TO THE PROPER POSITION FOR A 50 VOLT-METER IS SHOWN IN FIG. 10. TO DO THIS, WE FIRST CONNECT THE VOLTMETER ACROSS A 45 VOLT "B" BATTERY WITHOUT USING THE RHEOSTAT AND THIS WILL GIVE US THE TRUE VOLTAGE READING OF THE BATTERY. NOW WE CONNECT THE RHEOSTAT IN SERIES AS SHOWN, AND ADJUST ITS ARM UNTIL THE VOLTMETER READS JUST ONE-HALF THE BATTERY VOLTAGE. WITH THIS METER SETTING, OUR RANGE IS DOUBLED AND THE READINGS MUST ALL BE MULTIPLIED BY 2 IN ORDER TO GIVE US THE ACTUAL VOLTAGE. REMEMBER THIS USE OF THE MULTIPLIER BECAUSE YOU WILL FIND MANY CASES WHERE IT WILL BE OF A GREAT HELP TO YOU.

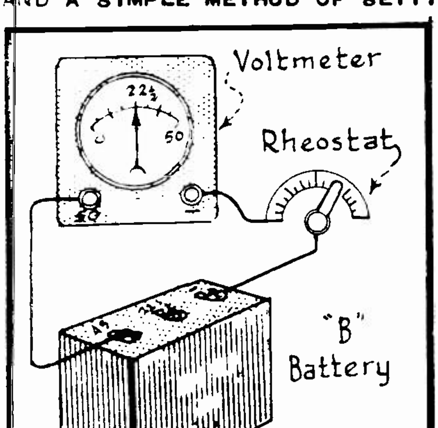

FIG. 10
Using a Rheostat for a Multiplier.

A.C. VOLTMETERS

A TRIPLE-RANGE, PORTABLE A.C. VOLTMETER

IS SHOWN IN FIG. 11. IN GENERAL APPEARANCE, IT IS QUITE SIMILAR TO THE D.C. TYPE VOLTMETER BUT THE COMMON TERMINAL ON THE A.C. METER IS LABELLED BOTH POSITIVE AND NEGATIVE, SO THAT IT MAKES NO DIFFERENCE WHETHER THIS TERMINAL IS CONNECTED TO ONE SIDE OR THE OTHER OF THE A.C. CIRCUIT. THE REMAINING TERMINALS ARE MADE USE OF IN THE SAME MANNER AS EXPLAINED RELATIVE TO THE D.C. INSTRUMENTS.

THE MILLIAMMETER

FIG. 11
Triple-Range A.C. Voltmeter.

IN FIG. 12, A MILLIAMMETER WITH A SCALE READING OF ZERO UP TO 100 MILLIAMPERES IS SHOWN. THIS INSTRUMENT IS ALSO CONTAINED WITHIN A CASE, WHICH MAKES IT ESPECIALLY SUITABLE FOR PORTABLE USE. IN FACT, ALL OF THE METERS SHOWN YOU SO FAR ARE HOUSED IN AN INDIVIDUAL CASE, WITH THE INTENTION OF KEEPING THEM PROTECTED AGAINST INJURIES, WHICH ARE LIKELY TO OCCUR WHEN CARRYING THEM IN A SERVICE KIT.

EVEN THOUGH A METER BE WELL PROTECTED IN THIS WAY, BEAR IN MIND THAT THESE DELICATELY POISED INSTRUMENTS ARE QUITE FRAGILE AND MUST THEREFORE ALWAYS BE HANDLED WITH DUE CONSIDERATION.

MISCELLANEOUS EQUIPMENT

NOW BESIDES THIS ESSENTIAL TESTING EQUIPMENT, IT IS ALSO ADVISABLE TO CARRY ONE GOOD TUBE OF EACH POPULAR TYPE WITH YOU. THIS WILL ENABLE YOU TO REPLACE SOME TUBE IN THE RECEIVER OF WHOSE OPERATION YOU ARE SUSPICIOUS, THEREBY PERMITTING THIS TUBE TO SERVE THE PURPOSE AS AN EFFECTIVE TESTING UNIT.

SOME SERVICE MEN EVEN GO SO FAR AS TO CARRY SUCH MISCELLANEOUS REPLACEMENT PARTS WITH THEM, AS ASSORTED BY-PASS CONDENSERS, RESISTORS, TUBE SOCKETS, A REPLACEMENT A.F. TRANSFORMER ETC. THIS, HOWEVER IS NOT ABSOLUTELY NECESSARY BECAUSE IT MEANS THE ADDITION OF A LOT OF EXTRA EQUIPMENT TO YOUR KIT, WHICH YOU MIGHT BE COMPELLED TO CARRY WITH YOU OVER LONG PERIODS OF TIME WITHOUT HAVING ANY USE FOR THEM. FURTHERMORE, THE WORK OF MAKING REPLACEMENTS OF MOST PARTS IS GENERALLY MADE MOST CONVENIENTLY AT THE SHOP.

