Trouble Shooter's Manual

by

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Assoc. Mem. Amer. Inst. of Elec. Engrs.

Volume II

THE SERVICE MAN'S MANUAL

RADIO TREATISE COMPANY
1440 Broadway New York City

I N T R O D U C T I O N

It is with pleasure that we offer this material which has been compiled through the courtesy of the manufacturers represented in this work. The representation is in the form of the wiring diagrams of the units produced by these organizations. Unfortunately, space did not permit the publication of all the wiring diagrams submitted to the author. We herewith tender our thanks to the men who have been in communication with the author and who saw fit to foster the servicing industry by permitting publication of their diagrams. However, we wish it definitely understood that whatever analytical information is contained in this work pertaining to the function of units, unless special mention is made, is not that of the manufacturers represented in the book but solely of the author, thus absolving these manufacturers from blame in connection with any and all statements.

We hope that this material will be of aid to the practicing service man and to the host of experimenters who delve into the innards of their radio possessions and who make their own repairs.

Permission to publish the enclosed wiring diagrams was secured from the various manufacturers with the understanding that they would not be reproduced in magazines and newspapers without special permission and we trust that the readers of this book will cooperate with the author in this respect.

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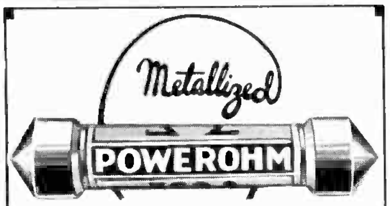

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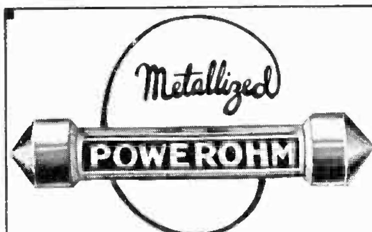

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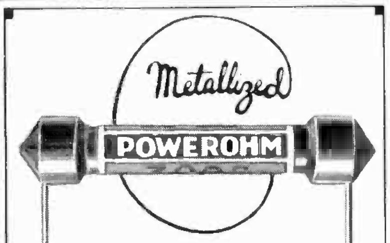

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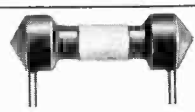

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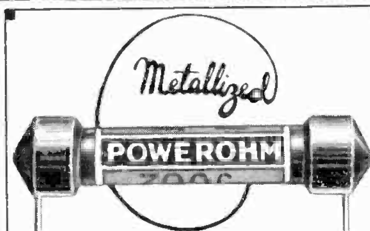

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T A B L E O F C O N T E N T S

Procedure Preparatory to Actual Testing

Considering the status of the radio service field, and recognizing the interest evidenced therein by all large publications and manufacturers, it is needless to mention or to discuss the need for the radio service man ---- he serves a very beneficial purpose. Of greater interest is his work; what he should do and how he should do it. Hence, without further preliminaries, we might just as well delve right into the work at hand.

The visiting service man is our subject. Strange as it may seem to many who are interested in this work, much can be said from a desk, via a typewriter, about what the service man should do out in the field. To those who feel skeptical, let us say that this discussion is not analogous to the Sunday sermon about the problems of the working man, by an individual who has never labored. We have been out in the field and have had the occasion to make extensive observation.

We have had the pleasure of calling numerous service men to repair defective receivers in order to study their working methods and have found plenty to speak about. We realize fully that many visiting radio-tricians operate along the proper lines, but we also know that many do not.

Query the Receiver Owner

The search for the possible source of trouble can frequently be expedited by the radio receiver owner. The average radio service man who calls upon a set owner makes a stock query, which actually has little significance. "What seems to be the trouble?" is the usual introductory comment. On first thought, the question may appear logical but upon second thought, it is just the contrary because the reply is seldom informative. It is quite unlikely that the receiver owner can tell the visiting service man the source of trouble, or even the trouble other than to say that the receiver does not perform satisfactorily. In sum and substance, the method of attack is wrong.

Then again, many visiting service men do not ask this query, but ask to be shown the receiver and they immediately start their diagnosis. This method of procedure is extremely faulty and the reasons are self-evident. We do not mean to disparage the operating methods of others. Our purpose is to set forth a process of operation which has been found to be successful and conducive to more profitable operation and which we know to be superior to the two examples mentioned. We further make use of the radio knowledge possessed by the receiver owner no matter how sparse it may be. It is true that this information is not always available, that is to say, all of it is not available, but quite a good deal is at hand at all times.

The Cross-Examination

It is our belief that a short cross-examination of the receiver owner by the visiting service man is in order immediately upon entry. If the man of the household is absent, the lady may be questioned. Her replies will be hazy, it is true, but informative to a certain degree, and every bit of information is valuable. Such a cross-examination should supply the service man with certain information, data which he cannot secure by observation of receiver performance --- data which will lead to more rapid and therefore more profitable analysis of the receiver and more rapid isolation of the trouble.

Many factors associated with the operating life of the receiver; the batteries, the tubes, the accessories and the performance prior to the trouble or defect are of great importance in the analysis of the trouble. Such data expedites the diagnosis. Therefore, the first step is to ascertain this information. A few such questions are:

1. How old is the receiver?
2. How long has it been in use?
3. How old are the tubes --- the batteries --- the accessories?
4. Did you make any internal wiring changes --- any battery changes --- any tube changes --- where?
5. Was the receiver subjected to any physical jars or shocks?
6. Was the receiver moved from one locality to another?
7. Was the receiver in operation when the failure occured?
8. What control or controls were being manipulated at the moment of failure?
9. Were any changes made upon the accessories --- the eliminator?
10. Is the aerial in good condition --- the ground in good condition?
11. Did you make any mechanical changes upon the receiver or the accessories?

In short, the customer must tell all he knows about the receiver, because such information is vital. It is astonishing to note the amount of time actually saved by such an examination. Time and again, the information thus secured points directly to the source of trouble. Rapid diagnosis and analysis is profitable to everyone concerned. It means rapid repair and a satisfied customer. Besides, rapid repair means profit to the service man because he spends the minimum amount of time on each job. The service man sells time and knowledge. These two items constitute his entire stock.

With few exceptions, receiver failures are attributable to faults common to myriad receivers. The introduction of the AC electric receiver increases the number of possible sources of trouble, but not by a large figure. The period of operation is a limiting factor in the possible sources of trouble. For example, mechanical failures are seldom encountered a short period after the installation of a new receiver, but a defective tube or a defective battery or a broken connection, jarred loose during local transit, will impair the operation of a new receiver. Hence, the first query.

The answers to the second and third questions, govern the number of probable sources of trouble. The older the set the more numerous the sources of trouble. This information supplemented by the present performance of the faulty receiver guides one to the tubes or the batteries in the installation. Mechanical failures are more likely in a receiver operated over a period of a year than in a new receiver. Old tubes or run down batteries will cause poor receiver performance. Low electronic emission of filament type rectifiers and defective gaseous rectifiers will cause insufficient plate and grid voltages. Continual overloading of a loud speaker will alter the physical alignment of the moving parts within the speaker.

The answer to the fourth question will show possible incorrect wiring changes. Many receiver owners who have made such changes and found them disastrous, are loathe to provide this information and will only speak about the changes, when questioned. The change may be simple, yet an hour may pass before the service man who has not queried the receiver owner, discovers the alteration in wiring. The answer to the query "where" will save much time. Many receiver owners are tinkerers and like to make what they believe will be improvements. Incorrect placement of a fixed condenser and the set tunes broadly! An incorrectly placed resistance and the filament voltage is low with unsatisfactory receiver performance. Many are apt to purchase accessories which, while secured in good faith, are not suited to the receiver at hand.

The average owner thinks nothing of a shock applied to a receiver during transit, particularly if the receiver performs well after the period of transit and then goes dead during operation. Yet, many imperfect connections are jarred loose during transit and contact broken during the reproduction of a loud signal, when the speaker causes a slight vibration of the receiver chassis and cabinet. Such cases are very frequent when the speaker is within the cabinet housing the receiver. Then again, internal plug connections are frequently "opened" during transit. Such imperfect contacts cause crackling disturbances and as far as the fan is concerned, the new locality is very poor because "static" is prevalent. His reception was perfect in the old locality --- before the connection was impaired and the contact rendered imperfect.

The answer to the seventh question is usually valuable, particularly when the trouble is noisy operation, or when the set ceased operation suddenly. Once again the period of operation is important and the answers to two or more queries are interlocking. Mechanical failure is more likely in an old set and if noise developes during the manipulation of a variable resistance, and the receiver is months or perhaps a year old, it is very likely that the contact between the various elements of that certain control resistance is imperfect or oxidization has reached the stage where it insulates one member from the other and the set becomes inoperative. The trouble is easily remedied yet the receiver is useless, and as far as receiver operation is concerned, this minor trouble is equal to any major trouble. Association of the answers to questions seven and eight, will usually point to such troubles. In many cases, manipulation of B eliminator resistances will cause major troubles, particularly when the eliminator is old. Very often the trouble is not in the unit itself but in some other part of the installation associated with that unit.

Practical Chart System

We have something else to say about the service man's visit. While the function of the service man is to repair a receiver and restore it to its original high electrical efficiency, repeat business is a basis for success - also recommendation by one another to another receiver owner. To secure this business, it is necessary to show that the work is carried out in a systematic manner. Repeat calls for the capable service man are few and far between, but each call made can be arranged to produce more customers by means of a silent, yet effective form of advertising. It is difficult to estimate the number of repeat calls for service upon one particular receiver owned by one man. The controlling factor in this instance is the receiver owner. If he is a tinkerer, repeat calls are numerous. If he knows enough to leave well enough alone, the calls are ihfrequent. No matter what the arrangement, detailed knowledge of the past record of the receiver, its ailments, its components, its previous operating life, and other such data, is of vital importance to the man who makes the call. It is not always possible to send the same individual if the servicing organization employs many men, or to see the master of the household when the call is made. Detailed cross-examination on each occasion is aggravating to the customer, yet the knowledge must be secured.....Why not apply an ailment chart system?

A permanent record made at the time of service, after the original cross-examination, will be of aid to whomever calls to service the radio receiver. The original chart can be fastened inside the receiver cabinet. A copy of this chart should be kept in the service man's file for reference purposes.

In this connection, the reader should not believe that he is aiding the cause of his competitor in the event that his customer moves into a new locality and a new organization is called upon to service. What is true with his competitor is true with himself. If all service men make such records, all benefit and improve the status of the field. A permanent record of material gleaned after a cross examination and the analysis of the receiver, will benefit everyone concerned. It is a record good for years of service and facilitates diagnosis and service at a later date.

Like the original cross-examination, the chart helps point to the trouble. If the records show that the tubes are a year old, and the present receiver affords little amplification, one immediately suspects the tubes. If the record shows that the last repair was the replacement of a certain audio frequency transformer because the original unit "blew" , and the present receiver is dead, one immediately suspects that stage of audio frequency amplification and examines the continuity. If the records do not point to the ailment, they at least facilitate the complete analysis by providing information otherwise unavailable, unless the master of the house who purchased and cared for the receiver, is at home.

The data contained on this chart should include the date of installation. If such a chart is not available at the first service call, the service man should ascertain the date of installation and make his permanent records. A full record of tube performance and electrical condition is necessary. Peculiarities of receiver performance, local conditions, past symptoms and repairs are also of aid and should be recorded. The making of such a chart and application to a serviced receiver shows conscientious, capable servicing. It shows that the work is carried out in a systematic manner and the final result is the creation of public confidence. The chart is a continual reminder of good service. In the event of future trouble, the receiver owner has a simple means of locating the name, the address and the telephone number of the service man. This information is accessible when he desires to give the name to his friends....A silent, yet effective salesman.

Knowledge of Circuits and Operating Conditions

It is needless to continue examples of the beneficial effects of cross-examinations and charts. What has been said should suffice for the present. Let us turn back the progress of time and consider the case of the original call for the radio service man. We know, and definitely so, that in few instances do service men or men in service stations ask questions about the problem at the home of the receiver owner when the original call for the service man is made. In this connection, we do not wish a hasty conclusion on the part of the reader. The queries in this case, do not refer to those mentioned before. Here our interest is in the wiring diagram of the faulty receiver, or the power unit if such be the case. Assuming that a call is received and an appointment made, what information is available to the service man? To declare a receiver repaired, he must know the correct operating conditions as set forth by the manufacturer. He likewise must know, wherever possible, the electrical constants of the various units within the receiver. This information is available on the wiring diagram of the receiver. Unless tabulated, the service man is at a loss when he attempts to analyse the radio set. (Tabulated data of this nature is contained in this Manual). Without questioning --- without asking about the type of installation involved, he seeks an unknown quantity. Hence, the suggestion that inquiry be made regarding the type of equipment involved and that the correct wiring diagrams be carried by the visiting service man. (Popular wiring diagrams are published in this Manual).

The significance of the wiring diagram cannot be fully appreciated unless one is confronted with the problem of servicing a radio receiver and the internal connections are unknown. In this connection we know that many regret failure to clip the wiring diagrams shown in many radio publications. We also know that many claim wiring diagrams unnecessary. Unfortunately we cannot concur with the latter group. The development of the AC receiver wherein the B eliminator is an inherent part and binding post connections with voltage designations are not available, aggravates this condition.

With respect to the need for wiring diagrams, may we refer to the three shown here, on the next three pages. These are the Atwater Kent 37, the Freshman Q15 and the Stromberg-Carlson 635-636 AC receivers. Without a wiring diagram for reference, how can the service man know that the grid bias arrangements differ.

Compare the detector circuits in the Stromberg-Carlson and the Atwater-Kent receivers. If one were to test between the cathode and the B minus terminals of the detector system in the first mentioned receiver, a biasing voltage would be evident, whereas in the second receiver no such voltage would be evident because the cathode is connected to the B minus terminal. Examine the source of grid potential applied to the 171 output tube in these receivers. In the Stromberg-Carlson installation, the grid bias is secured from the B eliminator, in the Atwater-Kent installation by means of a voltage drop across a resistance in the grid-filament circuit. In the first case, the total eliminator current flows through a resistance and the voltage drop is applied to the 171 tube grid. In the other case, the plate current of the 171 tube is caused to flow through the resistance mentioned. The voltage produced is then applied to the grid of the tube. No matter what the arrangement, it is evident that a wiring diagram is necessary in order to correctly analyse the re-

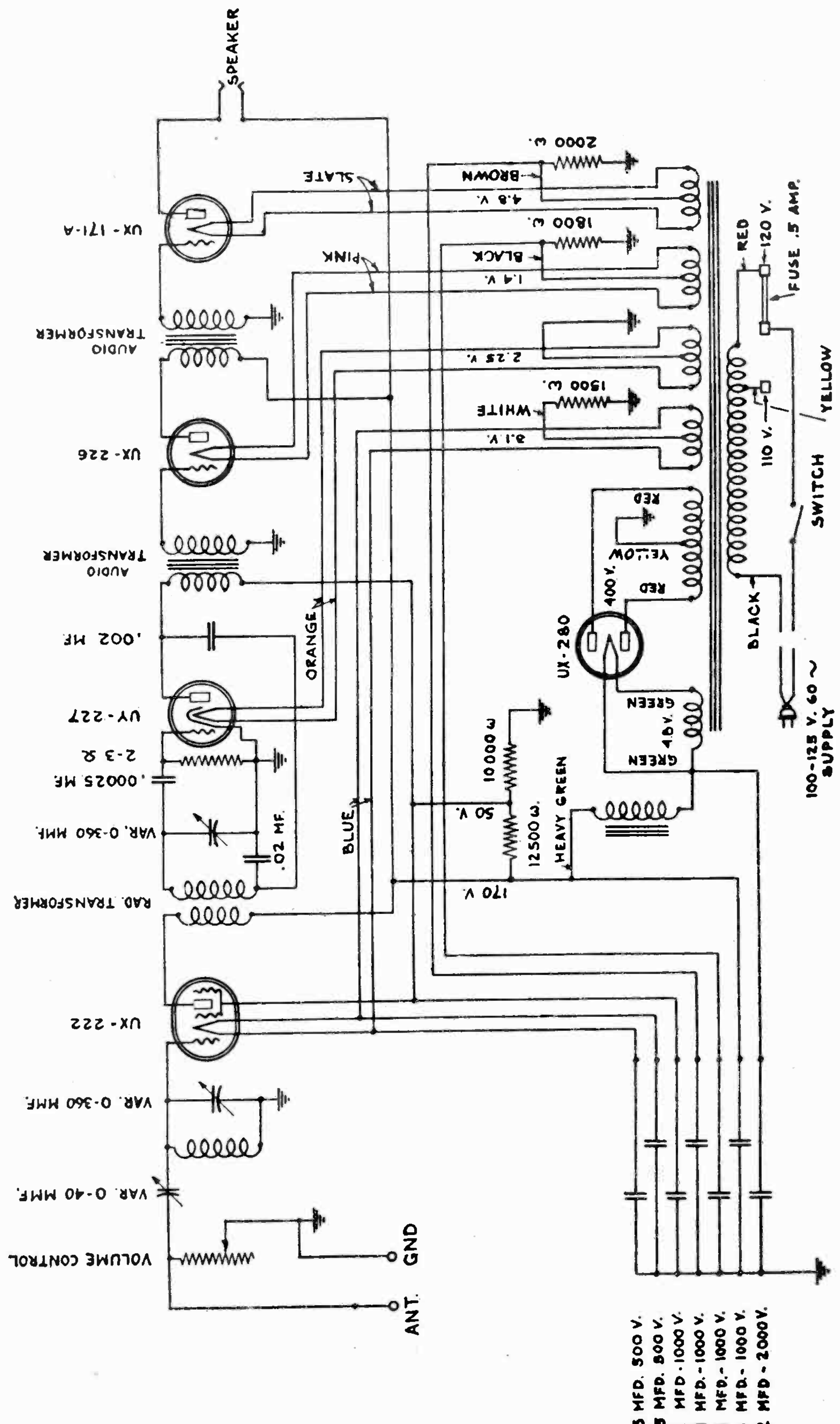


Fig. 1 Schematic diagram of the Freshman Q15 receiver

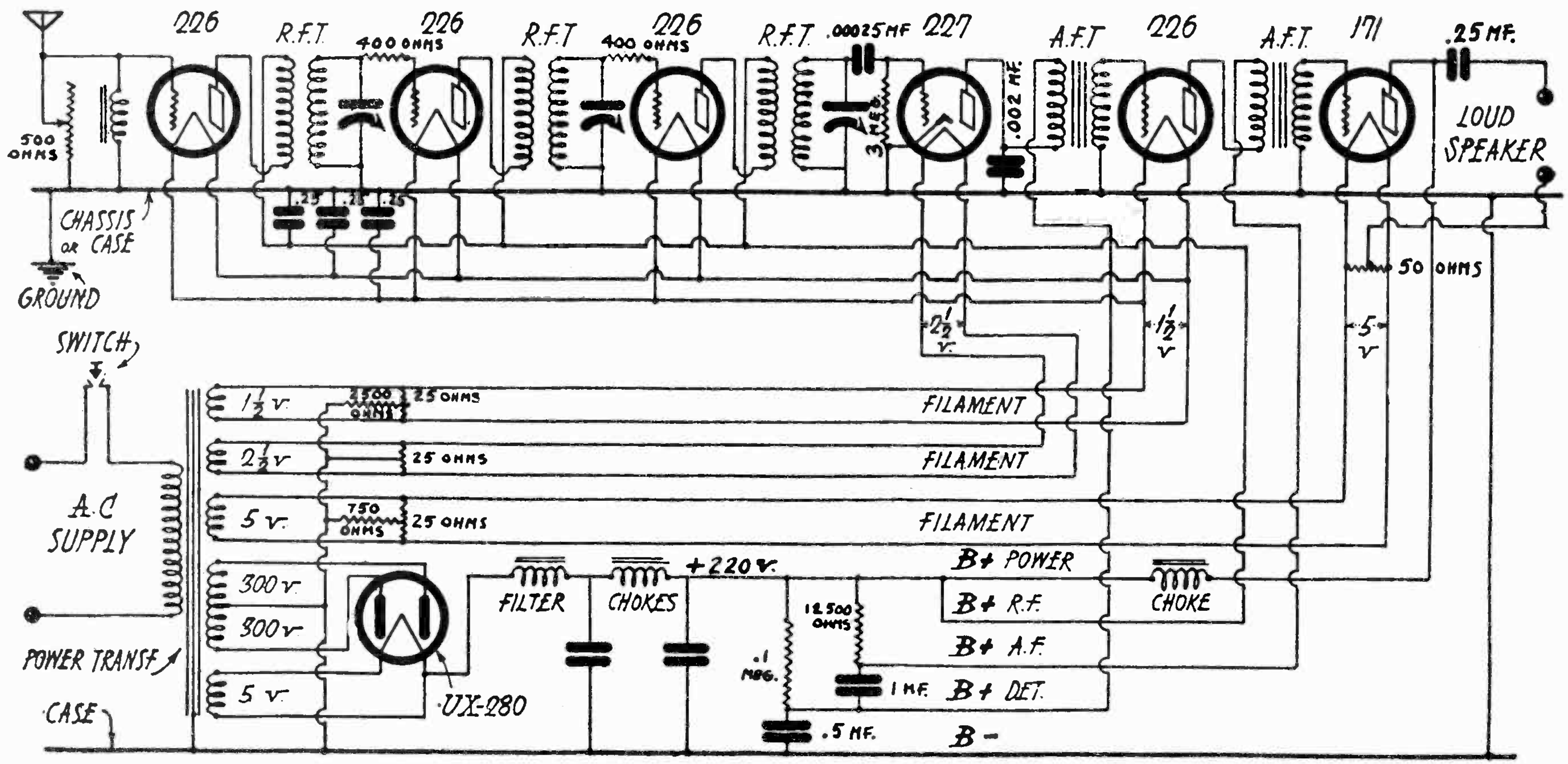


Fig. 2 Schematic diagram of the Atwater-Kent No. 37 receiver.

ceiver. If repairs are necessary, the problem is even more acute. How can one determine the correct electrical constant if the unit is damaged? It is naturally impossible and replacement is likewise impossible. Furthermore, many wiring diagrams do not show the electrical value, instead, the manufacturers' stock number for that individual unit. Replacement of any one component by another of different manufacture but like electrical value is not recommended, as a matter of fact should not be made because the physical design of the receiver limits the product which may be employed in the installation. Hence, in order to secure the correct replacement unit, reference must be made to the stock number, which data is frequently supplied in the schematic diagram.

It is likewise unsafe to judge wiring systems of defective receivers by tracing circuits. One is not certain if the arrangement present is correct or incorrect, and a wiring diagram is imperative. As a concrete example, we have the filter circuits of the Freshman and the Atwater-Kent receivers shown in figures 1 and 2. The Freshman utilizes a choke input whereas the Atwater-Kent system employs a condenser input. The need for the wiring diagram is very evident.

There are many other cases which prove the advantage of having at hand the circuit diagram of the receiver being serviced . Do not forget that every set has its own circuit peculiarities. He who believes that he can operate successfully without a wiring diagram is harboring a false premise of superior intellect.