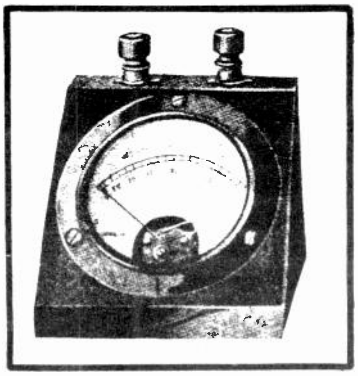

FIG. 12
Portable Milliammeter with 0-100 M.A. Scale.

IF YOUR VOLUME OF WORK MERITS A STOCKING UP OF REPLACEMENT PARTS, THIS IS O.K. BUT TO START WITH, YOU CAN ALWAYS PURCHASE THESE PARTS AS YOU SEE A NEED FOR THEM. IN OTHER WORDS, IT IS WISER NOT TO INVEST MORE MONEY AT FIRST THAN YOU ABSOLUTELY HAVE TO AND THEN AS YOUR BUSINESS INCREASES, YOU CAN INCREASE YOUR BUYING POWER ACCORDINGLY AND BY DOING SO, YOUR WHOLESALE DEALER WILL GENERALLY GIVE YOU A CONSIDERABLY GREATER DISCOUNT RATE.

THE SERVICE KIT

HAVING OUR SERVICE EQUIPMENT OUTLINED, OUR NEXT CONSIDERATION, OF COURSE, IS THE MATTER OF ARRANGING THIS EQUIPMENT IN COMPACT FORM, SO THAT

IT CAN BE CARRIED FROM PLACE TO PLACE CONVENIENTLY. ALTHOUGH AN ORDINARY GRIP OR SACK WILL SERVE AS A RECEPTACLE FOR THIS EQUIPMENT, YET SUCH A CONTAINER IS NOT ADVISABLE. IN THE FIRST PLACE, THIS METHOD WOULD NECESSITATE THE TOOLS AND TESTING EQUIPMENT ALL BEING HOUSED IN ONE COMPARTMENT AND BEFORE YOU KNOW IT, A WRENCH OR SOME OTHER TOOL IS GOING TO CRACK THE GLASS CRYSTAL ON ONE OF YOUR METERS. FURTHERMORE, IF ALL THE EQUIPMENT IS MIXED UP LIKE THIS, YOU ARE GOING TO HAVE QUITE A JOB ON YOUR HANDS IN TRYING TO LOCATE THE TOOL YOU NEED WHILE OUT ON A SERVICE CALL AND NINE TIMES OUT OF TEN, JUST THE TOOL YOU WANT IS GOING TO BE AT THE VERY BOTTOM OF THE PILE. A SCENE AS THIS IS NOT PLEASING TO YOUR CUSTOMER BECAUSE HE ISN'T PAYING YOU TO LOOK FOR TOOLS--HE'S PAYING YOU TO REPAIR HIS RECEIVER IN AS SHORT A TIME AS POSSIBLE.

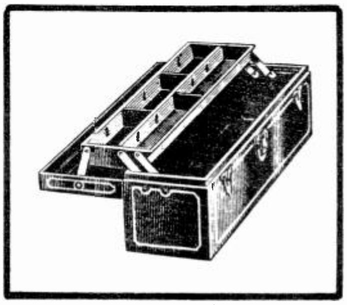

FIG. 13
A Typical Service Kit.

VARIOUS NEAT AND COMPACT TOOL BOXES ARE AVAILABLE ON THE MARKET AND ONE SUCH TYPICAL CONTAINER IS SHOWN IN FIG. 13. GENERALLY, THESE ARE MADE OF METAL, SO AS TO AFFORD A SUBSTANTIAL AND SERVICEABLE EQUIPMENT CARRIER. THE CASE IS MADE UP OF SEPARATE COMPARTMENTS, SEVERAL OF WHICH ARE REMOVABLE AND IN THIS WAY, IT IS A SIMPLE MATTER TO KEEP ALL OF THE SERVICE EQUIPMENT NEATLY ASSORTED.

THERE WILL BE LITTLE POSSIBILITY OF INJURING A METER AND ANY DESIRED TOOL CAN BE LOCATED AT ONCE, WHEN YOU HAVE YOUR EQUIPMENT ARRANGED IN THIS MANNER. OF COURSE, ANY HANDY FELLOW CAN MAKE HIS OWN CARRYING KIT, SO THAT IT WILL BE JUST AS WELL ARRANGED AND NEAT APPEARING AS ONE HE MAY BUY AND IT NEED NOT NECESSARILY BE MADE OF METAL.

NOT ONLY IS A NEAT SERVICE KIT A DECIDED ADVANTAGE TO THE RADIO SERVICE MAN HIMSELF BUT IT ALSO SERVES ITS PART UPON MAKING A GOOD IMPRESSION UPON THE CUSTOMER. IN OTHER WORDS, IT MAKES THE SERVICE MAN LOOK MORE BUSINESS LIKE AND EFFICIENT--SUCH IMPRESSIONS COUNT.

SET ANALYZERS

IN ORDER TO DISPENCE WITH THE NEED FOR CARRYING SEVERAL INDEPENDENT METERS TO THE JOB, A NUMBER OF PROGRESSIVE METER MANUFACTURERS CONCEIVED THE IDEA OF INCORPORATING ALL OF THE NECESSARY METERS INTO A HANDY COMPACT TESTING UNIT. THESE TESTING UNITS ARE GENERALLY KNOWN AS SET ANALYZERS AND ARE DESIGNED TO BE CARRIED ABOUT IN ATTRACTIVE CASES. ADDITIONAL FEATURES ARE INCORPORATED INTO THESE ANALYZERS, SO THAT ALL NECESSARY RECEIVER TESTS CAN BE ACCOMPLISHED WITH THE MAXIMUM AMOUNT OF CONVENIENCE, SPEED AND ACCURACY.

SEVERAL YEARS AGO, SUCH SET ANALYZERS WERE EXCEPTIONALLY EXPENSIVE, SO THAT MOST OF THE "BEGINNER" SERVICEMEN DID NOT FEEL THAT THEY COULD AFFORD SUCH A DESIRABLE PIECE OF EQUIPMENT. FORTUNATELY, A GREAT CHANGE HAS TAKEN PLACE, SO THAT THE PRICE OF THESE UNITS HAS BEEN REDUCED MATERIALLY AND MANY DIFFERENT "MAKES" ARE NOW BEING MANUFACTURED IN VARIOUS STYLES AND QUALITY, RANGING IN PRICE FROM ABOUT $16.00 UPWARD.

THE MODEL 710 READRITE SET ANALYZER AND TUBE TESTER

IN FIG. 14 YOU ARE SHOWN A REPRODUCTION OF THE MODEL 710 READRITE ANALYZER AND TUBE CHECKER. AS YOU WILL OBSERVE, THIS UNIT IS CONTAINED

IN A CONVENIENT CASE WITH LEATHERETTE COVERING AND A DETACHABLE COVER. THE COVER HAS BEEN REMOVED IN THIS PARTICULAR ILLUSTRATION SO THAT THE TESTING EQUIPMENT MAY BE VIEWED IN GREATER DETAIL. THE OVERALL DIMENSIONS OF THIS ANALYZER ARE 10¾", X 3½" X 8".

IT IS EQUIPPED WITH THREE INDIVIDUAL METERS--A D.C. VOLTMETER WITH SCALES RANGING FROM 0 TO 20-60- 300 AND 600 VOLTS; AN A.C. VOLTMETER WITH SCALES RANGING FROM 0 TO 10-140 AND 700 VOLTS AND A MILLIAMMETER WITH SCALES RANGING FROM 0 TO 15-150 MILLIAMPERES.

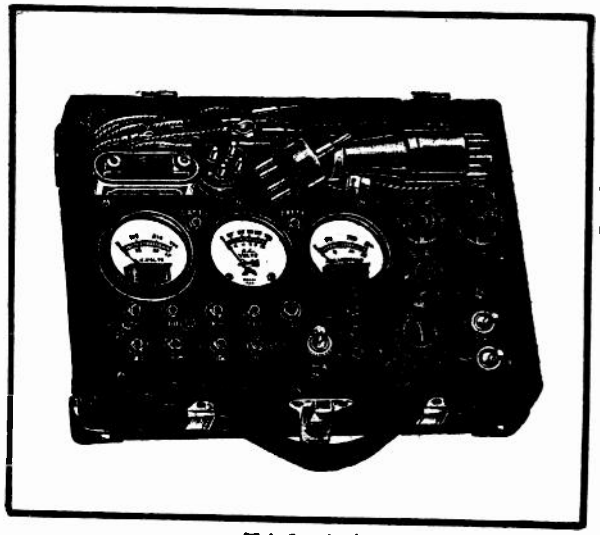

FIG. 14
Readrite Set Analyzer.

FOUR SOCKETS ARE MOUNTED ON THE ANALYZER TO ACCOMMODATE 4, 5, 6 AND 7 PRONG TUBES. A SPECIAL PLUG ATTACHED TO THE ANALYZER THROUGH A FLEXIBLE CABLE, TOGETHER WITH AN ASSORTMENT OF ADAPTER PLUGS, MAKES IT POSSIBLE TO CONNECT THE ENTIRE ANALYZER TO THE VARIOUS RECEIVER CIRCUITS THROUGH ITS TUBE SOCKETS SO THAT ALL COMMON TESTS CAN BE CONDUCTED WITH THE UTMOST EASE.

A HANDY SELECTOR SWITCH OFFERS A MEANS WHEREBY PLATE, GRID, CATHODE, SUPPRESSOR GRID, SCREEN GRID VOLTAGES ETC. CAN BE QUICKLY CHECKED AT ANY ONE SOCKET OF THE RECEIVER THROUGH ONLY ONE CONNECTION OF THE TESTER. IN ADDITION, FILAMENT VOLTAGES, PLATE CURRENT A.C. LINE VOLTAGE ETC. CAN ALL BE MEASURED.