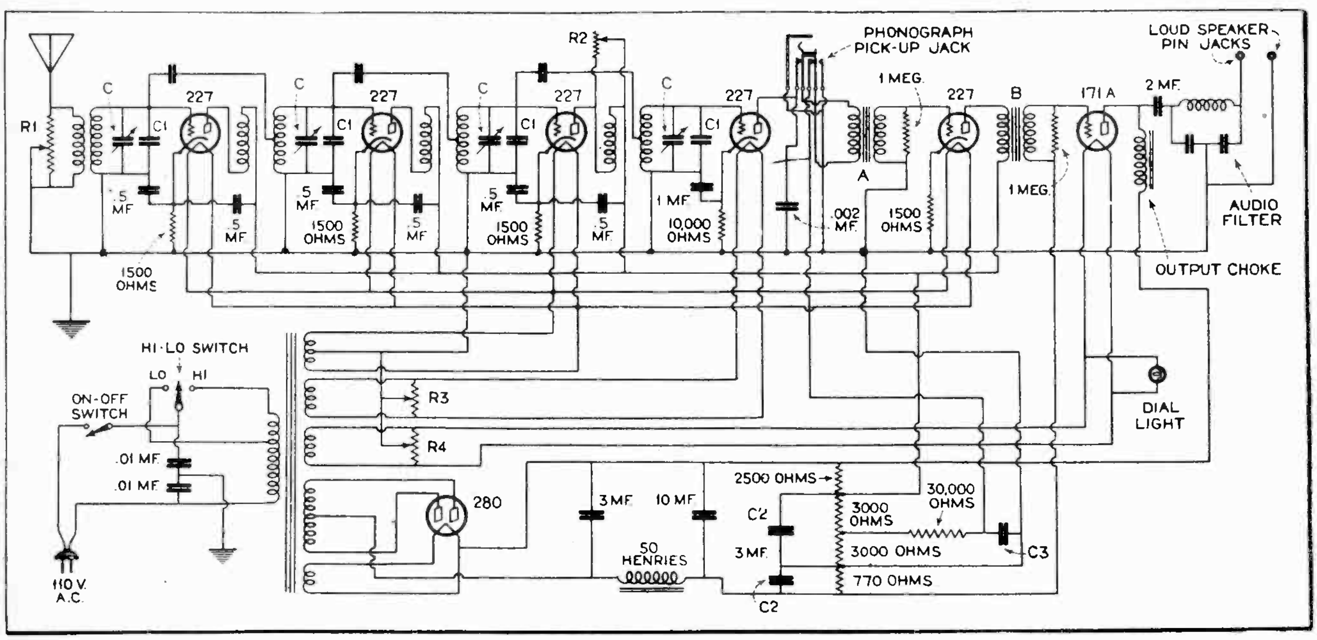


Fig. 3 Stromberg-Carlson 635-636 receiver

Practical Application of Analysis

These few pages will be devoted to the consideration of a certain phase of radio servicing which we believe to be of vital importance because it has a definite bearing upon the monetary profit accruing from the work. This phase will be known as the "process of elimination," or the "common-sense application of technical knowledge."

The application of the word "technical" should not lead the reader to believe that we mean a thorough theoretical grounding. The serviceman should be in possession of a certain amount of knowledge which must be applied in the proper manner. However, before we enter into this discussion, it is necessary to consider another significant item.

Repairs in the Home

"Where shall the serviceman do his work?" This question is undoubtedly of interest to every one in the fold. To come to a satisfactory conclusion, we must consider two sides of the problem; that of the serviceman and that of the receiver owner. All things considered, the serviceman is really the judge. He alone knows where he can operate to best advantage, but a few reasons in connection with this subject will undoubtedly throw a little light upon limitations encountered.

Let us first analyze the position of the receiver owner. It is true that he wants rapid service when he needs it. This is logical because a faulty receiver affords very little pleasure as an entertaining medium. Though the man desires rapid repair of the receiver, he does not wish to have his home littered with wrappers, frayed insulation, an assortment of tools and other paraphernalia usually carried by the serviceman. Granted that the serviceman is a neat worker, but he must operate at his convenience. The soldering iron must be connected to the power socket. A resting place for the iron support is necessary. Investigation of the chassis however, cannot rest on thin air, so amidst the surroundings of a well appointed room the operations of the serviceman and his equipment cannot help but be an eyesore.

On the other hand, rapid work is of importance to the serviceman. If the repair is effected in the home of the radio receiver owner, one service call suffices. If it necessary to make an inspection call followed by removal of the receiver chassis to the service station, an additional charge must be made. Charges of this nature are not viewed with pleasure by the receiver owner. Being unaware of the fault he may feel that the repair could have been made at his home.

Many servicemen cannot conveniently work at the home of the receiver owner, and unless the work is of a trivial nature, he should not do so. In view of the fact that the serviceman cannot carry all of his testing equipment, the necessary testing apparatus is not available and unless convenient operation is possible, work progresses slowly. Under the circumstances the serviceman should not attempt major repairs in the receiver owner's home. The psychological influence is not good in the first place.

In all of this discussion, we are concerned with actual receiver repair.

The replacement of a tube, the soldering of a broken or a loose connection does not call for the removal of a chassis to the service station. Receiver analysis, however, should be carried out in the home because upon its conclusion it is possible to advise the cost for repair. In connection with this work, it is necessary to consider the equipment required by the visiting serviceman. It is practically impossible to carry testing devices which will permit all types of analytical work, hence this equipment is limited to devices which will make possible a cursory analysis. The average a-c. and d-c. set tester, plus a continuity tester, are excellent representatives of this equipment. Tools, a soldering iron, solder, friction tape, etc. are beyond discussion. They are imperative and must be carried. In addition, every serviceman should have with him a headset, which device finds frequent application, yet is seldom a part of the average receiver installation, and last but not least, the wiring diagram of the receiver or unit to be serviced.

Methods of Operation

We queried numerous servicemen to ascertain their method of operation; to determine just how they managed to carry out their duties without overloading themselves with superfluous equipment. Their replies were very similar. We quote one, "I usually query the person calling, assuming that the need for service is advised in person or by telephone, and ascertain the type of receiver to be serviced and make an effort to determine the possible fault from the owner's statements. In many cases, this is possible. In others, I must excercise my own discretion. If I am advised that the receiver lacks volume and the tubes are old, I make a notation about tubes for future reference. If the condition is the same and the tubes are new and the batteries old, I make a notation about batteries. If the receiver is power operated, the batteries are eliminated. These notations find use when the wiring diagram of the receiver or unit is analyzed. Upon analysis, I know the types of tubes used and if possible I carry a full set to the job. A slight inconvenience, it is true, but if the tubes are at fault as is the case in many instances, I sell a full set and obviate the necessity on the part of the receiver owner, to visit a radio store and buy the necessary tubes."

"If the receiver employs B batteries and I believe that these batteries are run down, I usually carry a single 45 volt block. The addition of this new battery is sufficient to prove that the old B batteries are at fault, assuming of course, that the B batteries are actually useless for further utility. As a matter of fact, if the source of plate potential is unsatisfactory and the replacement of a defective B unit improves reception, it is conclusive evidence in the owner's eyes that the fault is what I claim it to be."

Spare Tubes

"I find very little occasion to carry receiver parts such as transformers, resistances and condensers, fixed or variable, because I seldom attempt to make major repairs at the home. If the receiver is "dead," that is reported dead, I do not carry any equipment particularly suited to the receiver in question unless I am advised that a tube or a number of tubes are burned out. With respect to tubes, I make it a practice to carry a single tube of each type. In other words, I carry a 201-A, a 226, a 227, a 281 a 171 and a Raytheon. These tubes consume very little space and are available when necessary to determine the efficacy of the tubes employed in the receiver. However, such tubes are not necessary if the analysis is complete and it is possible by virtue of elimination, to isolate the trouble with accuracy.

"In connection with "dead" receivers when I am so advised, I suggest various remedies over the telephone which are frequently effective and go a long way to create good will. It is my opinion that the insertion of a phone cord tip or a power plug into a power socket or the proper placement of a tube into a socket does not justify a service call. I prefer to suggest the remedy to the receiver owner. These suggestions can be made only when a wiring diagram of the receiver is at hand. The tube layout and connections to the receiver are also of importance and I make notations of various receivers when I make a call so that I have a layout for future reference. I very frequently advise receiver owners to interchange tubes and to determine if a tube filament is actually burned out because in numerous instances the tube prongs do not make proper contact and when the supposedly defective tube is placed into another socket, perfect operation is secured."

There you have the picture. The significant facts are evident. The serviceman equipped with an automobile is more fortunate than he who must use public conveyances but even the car owner will find it more convenient and profitable to repair defective receivers at the service station and to limit his testing equipment to such devices which will enable most rapid and accurate analysis.

The Process of Elimination

The isolation of a fault is the conclusion based upon analysis of the performance and operating conditions. The former is a function of the latter, being good when the latter is correct and poor when the latter is incorrect. Unfortunately, however, faults do not become evident immediately upon the analysis of performance because in many cases, the defect is present is present despite the correct operation of accessories which supply the required potential. After all, radio ailments are never mysterious, despite prevalent opinion to the contrary. Every ailment has its cause and every ailment displays some effect. In some cases, the symptoms are more readily recognized, in others, recognition is more difficult. In some cases, the effect is very evident, in others it is partially obscured.

The problems of radio servicing do not harbor as many puzzling phenomena as we are apt to believe, but without a definite method of procedure, the work will be made more difficult rather than simplified. Generally speaking, troubles do not occur in groups. Invariable they are singular unless a certain ailment, closely allied with potential in the receiver installation will so effect the system that some other portion will be damaged thus causing trouble in more than one section of the receiver. Neglecting the preceding sentence, trouble is usually limited to one part of the receiver system, unless as we have mentioned, the failure of one unit causes the failure of another. Therefore, we have two fundamental facts which are invariable substantiated in actual practice. Namely, that in practically every case, the fault is singular with respect to numbers and in one location with respect to the complete receiver. The exception is the ruptured filter condenser which causes an overload upon the eliminator rectifying tube and damage to the tube.

Albeit the fact that several ailments will manifest the same effect and influence, variations in effect are discernible to the close observer and isolation is greatly expedited by the process of elimination; the system of operation which we recommend. This line of progress necessitates recognition of the function of each unit and each complete system in the receiver. By units, we mean the various components such as resistances, condensers, coils, tubes, etc. By systems, we mean the radio-frequency amplifier, the detector and the audio-frequency amplifier. The systems have sub-classifications such as the filament circuit, the grid circuit and the plate circuit, all of which are associated with the vacuum tube.

Recognition of Symptoms

One cannot be a serviceman unless he is familiar with the work he must do and at the present moment, we take this familiarity for granted. Receiver analysis and diagnoses makes necessary recognition of symptoms which become evident in some form or other when devices perform in an incorrect manner. Recognition of these symptoms and association with certain parts of the receiver installation is half the battle and the actual basis for the process of elimination. Fortunately, the modern set analyzer greatly expedites diagnosis--but, if by applying the process of elimination, one can expedite the application of the set analyzer to a certain part of the system, time is saved and greater profit secured.

Explained in simple language, our suggested method of procedure is recognition of effects and the commonsense application of this knowledge. Specific phenomena are associated with various systems in the receiver and thoughtful discrimination between phenomena is a big stride towards the solution. It is indeed surprising to note how much is gained by a few moments of concentrated thought prior to the actual application of a set analyzer. The process of elimination does not obviate the necessity for the set analyzer. The two go hand in hand just like sales and service. The set analyzer is absolutely necessary, but the correct application of the process of elimination makes possible more profitable utilizatiin of the set tester.

The set tester supplements the process of elimination. This method of procedure is not a sure-fire proposition. Neither is every diagnosis made by a physician the correct diagnosis, but the failures are not numerous. The success is based upon how much technical information the applicant knows, i. e., the amount of technical knowledge at his finger tips. The many excellent textbooks afford detailed technical information, but this data must be applied to practice; it is unsatisfactory in its theoretical form. Much of the data pertaining to receiver performance is not to be found in the average text book, because while the phenomena are the results of theory, practice and theory are divorced.

Examples of Practical Application

Let us consider a few examples of the process of elimination when diagnosing. Again we wish to stress that the applicant must have a certain amount of technical knowledge. Not necessarily thorough theoretical training necessary for design work but practical knowledge of radio. As an illustration of the process, let us consider the Atwater-Kent receiver shown in figure 1. (The process of elimination was briefly mentioned in the previous chapter.) Our suggested process of operation is not limited to the receiver shown, but to all receivers regardless of type, of the number of tubes and to all amplifiers, eliminators, etc. The explanation is lenghty but the application is rapid.

The first example, involves lack of selectivity on certain stations, say 1 or 2, and also a low signal level when the receiver is tuned to these stations. Particular mention of the limited range of this condition is made because selectivity and signal level are satisfactory on the other wave lengths or stations. Selectivity is well-known, is a function of the radio-frequency amplifier, particularly the tuning circuits; also, the aerial and ground system. Since the detector input circuit is a part of the radio-frequency system, it is included under this heading. If this be true we can immediately eliminate the entire audio-frequency amplifier, because in function it has no connection whatsoever with the radio-frequency system, other than to amplify the audio-frequency signals passed to it from the detector plate circuit. Since the receiver operates normally over a certain portion of the broadcast waveband, it is logical that the operating potentials, such as filament, grid and plate voltages are correct and since these values do not vary with wavelength, we can likewise eliminate the power supply system. Analytical interest is, therefore, focused upon one certain portion of the receiver; the aerial and ground and the radio-frequency tuning system.

In view of the fact that the tubes in the radio-frequency system perform well over a certain portion of the waveband and the design of the 226 type of tube is such that wavelengths within the normal waveband, have no effect upon its operation we can immediately eliminate the tube as a possible source of trouble. Bearing in mind that the lack of selectivity is accompanied by low volume signifies that the trouble is not due to a poor receiving locality. Were this the case, the signal level would be low but lack of selectivity would not be a fault.

The search, therefore, narrows down to the tuning units. It is evident that the trouble, whatever it may be, is not present over the entire wavelength range. We know that a shorted turn or a number of shorted turns in an inductance, will reduce the electrical efficiency and cause broad tuning. This, however, cannot be the case since satisfactory performance is secured over a certain portion of the waveband. According to the wiring diagram, tuning is accomplished by means of a series of variable condensers, gang controlled, in shunt with a number of transformer windings. A resistance in one of these circuits would cause broad tuning but it would not be limited to one or two stations and it would not cause a decided reduction in signal intensity.

Since the coils are presumably in good condition, the only possible source of trouble is the tuning condenser system. A definite short circuit across one of the condensers would impair reception over the entire band. A short across the condenser when the plates are in a certain condition would so effect reception that the signals would cease. If the sensitivity of the receiver is so great that reception is possible with a shorted condenser, the short in one position of the condenser rotor would manifest itself by a series of clicks. Since this is not the case, the trouble is not a short circuit. The design of the tuning unit is likewise beyond discussion because of its performance over the remainder of the waveband.

Were the radio-frequency characteristic such that response on high wavelenghts would be less than low wavelengths, the lack of volume would not be accompanied by lack of selectivity. Hence, the only possible cause can be incorrect resonance at a certain setting of the tuning control. A checkup of condenser capacity at various settings of the tuning dials, is therfore in order.

Tracing Distortion

As the second illustration, let us consider the subject of distortion. Receiver output volume is satisfactory, or judged to be so, but the music and speech are not clear. The causes of distortion are numerous and the points of trouble in a receiver which might cause distortion are likewise numerous but as a general rule, distortion occurs mainly in the in the audio-frequency system. Distortion may be present in the audio-frequency coupling units and present in the form of frequency distortion where the audio coupling unit accentuates or attenuates certain frequencies. In view of the fact that this is a design detail, it may be eliminated at the start of the analysis, since its effect is not of the type generally understood as distortion.

In view of the fact that distortion may be due to incorrect tube operation and since it is to be found most frequently in the audio-frequency amplifier. Since operating potentials govern the performance of the vacuum tube, the first step is to check the grid, filament and plate potentials. If these are correct, the source of potential may be eliminated as the possible source of trouble.

Now in connection with this work, if the trouble is actually in the audio-frequency amplifier, the operating potentials may not always be correct. However, if the plate current of the 171 is excessive, it is necessary to analyze the wiring of this stage. As is evident in the wiring diagram, the filament circuit of this tube is an individual circuit. The grid bias for this tube is supplied by a separate resistance, hence whatever the trouble within this tube circuit, it is safe to assume that it has no connection with any other part of the receiver and it is therefore, unnecessary to check the other systems in the receiver until the incorrect condition in the 171 stage is rectified.

Tracing Electrical Disturbances

The third illustration is that of electrical disturbances such as crackling sizzling and frying sounds. Sounds such as the above may be attributed to many sources, but their possible locations are fortunately less numerous. Generally speaking, four sources need be considered: 1. Outside of the receiver with entry through the aerial-ground system. 2. In the power line circuit with entry through the power devices connected to the receiver, such as A and B eliminators. 3. External of the receiver with entry, by means of induction, to the receiver or the speaker lead when a long connecting lead is employed. 4. In the receiver itself, including of course, battery supply when used in place of the eliminators.

To determine the origin we must proceed step by step and eliminate each channel after test. The aerial and ground system is, of course, the simplest and should be tackled first. With the receiver adjusted to maximum sensitivity so that the disturbance is loudest, disconnect the aerial. If the disturbance ceases, its source is external of the receiver and the associated power equipment. By this simple process, we preclude the necessity of testing the remaining equipment. Since we know the means of entry, the aerial, we must attempt to locate the origin. Unfortunately, this test is very limited but the results are conclusive nevertheless.

An examination of the aerial is the next step, because a swaying aerial which strikes or makes intermittent contact with grounded objects, such as pipes, stacks metal poles, metal skylights or other aerials, will cause a click each time contact is made and broken. If the trouble originates at this source, remedy is simple, but if the aerial is perfect, the disturbance originates at some nearby source and is radiated, just as the radio signal to be picked up by the aerial and passed into the radio receiver as if it were a desired signal. Remedy at the receiving end is impossible--the disturbance must be suppressed at its source. Any device connected into the aerial system in order to attenuate or eliminate the disturbance, will also eliminate the desired signal. Complaint that such disturbance is more pronounced at the lower end of the tuning dial or on the low wavelengths, is due to greater receiver sensitivity on the low wavelengths.

Vacuum Tubes

To disseminate radio information pertaining to radio service work is a lengthy procedure. Not necessarily tedious--but lengthy. In view of the fact that a little knowledge is dangerous, we believe that a detailed analysis will serve better than a cursory explanation of the details involved.

We concluded the last installment, relative to the "process of elimination" by stating that the following article will concern radio-frequency amplifiers. We are going to change the routine and delay comment upon this subject until some future time--as there are a few other points we had best cover first.

Service data associated with any part of the radio receiver involves the vacuum tube, since this tube is a part of each system and its operation is controlled by the condition of the various systems, including the power supply units and circuit continuity. Hence, we believe that the first item subsequent to the general discussion contained in the first two installments, should be the vacuum tube. Now, we wish to make clear that we are not attempting an elementary course in vacuum tube design or radio in general. We recognize fully that some of the information contained in these pages is known to some of the readers, but we are also certain that some of the data supposedly known is not fully comprehended. Hence, we move along this line of progress. By discussing vacuum tubes at this time we eliminate the need for futher discussion as we progress through trouble diagnosis and isolation.

We take for granted that the reader is familiar with the structure of the conventional type of three-element vacuum tube,and to a certain extent with the function of the various elements. We will dwell to a certain extent upon the latter in a manner somewhat different than the conventional.

Vacuum Tube Tests

Radio receiver servicing, to be profitable, requires the most rapid form of work consistent with accuracy and the attainment of results. With this in mind, one cannot help but wonder about the most suitable test for a vacuum tube to show its condition and to prophecy its degree of performance. In this connection, we must realize two conditions: first, the tube which is new and second, the tube which has been in use for a period of time.

The average vacuum tube has four important constants; electronic emission, plate impedance, amplification constant (mu) and the mutual conductance. Now, it is quite logical that a rapid test of the vacuum tube need not involve the determination of all of these constants, particularly if the tube is new. The same is true if the tube is removed from a defective receiver. The reason for this is that these constants are governed by one major element, the condition of the filament. If the filament is intact and in perfect condition, and if the physical structure of the tube elements has not been altered, the various electrical constants will be as decided upon in the design. If, however, the most vulnerable part of the tube--the filament-- has undergone some change, it will influence some of the electrical constants of the tube, since the value of the constant is governed by the number of electrons emitted by the filament. By this we do not wish to imply that the design of the filament governs the constants. What we mean to s ay is that the electronic emission from the filament exerts a tremendous influence upon the two most important tube characteristics; the plate impedance and the mutual conductance. The amplification constant remains uniform over a very wide range of filament temperature and electronic emissivity. Therefore, as a rapid test, the electronic emission is as good as any, assuming no physical damage to the tube.

As an illustration of the above, the amplification constant of the average 226-type tube remains between 8.2 and 8.4 over a filament potential range from .5 to 1.7 volts, whereas the plate impedance is approximately 43,000 ohms at .75 volt and 8,000 ohms at 1.5 volts-- and the mutual conductance is approximately 250 micromhos at 1.5 volts on the filament.

Electronic Emission

The importance of satisfactory electronic emission is self-evident. With respect to the test of a tube removed from a receiver, the paramount test is that for electronic emission, bearing in mind that the tube has been in use for a period of time, rendered satisfactory service during that time and that the physical structure of the tube does not undergo a change, unless of course, the tube is subjected to a violent physical shock, which might jar an element loose or break continuity between the wires connected to the tube prongs and the elements. Usage will not alter the plate impedance or the mutual conductance values if the filament emissivity remains constant. With respect to disconnected elements, this condition will be evidenced by certain symptoms and will become evident in a simple plate current test which follows the filament emission test, the latter, however, being the first test made.

We can state without detailed explanationthat the most vulnerable part of any vacuum tube, irrespective of type, is the filament. Furthermore, the element which deteriorates most rapidly during operation of the vacuum tube is the filament. In the filament type of a-c. tube, the filament is the source of electrons, exactly as in the case of the d-c. tube. In the cathode type of a-c. tube, the cathode is the source of electrons. Hence, if in the first two instances, the source of electrons undergoes the most rapid change, the same may be considered to be the case in the cathode type of a-c.tube. In addition, we must consider volatilization of the filament in this tube and the production of less heat with which to heat the cathode and also burnout of the filament. Since the operation of the tube is governed by the electronic emission by the electron emitting element, the primary test is that for electronic emission. In the d-c. type of tube employing a thoriated filament, the thorium is burned away and the abundant emission of electrons, due to the thorium ceases. Since the tube is designed for operation with the thorium in the filament, deactivation of this type of filament will impair the operation of the tube.

The same is true in the case of the filament type of a-c. tube, with the exception, that in this instance, the abundance of electrons is due to an oxide coating upon the filament. After this oxide is burned away, the filament does not emit sufficient electrons for satisfactory operation. In the cathode type of a-c. tube, the cathode is the electron emitter, and if the heat generated by the filament (heater) is insufficient, the electronic emission will be insufficient. If, on the other hand, the oxide coating upon the cathode is burned away during operation, the number of electrons emitted will reach a low level where the tube is useless.