ANY SCALE OF ANY ONE OF THE METERS CAN ALSO BE USED INDIVIDUALLY FOR VARIOUS TYPES OF TESTING BY SIMPLY INSERTING A PAIR OF TEST LEADS INTO THE PROPER JACK TERMINALS PROVIDED ON THE PANEL OF THIS OUTFIT. A 4½ VOLT "C" BATTERY IS ALSO SUPPLIED SO THAT EFFECTIVE CONTINUITY TESTS CAN BE CONDUCTED WITH THE AID OF THE D.C. VOLTMETER. PROVISIONS ARE ALSO MADE FOR MEASURING RESISTANCE AND CAPACITY.

BY CONSIDERING ALL OF THE RECEIVER TESTS MADE POSSIBLE BY THE MODERN ANALYZER, YOU CAN READILY SEE WHY EQUIPMENT OF THIS TYPE HAS BECOME SO EXCEPTIONALLY POPULAR AMONG SERVICEMEN.

THE MODEL 56 "SUPREME" ANALYZER

THE MODEL 56 "SUPREME" ANALYZER IS SHOWN YOU IN FIG.15. THIS COMPACT UNIT IS SUPPLIED WITH ONLY A SINGLE METER BUT THE METER IN THIS CASE IS A SPECIAL FORM OF COPPER-OXIDE RECTIFIER TYPE METER, PERMITTING THE READING OF BOTH ALTERNATING AND DIRECT CURRENTS AND VOLTAGES.

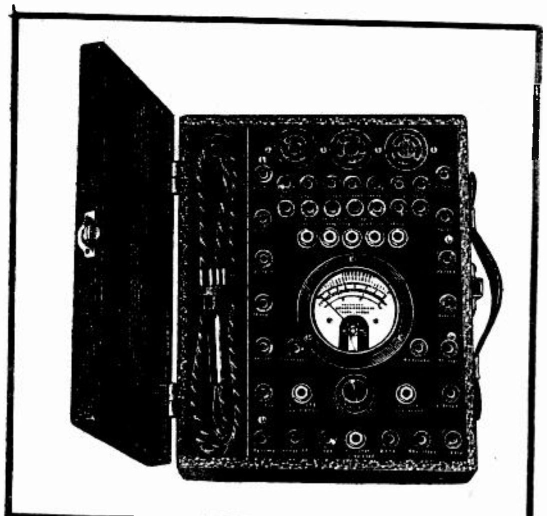

FIG. 15
Model 56 Supreme Analyzer.

A double scale of the meter reads from 0 to 3 and 0 to 9. A scale selector switch increases the range of these two simple scales giving voltage ranges of 0 to 3, 0 to 9, 0 to 30, 0 to 90, 0 to 300 and 0 to 900 volts A.C. or D.C. at internal meter resistances of 1000 ohms per volt. In addition, the same meter has ranges of 0 to 3, 0 to 9, 0 to 30, 0 to 90, and 0 to 300 milliamperes, A.C. or D.C.

This analyzer tests all types of tubes and is equipped to test external voltages on scales ranging from 0 to 3.2, 0 to 32 and 0 to 320 volts at 2500 ohms per volt for testing resistance coupled circuits. These readings are in addition to the regular external voltage ranges of 0 to 3, 0 to 9, 0 to 30, 0 to 90, 0 to 300 and 0 to 900 volts A.C. and D.C. Any range of the meter can be used in any analyzer circuit at any time--in other words, you can read filament voltages as high as 900 volts A.C. or D.C. or negative grid bias as high as 900 volts negative, or plate current as high as 300 milliamperes etc.

FIG. 16
Model 90 Supreme Analyzer.

It is also equipped with a self-contained 4½ volt battery, which when used in conjunction with the instrument, makes possible the reading of all resistances from 0 to 500 ohms and 0 to 500,000 ohms. The meter is calibrated directly in ohms. It is also capable of accurately measuring condenser capacities from .002 mfd. to 7 mfd.

THE MODEL 90 "SUPREME" ANALYZER

The model 90 Supreme analyzer also uses a single, all-purpose, copper oxide rectifier type meter but the two simple scales in this case range from 0 to 2.5 and 0 to 10. A plug and cable offer a convenient means for connecting the analyzer to the receiver.

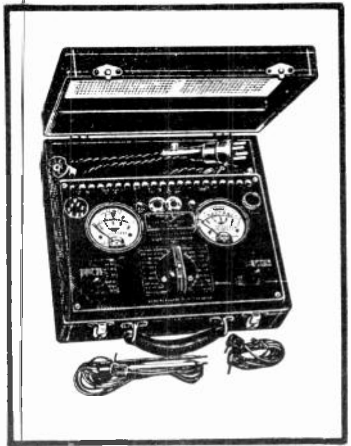

FIG. 17
Model 444 Jewel Analyzer.

By the use of a rotary scale selector switch, the range of the meter can be changed at will to read voltages of 0 to 2.5, 0 to 10, 0 to 25, 0 to 100, 0 to 250 and 0 to 1000 volts A.C. or D.C.

When reading A.C. or D.C. milliamperes, the same scales are used and the same selector switch gives ranges of 0 to 2.5, 0 to 10, 0 to 25, 0 to 100 and 0 to 250 milliamperes. All voltages and milliampere ranges are also available externally through two tip jacks and the scale selector switch. Also, any range of the meter is available for any reading on the analyzer. Filament voltages can be read up to 1000 volts, grid bias to 1000 volts negative, plate or screen current up to 250 milliamperes etc.

The meter scale also carries a simple, easily read resistance calibration, reading from 0 to 5000 ohms in the low position and from 0 to

500,000 ohms on the high range. The full range of the meter is also adaptable to being used as an output meter.

Provisions are also made for testing all types of receiver tubes.

THE MODEL 444 JEWEL ANALYZER

The model 444 Jewel analyzer is shown you in Fig. 17. This unit is equipped with an individual A.C. meter offering the following ranges: 0-4-8 amperes, 0-20-100 milliamperes and 0-4-8-160-800 volts. The D.C. meters offer the following ranges: 0-12-60-120 milliamperes, 0-6-12-30-60-120-300-600-volts, 0-1,000-10,000-100,000 ohms and low, medium and high output ranges.

This Jewel analyzer also includes a plug and cable connection, test leads, adapters, and various accessory equipment.

SERVICE OSCILLATORS

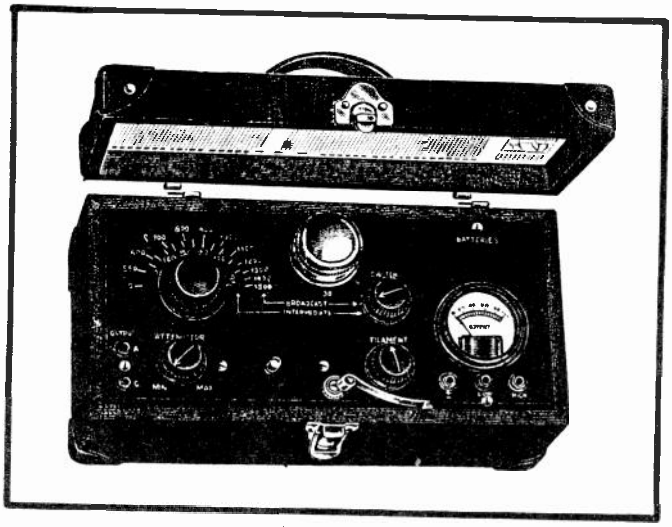

FIG. 18
The Model 550 Readrite Oscillator.

Another valuable testing instrument, which is used a great deal in radio service work, is known as the SERVICE OSCILLATOR. This handy device is a great aid in balancing a receiver's tuning circuits, adjusting neutralizing condensers, adjusting I.F. transformers in superheterodyne receivers and many other tests where a radio frequency signal is desired.

Briefly, a service oscillator is a generator of radio frequency energy and offers a means whereby the serviceman may produce a signal wave of any frequency he may wish. In this way, one is not dependent upon the signals emitted by the regular broadcast stations when conducting work where some form of signal is necessary.

THE "READRITE" SERVICE OSCILLATOR

The Model 550 Readrite service oscillator is shown you in Fig. 18. This particular unit consists of a completely shielded self-modulated oscillator employing a single type -30 tube and is furnished with one self-contained $22\frac{1}{2}$ volt battery and one 3 volt battery. It is capable of generating modulated signals covering the entire broadcast and superheterodyne intermediate frequency bands.

The tuning dial at the upper left of the instrument's panel is direct reading for the 550-1500 Kc. broadcast range, as well as for the 120-185 Kc. intermediate frequency band. Sharp 2nd and 3rd harmonics cover the intermediate 260-262 and 475Kc. frequencies.

The switch at the upper right of the panel offers two positions, one

FOR THE BROADCAST FREQUENCIES AND ANOTHER FOR THE INTERMEDIATE FREQUENCIES. IN OTHER WORDS, TO GENERATE A 600 KC. SIGNAL, THE SWITCH AT THE UPPER RIGHT IS TURNED TO THE BROADCAST POSITION AND THE DIAL OR FREQUENCY SELECTOR AT THE UPPER LEFT IS THEN SET TO THE POSITION MARKED "600". ON THE OTHER HAND, IF AN INTERMEDIATE FREQUENCY OF 175 KC. IS WANTED, THEN THE DIAL IS SET TO THE "175" MARK AND THE SWITCH AT THE UPPER RIGHT IS SET AT THE POSITION WHICH IS MARKED "INTERMEDIATE".

THE FILAMENT CONTROL AT THE LOWER RIGHT OF THE PANEL PERMITS ADJUSTMENT OF THE -30 TUBE'S FILAMENT VOLTAGE TO EXACTLY 2 VOLTS WHILE THE ATTENTUATOR CONTROL AT THE LOWER LEFT SERVES TO CONTROL THE INTENSITY OF THE GENERATED SIGNAL.