Emission Tests

Electronic emission tests must be made under definite prescribed conditions, a requirement which is not fullfilled in everyday practice. These specifications are compiled by the vacuum tube manufacturers. It is true that each individual serviceman can develop his own calibrations for electronic emission, but no matter how it is arranged, definite values must be employed. Every type of vacuum tube has a definite minimum value of electronic emission at certain values of filament and plate potential. This, however, does not signify that all tubes are tested under identical conditions, unless they are of similar type, in which case what has been said does not apply, and all tubes of similar type are tested under identical conditions. Electronic emission in excess of the minimum value is permissable.

The following is the minimum electronic emission value of each tube mentioned and the recommended operating voltages. These values are recommended by E. T. Cunningham, Inc., and are excerpts from their engineering bulletins.

Tube	Fil. Volts	Plate Volts	Minimum Emission (Millia-) ampers)
12	1.1	50	6.0
299	3.3	50	5.5
220	3.3	50	13.0
301A	5.0	50	20.0
300A	5.0	50	14.0
340	5.0	50	14.0
112	5.0	50	45.0
112A	(No emission tests)		
371	5.0	50	40.0
310	6.0	100	85.0
350	6.0	250	505.0
326	1.5	50	35.0
327	2.5	50	35.0
313	4.0	100	40.0 (each anode)
316B	6.0	125	85.0
380	5.0	80	100.0
381	6.0	150	200.0

(The plate voltage values mentioned are the voltage applied to the grid and plate connected together as an anode. Although Cunningham designations have been employed, these values are applicable to the UX and to all similar type tubes.)

The practice of judging a tube by the normal plate current reading alone, gives very little indication of the tube performance as an audio amplifier, a detector or as a radio-frequency emplifier. As a matter of fact, while the plate current is a function of the electronic emission (since the condition of the filament influences the plate reading) filament condition is best determined by an electronic emission test. As a guide to performance as an amplifier, the plate current reading alone will not afford conclusive evidence to the negative or the affirmative since other items must be taken into consideration. These are the amplification constant and the mutual conductance. Fortunately, however, as we stated earlier in this text, measurement of these values is unnecessary. The electronic emission test should be the the first observation followed by any simple test to show correct operating conditions and continuity of the elements.

Tube voltage specifications must be strictly observed. This applies to all voltages; filament, grid and plate. Frequent mention is made that tube filament life is prolonged by operating below the rated filament potential or temperature. This is true under certain conditions, which due to the trend in tube filament structure design is applicable to all a-c. receivers. Sub-normal filament potential operation of the thoriated tungsten filament prolongs the life of the thorium, that is, the period of operating life, but it alters the molecular structure of the tungsten, making it more brittle and subject to fracture more easily. Excessive filament temperature dissipates the thorium more rapidly and increases volatilization of the tungsten. Hence, such filaments should be operated at normal filament potential and temperature. The same is not true of the oxide coated filaments, where operating life is prolonged by operation below the rated temperature. So much for that at the present time.

Plate Current Tests

In contrast to the electronic emission value when testing a tube, the plate current value is a barometer of circuit conditions when testing receivers with the vacuum tubes in the respective sockets and in the tester socket connected to the receiver. Experience plus the manufacturer's specifications will advise advise the correct plate current values for various values of plate voltage, as measured with the test set. Correct interpretation of these values expedite isolation of the trouble.

In connection with what is to follow, we wish to make clear that these conditions are not the only ones encountered. Many others will confront the serviceman, but if we remove the haze around a number, the remainder will be viewed in much better light. As we stated, we are concerned with the vacuum tube, and we will consider the items which are associated with the vacuum tube and which manifest some effect upon it.

In view of the fact that receiver installations are of two types, namely, those employing batteries as sources of potential and those employing power devices, such as eliminators, for sources of potential, it is necessary to consider them separately. Let us take the battery source of potential first. The first condition shall be excessive plate current, as indicated upon a set tester or analyzer, when this device is being employed to check a receiver and to locate the defective part. Excessive plate current may be due to several conditions and for purpose of illustration we show two plate current grid voltage curves in Fig. 4. These curves are for different values of plate voltage and are not the curves of any one specific tube, but are used merely to illustrate the point mentioned. The plate current values are designated upon the ordinate line on the extreme left and the positive and negative values of grid voltage are shown upon the abscissa. These curves are allied with receiver operation and circuit conditions may be applied to these curves for interpretation. If one comprehends this data, much will be gained.

The designations "Ep 90" and "Ep 135" mean that the first curve is representative of a condition when the plate voltage is 90 and the other when the plate voltage is 135. Let us consider the point "o grid volts" as the starting point for our discussion. The plate current values indicated on the ordinate are the values indicated on the set analyzer plate current meter. According to the curves in Fig. 4, the normal plate current for Ep90 and 0 grid bias is 10 milliamperes and for Ep 135 and 0 grid bias, the normal plate current is 12.5 milliamperes. It is, therefore, obvious that as the plate voltage is increased, everything else being normal, the plate current increases. Discounting the plate current saturation point governed by the maximum filament emission, it can be said that excessive plate current may be due to excessive plate potential. If we could draw a curve for Ep equal to 200, the plate current with 0 grid bias would be much greater than 12.5 milliamperes.

Now, suppose that we operate with the curve marked Ep 90 and consider the positive and negative grid bias voltages. According to the graph, the negative voltage has a maximum of 20 volts and the positive voltage a maximum of 8 volts. The reason for the unequality is that positive bias is seldom employed. We neglect the small positive bias employed with grid leak condenser systems of detection, since the bias does not approach the maximum of 8 volts shown. For a plate potential of 90 volts, the usual grid bias is about 4 volts or perhaps a little more. According to the curve, the normal plate current with this plate and grid voltage is about 6.3 milliamperes. We are aware that this value is in excess of the usual value encountered in receivers, but we employ it because it is better for illustration. At 0 grid bias the plate current is 10 milliamperes, an increase of approximately 3.7

milliamperes when the 4 volt grid bias is removed. It is, therefore, evident that the grid bias controls the plate current and if the grid bias is less than normal, the plate current will be more than normal, hence excessive plate current may be due to insufficient grid bias. If we move into the territory occupied by the positive grid bias voltages, we find that with a grid bias of plus 4 volts the plate current is increased to 12.5 milliamperes, (the curvature of the plate current curve has no significance) and if the normal plate current is supposed to be 6 milliamperes (Ep 90 with 4 volts negative grid bias), it stands to reason that excessive plate current may be due to incorrect polarity of the grid bias--the bias being positive instead of negative.

Referring again to Fig. 4, it is evident that the grid bias controls the value of plate current, when the plate voltage is normal. Also that if the plate voltage is less than normal it is still possible that the plate current should be excessive as for example--the normal plate current for Ep 135 and 8 volts negative grid bias is 6 milliamperes, the plate current for Ep 90 and 1 volt negative grid bias is 9 milliamperes. Although lacking an illustration, excessive plate current may also be due to excessive filament potential.

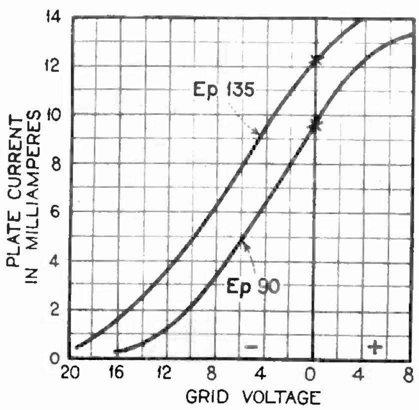


Fig. 4

Representative plate current, grid voltage characteristic curves of a vacuum tube.

With the above in mind and with one exception, it stands to reason that the reverse conditions may cause insufficient plate potential with normal bias may be the cause for insufficient plate current. Likewise, excessive negative grid bias may be the cause for insufficient plate current. The exception we mention is the application of a positive grid bias, which can never cause insufficient plate current, since it will always increase rather than decrease the plate current.

Floating and Positive Grids

In connection with this discussion of plate current, we must mention another condition before we move on, and this is an unsteady or fluctuating plate current observation. Contrary to the opinion of many, this condition does not indicate a poor contact inthe plate circuit. Instead, it is due to an open in the grid circuit, resulting in a "free" or"floating" grid. The fluctuating plate current is an indication that the grid is not at a steady operating potential; the grid intermittently accumulating a heavy negative charge which reduces the plate current to zero or therabouts and then losing this charge, again permitting normal plate current, only to again repeat the procedure. The proof that this condition is not due to a poor contact is that the variation is uniform in frequency and is found when the receiver is not passing signals and that the plate voltage is normal and steady at all times, even when the plate current is zero.

Now, we refer to Figs. 5 and 6 to illustrate the points mentioned in connection with the curves in fig. 4 and to bring out a few pertinent details which were not represented and discussed in Fig. 4. In Fig. 5, we view an ordinary stage in an electric receiver, employing an eliminator as the source of grid potential, the potential being due to the passage of the tube plate current through the resistance and the consequent voltage drop. Referring to excessive plate current with normal plate potential we find that a leak between the plate winding of the transformer connected to the plate of the preceding tube and the grid winding of the tube in question will cause the application of a positive potential upon t he grid, which will either neutralize the negative grid bias or will submerge the negative grid bias, and cause a positive bias. This condition arises frequently in resistance-capacity audio amplifiers and in some impedance-capacity audio amplifiers, due to a leak through the isolating or coupling capacity as many call this condenser. Other cases have been the radio-frequency transformers where scraping of the insulation permitted contact between the plate and the grid turns, or some other form of short; also a leak between the plate and grid windings of audio-frequency transformers or between the plate and grid leads.

General Voltage Checks

Referring to Fig. 5, we have designated four important sources of potential; V, V1, V2 and V3, each one having a bearing upon t he reading observed upon the plate current meter, MA. If the plate current is excessive and the measurement of the plate voltage shows it to be greater than normal, V, V1 and V3 are not involved and examination of V2 is in order. The possible troubles in the source of V2 are two in number. First, the input voltage, and second, the voltage drop across the voltage divider resistance, or an open in the voltage divider resistance, The condition of the voltage divider system is evidenced by the plate voltages applied to the other tubes in the receiver. If voltage is being applied to the detector tube plate and the voltage divider system is of the potentiometer type, it is safe to assume that nothing is wrong with the divider resistance. Even if the resistance usually employed between the detector tap and the B minus is open, satisfactory operation will be possible, although the output voltage will be higher along the various taps, because the insertion of this resistance increases the current load upon the eliminator.

It is now necessary to consider the operating characteristic of the average B eliminator. If the current load is reduced the output voltage increases and, conversely, if the current load is increased the output voltage decreases. This condition is influenced by the grid bias, the output voltage increasing as the negative bias, the output voltage necessary bias is increased, since this action reduces the plate current, hence the current load. In this case however, the plate current is excessive, hence it is doubtful if it is due to excessive grid bias. If the grid bias were positive, it would cause the increased plate current, but such an increase in plate current load would have a tendency to reduce the output plate voltage. But one conclusion is possible --- at some other point in the receiver the load upon the receiver eliminator has been removed or reduced. Perhaps a plate circuit is open, or if the voltage divider employed in the eliminator utilizes individual resistances, one of these resistances is open. In this connection one can eliminate the detector tap. since the current consumption at this tap is so small that the removal of this small load will have very little effect upon the system.

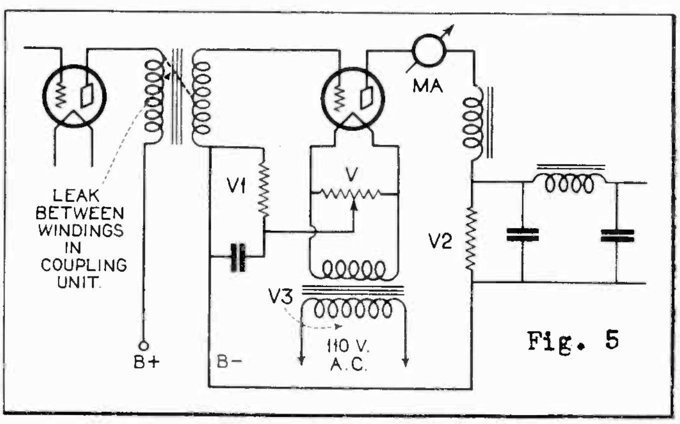


Fig. 5

Generalized circuit indicating the four important sources of voltage, and a possible source of leakage.

If the tube under observation is the output tube, it is possible that the lead supplying plate voltage to the other tubes is open, and vice versa. If the voltage divider system is of the potentiometer type and the tube being tested is one of the amplifying tubes, exclusive of the output tube, an open in the voltage divider system between the amplifying tube tap and the main lead is out of the question, since such a break would open the circuit and the plate voltage necessary for the work would not be available for the tube being tested. However an open between the maximum voltage tap and the output tube plate is possible and such a condition would cause the application of excessive potential upon the plate of the tube being tested.

We must also consider another possibility, the lack of function of voltage reducing resistances in the plate circuits, exclusive of the voltage divider resistances in the eliminator. An idea of what we mean is shown in figure 6. The tendency towards excessive plate current with excessive plate potential, due to the condition cited, is greater when the C bias resistance is incorporated in the eliminator, rather than in the grid circuit of the tube in question, as shown in figure 5. In the latter position the grid bias voltage increases as the plate voltage and plate current increase.

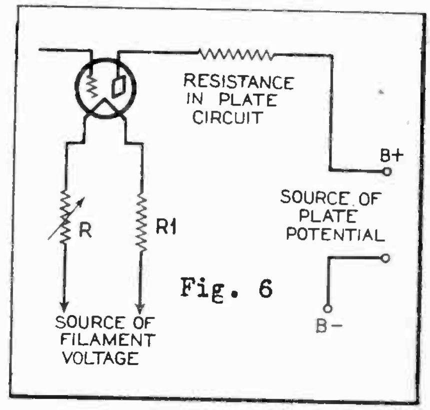


Fig. 6

In trouble shooting, it is well to keep in mind that voltage-reducing resistors are often incorporated in the receiver circuit proper.

Causes of Low Plate Voltage

It is impossible to give a detailed analysis of the reasons for all conditions to be encountered in a defective radio receiver. However we shall consider at length, the condition mentioned above and later make mention of the reasons for other conditions, without delving into the ramifications of the subject.

Insufficient plate voltage and plate current may be due to several conditions in the system. First, a marked reduction in the input voltage feeding the B eliminator. Second, excessive voltage drop in the eliminator rectifier tube or element, due to defective condition of the tube or element. Third, excessive voltage drop in the filter system. Fourth,a shorted bypass condensers across one of the sections of the eliminator voltage divider resistance network, which would reduce the total network resistance, increase the current flow through the network, hence the current load. This would cause a reduction in the total output voltage. Furthermore, if the C bias resistance is located in the B eliminator, the action mentioned would cause a marked increase in negative grid bias, consequently increases negative grid bias and greatly reduced tube plate current. In this discussion we assume that the shorted condenser is not connected across one of the plate voltage taps which supplies plate voltage to the tube under test. The effect of the shorted bypass condenser would become evident during the plate voltage

With respect to V1 in figure 5, we must mention a similar resistance located in the B eliminator. In both cases the resistance is bypassed with a capacity. A short in this condenser will short the resistance and eliminate the C bias, thus greatly increasing the plate current and reducing the plate voltage, due to the operating characteristic of the B eliminator. However the reduction in plate voltage will not equal the increase in plate current, that is, in effect.

With respect to an open in the grid circuit, two conditions may prevail, depending upon the position of the break. If the "opn" is located between the grid of the tube socket and the grid end of the unit connected across the grid-filament circuit the "free" grid condition mentioned will prevail. On the other hand, if the break is located at a point where it opens the filament and -B circuits, the plate current meter will read zero, since circuit continuity between the plate and filament has been broken

Such a condition would exist if the grid bias resistance supplying V1, in figure 5, were to open.

The value of the resistance associated with the designation V1 in figure 5, governs the value of the grid bias applied to this tube. If it is excessive, the negative grid bias is excessive and the reading on the meter MA will show insufficient plate current. Conversely if the value of resistance is less than normal, the reading on the meter MA will be greater than normal, showing excessive plate current.

Insufficient or excessive values of V, the filament potential, is governed by the value of V3, the input voltage, when a transformer is used, and the potential value of the battery, if a battery,or an eliminator is used. Also upon whatever voltage reducing resistances may be employed in the filament circuit, as shown in figure 6. If, assuming correct source of potential, these resistances are excessive in ohmic value, the value of V will be less than normal and the reading on MA will be less than normal. If, on the other hand, the ohmic value of these resistances is less than normal, the value of V will be greater than normal and the reading on MA will be greater than normal.

As we stated we cannot delve into the innermost details associated with various conditions. We will however enumerate the possible reasons or causes for various conditions. In connection with these details it is necessary that the reader realize the various conditions. We of course understand that reference to these details cannot be made during the process of servicing. However comprehension of what is contained in these pages will fortify the service man with sufficient knowledge that he may interpret into practice. We hope that the reader realizes that these details pertaining to filament,grid and plate voltages are associated with the commercial or as far as that goes, with all set analyzers. It is unnecessary to mention the application of these testers, i.e. how to employ the testers. We hope to explain the interpretation of the meter indications.

Let us therefore devote some time to facts associated with various voltage and current indications, since these figures constitute the basic analysis.

Excessive plate current with normal plate voltage may be due to:

1. Excessive filament voltage
2. Insufficient grid bias
3. Defective tube
4. A leak between the grid and plate windings of the coupling unit.
5. Incorrect polarity of the grid bias voltage
6. A leaky isolating condenser in a resistance or impedance coupled amplifier.

**** The foregoing are probable causes for excessive plate current with subnormal plate voltage. It is possible that one of these conditions may cause excessive plate current when the plate voltage is excessive. In this connection it is necessary to add the possibility of excessive plate voltage.

Insufficient plate current for normal and excessive plate potential may be due to :

1. Insufficient filament potential
2. Excessive grid bias
3. Excessive voltage drop across unit in plate circuit
4. Incorrect polarity of grid bias, where correct bias is positive to grid

5. Open grid circuit
6. Defective tube
7. Deactivated filament

**** Erratic behaviour was mentioned earlier in the text.

Excessive plate potential may be due to:

1. Insufficient load upon power B device
2. Excessive battery voltage
3. Insufficient voltage drop across units in the circuit
4. Excessive line voltage feeding power B unit.
5. Excessive grid bias potential when secured from separate device
6. Insufficient grid bias potential when secured from B unit.
7. Incorrect tap on battery or power B unit
8. Open in voltage divider system of B unit, between Det. and B-
9. Shorted filter chokes

Excessive filament potential may be due to:

1. Incorrect adjustment of voltage reducing resistance
2. Excessive battery voltage
3. Insufficient load upon transformer winding
4. Excessive line voltage feeding transformer
5. Incorrect voltage reducing resistances
6. Incorrect adjustment of power A device
7. Excessive line voltage feeding A eliminator
8. Shorted filter choke in A eliminator

**** Insufficient filament potential is due to the reverse conditions mentioned for excessive filament potential. Also

1. Incorrect line voltage reducing resistance
2. Wrong tube in socket and excessive current drain.

Excessive grid bias may be due to:

1. Excessive grid bias battery voltage
2. Excessive value of resistance when bias is secured from power B unit
3. Excessive value of grid bias resistance at any point in system

**** Insufficient grid bias may be due to the reverse conditions mentioned in connection with excessive grid bias. Also

1. Shorted grid bias resistance bypass condenser
2. Leaky grid bias resistance bypass condenser

Insufficient plate potential may be due to:

1. Defective rectifying tube or element
2. Excessive load upon power B device
3. Excessive voltage drop in power B filter system
4. Leak across rectifying system
5. Insufficient line voltage input

6. Insufficient voltage input into rectifying system
7. Excessive current drain across voltage divider network
8. Shorted section of voltage divider network
9. Excessive resistance in cable between source of potential and tube
10. Excessive voltage drop across voltage reducing resistance in plate circuit
11. Leaky plate circuit bypass condenser

Operating Systems

Inorder to facilitate comprehension of subsequent data, it is essential to discuss certain parts of complete receiver systems. Not because the system itself is of importance in servicing, but because mention of a defect in these systems appears quite frequently and the interpretation of the location of the defect is essential.

Neutralizing Systems

Stability is an important feature of every radio frequency amplifier. The greater the number of stages employed in the system, the greater the tendency towards instability. Minimization of regeneration or feedback from one stage to the other or from one circuit to the other is of extreme importance. Now, in connection with what is to follow, it should be definitely understood that the manufacturers of radio receivers represented in this book in the form of receiver wiring diagrams are in no way responsible for statements made in this book. Whatever analytical statements are made, they are the conclusions of the author of this work and not the opinions of the organizations whose wiring diagrams are shown herein.

Stabilizing or neutralizing systems employed today are of various types, usually employed in the radic frequency amplifier. Anti-regeneration units are in some case employed in audio frequency amplifiers as well, but these do not require discussion. The most freqent systems employed for stabilization involve the use of a condenser whereby a certain magnitude of voltage is fed back from one circuit to the other to counteract the voltage existing across the grid and plate of the radio frequency tube involved; the grid and plate of this tube constituting a capacity. The second system involves the use of a resistance in the grid or grid filament circuit of the vacuum tube in question. usually external of the tuned circuit.

Fig. 7

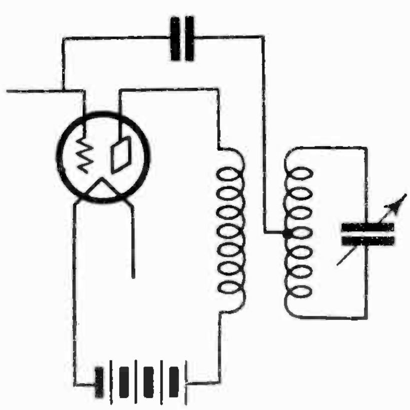


Fig. 8

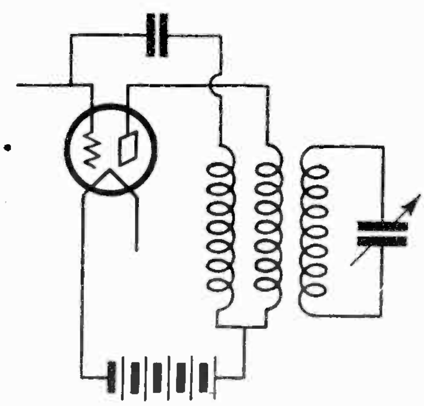


Fig. 9

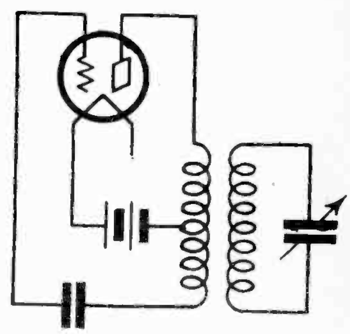


Fig 10

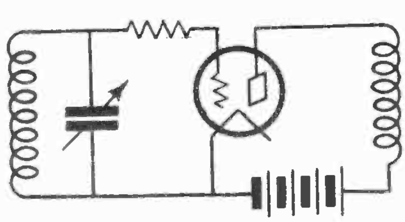
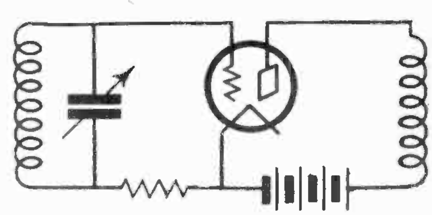


Fig. 11



The degree of stability with the grid suppressor arrangement is a function of circuit conditions and the value of resistance employed.

As is evident the association between the grid circuit of the tube and the stabilizing agent is closer in the case of the grid suppressor, since it is an actual part of the grid circuit and grid circuit continuity is via this resistance. As in the case of the condenser system incorrect adjustment of the resistance, in this case a matter of ohmic value, will influence receiver operation. If the ohmic value is too low, the system will oscillate and impair reception. If the ohmic resistance is too high, it will impair reception by reducing sensitivity. An "open" resistance will naturally impair reception since the grid circuit is open.

In connection with the condenser arrangement, the need for perfect insulation in the condenser is very evident. In one arrangement it shorts the plate circuit and in the other it shorts a portion of the grid circuit or rather the grid inductance. An open in the neutralizing system of this type will mar reception by creating an unbalanced state.

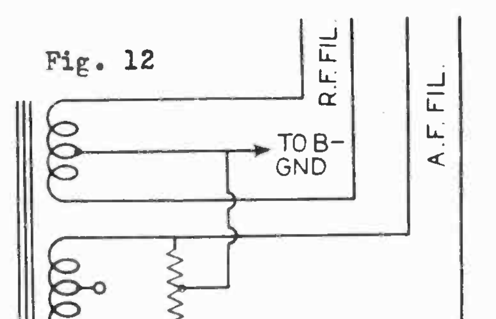
Filament Circuits

Troubles arising in the filament circuits of battery operated receivers are easily discovered and manifest operation in such manner that isolation of the fault is simple. In A.C. circuits however, diagnosis is a little more difficult. Here we must consider the type of tube involved. Fortunately, one type of tube is the greatest offender. Rather the equipment employed in the filament circuit of this tube is the basis for the trouble. Albeit the explanation of A.C. filament circuits in the first volume of this series, in "The Mathematics of Radio", we will give a short resume in this book. In view of the use of alternating current for actuation of the A.C. tube filament it is necessary that a certain point of stability be secured in the filament circuit so as to provide a point of return for the grid and plate circuits.

In the 226 type of tube, the filament is the source of electrons and as such constitutes a part of the grid and plate circuits. Bearing in mind that the filament potential is A.C. and that the potential difference between various points of the filament and the other elements of the tube is not constant, it is necessary to obtain a point in the filament circuit where the potential difference between the filament and the grid will remain constant, thus avoiding the hum due to the variation in potential difference due to the type of potential employed to operate the filament. This condition of filament circuit stability is secured by means of a centre tapped transformer or a resistance with a variable centre tap, in shunt with the filament, as shown in figure 12. The centre tap of the transformer or the centre tap adjustment of the filament shunt resistance constitutes the B- and the grid and plate return.

If this resistance is necessary to secure balance, it stands to reason that accur- adjustment of the centre tap is necessary. This happens to be the case and when non-existent is the cause for disagreeable hum. Hence accurate adjustment of the filament shunt resistance is always necessary when the 226 type of A.C. tube is involved. Furthermore one adjustment does not hold good with all types of tubes and a change in tubes necessitates a change in adjustment. Sometimes such a change is necessary and at other times it is not. In some cases, the centre tap on the transformer is not the electrical centre

Fig. 12



in which case it is necessary to replace the transformer centre tap with a filament shunt resistance, employing the centre tap on this resistance in place of the transformer centre tap.

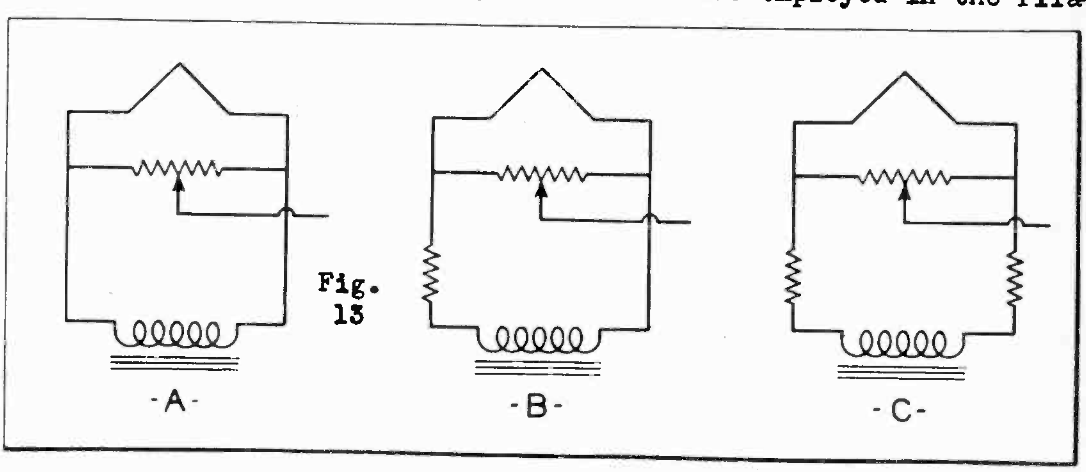
Since so much stress is being placed upon the location of the centre tap much discussion is not necessary to show that an open in this resistance will cause a great deal of hum. An examination of figure 12 will show that an open between one side of the resistance and one side of the filament winding will not impair reception since the B- lead is still intact between the filament and the plate circuits. However the required balance is not be obtained and the result is a bad hum, which will not reducing the magnitude of amplification available with the system does interfere with the quality of reproduction.

In the 227 type of tube, the filament is not the source of electrons. Instead, the electrons required for operation of the tube are emitted by the cathode and the voltage fluctuations present across the filament are not encountered in the cathode and the consequence is that the adjustment of the filament circuit centre tap is not of particular importance, other than that it should be intact with respect to continuity.

Comparison of the data mentioned will show that a fixed centre tap used in conjunction with the 226 type of tube is not conducive to best operation. This is recognized by the receiver manufacturers and the "hum balancing" resistances are usually provided with a variable control and are accessible to the service man. As is to be expected in view of the fact that the 60 cycle hum is within the audible range, correct adjustment of the balancing resistances is of greatest importance in the audio frequency amplifying system.

In connection with "hum" due to conditions in the filament circuit, we muct make mention of induction from the filament wiring to associated grid and plate circuits. Close proximity of the filament wiring to either grid or plate circuits will cause a hum and wherever possible the filament circuit should be isolated. With respect to the actual wiring, the filament circuit wiring should be of the twisted cable type.

Reference must again be made to the centre tapped filament transformer. Experience has shown that in many instances the centre tap is not the actual electrical centre tap, due to unbalanced filament circuit wiring. The suggested remedy should be tried. In the event that filament voltage reducing resistances are employed in the filament circuit, they should be utilized as shown in figure 13 A,B and C. The filament shunt resistance should be nearest the tube, between the tube and the filament voltage reducing resistances. In the event that the transformer centre tap is employed in conjunction with filament voltage reducing resistances, two such resistances must be used as in figure 13 C.



Grid Circuits

Special reference to grid circuits involves the use of various arrangements to secure the required grid bias voltages. This discussion is necessary because the receivers in use today do not employ a common system. Some employ the bias secured from the B eliminator, whereas others employ a resistance in the cathode circuit and for certain types of tubes, employ a resistance in the grid-plate-filament circuit. Also various arrangements are employed in the detector circuit.

Fig. 14

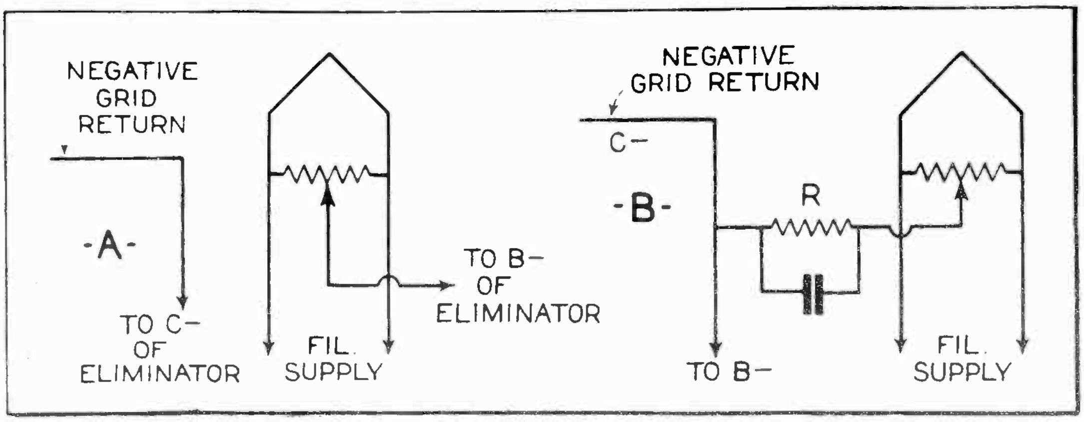


Figure 14, shows the 226 type of tube arranged in two ways. First, with the C bias secured from the B eliminator (A) and second, with the C bias secured by means of a resistance, (B). The former method will be discussed when B eliminators are discussed. With respect to the latter method however, let us analyze the position of the resistance R. Note the position of the B- lead. Since the filament is the source of electrons and B+ is connected to the plate of the tube, the plate current, inorder to reach the filament, must needs flow through the resistance R. We refer to the plate current of the tube shown. Since it flows through R, it causes a voltage drop across this resistance, which drop is applied to the grid as the negative grid bias.

In connection with these two systems it is necessary to note that in one case the centre tap of the filament shunt resistance is connected to B-, whereas in the other it is connected to the grid bias resistance. This means that in one instance a potential difference is to be found between the filament centre tap and the B-. In the other case, no such difference is present. It is present in B and not in A.

With respect to trouble, it is evident that a short in the condenser bypassing R will short the C bias but it will not interfere with continuity in the plate-filament circuit. An open in R will however interfere with the circuit cintinuity mentioned and will at the same time eliminate the C bias. A leaky bypass condenser, as is evident will interfere with the C bias, since it will affect the ohmic value of R.

The circuit arrangement employed with the 227 type of tube is somewhat different. Once again the grid bias may be secured by means of a resistance in the plate filament circuit. In this case however, the resistance is not in the filament circuit, since the filament is not the source of electrons. In this tube, the cathode is the electron emitter and the resistance is in the cathode circuit so that the plate current inorder to reach the cathode must flow through the grid bias resistance. This is shown in figure 15, the system being employed to secure the grid bias for the radio frequency amplifying tube. The system however is not limited to use in amplifying stages. It is applicable with equal facility in detector systems, designed for operation as grid bias detectors. An idea of what we have in mind is shown in figure 16 D. In some cases the cathode of the 227 is connected directly to B−; usually when gridleak and condenser systems are employed. This is shown in figure 15 and in 16 B. The application of the grid bias resistance in the plate-filament or rather plate-electronic emitter circuit is shown in the various illustrations in figures 15 and 16.

Fig. 15

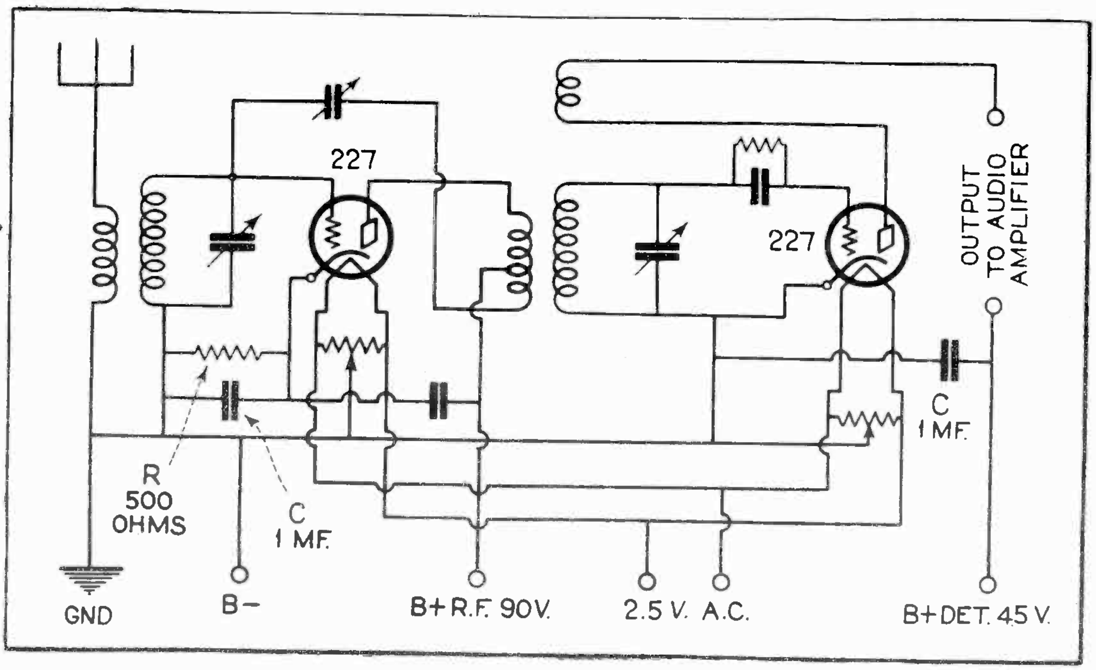
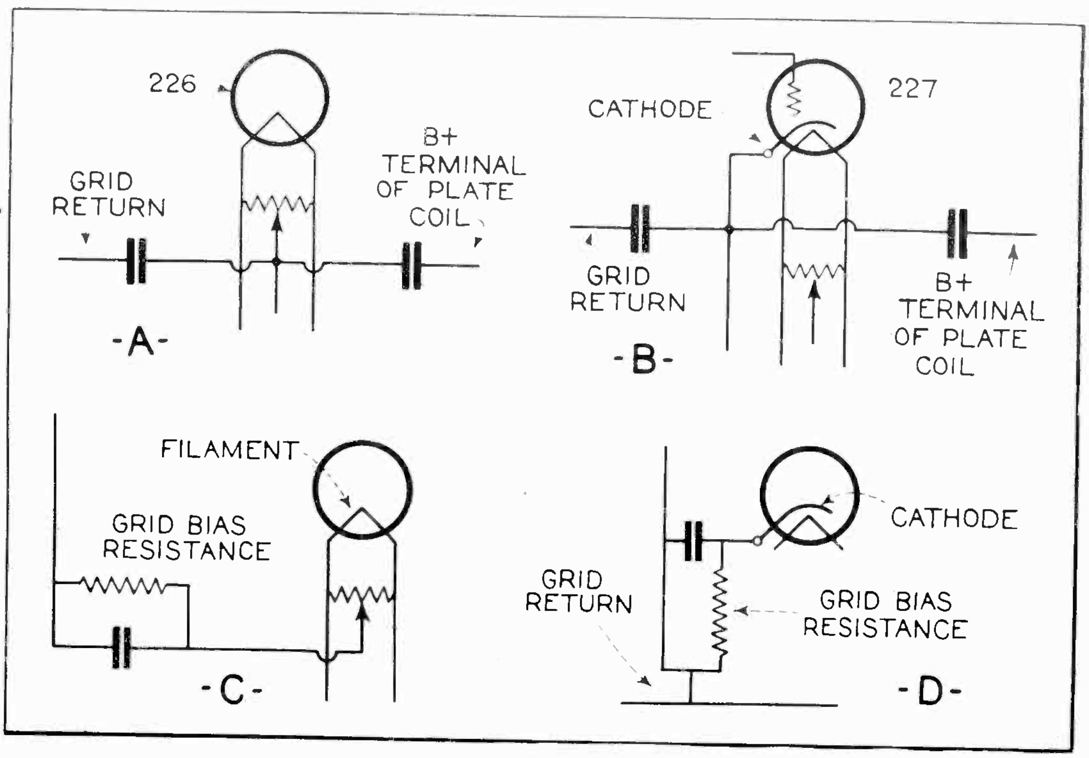
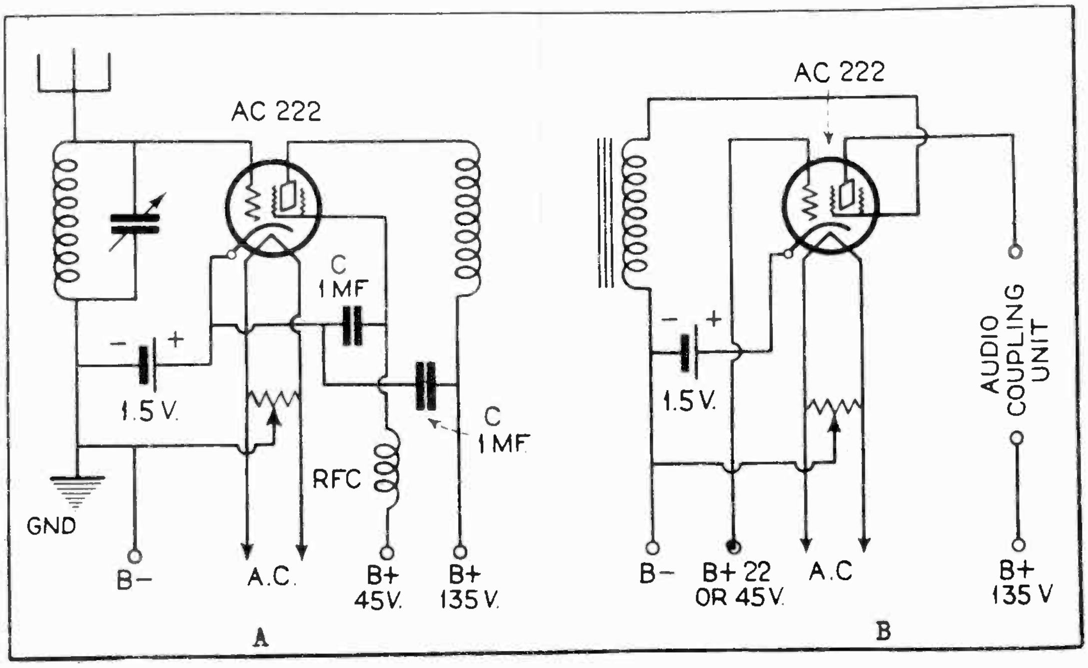


Fig. 16



The application of the grid bias with the A.C. screen grid tube is shown in figure 17 A and B. In A the circuit arrangement is that for the tube when employed as a screen grid tube. In B it is employed as a space sharge audio amplifying tube. Here we show the use of a battery bias connected into the cathode circuit. It is doubtful

Fig. 17



if such battery systems will be employed. However that should make very little difference. The battery may be replaced with the conventional resistance and bypass capacity. The illustrations quoted are shown simply to afford an idea, in the event that the battery is used, of how the battery arrangement is employed.

We wish to make mention at this time, that these various systems should be studied with care. It is evident that the various grid circuit arrangements are numerous. All receiver designers do not employ the same systems, hence it is imperative that the service man be familiar with the systems in use. To expedite comprehension we show in figure 18, the method employed to secure the negative grid bias for the 227 when employed as the negatve grid bias detector. Compare this arrangement with that shown in figure 15, wherein the detector is arranged for grid leak and condenser detection. Note the absence of the grid bias resistance in figure 15 and its presence in figure 18. Some receivers employ the arrangement shown in figure 15 whereas other arrangements use the system shown in figure 18. The plate current in the latter system is less than in the former. Unless the distinction between the two systems is recognized, the plate current indication may prove very confusing.

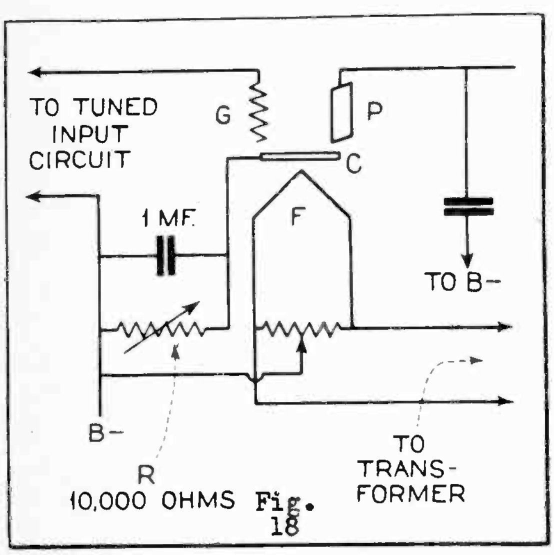


Fig. 18

We made mention that reference to the receiver wiring diagram is imperative. We cannot place too much stress upon this subject. How can one tell without reference to the wiring diagram, which one of the systems mentioned in this chapter is employed to secure the grid bias. Examine once more the two circuit diagrams in figure 14. In one case the grid bias resistance is in the receiving system. On the other it is in the B eliminator. Accurate circuit analysis makes necessary knowledge relative to the location of this resistance, since in one case it manifests an effect upon but one tube, and in the other upon the entire receiver, since an open in this resistance, when located in the B power unit, will upset the operation of the entire B unit, consequently the entire receiver.

In some cases, one grid bias resistance located in the receiver is used to supply the grid bias for more than one radio frequency amplifying tube. This is usually the case when 226s are employed. Furthermore individual filament shunt resistances are employed. The magnitude of grid bias in the system shown in figure 16 C is governed by the plate current of that individual tube. Where more than one tube is supplied with grid bias by one resistance as in figure 19, the magnitude of grid bias is controlled by the total plate current consumption of all the tubes supplied with grid bias by that one resistance. It is unnecessary at this time to give the formula employed to determine the voltage when the current and the resistance are known. For all such details we refer the reader to the first volume of this series, "The Mathematics of Radio" wherein all calculations are discussed at length and with simplified explanations of the complex problems.

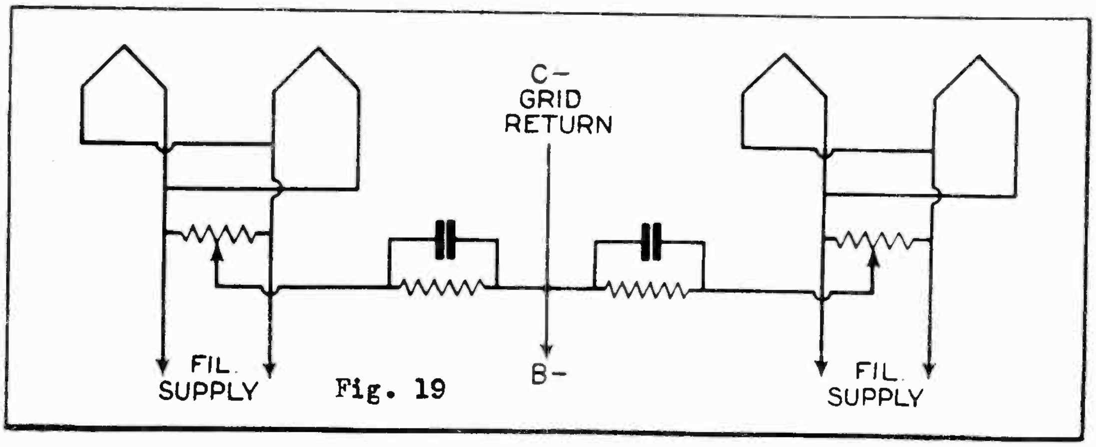


Fig. 19

Although we are a bit ahead of the progress of this discussion we must mention the difference between the amount of current involved when securing the grid bias for one or more tubes, when the grid bias resistance is in the B eliminator and when it is in the plate-filament circuits shown in this chapter. In the former case, the total eliminator plate current drain flows through the resistance whereas in the cases cited only the plate currents of the tubes involved flow through the resistance. It is customary in many receivers employing the 227, to provide a separate grid bias resistance for each tube. This arrangement is very satisfactory with respect to servicing, since each tube is independent of the other.