THE "OUTPUT METER" IS CONNECTED TO THE OUTPUT OF THE RECEIVER AND THUS OFFERS A VISUAL INDICATION AS TO HOW THE CHANGE IN SETTING OF ANY ONE OF THE RECEIVER'S ADJUSTMENTS AFFECTS THE OVERALL PERFORMANCE OF THE RECEIVER.

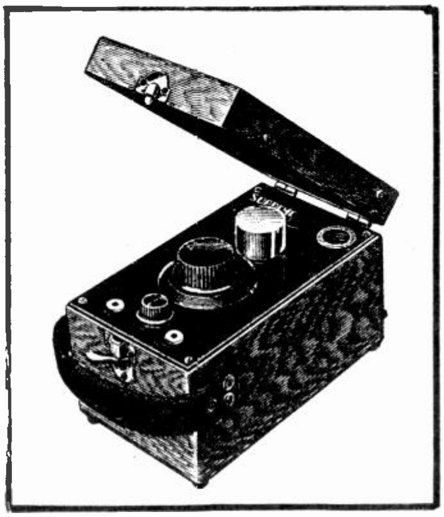

FIG. 19
Model 60 Supreme Oscillator.

THIS ENTIRE TESTER IS HOUSED IN A LEATHERETTE--COVERED CASE MEASURING 6"X12" X5". THE COVER IS REMOVABLE AND THE COMPLETE UNIT WEIGHS BUT 8 POUNDS

THE MODEL 60 "SUPREME" OSCILLATOR

THE MODEL 60 "SUPREME" OSCILLATOR, WHICH IS SHOWN YOU IN FIG. 19, OPERATES DIRECTLY FROM THE 110 VOLT, 60 CYCLE LINE AND GIVES A CLEAR STRONG SIGNAL WHICH IS 100% MODULATED AT THE LINE FREQUENCY. THIS UNIT IS CALIBRATED OVER A FUNDAMENTAL FREQUENCY BAND OF 90 TO 250 KC. AND BY MEANS OF HARMONICS, ANY DESIRED FREQUENCY BETWEEN 90 KC. AND 1600 KC. CAN BE OBTAINED. (BY A "HARMONIC," WE MEAN A FREQUENCY WHICH IS A SIMPLE MULTIPLE OF ANY FUNDAMENTAL FREQUENCY. FOR INSTANCE, THE HARMONICS OF 150 KC. WOULD BE 300 KC., 450 KC., 600 KC. ETC.)

A SIMPLE CONTROL PERMITS ACCURATE ADJUSTMENT SO AS TO CONTROL THE INTENSITY OF THE GENERATED SIGNAL. THE ENTIRE UNIT IS ENCLOSED IN A CAST ALUMINUM CASE AND ALUMINUM SUB-PANEL COVERED WITH THE ENGRAVED BAKELITE CONTROL PANEL. A STRONG HARD WOOD CARRYING CASE WITH DETACHABLE COVER IS ALSO SUPPLIED, TOGETHER WITH A DETACHABLE A.C. CORD AND SHIELDED LEADS. THIS INSTRUMENT CAN BE USED TOGETHER WITH ANY STANDARD OUTPUT METER.

THE MODEL 590 WESTON I.F. AND R.F. OSCILLATOR

THE MODEL 590 WESTON OSCILLATOR, WHICH IS SHOWN YOU IN FIG. 20, HAS AN INTERMEDIATE FREQUENCY RANGE FROM APPROXIMATELY 110 TO 200 KILOCYCLES AND A BROADCAST RANGE FROM 550 TO 1500 KILOCYCLES. FREQUENCIES BETWEEN 200 AND 500 AND ABOVE 1500 KC. MAY BE OBTAINED BY MEANS OF HARMONICS. THIS OSCILLATOR IS ALSO PROVIDED WITH A "GRID DIP" MILLIAMMETER WHICH ASSURES THE SERVICEMAN THAT THE OSCILLATOR IS DEFINITELY OPERATING SO THAT WHEN NO OUTPUT IS OBTAINED FROM THE RADIO RECEIVER, IT IS THE LATTER WHICH IS AT FAULT.

TWO TYPE-30 TUBES ARE EMPLOYED IN THIS OSCILLATOR--ONE FOR GENERATING THE R.F. AND THE OTHER TO MODULATE THE R.F. SO AS TO PRODUCE AN AUDIBLE NOTE OF 400 CYCLES PER SECOND. THE OUTPUT OF THE OSCILLATOR IS CONTROLLED BY A SPECIALLY DESIGNED ATTENTUATOR, ADJUSTABLE FROM PRACTICALLY ZERO UP TO ITS MAXIMUM RANGE BY SMOOTH GRADUAL CHANGES. A FILAMENT VOLTMETER IS USED TOGETHER WITH A HANDY CONTROL SO THAT THE FILAMENT VOLTAGE FOR THE -30 TUBES CAN AT ALL TIMES BE KEPT AT 2 VOLTS.