Before concluding this chapter it necessary to make mention of the 227 detector arrangement wherein the cathode is connected to B- and the filament centre tap is connected to B+ 45. This system is shown in figure 20. The filament circuit is arranged in two ways, for use with the centre tap of the transformer and for use with a centre tapped filament shunt resistance. Either system may be employed with very little difference in effect. Compare this arrangement with that shown in figure 15. This comparison is mentioned because of the difference found when voltage tests are made between B- and

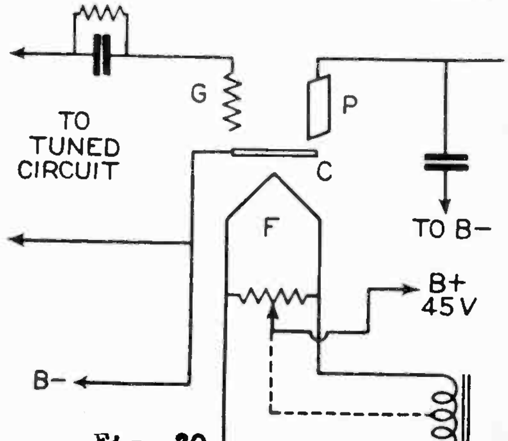


Fig. 20

other parts of the system.

The grid bias arrangements employed in the output stages differ very little from the systems employed in the conventional radio frequency or audio frequency sections of the receiver. The type of tubes employed in the output stages are identical to the 226 hence the same method of securing the grid bias is applicable. Figure 21 shows the grid bias arrangement employed to supply grid bias for four tubes arranged in parallel push-pull fashion. Due to the arrangement employed one grid bias resistanec suffices for the four tubes. However, four tubes arranged in parallel as shown in figure 22, make necessary the use of two grid bias resistances, one for each unit of two tubes.

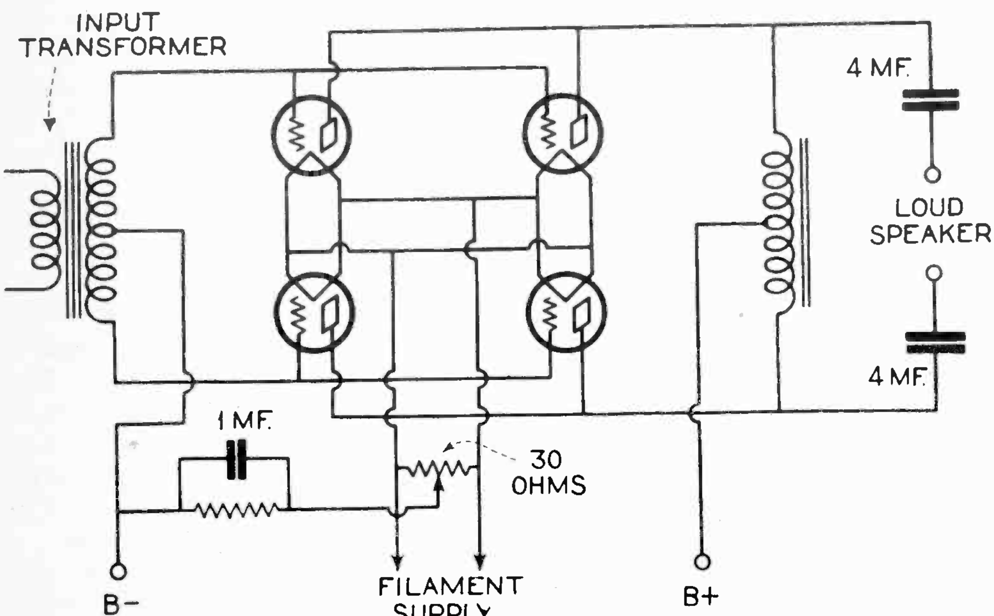


Fig. 21

With respect to numerical values quoted in conjunction with the various items shown, these are empirical values which have been found very satisfactory in use. However, service men should not change existing systems to conform with this values unless the units in the receiver are defective and the manufacturers' ratings are unknown.

The suggestion to employ two grid bias resistances is based upon minimization of regeneration in the output system and upon the possibility of non-uniform tubes. By providing separate grid bias resistances it is possible to arrange the pairs of tubes to best advantage.

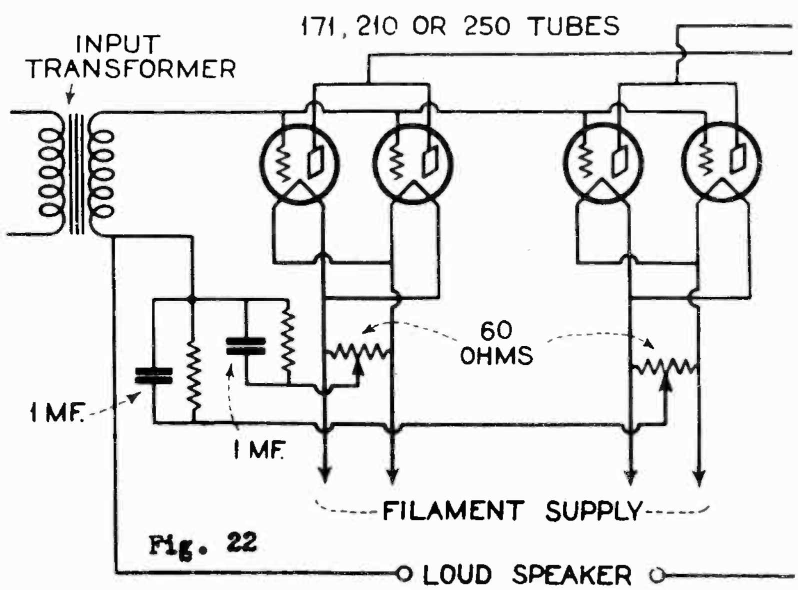


Fig. 22

Plate Circuits

The plate circuit arrangements employed in standard radio receivers are not always of the same type. By this we mean that the components located in the plate circuits are not always the same. The exact items are governed by the design of the radio receiver and the ideas of the design engineer. Like the grid bias systems, it is necessary that the man interested in diagnosis be familiar with the units employed in the plate circuit inorder that his tests for continuity through the various components be correct.

Many radio receivers are designed for operation with certain potential arrangements. That is to say, the design of the power supply unit is the simplest possible with respect to the number of output voltage taps and connections. This means that some arrangement must be employed in the receiver proper inorder to secure the correct operating potentials. In some cases the plate voltage applied to the radio frequency tubes is the same as that applied to the plate of the first audio frequency tube. In other cases the plate voltage applied to the R.F. tubes is less than that applied to the audio tube, yet the same output voltage tap is employed. This means that a resistance is located in the radio frequency plate circuit inorder to cause a voltage drop. The presence of this resistance must be known because it increases the hazard of trouble and is a possible source of trouble. Its electrical condition is of importance. Unless its presence is known, the lower value of radio frequency tube plate voltage is mystifying.

In other cases the plate voltage is not applied to the tube plate through the radio or audio frequency transformer primary. Instead, shunt plate supply is used and the coupling unit primary is isolated from the tube plate by means of a condenser. The plate current is caused to flow through a special resistance or a choke. This resistance or choke may "open" and continued tests of the coupling unit primary show a closed circuit through the unit, yet plate potential does not reach the tube. The effect is mysterious --- mysterious because the man does not know that the plate current does not flow through the coupling unit. He does not know that the plate current is arranged to flow through a special unit. This is particularly true with many receivers employing audio frequency transformers equipped with alloy cores.

In connection with such audio frequency transformers, it is necessary to stress the fact that when plate current does flow through the transformer winding, it is definitely limited in magnitude. The use of the alloy core permits a certain value of plate current. Plate current in excess of this value will damage the core and alter the operating characteristic of the transformer. This effect is a loss of low notes or poor operation on the lower portion of the audio frequency spectrum. To all appearances the unit is intact, yet it has been damaged electrically.

A similar condition exists in the radio frequency part of the receiver, Not necessarily associated with the radio frequency transformer but with respect to continuity. Examine the various neutralizing systems employing condensers. In one case continuity through this condenser will show connection with the tube plate circuit. In another this is not true. Hence the elements in the plate circuit must be known.

Volume controls in radio frequency plate circuits are quite common, but they are not of the same type. In some cases the volume control in the plate circuit is a series resistance reducing or increasing the plate voltage. In other cases it is a variable resistance across the radio frequency transformer primary. A defect in these volume controls will display different effects. In one case it will short the primary. In the other it will "open" the plate circuit. In one case signal strength will be reduced and in the other the receiver will be wholly inoperative.

The latter will display an effect upon the other voltages in the receiver. The effect of the former will be limited to that one tube and stage of amplification.

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Aerial Systems

The aerial system is very frequently the source of much annoyance, but it is not always the source of trouble, despite the fact that so much stress is placed upon the aerial. We too believe that the aerial must be well erected, yet we have found numerous instances of poor aerial construction and very satisfactory receiver performance.

In this connection we wish it understood that by poor aerial construction we do not mean shorted aerials, or the use of defective insulators. A certain height is necessary but it is not necessary to strive to be above every other aerial on the roof. Of greater importance is the location of the aerial and the leadin so that they are removed from steel or other large metalic structures. Also the use of electrically efficient insulators and freedom from contact with grounded objects.

Conventional radio receiver design ordains the use of an outdoor elevated aerial with a total length between 100 and 150 feet. This length is the overall length and will be found to work best with the average radio receiver. In many instances shorter aerials are required but in no case should it be necessary to use a longer aerial. Generally speaking insufficient receiver length reduces receiver sensitivity and in many cases, where some of the old type Neutrodyne receivers are involved insufficient aerial length causes instability of the radio frequency amplifying system.

Excessive length on the other hand impairs selectivity, by applying excessive signal voltage to the receiver and in every case receiver selectivity is closely allied with the amount of power in the receiver circuits. Excessive length has a tendency to reduce the signal-noise ratio since the longer aerial is more responsive to electrical disturbances of various nature. Excessive aerial length has a tendency to broaden tuning at the lower end of the tuning dial due to closer approach to the fundamental wavelength of the aerial. The above condition may be the cause for broad tuning on the lower end of the dial when the receiver tuning system is satisfactory, yet the undesired condition exists.

From the above we can deduce that reducing the length of the aerial will increase selectivity. This is true regardless of receiver conditions, since the shorter the aerial the less the signal voltage passed into the receiver. In connection with aerial systems it is necessary to consider location,i.e. the location of the complete receiving system with respect to the broadcasting stations. In many cases, certain broadcasting stations are received with excessive signal strength, yet the other broadcasting stations are received with normal strength. To reduce the aerial length would diminish the strength of the interfering station, but it would also reduce the strength of the other stations. Hence haphazard aerial reduction is unsatisfactory. If the strength of the other stations is such that reduction will not impair reception, the aerial length should be reduced. If however this is not the case, the strength of the offending station should be reduced by means of a trap or the receiver owner educated to detune when listening to this station. As a last resort, arrangement can be made whereby the aerial length is reduced with a series capacity when tuning to the powerful station.

Certain definite faults may develop in the aerial system. First, is grounding of the aerial or the leadin. Second, is intermittent grounding of the aerial or the leadin. Third, is a short circuit in the lightning arrestor if one is used. Fourth, is swaying of the aerial if the slack is too great. Fifth, is a partial short or leak through defective insulators. Sixth, is corroded or loose contacts in the aerial leadin or c onnection thereto.

The effects of these defects are varied. Intermittent grounding will cause a series of clicks. If the aerial or the leadin scrapes a grounded object, a sputtering and frying sound will be heard during that time. In addition the intermittent grounding will cause a diminuation of signal intensity, a phenomenon somewhat similar to fading. An action similar to fading may be experienced when an aerial sways in the wind. This is particularly true if the aerial (flat top) is parallel to other aerials and to certain large metalic structures.

Partial leaks or shorts to ground will cause low signal level and even broaden tuning. The greatest effect however is the decrease in receiver sensitivity. In some cases, this action is accompanied by sizzling sounds which are loudest when the radio frequency stages are tuned to resonance. A grounded aerial need not cause entire lack of signals. This is particularly true when the ground is located at the remote end of the elevated part of the aerial system furthest away from the receiver. In this case, particularly if the aerial length is appreciable, the complete aerial system functions like a loop. Signal strength will be reduced, it is true, but signals will be audible.

Many complaints of poor receiver sensitivity are attributable to poor location. In other words the aerial is shielded. In such instances, the best aerial will have very little effect. The location of such dead spots cannot be charted, but every effort can be made to so locate the aerial that it is not behind large masses of metal; that it is open to the signals emanating from the station.

Electrical disturbances find their way into the receiver via the aerial and to minimize such effects, certain precautions must be exercised when erecting the aerial. 1. It should not be parallel to power lines. 2. It should not cross power lines. 3. The leadin should not be parallel to power or telephone cables entering the home or building. 4. The lead in should be far removed from localities adjacent to power transformers located atop power line poles. 5. The aerial and leadin, if possible should be removed from arc lights, flasher signs, etc..

Imperfect contact of any kind will cause various forms of electrical disturbance, usually of the crackling and sputtering variety. This is particularly true in the case of the A.C. electric receiver. In this connection we include the ground as well. Perfect contact to the ground is imperative. We are not greatly intersted in the electrical efficieny of the ground. Existing conditions impose limitations in this respect, but what we do say is that the connection to the ground should be perfect.

Various forms of disturbance find their way into the receiver by means of the aerial. If examination shows this to be the case, very little can be done, other than to either change the location of the aerial or to alter its position with respect to the source of interference. Wherever possible aerials should run at right angles to all power and telephone cables.

It is needless to dwell upon the fact that the electrical efficiency of the complete aerial system influences receiver operation. This fact is well known and we shall leave well enough alone. However, the ground too is important, not so much because of the variation in electrical efficieny, but because it is necessary. Many receivers are designed for operation with a ground --- and a ground is imperative. Omit the ground and receiver performance is very poor.... In many other cases, the ground is of very little importance -- optional on the part of the receiver owner.. However, wherever used secure the best obtainable.

Although frequently denied, the average inverted L aerial used with the average radio receiver possesses directional properties, being more directional towards the end of the aerial connected to the leadin. This property may be utilized to good advantage. We say this because we have made use of the directional and anti-directional properties of aerials. We made mention that in certain localities station interference is very annoying; that one particular station is recived with exceptional intensity. A change in aerial direction, to that the free end is towards or points towards this station will frequently reduce the signal intensity to the normal value and the need for aerial reduction or wave traps is obviated.

We made the statement in a part of this chapter that it is possible to receive signals with a grounded aerial. This however does not include the case when the ground is in the lightning arrestor because this unit is close to the receiver and is the equivalent of a direct short across the aerial coil, choke or resistance, whichever device is employed in the antenna system.

"A" Battery Eliminators

The "A" battery eliminator has replaced the conventional storage battery as a source of filament potential, carrying out exactly what the name denotes. These devices are classed into two categories;

1. "A" eliminators employing low voltage rectifiers
2. "A" eliminators employing high voltage rectifiers.

A third classification maintained separate from the rest is the use of 110 volt D.C. power systems to supply the required D.C. filament potential. In view of the fact that 2 and the special classification are closely allied with high voltage B eliminators we shall reserve discussion of those types for the chapter on B eliminators.

The "A" eliminator or power A device supplies the required D.C. filament potential to the tubes in the receiver. The original source of the filament potential is the A.C. house supply. The power device employs a transformer which is connected to the line supply and also to a rectifying device, which converts the A.C. potential into pulsating D.C. potential, a combination of A.C. and D.C. The output of the rectifier is connected across a filter system consisting of a choke or a number of chokes and condensers arranged in such manner that the A.C. component in the rectifier output voltage is removed or filtered and the D.C. passed to the output system of the power A unit. The schematic wiring diagram of such a circuit arrangement is shown above. In some cases a switch is incorporated for the purpose of varying the output voltage and current. This switch governs the voltage applied to the rectifiers from the secondary of the power transformer.

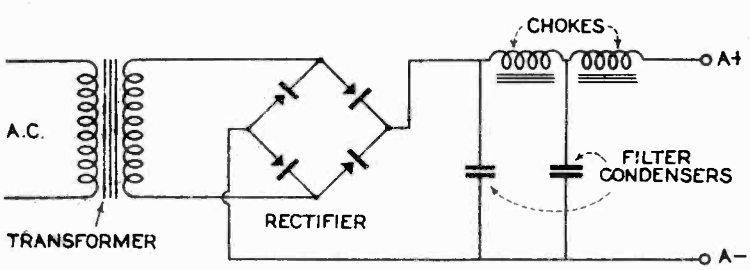


Fig. 23

Rectifiers connected in Wheatstone bridge form with 1500 mfd. condensers and .2 henry chokes used as a power supply for parallel connected tube filaments.

Now, inorder that the proper output voltage and current be available, it is necessary that certain conditions be fulfilled.

1. That the A.C. line voltage input be normal
2. That the voltage applied to the rectifiers be normal
3. That the rectifiers perform in normal manner and be in good condition
4. That the voltage drop across the filter system be normal
5. That the inductance of the filter chokes be normal
6. That the filter condensers be in perfect condition
7. That all connections in the filter circuits be intact
8. That all connections in the complete unit be intact
9. That the electrical constants of the filter system be correct
10. That the load applied to the power A unit be normal

Any deviation from the above will create one or more detrimental effects, effects which will interfere with everyday operation..... Let us see why...

1. If the line voltage is low, the operating voltages will be low and consequently the rectifier output will be low and the filament potential applied to the tubes will be less than the required value.

2. If the voltage applied to the rectifiers is less than the required value for predetermined voltage and current output, the required output will not be available. Furthermore the successful operation of the rectifier elements depends upon the application of a certain value of A.C. potential. If the line voltage is high or the transformer output is high, the normal operating life of the rectifier will be reduced.

3. If the rectifiers are worn out or defective, the output voltage will not be up to requirements. Furthermore a defective rectifier system will cause appreciable "hum" in the output because of defective rectifier action

4. If the voltage drop in the filter system, due to exceptionally high resistance of the filter chokes, is in excess of the predetrmined value, the output voltage will be less than the required value.

5. If the inductance value of the filter chokes is less than the required value, filtering will suffer and while the output voltage and current requirements will be fulfilled the D.C. output will contain an appreciable value of A.C.

6. What has been said in 5 is applicable to the filter condensers. In addition if the filter condensers are not electrically perfect and the leak across the condenser is appreciable, the output voltage will be reduced. If the filter condenser breaks down, it shorts the rectifier elements causing a heavy overload and possible injury.

7. If interconnection contacts are imperfect they introduce points of resistance, reducing the filter action and the output voltage.

8. What has been said in connection with reason 7 is applicable to 8.

9. If the constants of the filter are incorrect, as for example insufficient filter capacity, filtering action will be impaired and the D.C. output will contain A.C. and cause a bad hum.

10. Here we meet a new situation, one which concerns the operating characteristic of all such devices. Eliminators of this nature, employing one of the popular types of rectifying devices are not sources of constant potential, nor do they afford unlimited current output. The output voltage is a function of the current load and vice versa. If the current drain is excessive, the output voltage will drop. On the other hand, if the current drain is less than the required value according to the adjustment made, the output voltage will be in excess of the normal value. This operating characteristic must be borne in mind because much dissatisfaction is due to overload. Voltage regulation curves of such devices are shown in Volume 1, hence repetition is unnecessary.

It is therefore imperative, that wherever voltage adjustments are available the voltage output should be proportioned acdording to the number of tubes to be supplied by the device.

Additional comment is necessary about two of the components in the power A device. We refer to the rectifier and the "dry" A condensers employed in the filter system. The operating life of the "dry" disc rectifier when employed in an A eliminator is about 30 to 40% of the life available when utilized in a B eliminator, operating at comparatively low values of current drain. At best its operating life as an A rectifier is about 1500 hours.

No matter what the operating life, it should be understood that the operating life is definitely limited; that after a period of time the rectifier is useless and replacement is necessary. The effect of a worn out rectifier element is practically the same as that of a defective element, both giving rise to

1. Appreciable hum in the output
2. Insufficient voltage output
3. Unsteady voltage output

With respect to the filter condensers, it is necessary to dwell upon the construction since it influences the operation and life. The design of the condenser involves a certain amount of leakage current between the active surfaces in the unit. This condenser in contrast to the usual B power unit filter condenser takes advantage of the chemical reaction of certain oxides which are deposited upon one of the plates during the process of "forming". If the design of the condenser is poor, the leakage current is appreciable and causes rapid deterioration of the condenser and ruins its operating efficiency. Now, in connection with this action we must state that a certain form of satisfactory operation is secured at the outset, even if the value of leakage current is greater than normal. However, as the period of usage increases the detrimental effect of the leakage current manifests itself and the unit becomes unfit for further use. This explains the reason for the satisfactory performance at the start and unsatisfactory performance after a period of time. With respect to this period of operation, a close observer will note that the percentage of hum, as discerned by aural observation increases gradually until it becomes annoying.

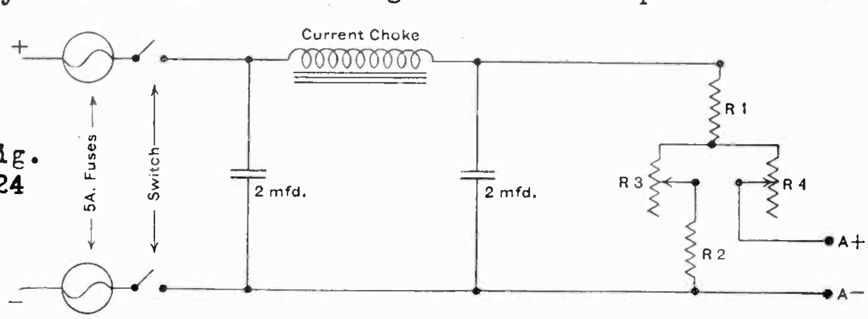
The effect of the high leakage current is to reduce the capacity of the condenser and to reduce its resistance, the former interfering with filtering and the latter manifesting an effect upon the output voltage.

Last but by far not the least, the chemical action in a defective "A" condenser will give rise to frying and sputtering sounds which are actually varying potentials and are transmitted to the receiving system via the filament connections and the tube filaments.

D.C. A Battery Eliminators

A battery eliminators need not always employ A.C. input. In many instances, the 110 volt DC house supply is utilized as the original source of power. Since it is of DC character rectification is unnecessary. However a filter system and a voltage divider are used as shown in figure 24. In contrast to the filter condensers employed in A.C type A eliminators, the filter condensers in D.C. type are of conventional linen paper construction. Another difference is that the current output of a DC A eliminator is not limited because of the characteristic of the source of supply. The voltage divider network consists of a number of resistances as shown arranged to provide a definite voltage drop and also variable control of the output voltage.

Fig. 24



Troubles in "A" Eliminators

Albeit the popularity of the A.C. tube many receiver installations make use of the D.C. tube operated from the A.C. house main by means of an "A" eliminator. In this device a rectifying element is employed to rectify the A.C. into D.C. and a filter system is employed to smooth out the pulsating output from the rectifier, so that the output voltage applied to the filaments of the tubes is smooth D.C. with very little if any A.C. component.

Troubles in such systems are usually of two types.

1. Insufficient voltage output
2. Excessive hum in the output voltage.

Each of these troubles has its associated causes, but as far as the application of the device is concerned, the above are the two major faults. Classification 1 however, involves

1. Low line voltage feeding the eliminator
2. Low voltage input into the rectifier element
3. Defective or worn out rectifier element
4. Excessive voltage drop in the filter system
5. Leak across filter system
6. Excessive load upon the eliminator

and among these faults will be found some which are allied with the second classification, which involves several additional factors.

Excessive hum is possible with normal output voltage and with insufficient output voltage. The difference between the possible troubles in each case is quite marked. If the output voltage is normal, it eliminates numbers 1 and 2 of the six possible reasons. It also eliminates 4,5 and 6 since all of these tend to reduce the output voltage and are quoted as possible reasons for insufficient output voltage. Of the above mentioned six possible faults only one is directly connected with the second classification of major trouble. Let us see what conditions may cause excessive hum with normal output voltage.... Even possible trouble number 3 may be omitted since a worn out rectifying element will not afford normal voltage output. Hence under the conditions mentioned excessive hum may be due to

1. Defective rectifying element
2. Defective filter condensers
3. Shorted filter chokes
4. Open filter condensers
5. Reversed line plug connection

A comparison of the possible reasons for the two major troubles shows the difference between the two, i.e. each has a definite group of possible reasons. Of course if the excessive hum is also accompanied by low output voltage, it is necessary to consider both groups of possible reasons.

"A" battery eliminators are frequently noisy although the voltage output is normal and the hum not objectional. The noise is in the form of sizzling and frying sounds. The possible reasons for this condition involve what was said about audio frequency transformers and in addition the following:

1. Defective rectifier element
2. Partial short in filter choke
3. Defective filter condensers
4. Electrolysis at soldered terminals
5. Corroded connections and contacts

These causes are also associated with hum in the output. In addition, electrical disturbance of this nature finds its way into the receiver through the power supply line feeding the "A" eliminator.

Glancing back over the possible reasons for excessive hum in the output we note omission of

6. Insufficient filter inductance
7. Insufficient filter capacity

which would make the total number of reasons 7 instead of 5 as enumerated.

In D.C. units we omit all items allied with the rectifier system. This includes the transformer and the rectifier.

Insufficient voltage output may be due to

1. Low line voltage
2. Excessive voltage drop in the filter system
3. Incorrect adjustment of the voltage divider system

Excessive hum may be due to

1. Incorrect design of the filter system
2. Shorted filter choke
3. Insufficient filter capacity

The hum in D.C. circuits is due to the commutator ripple and the function of the filter is to remove this ripple.

Since one side of the D.C. power supply system is grounded it is necessary to exercise precautionary measures against accidental grounding of the receiver which condition may cause a short across the line and burn out many units in the receiver. The means of preventing such condition is to ground the receiver through a .5 mfd. condenser and to locate fuses in the line side of the A eliminator. An accidental ground in the receiver or an accidental short across the voltage divider may "blow" these fuses.

Shooting Trouble in "A" Eliminators

Shooting trouble in any system involves the application of knowledge in the most economical and rapid manner and the faculty of focusing one's mind upon one problem at a time.... It is surprising to note how much information may be procured with the simplest testing equipment, if one makes an effort to correctly interpret existing phenomena.

Now, it is very likely that some of the wiring diagrams shown in this section are not the identical duplicates of the wiring systems employed in the commercial receivers, -- perhaps the receiver involved.... It is really of very little significance since certain basic facts apply to all systems, providing that similar items are used in both cases. The section devoted to a general discussion of power A devices contained an illustration showing the schematic wiring diagram of a power A unit employing the "dry" disc rectifier. The diagram is of utility in this discussion and we will show it once more, in figure 25 . In addition we also show an A unit wherein the rectifier is the Tungar bulb. See figure 28 . In many respects these two systems are identical and we show this arrangement because it involves a filament winding, omitted in figure 25 . The plate voltage applied to the tube is governed by the three point switch designated L and H meaning Low and High with respect to the value of plate potential. According to the illustration two separate transformers are employed. This practice is not common, insofar as individual units are concerned. It is customary to employ one transformer with two windings or an auto transformer arrangement where one winding is used and tapped for the filament potential. Regardless of the input system, all of the details mentioned in connection with such devices are equally applicable to all types of rectifiers. The circuit diagram of the use of the Tungar bulb is shown in figure

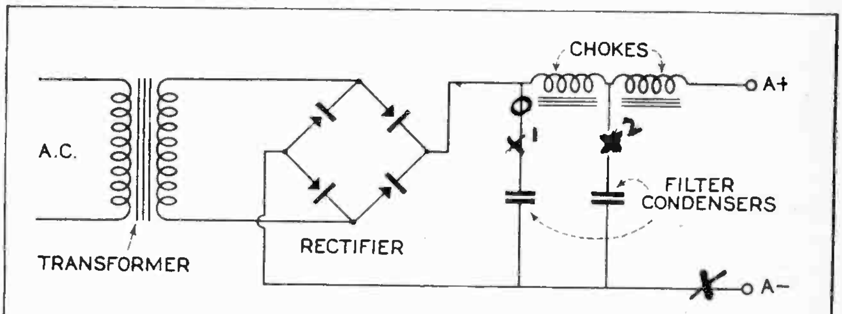


Fig. 25

Let us take as the first example, a condition of "hum" in the power A device..Replacement with a storage battery proved that the hum in the receiver was due to the eliminator.... What now?...Measurement of the voltage output under load shows that the output voltage is satisfactory. This state eliminates at least one possible fault, the defective rectifier tube or element. Since chokes coils do not short under normal conditions we concern ourselves with the filter condensers. If the condenser circuits test okey, we will then apply ourselves to the chokes. According to the possible reasons for excessive hum, the filter condensers are associated with two items, defective and open circuit, Since it is necessary to remove the condenser to determine if it is defective we test for open. It is needless to check the open through the chokes since the fact that voltage is available across the output circuit proves the condition of the chokes, at least circuit continuity. We therefore test across the condenser and contacts, between X and X1, after the eliminator circuit has been broken at the point O, the eliminator has been disconnected from the receiver and of course, the power turned "off". The test is made with a simple continuity tester consisting of a 4.5 volt battery in series with a low voltage range voltmeter. A small deflection shows continuity through the connections and the condenser. The current indication is that due to the comparatively low resistance of the condenser. We now shift one contact to X2. We note circuit continuity but the meter indication is greater than before. Apparently the resistance in the circuit is less. The only likely change in resistance is that of the condenser. A defective condenser will cause excessive hum... The thing to do is to test the leakage current through the condenser or the capacity of the unit... The former is simplest. Since the condenser is used at an operating potential of 6 volts we test at 6 volts. The testing unit consists of a 6 volt battery and a 100 milliampere D.C. milliammeter connected as shown in figure 26 . We need not fear a short, since the condenser did not short the filter system. It is however necessary to connect the testing equipment according to the polarity markings of the condenser. This is accomplished and the meter indicates a leakage current of 38 milliamperes. Now, as far as we know, the engineers associated with the manufacture of such units state that the average normal leakage current varies between a fraction of a milliampere and about 4 to 5 milliamperes, when the test is made at the normal operating potential. According to our test the leakage current is excessive and the condenser shows signs of being defective.

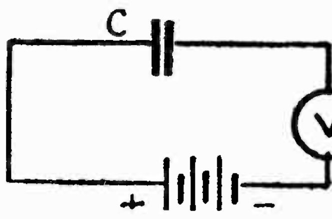


Fig. 26

It would be simple to check this observation by replacing the supposedly defective condenser with a known condenser. Let us however proceed to check the capacity of this A condenser. This work involves some computation, but it is simple multiplication and division and cannot be avoided. This method of measurement should interest everyone since it finds frequent application. To check the capacity it is necessary to use A.C. at a potential of 3 volts, the standard employed during the manufacture and test of the new product. This value of voltage may be secured from a filament transformer rated at 5 or 7.5 volts utilized in conjunction with a series resistance, or if possible the transformer should afford the required 3 volts. The current rating should be about 5 or 6 amperes. This high value of A.C. current flow does not damage the condenser. The testing system is shown in figure 27 The frequency of the A.C. supply, the current flow and the voltage across the condenser at the time of test must be known. It is understood of course that the ammeter and the voltmeter must be of the A.C. type. The capacity of the condenser under test is

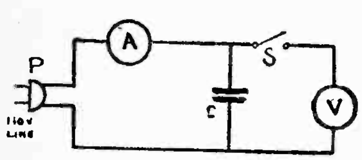


Fig. 27

$$C = \frac{I \times 1{,}000{,}000}{6.283 \times f \times E} \quad \text{where}$$

I = current flow
f = frequency of supply voltage
E = voltage across the condenser

In our case the current is just about 1 ampere which makes the capacity of the condenser about 885 mfds. The normal rating is 2000 mfds. The capacity test checks the leakage current test. The defective condenser is replaced and normal operation is secured.

It is impossible to give equally lengthy details about each test associated with defective units, hence we shall discuss the possible tests and the points of test. As it happens practically every test can be carried out with the voltmeter and the continuity tester. The section devoted to testing apparatus gives constructional details of the calibrated ohmmeter suitable for use when resistance measurements are necessary.

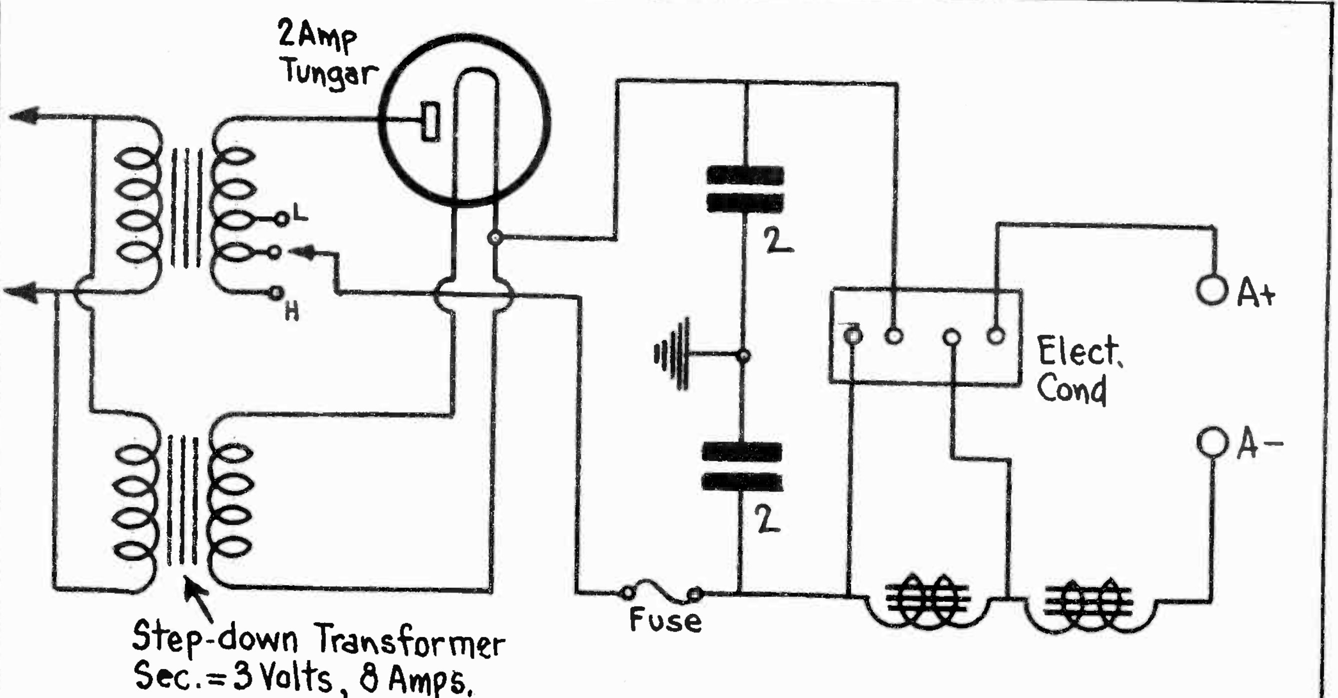


Fig. 28

When shooting trouble it is necessary to consider the advent of the trouble. If it is gradual it stands to reason that whatever unit is failing, is failing gradually. Such items in an A eliminator are two in number, the rectifying element and the filter condensers. The failure of both these items is associated with low voltage and hum. Hence when these troubles or defects present themselves it is necessary to look to these two units. To determine the reason for low voltage output it is necessary to check as follows, using an ordinary A.C. voltmeter of the proper range for the A.C. voltages and a good low range D.C. voltmeter for the D.C. voltages.

1. Ckeck A.C. line voltage input
2. Disconnect rectifier leads and check A.C. voltage output.
3. Check D.C. voltage output from rectifier with filter disconnected and rectifier connected to transformer.
4. Check D.C. voltage output from rectifier with input condenser across circuit.
5. Add first filter choke and measure D.C. voltage output
6. Add second condenser and check D.C. output
7. Add second filter choke and measure D.C. output

The D.C. output of the rectifying system must be several volts higher than the D.C. output of the complete system since the load is removed and the voltage drop in the filter system removed. If the input and the transformer voltages are correct and the rectifier output is not the value mentioned, the rectifier is at fault. If the voltage drop in the filter system is excessive, it is necessary to check the filter condensers and the chokes. The progress mentioned will show the defective unit.

Now, in many cases the hum will be excessive and all the units will check normal. In this case it will be necessary to check the condenser values, since insufficient capacity in the filter will cause excessive hum. The method of condenser test has been outlined.

Suppose that the eliminator is "dead". A definite method of procedure is necessary. The condition mentioned may be due to

1. No line voltage
2. Open transformer primary
3. Open transformer secondary
4. Open circuit between the transformer and the rectifier
5. Defective rectifier system
6. Open between rectifier and input filter condenser
7. Shorted filter condenser
8. Open filter choke (first)
9. Shorted filter condenser (second)
10. Open filter choke (second)

hence it is necessary to check continuity and output voltages. A shorted input filter condenser will show voltage into the rectifier but nothing across the output.... At this point it is possible that the rectifier is open. It is therefore necessary to disconnect the input filter condenser and to repeat the test. If the second filter condenser is open voltage will be present across the first but not across the output filter choke. If the filter choke (input) is open voltage will be present across the input filter condenser, but not across the second. If the second filter choke is open, voltage will be present across the second filter choke but not across the output. A short in the second filter condenser or a bad leak in the filter condensers will show voltage across the output circuit of the rectifier, but this voltage will be less than normal. Such a condition is not indicative of a defective rectifier. Instead, it shows excessive current drain, which fact may be proved by connecting a D.C. ammeter into the circuit between the rectifier and the input filter condenser

B Battery Eliminators

The B battery eliminator is really a misnomer. The unit employed to replace the B battery is really a power B supply unit, rather than a B battery eliminator. Common usage of the term caused its acceptance and we too, will follow in line.

Power B supply units are of three types,

1. Supplying plate potential
2. Supplying plate and grid potential
3. Supplying filament,plate and grid potential

These eliminators utilize two rectifying systems,

1. Half wave
2. Full wave

and make use of three types of rectifying devices

1. Filament type rectifier tube

    a. Half wave
    b. Full wave

2. Gaseous rectifier tube

    a. Full wave

3. Dry disc rectifier (magnesium-cupric sulphide)

    a. Full wave

In view of the fact that the type of rectifying system is decided upon when the receiver is constructed, it is needless to dwell upon the ramifications of each system -- particularly so when the various systems are described at length in Vol. 1,"The Mathematics of Radio". However it is necessary to mention that unless special circuit arrangements are employed, the filament type of rectifier tube only, finds application where plate voltages in excess of 350 volts are required. At lower plate potentials the three types of rectifiers are interchangable, providing of course that the transformers are suited for use with the rectifier insofar as output voltage (A.C.) and output current are concerned, and that the correct wiring changes are made.

The need for these changes in wiring becomes evident when the conventional B eliminator wiring diagram is examined. As is evident, the dry disc rectifier and the gaseous type of rectifying tube, do not employ a filament winding, hence the two filament terminals on the socket find utility when the filament type of rectifier is used in connection with the filament voltage and the filament winding. With the gaseous rectifier however these two terminals connect to the plate voltage winding instead of the filament voltage winding.

The sole difference between the three types of power supply units mentioned above, is found in the arrangment of the voltage divider system, it being understood of course that the proper rectifying medium is selected to fulfill existing requirements and that the proper transformer is used. The filter systems employed in conventional power B supply units are usually alike and when differing, according to the ideas of the design engineer, the difference is found in the use of a filter condenser connected across the rectifier output circuit as in the Stromberg-Carlson receiver, figure 3 and in the omission of the input filter condenser as in the case of the Atwater-Kent receiver shown in figure 2.

We wish it understood that we make refernce to circuit structure and not to the design of the individual units employed in such systems. The reason for this special mention is that we cannot place too much stress upon the fact that it is imperative to analyze the wiring diagram of each and every system, inorder that the tester know the circuit structure, what operation to expect and what readings he should secure when testing apparatus are applied.

Fortunately circuit structure differs very little in commercial B eliminators although the exact design of the unit has not been standardized. In some cases, depending upon the design of the radio receiver, B and C voltages are secured from the eliminator. In other cases the B and the output tube C voltages are secured from the B eliminator and in still other instances, only the B voltages are secured from the B unit. The last and by far not the least important power supply unit is that employed in connection with series filament wiring, wherein the filament potential is D.C. secured from a high current rectifier and the B unit supplies A,B and C potentials.

An idea of circuit structure in the rectifying systems of a full wave eliminator employing the gaseous rectifier typified by the Raytheon may be had by

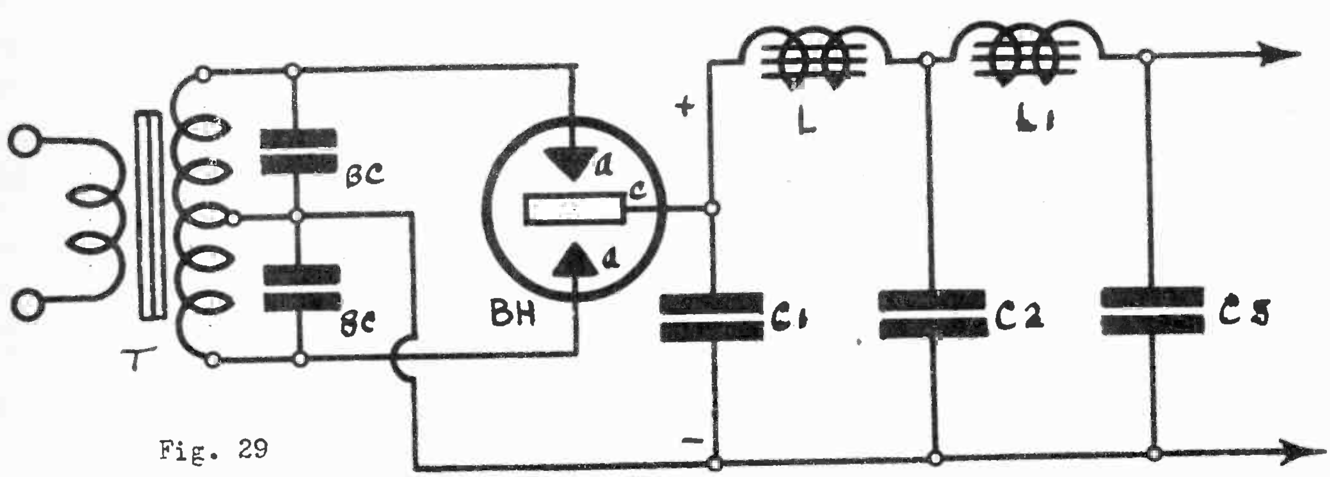


Fig. 29

examination of the above wiring diagram. The symbols designate the various components.

T is the power transformer
BC are the buffer condensers employed to reduce radio frequency energy in the rectifier tube.
A designates the anode terminals, F- andF+ on the tube socket
C designates the cathode terminal, P on the tube socket
L and L1 are the filter chokes
C1,C2 and C3 are the filter condensers

With C1 in place the filter system consisting of C1,C2,C3,L and L1 employs condenser input, but with C1 omitted the filter system employs choke input. As is evident the cathode is the positive terminal, just as in the average filament type of rectifying system. The two arrows point to the voltage divider resistance network, which units will be considered in a little while.

In some instances, the two filter chokes are replaced by one choke or greater inductance value and two filter condensers are employed instead of three as shown. We make mention of this condition for the sake of clarity, in case the reader compares the system shown with one which mayhap appeared in some journal.

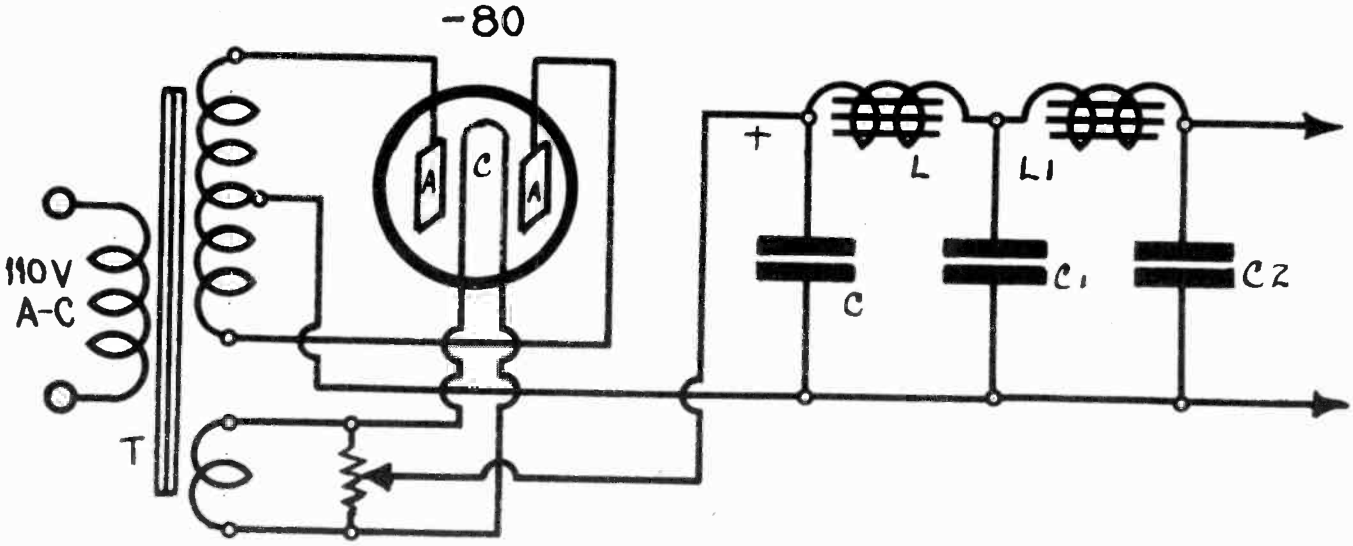


Fig. 30

The equivalent of the full wave gaseous rectifier is the full wave filament type rectifier typified by the 213 and the 280 type tubes. These tubes employ two plates or anodes in one chamber with one or two filaments, depending upon the design. In contrast it is possible to secure the equivalent by employing two half wave rectifiers (filament type) connected into a full wave rectifying system. The wiring diagram of a rectifier and filter system employing the single tube full wave rectifier, the 280 is shown above in figure 30 and the schematic diagram of two half wave rectifiers such as the 216B and the 281, connected into a full wave rectifier is shown adjacent to these words. Note how the two tubes are connected to be the equivalent of two plates within one chamber ... Note the similarity of the filter system and the use of the filament winding centertap as the positive terminal. A midtapped filament shunt resistance is employed in figure 30 because the transformer winding is not equipped with a centre tap.