THE BATTERIES FOR OPERATING THE OSCILLATOR ARE HOUSED IN A SHIELDED COMPARTMENT OF THE UNIT AND THEY CONSIST OF A SMALL $22\frac{1}{2}$ VOLT "B" BATTERY AND FOUR $1\frac{1}{2}$ VOLT FLASHLIGHT-TYPE DRY CELLS CONNECTED IN SERIES -PARALLEL. THE COMPLETE OUTFIT IS HOUSED AND SHIELDED WITHIN A CAST ALUMINUM CONTAINER, WITH A SUITABLE HANDLE AND COVER PROVIDED SO THAT THE ASSEMBLY WILL LEND ITSELF FAVORABLY TO PORTABLE USE.

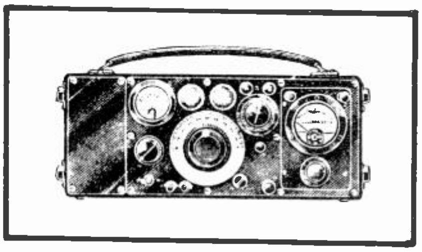

FIG. 20
The Weston Oscillator

THE "SUPREME" DIAGNOMETER

IN FIG. 21 YOU ARE SHOWN A RATHER ELABORATE TESTING OUTFIT. THIS IS THE AAA-1 "SUPREME" DIAGNOMETER, WHICH IS A COMBINATION SET ANALYZER, TUBE TESTER, CALIBRATED SERVICE OSCILLATOR, RESISTANCE CHECKER, CONDENSER CAPACITY CHECKER, AND OUTPUT METER.

THE ANALYZER CIRCUITS PROVIDE QUICK AND EASY READINGS OF ALL VOLTAGE AND CURRENT READINGS IN ANY CIRCUIT BY MEANS OF THE COPPER-OXIDE RECTIFIER "MULTIMETER" WHICH THROUGH ITS SCALE SELECTOR SWITCH READS AS HIGH AS 1000 VOLTS A.C. OR D.C. AT 1000 OHMS PER VOLT. DURING ANALYSIS, THE MILLIAMMETER, SHOWN AT THE RIGHT OF THE PANEL, INDICATES THE PLATE CURRENT OF THE TUBE UNDER ANALYSIS.

THE "MULTIMETER" (VOLTMETER AND RESISTANCE METER) HAS SCALES OF 0-2.5, 0-10, 0-25, 0-100, 0-250 AND 0-1000, ALL OF THESE RANGES BEING AVAILABLE EXTERNALLY AND CONTROLLED BY THE SAME SELECTOR SWITCH. THE "MULTIMETER" ALSO ACTS AS AN OUTPUT METER WITH SIX RANGES FROM 0-2.5 VOLTS TO 0-1000 VOLTS.

THE SHIELDED OSCILLATOR IS OPERATED FROM THE A.C. LINE THROUGH A LINE VOLTAGE CONTROL SWITCH AND PROVIDES ALL FREQUENCIES FROM 90 KC. TO ABOVE THE BROADCAST BAND. THE OSCILLATOR HAS A STRONG CLEAR NOTE UNDER FULL CONTROL OF A SPECIAL KNOB ADJUSTMENT AND THE LINE VOLTAGE CONTROL COVERS 100 TO 120 VOLTS AND 200 TO 240 VOLTS.

THE TUBE TESTER CIRCUITS PROVIDE ACCURATE AND SIMPLE CHECKS SO THAT THE "WORTH" OF ALL TYPES OF TUBES CAN BE READILY DETERMINED.

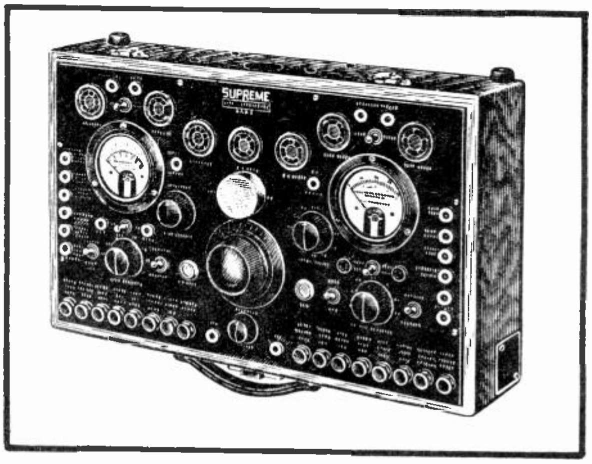

FIG. 21
The Supreme Diagnometer.

RESISTANCE READINGS ARE OFFERED RANGING FROM 0 TO 25 MEGOHMS,

WHILE CONDENSER CAPACITIES CAN BE CHECKED RANGING FROM .002 MFD. TO 10MFD.