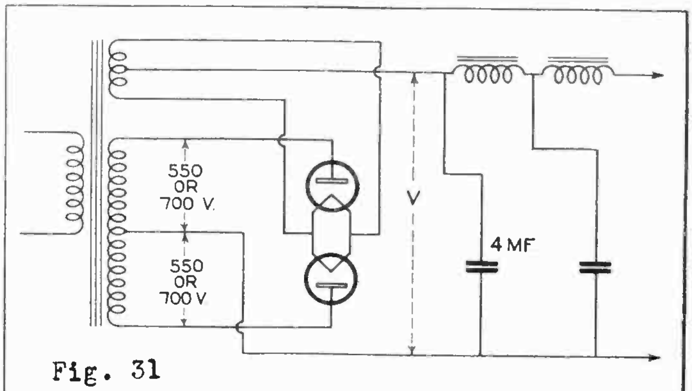


Fig. 31

One distinct difference between the filament type of rectifier and the gaseous type of rectifier is that buffer condensers are not employed in the former systems. Another distinction is that the conventional commercial B eliminator employs the gaseous rectifier as a full wave rectifier, whereas the filament type of rectifier is employed as a half wave rectifier in some cases and as a full wave rectifier in others. The final decision is one of receiver design, operating voltages, current output requirements and economy. The designations in figure 30 correspond with the designations in the wiring diagram of the gaseous rectifier.

T	is the power transformer
A	designates the anodes (plates)
C	is the cathode of the tube (filament)
L and L1	are the filter chokes
C ,C1 and C2	are the filter condensers

Once again the arrows point to the voltage divider network.

The use of the dry disc rectifier involves but few changes. The units are usually arranged for full wave rectification and the design of the rectifier is such that it may be plugged into the conventional tube socket. In some cases a few changes are necessary in the wiring. This work is so simple that we do not deem it necessary to show the rectifier and filter systems of such units.

Now, in connection with half wave and full wave rectifiers, we find that the two types of systems govern voltage and current output. The first advantage of the full wave system is that the current output is increased to approximately twice that of the half wave rectifier, assuming tubes of similar type and the same voltage output. In other words, if a 216B tube affords a voltage output of 500 volts at 80 mils with an input voltage of 550 volts A.C. two such tubes connected in full wave fashion will afford an output voltage (D.C.) of 500 volts at 140 mil drain. This data is shown in the accompanying graph, figure

The second advantage of the full wave system is that the frequency to be filtered is twice that encountered in the half wave system, (See "Rectifiers" in Vol.1.) and filtering is much easier, permitting the use of lower values of inductance and capacity in the filter. Incidently the frequency to be filtered in a half wave rectifier is the frequency of the input 60 cycles with 60 cycle line supply and 120 cycles with 60 cycle line supply when the full wave arrangement is used. Of course the harmonics of 60 and 120 cycles are present in the respective filters.

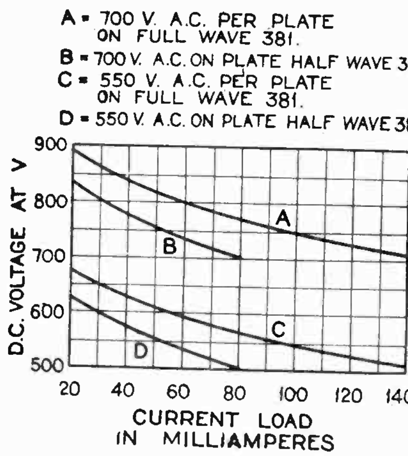


Fig. 32
Current-voltage curves of high and low voltage, single and double wave B-eliminators.

According to the accompanying graph on this page that the use of the full wave system boosts the voltage about 15% at any one value of current drain. This data pertains to the filament type of rectifier tube operated with similar values of A.C. voltage input. In this connection it is necessary to mention the distinction between the 280 and the 281. The former is a full wave rectifier supplying a maximum output voltage (D.C.) of about 220 volts, whereas the latter supplies an output voltage (D.C.) of about 450 volts. These values are the output voltage values under load and not the voltage values shown in the graph. The voltage values in the graph refer to the voltage at V in figure .

With respect to the function of the elements shown in these illustrations, what is to follow, applies with equal facility to all eliminators regardless of type of rectifier and filter.

The transformer the A.C. plate potential to rectifiers which do not require filament potential and filament and plate potential to filament type rectifier tubes.

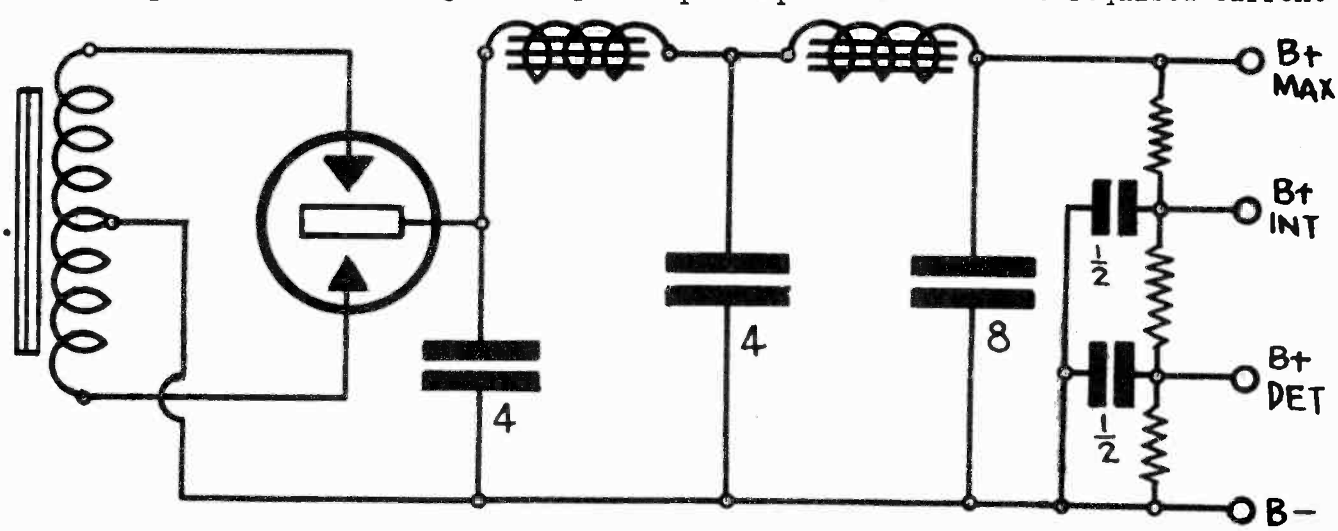
The rectifier does what its name denotes. It rectifies the A.C. voltage fed to it by the transformer so that the output voltage is pulsating D.C.

The pulsating D.C. is then fed to the filter system, wherein the combination of chokes and condensers smooths out the pulsating D.C., eliminates the A.C. ripple and passes pure D.C. to the voltage divider network, which part of the complete eliminator system will be shown later.

As is evident each part of the complete eliminator performs a definite function and as such must fulfill certain requirements inorder that the complete eliminator function in a normal manner. These requirements will be considered in the next section devoted to "Troubles in B Battery Eliminators".

Many receivers in use today employ eliminators which have not been designed specifically for the receiver and satisfactory operation isnot secured because the salient points pertaining to eliminators are unknown to the user. In the first place the B eliminator, in fact every eliminator is a limited current and voltage output device. That is to say, the total voltage and current output are limited. Furthermore the operating ranges are limited. Second, each eliminator possesses what is known as a voltage regulation curve, showing how the current output decreases as the output voltage requirement increases. This means that the greater the current drain the less the voltage output and conversely,the greater the voltage output, the less the current output The significance of this characteristic is that the eliminator cannot be used with any number of tubes or with all types of tubes, unless of course the eliminator has been designed to provide operating potentials for the tubes in question. This fact is of importance in receiver operation when the output tube is to be changed. It is a simple matter to replace a 171 with a 250, but it is important that the source of B and C potential be capable of delivering the required plate potential at the required current load.

Fig. 33



The division of the voltage available from the eliminator is accomplished by a number of resistances connected across the output of the filter. This network of resistances constitutes the voltage divider. The design considerations of voltage dividers will be omitted from this volume, because of the extensive discussion in volume 1. Such networks are of two types, the potentiometer arrangement shown in figure 33 on the previous page and the individual resistances as used in the Atwater-Kent receiver illustrated in figure 2. The potentiometer system is most frequent and is preferred because of a stabilizing effect upon the eliminator system and because it discharges the filter condensers when the tube filaments and the eliminator are turned "off". The division of voltages is achieved by producing definite voltage drops across the various sections of the resistance, by tapping the total resistance at certain points or by utilizing a number of indiviaul fixed resistances or by employing a number of resistances of the potentiometer type with a movable or adjustable tap. The voltage divider system in figure makes use of a number of fixed resistors.

An examination of the binding posts designations shown in figure shows that all the output voltages are plate voltages. Although three values of B + voltage are shown, the design of the eliminator is not limited to three values, any number being available.

We made mention that the current output of the rectifier system governs the utility of the eliminator. When so designed the eliminator may be used to supply filament and plate potential and even grid bias potential for one or more tubes. Figure 34 illustrates a combination A,B and C eliminator employing the Raytheon BA tube.

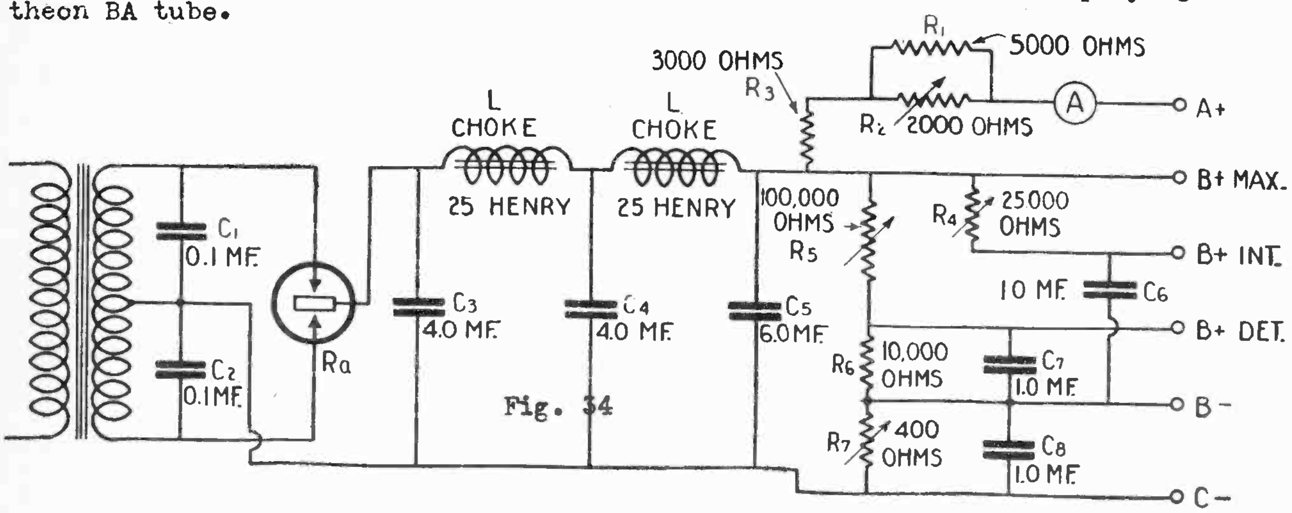


Fig. 34

Figure 35 illustrates another arrangement supplying the same potentials and employing the same tube. We show the two illustrations to illuminate upon the different voltage divider systems. Both of these eliminators find application when the tubes in the receiver are of D.C. type and connected in series, that is, the filaments are connected in series. In all such installations A- and B- are common or connected together. The arrangement shown in figure 35 is most common in commercial installations.

In connection with such eliminators we must make mention that the A supply for the output tubes, while secured from the power pack is seldom D.C. and is secured from a separate transformer winding, which is a part of the complete power transformer.

These units differ from the conventional A eliminators in that the rectifier tube operates at a high potential and the voltage for the filaments is secured by means of a drop across a resistance. The filter systems however are practically identical.

The choice of variable instead of fixed resistances is a matter associated with the need for accurate adjustment and the design of the unit. Where a variable voltage control is used, it is necessary to incorporate a filament current meter so as to show filament current flow and preclude overloading of the filaments. Extensive data about series filament wiring will be found in a separate chapter devoted to that subject.

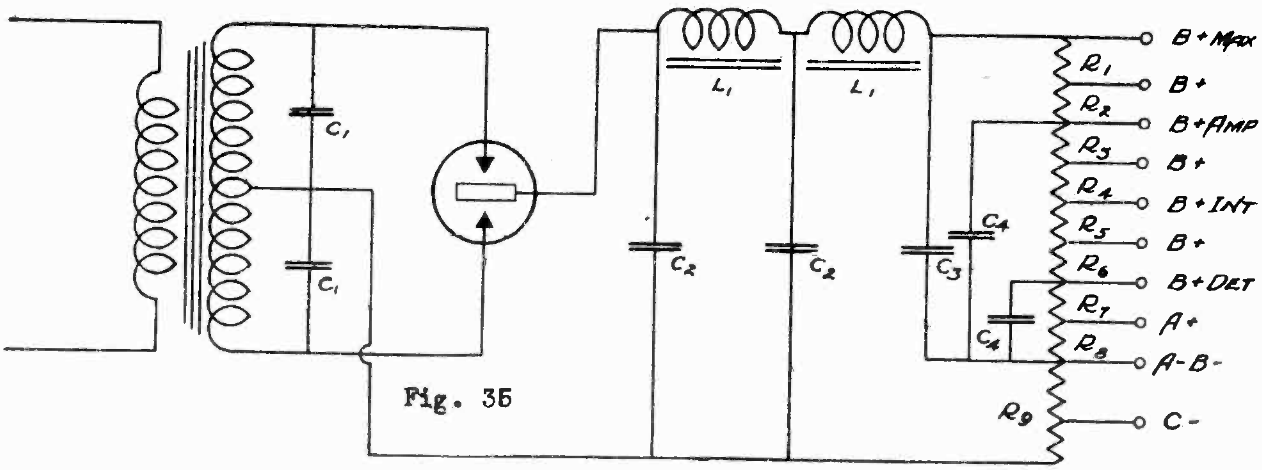


Fig. 35

Special wiring arrangements are frequently employed to provide output voltages in excess of the usual. One such system is shown below, utilizing the gaseous rectifier. The system involves one limitation, that of reduced output current. In addition, it is necessary to employ two separate transformers, sockets, two sets of buffer condensers, etc.. The system as shown is the equivalent of two tubes in series. See figure 36

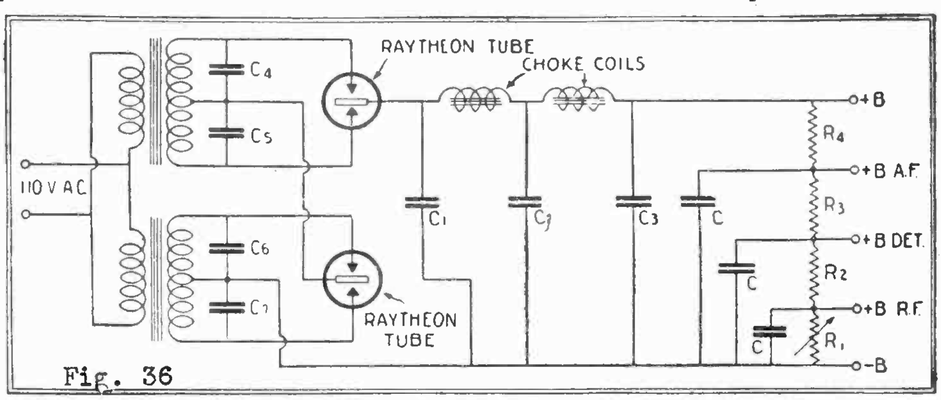


Fig. 36

The system is equally applicable to the filament type of rectifier tube and the wiring diagram is shown in figure 37 , on the next page. The fact that one choke is employed in the filter system is of little consequence and should be neglected. The advantage of this system over the other is that but one transformer is required although two filament windings are necessary. The output voltage is doubled, but the current output is somewhat less than that of one tube. The transformer voltage (A.C.) fed to the tube plates need not be greater than that required for but one tube connected in the normal half wave arrangement.

This arrangement may be utilized to good advantage when the required voltage (D.C.) is around 800 volts and the required current output about 50 to 60 mils.

The introduction of these modified circuit arrangements doe not alter the operating characteristic of the eliminator. The output current is still governed by the output voltage. As the load (current drain) increases, the output voltage decreases and conversely, as the load decreases, the output voltage increases.

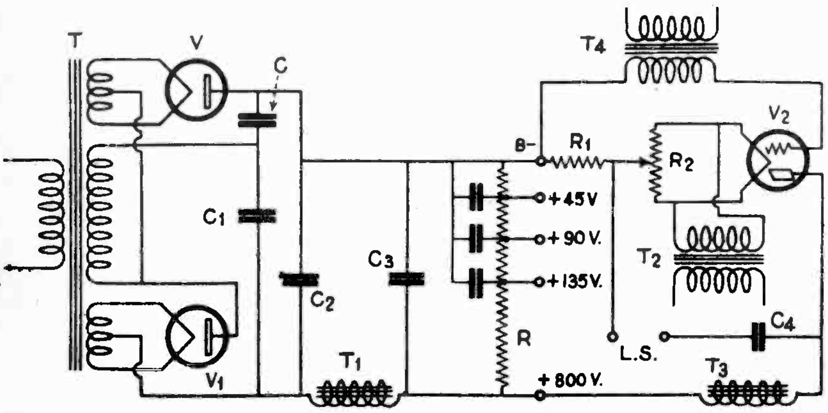


Fig. 37

Schematic diagram of double voltage eliminator and 210 power amplifier. The grid biasing resistance R. might well be variable

Many special circuit arrangements are applied to B battery eliminators to achieve certain ends. In some cases two voltage divider networks are employed, one near the rectifying system and the other in the regular position. The effect is to provide a voltage control of the A.C. voltage applied across the filter condensers.

In still other cases separate filter systems are applied to the individual voltage output taps, this arrangement providing better filtering. Still another system employs two filter networks connected across the rectifier output, one network filtering the detector and radio frequency plate voltages and the other network filtering the audio frequency voltages.

D.C. B Eliminators

All of the B units mentioned thusfar employ A.C. input and rectification by means of a rectifying element. However many localities are not provided with A.C. power mains. Instead the power supply is D.C. in which case the power supply voltage is fed to the plates of the receiver tubes without rectification of any kind. However, the D.C. line potential while sufficiently smooth for lighting and power work, contains a ripple due to the segments on the commutator and this ripple when present in the plate voltage and applied to the plates of the receiver tubes will cause a hum. Hence filtering is necessary and the filter system employed in D.C. installations is identical to the filter systems employed in A.C. type B eliminators, as shown in figure 38. However the two section filter is replaced with a single section, although two sections are frequently employed.

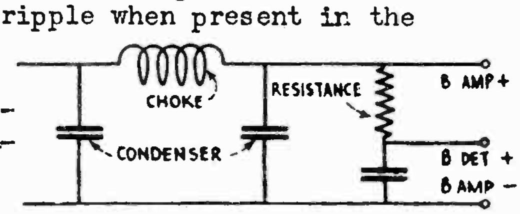


Fig. 38

Such eliminators differ from the A.C. type in several respects. First, the output voltage is definitely limited by the maximum line voltage and the voltage drop in the filter system. If the D.C. line voltage is 110 volts, the B eliminator output voltage will have a maximum value somewhat less than 110 volts because of the voltage drop across the filter choke. Second, the current limitation encountered in the case of the A.C. type B eliminator is absent in the D.C. eliminator because of the high current capacity of the source.

It is obvious that the utility of a D.C. B battery eliminator is limited with respect to the tubes employed in the receiver. In other words if the line voltage is 110 volts, the eliminator cannot supply plate potential in excess of this value for tubes which require high potentials. In some cases these eliminators are designed for

220 volt supply, in which case the required 180 volts for the 171 tube are available.

D.C. eliminators are also available to supply filament as well as plate potential and the circuit arrangement is shown herewith. The B potential is secured in the normal manner and the voltage divider network is of the conventional potentiometer type. The filament voltage is secured by means of a voltage drop across resistances provided for the purpose. The chokes employed in a combination filament and plate supply (D.C.) unit are usually of two types, one which carries the total current drain and filters the A supply voltage and the other which filters the B supply voltage. These two chokes are designated as the "Current Choke" and the "Audio Choke" in figure 39 . This diagram is by courtesy of Ward Leaonard.

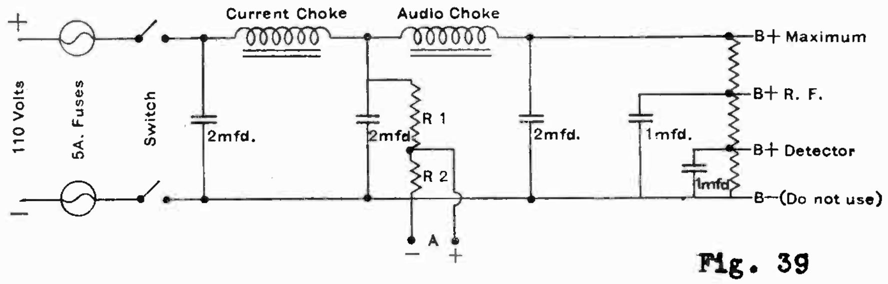


Fig. 39

Although not shown such filament supply units are equipped with a filament current meter or a filament volt meter, the exact unit depending upon the type of filament wiring.