ADDITIONAL SPECIAL FEATURES INCLUDE AN EXTERNAL VOLTAGE RANGE OF 0 TO 2500 VOLTS AT 1000 OHMS PER VOLT AND 0 TO 40 AND 0 TO 200 VOLTS AT 2500 OHMS PER VOLT, AS WELL AS AN EXTERNAL RANGE OF 2.5 AMPERES A.C, FOR CHECKING CHARGES ETC.

LINE VOLTAGE READINGS ARE AVAILABLE THROUGH A SIMPLE PUSH-BUTTON CONTROL AND PANEL LIGHTS INDICATE WHEN THE OSCILLATOR AND TUBE TESTER ARE IN OPERATION. THE ENTIRE INSTRUMENT IS HOUSED IN A HANDY CASE SO THAT THE UNIT CAN BE SUBJECTED TO PORTABLE USE.

ALL OF THE ANALYZERS, OSCILLATORS ETC. WHICH WERE DESCRIBED IN THIS LESSON ARE COMMERCIAL TYPES AND COMPLETE INSTRUCTIONS REGARDING THE CORRECT OPERATION OF THE PARTICULAR INSTRUMENT ARE FURNISHED BY THE MANUFACTURER TOGETHER WITH THE EQUIPMENT. BESIDES THOSE MENTIONED IN THIS LESSON VARIOUS OTHER MAKES ARE ALSO AVAILABLE.

THE REASON FOR MENTIONING THIS TEST EQUIPMENT IN THIS LESSON WAS SIMPLY TO INFORM YOU THAT EQUIPMENT OF THIS TYPE IS BEING MANUFACTURED AND USED IN RADIO SERVICE WORK. IN LATER LESSONS, YOU ARE GOING TO BE SHOWN HOW SUCH TESTING DEVICES ARE ACTUALLY APPLIED TO SERVICE WORK.

BESIDES THE TESTING UNITS DESCRIBED IN THIS LESSON, THE "UP THE MINUTE" SERVICEMAN ALSO USES COUNTER TUBE CHECKERS, A.F. OSCILLATORS, VACUUM TUBE VOLTMETERS ETC. BUT THIS EQUIPMENT IS CONFINED CHIEFLY TO USE IN THE STORE, SHOP OR LABORATORY RATHER THAN WHEN MAKING SERVICE CALLS AND WILL THEREFORE BE BROUGHT TO YOUR ATTENTION AT A MORE APPROPIATE SECTION OF YOUR TRAINING.

IT MIGHT ALSO BE OF INTEREST TO YOU TO KNOW THAT IN YOUR MORE ADVANCED STUDIES, YOU ARE GOING TO BE MADE FAMILIAR WITH THE DESIGN OF SUCH ELABORATE TESTING EQUIPMENT, SO THAT YOU CAN BUILD YOUR OWN. IN THE FOLLOWING LESSON, HOWEVER, WE ARE GOING TO CONSIDER THE MOST COMMON RADIO TROUBLES--THEIR SYMPTOMS, HOW TO LOCATE THEM AND HOW TO CORRECT THEM.

Examination Questions

LESSON NO. 20

> "Enjoy the present hour, be mindful of the past; and neither fear nor wish the approaches of the last."

1. - WHAT ARE THE MOST ESSENTIAL TOOLS WHICH ARE REQUIRED WHEN MAKING A SERVICE CALL?

2. - WHY IS IT ADVISABLE TO INCLUDE A FLASHLIGHT IN THE SERVICE KIT?

3. - WHAT TYPE OF TESTING EQUIPMENT SHOULD ONE PLAN ON TAKING TO THE HOME OF A RECEIVER OWNER WHEN MAKING A SERVICE CALL?

4. - IS IT ADVISABLE TO MAKE MAJOR REPAIRS IN THE SET OWNER'S HOME? EXPLAIN THE REASON FOR YOUR ANSWER.

5. - WHAT IS A "MULTIPLIER", WITH REFERENCE TO D.C. VOLTMETERS?

6. - A CERTAIN D.C. VOLTMETER, WHOSE SCALE IS CALIBRATED TO READ FROM 0 TO 500 VOLTS, IS KNOWN TO HAVE AN INTERNAL RESISTANCE OF 1000 OHMS PER VOLT. WHAT RESISTANCE VALUE SHOULD THE MULTIPLIER HAVE SO THAT THE RANGE OF THIS SAME VOLTMETER MAY BE INCREASED UP TO 1000 VOLTS?

7. - WHY IS IT ADVISABLE TO USE A TOOL BOX RATHER THAN SOME FORM OF BAG WITH WHICH TO CARRY SERVICE EQUIPMENT TO THE JOB?

8. - WHAT ADVANTAGES ARE OFFERED BY USING SET ANALYZERS INSTEAD OF INDIVIDUAL METERS?

9. - WHY ARE SERVICE OSCILLATORS USED?

10. - WHY IS IT SO IMPORTANT THAT ONE HAVE ADEQUATE EQUIPMENT IN ORDER TO CONDUCT RADIO SERVICE WORK SATISFACTORILY?

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