Troubles in B Battery Eliminators

Troubles in B battery eliminators are usually of similar type regardless of the type of rectifying element used. Concerning ourselves with the conventional B eliminator operated from an A.C. source and employing a rectifying device we find the possible troubles to be

1. Insufficient output current and voltage
2. Excessive hum in the output
3. Dead eliminator
4. Poor design

It stands to reason that each of the above faults has a number of contributory causes, for example

1. Insufficient output current and voltage

may be due to

a. Low line voltage
b. Defective rectifier tube or element
c. Excessive voltage drop in filter system
d. Insufficient voltage input to rectifier
e. Excessive load upon the eliminator

2. Excessive hum in the output

a. Low line voltage
b. Defective rectifier tube or element
c. Shorted filter choke
d. Poor filter condensers or defective filter circuit
e. Lack of bypass condensers

3. Dead eliminator

a. No line voltage
b. Defective transformer
c. Defective rectifier tube
d. Open filter circuit
e. Shorted filter circuit

4. Poor design

a. Incorrect transformer-rectifier combination
b. Wrong rectifier
c. Incorrect filter unit constants
d. Lack of bypass condensers
e. Imperfect contacts

Generally speaking troubles in radio receivers are singular with respect to numbers and the same is true in the B eliminator with one exception, the possibility of a damaged rectifier due to overload when a filter condenser "blows" in operation.

In all other cases of trouble it is safe to assume that the trouble is singular. Now, the list of troubles enumerated upon the preceding pages does not signify that, that list includes all the troubles, since each may involve additional items. Then again the presence of one fault or a fault of a certain type may eliminate all other faults as the possible reasons for the trouble on hand. To solve for these troubles we must be able to recognize symptoms and to do so, it is necessary to discuss the function of the various units in the eliminator, at least the important items. This discussion is necessary because many of the phenomena which might cause trouble are not evident upon the surface.

As an example, let us consider the B eliminator shown on the accompanying page, figure 40 , and analyze the conditions which will cause the first form of trouble --- insufficient output voltage and current.

Since the output voltage is a function of the input voltage it stands to reason that the line voltage must be correct and when used, the primary winding tap must be correct. If the line voltage is low, or the tap is incorrect, the A.C. voltage fed to the rectifier will be low. In turn the rectifier output will be low. This is true with all types of rectifiers and the 280 tube is used as an illustration. The tapped primary winding varies the transformation ratio within the transformer and consequently governs the output voltage with respect to the input.

If for some reason a part of the transformer secondary is shorted so that the required amount of turns are not in service, the output voltage (A.C.) fed to the rectifier will be low and the rectifier output will be low.

Since the voltage input (A.C.) to the rectifier is of such great importance, it is easy to understand that the tube used must be the correct one for the transformer and vice-versa and that these two govern the voltage and current rating of the eliminator.

The operating life of the filament type of rectifier tube is governed by the electronic emission from the filament. If this is low, the current output will be low and the tube is defective. The equivalent is true in the case of the gaseous rectifier but in this instance, the trouble is exhaustion of the gas within the tube and lack of current carriers. In the dry disc rectifier, it is the film. In all three cases premature death of the rectifier element is hastened by the application of higher than normal potentials.

In connection with the filter system, experience has shown that the system plays a small role when the trouble is of the nature mentioned, since a high resistance contact in the choke circuit would greatly reduce the voltage output and filter condensers seldom develop partial shorts. A leak across the filter condensers is possible and in this case a certain amount of energy would be lost in the filter system and the output would be reduced.

The design of the voltage divider network is of importance. A certain amount of bleeder current flows through the resistances. This amount of current is in excess of the amount of current consumed by the tubes. If the bleeder current is excessive, because the resistance of the voltage divider network is very low, the excessive drain will reduce the voltage and current output. A short in the voltage divider netwrok will cause an increase in the bleeder current, but this condition would also cause lack of voltage across one of the taps, hence an indication of what is at fault.

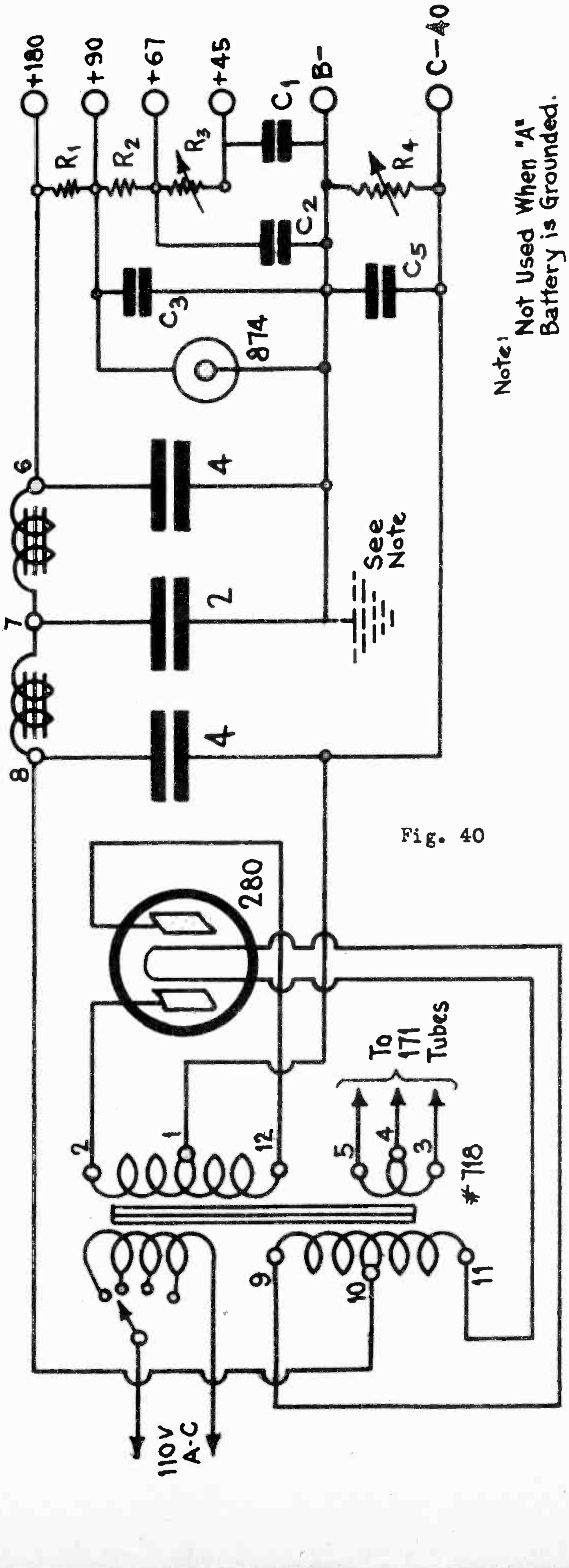

+180
+90
+67
+45
B-
C—40
R1
R2
R3
R4
C1
C2
C3
C4
C5
874
6
7
8
4
2
4
See Note
280
2
1
12
5
4
3
To 171 Tubes
#718
9
10
11
110V A-C
Note: Not Used When "A" Battery is Grounded.

Fig. 40

We made mention that the voltage regulation characteristic of the average B eliminator is such that an increase in plate current drain will reduce the output voltage. This means that the current and voltage output of an eliminator may be low because the current load, represented by the number of tubes being supplied with plate potential are greater than the number permitted by the desugn of the eliminator, i.e. the rectifier element and the transformer.

With respect to the second form of trouble --- excessive hum in the output, we find other important factors.

Once again the line voltage is important. Low line voltage interferes with the normal operation of the rectifier and causes hum. If the rectifier is defective because of old age or some other reason, it performs poorly and causes a bad hum. Here we find that troubles 1 and 2 are allied. If the hum is accompanied by low output voltage, it indicates the possibility of a defective tube. We do not wish to state definitely that the tube is at fault because one or two other items will cause similar conditions. However,if the voltage is radically less than normal and the input voltage is normal and the hum is bad ---- check the rectifying element.

The function of the filter system is too eliminate the A.C. ripple in the rectifier tube output so that the voltage across the voltage divider is pure D.C. If a short develops in the filter choke or chokes, the efficacy of the filter system will be reduced and a greater percentage of the A.C. ripple will finds its way to the output.

The filter condensers play an important role in filtering, as a matter of fact, with respect to general performance. If a condenser circuit is open, filtering is impaired and the hum is greater in the output. If one of the condensers is poor, filtering is impaired. The actual function of the various filter condensers will be discussed shortly.

The bypass condensers connected across the various sections of the voltage divider network are important with res ect to hum in the output. They play a small role in the actual filtering, but when correctly placed across the resistances, bypass the A.C. component in the output circuit so that it is removed from the D.C. supplied to the tubes in the receiver. This applies equally well to all resistances in the voltage divider ne work, including the resistors utilized to supply the grid bias voltage and the resistances used to supply the filament potential.

The possible reasons for "dead" eliminators are very simple to understand. If the power transformer primary is open or the power line disconnected from the eliminator, voltage output is impossible, since A.C. voltage is not be supplied to the rectifier. The same is true if the plate voltage winding or the filament voltage winding is open. If the rectifier tube filament is damaged operation is impossible, hence no voltage output. If the tube is defective, lack of gas in the gaseous rectifier,voltage output is impossible. If the filter condenser connected across the rectifier output is shorted voltage will not be passed to the remainder of the eliminator. In this case heating of the rectifier will show that the rectifier is in operation. A short in any one of the filter condensers will make voltage across the voltage divider an impossible feat, since the shorted filter condenser is a short across the voltage divider. An open in the filter system will not permit passage of D.C. to the voltage output. We refer to an open in the choke circuit.

A short in the bypass condenser network causes an effect very much different than the effect due to a short in the filter condenser system. A shorted bypass condenser will short one of the resistences or a portion of the voltage divider system. Consequently voltage will not be available across the shorted resistance or section, but voltage will be available across the complete output, i.e. between the maximum B+ and the B- or the maximum C- terminals. This is in direct contrast to the condition present when the short takes place in the filter condenser. When so located voltage is not available across any of the sections of the voltage divider network, irrespective of the type of voltage divider.

It is easy to comprehend that a shorted section of the voltage divider will reduce the total resistance connected across the eliminator filter. As a result, the value of the bleeder current will increase and the increased current drain will reduce the total output voltage. Hence when the output voltage is less than normal and voltage is not obtained across one section of the voltage divider, it is an indication of a shorted section.

Lack of voltage across one section of the voltage divider is possible under another condition, namely when the voltage divider network is open. In this case the maximum output voltage increases rather than decreases, because an open in the voltage divider network removes the load across the eliminator, rather than increasing the current load.

As is evident in the wiring diagram shown in figure 40 the C bias for the output tube is secured from the B eliminator. This is the resistance designated as R4. Therefore this resistance is a part of the complete voltage divider network. As is evident the voltage across the +180 and -40 terminals will be greater than the voltage across the B- and the +180 terminals since the sum of the C bias voltage and the maximum B+ voltage is the total output voltage. If the C bias voltage is removed or not used the output voltage is increased.

Now, an examination of this wiring diagram will show the important position of the C bias resistance and this is true in all such eliminators. If for some reason this resistance "opens" during operation, the complete load is withdrawn, since the C resistance (R4) provides the return path to the - of the rectifier output. With the load withdrawn, the rectifier output voltage will increase and the hazard of filter condenser puncture is present.

With respect to the fourth designation ---- poor design ---- we have several very interesting considerations.

In the first place the output voltage and current are dependent upon the rectifier element and in turn the performance of the rectifier is governed by the operating potentials. It therefore stands to reason that the combination of transformer and rectifier must be correct, so that the operating potential applied to the rectifier be the correct potential. Insufficient potential will prohibit correct output from the rectifier, whereas excessive potential may injure the rectifier and if not injure the rectifier will greatly reduce the operating life. In this connection it is imperative that the maximum voltage (A.C.) rating be followed, as set forth by the rectifier manufacturer.

Interpretation of the above means that rectifiers cannot be applied in a haphazard manner. If a tube or an element is designed for a 350 volt (A.C.) input the tube or element should not be employed with a 280 volt input, because the rated current and voltage output will not be secured. On the other hand the tube or element should not be used with a 400 or a 450 volt input because the operating life of the tube or element will be greatly reduced and permanant injury will result.... We realize that many rectifiers are operated at A.C. voltages much higher than the manufacturer's rating, but shortened operating life is the usual result.

Inorder to comprehend troubles in B power units it is necessary to consider the action within the unit. That the filter system smooths out the pulsating D.C. output fed to it from the rectifier system is well known, but the action of the individual units within the filter system is not so well known...It stands to reason that the electrical constants of the chokes and condensers constituting the filter must be of definite values inorder that the correct effect be secured.

The fundamental frequency or the strongest frequency to be filtered was mentioned earlier in this section and as far as filtering is concerned, the average arrangement function quite well, but the parts in the filter manifest an effect upon the operation of the eliminator in ways other than just the actual filtering. For example, the condenser nearest the rectifier system influnces the voltage output of the rectifier, consequently the voltage output of the complete eliminator. In addition it influences the voltage regulation of the system, i.e. the change in output voltage per milliampere increase in current drain. In this connection the design of the chokes is of importance. The midsection condenser designated 2, affects the hum in the system and is very important with respect to the elimination of the hum... The output condenser in turn displays an effect upon the hum and also upon the quality of the signal made audible by the speaker. This condenser functions as a storage tank supplying the required power when a strong signal calls for additional operating power from the eliminator inorder to per-

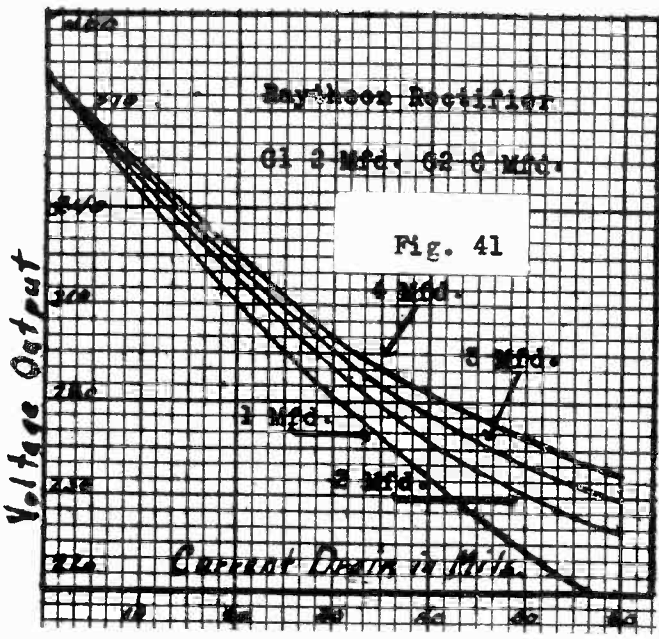


Fig. 41

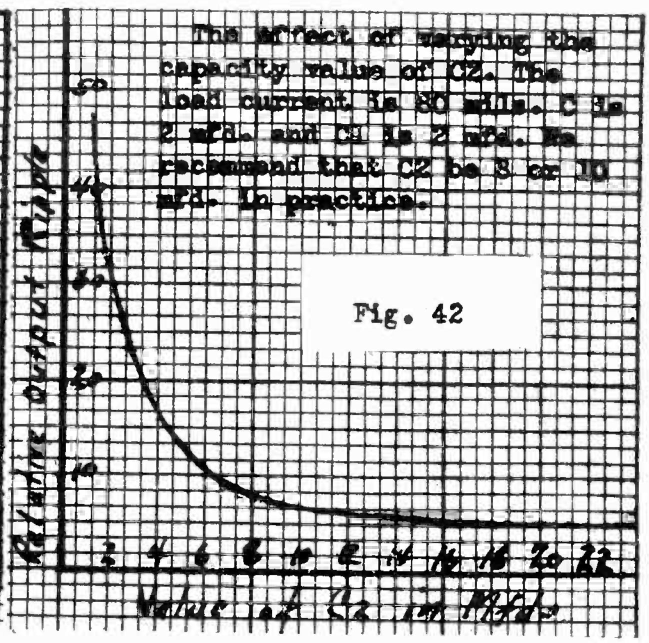


Fig. 42

mit the full plate current swing without reducing the available plate voltage. The above two graphs illustrate the effect of varying the condenser connected across the filter input and the effect of the output condenser upon the hum. These curves were made with a conventional B power unit employing a Raytheon BH tubes, but the data is applicable to other types of rectifiers. Conventional practice has standardized the values employed in the filter system. The input condenser is usually 2 mfd. although 4 mfd. is frequently used. The midsection condenser is 2 mfd. and the output condenser varies according to the likes and dislikes of the design engineer. This value varies between 4 and 10 mfd. the latter being preferable.

In certain cases the input filter condenser is omitted. The omission is based upon experimental data showing increased life of the rectifying element (filament type). However, many filament type rectifiers have been in use over normal periods with condenser input and the system is used.

The voltage drop in the filter system is usually the D.C. voltage drop across the filter chokes, since these units possess an appreciable amount of D.C. resistance. With respect to the chokes employed in such filter systems, it is necessary to consider the inductance of the choke when D.C. is passaing through the winding. The rectifier output contains a large percentage of A.C. and the filtering action in the filter is secured by virtue of the inductance and capacity present in the circuit. If the electrical constants of units in the filter system have been selected because they perform the required work, and if for some reason the inductance values is reduced, the filtoring action of the system is impaired and the hum in the output will be objectionable. It is for this reason that we state the importance of sufficient inductance in the filter chokes under normal load i.e. normal D.C. current flow through the chokes. Furthermore, the action of the D.C. is to reduce the inductance of the choke and if the reduction is appreciable filtering is impaired.

Then again the current flow (maximum) through the choke must be within the rating of the choke, because excessive current flow will so effect the choke that undesired harmonics will be introduced in the filter system and appreciable hum will be present in the output. The above is the result of core saturation.... Tha above is applicable with equal facility to all types of conventional B power unit filters, regardless of the type of rectifier employed.

One of the major troubles encountered with many old type B eliminators has been voltage fluctuation and the method employed to overcome this diffuculty has been the use of a voltage regulator tube, usually connected between the +90 and the B-taps. The use of the tube permits the attainment of constant output potential at the 90 volt tap over a range of current load. Such a tube is represented by the 874 tube in figure 40 . A similar type of tube, that is similar with respect to function is manufactured by the Raytheon Co. In connection with this tube, one significant fact is overlooked, a fact which governs the successful utility of the tube. This fact is the current consumption of the tube. In other words, the tube requires about 30 milliamperes for normal operation and this drain must be added to the normal current load. If the normal current load exclusive of the voltage regulator tube is equal to the eliminator output or practically the eliminator output, the voltage regulator tube cannot be applied, because the tube drain will overload the eliminator and cause a reduction in output voltage.

This tube has been found advantageous with respect to the elimination of motorboating, but in that respect, similar effects were obtained with a condenser of about 20 mfds. although the replacement of the tube with the condenser had no material effect upon voltage regulation. Such tubes may be connected in series to control the 90 and the 180 volt taps, in which case it is necessary to consider the drain of both tubes.

The bypass condensers in a B eliminator are important because of the effect upon the amplifier. First they function to bypass whatever A.C. is left in the output so that it is not impressed upon the plate of the tubes in the receiver. Second they bypass each resistance so that the A.C. component (signal) is not caused to pass through the resistance to other plate circuits in the receiver, causing excessive regeneration, howling and motorboating. In many instances the omission of a bypass condenser across a section of the voltage divider resistance, particularly the detector section, will cause extreme howling. The bypass condenser is of extreme importance across the grid bias resistance, because it removes all effect of the resistance as a coupling resistance between circuits and minimizes distortion in the event that the A. signal voltage causes a voltage drop across the C bias resistance in such phase with the signal voltage that some of the signal voltage (low frequencies) is balanced out.

The value of the condenser employed to bypass the grid bias resistance has been found to be very important with respect to regeneration in the audio amplifier and hum in the complete system. In this connection we must refer to Volume 1, "The Mathematics of Radio" wherein is discussed capacity reactance and the association of capacity reactance and the resistance to be bypassed. Alltogether too many installations employ low values of bypass capacity across the grid bias resistances in the system. A condenser with a reactance value of 1666 ohms at 60 cycles is of very little use as a bypass condenser across a 300 ohm resistance, since the hindrance offered to the flow of A.C. through the circuit is greater in the condenser than in the resistance, hence more will flow through the resistance into the circuit, than will flow through the condenser. In very many instances, each increase in bypass capacity diminished the magnitude of the hum in the output.

Before closing this section, we cannot help but make mention of two significant items, the operating voltage rating of the condensers in the power unit and the current carrying capacity of the resistances. The small condensers employed as buffer condensers in eliminators employing the gaseous rectifier are subjected to A.C. potentials from the transformer winding. Consequently the operating voltage rating of these condensers lies within the A.C. category. Now, A.C. voltages are of two classifications, effective and peak, the former being the value indicated on an ordinary A.C. voltmeter and the value actually useful for work. However the peak voltage is of importance when condensers are in the circuit since they are subjected to the actual peak voltage which, in value, is equal to the

effective voltage x 1.414

Hence the voltage impressed across the condenser is greater than the voltage indicated upon a meter connected across that A.C. winding. This means that the operating voltage (A.C.) rating of the condenser must be sufficiently great to withstand the peak voltage. If the transformer voltage is 350 volts (measurement by meter) the A.C. operating voltage rating of the buffer condensers should be at least

350 x 1.414 or = 495 volts

This data should be borne in mind wherever large values of A.C. voltage are involved, as a matter of fact wherever A.C. voltage is applied to condensers and the operating voltage rating of the condenser governs its operating life.

With respect to the resistances in the voltage divider network, overloading of the resistances will cause burn out and noise. As far as the current carrying capacity of the resistances is concerned, it is necessary to consider the position or the location of the resistance in the voltage divider system. For example the ohmic values of R1 and R2 in figure may be the same, yet R1 is called upon to carry more current than R2 and R4 is called upon to carry the entire eliminator drain.

Trouble Shooting in B Eliminators

Shooting trouble in a power B unit is not difficult if the parts used in the system are accessible. As a matter of fact trouble shooting is simple. If however the unit is not only sealed within a container, but the complete unit immersed in wax, the best thing to do is to send it back to the manufacturer. If the various units in the eliminator are contained in individual cans and are accessible for test by removing the cover, servicing of a defective unit is in order.

As a basis,let us consider the two eliminators shown in figures 43-44. With the exception of the circuit structure associated with the rectifying tube and the transformer, the troubles and diagnosis is the same in both cases... In what is to follow, we take for granted that the trouble whatever it may be, is in the eliminator and not in some other part of the receiver installation.

At this time, many wonder how it is even possible to measure the transformer voltages when the power transformer is sealed within a can. We have a system and it shall be discussed at the proper time.

Suppose that the trouble is a "dead" eliminator or no voltage at the taps.... What is the method of proceedure.... We shall enumerate the steps and diagnose.

1. Line voltage.

Inorder that voltage be supplied to the rectifier it is essential that voltage be supplied to the power transformer. The fact that the plug makes perfect contact with the line socket means very little. SEE THAT THE LINE CONTROL SWITCH IS ON AND THAT THE PRIMARY TAP SWITCH MAKES CONTACT..

Examine the rectifying tube or element. If it is warm, glowing if of filament type it is unnecessary to check continuity through the transformer primary winding. If however the rectifier is not operating, check continuity through the power transformer primary. The ordinary continuity tester will suffice.

2. Transformer output voltage

Satisfactory primary circuit continuity does not mean satisfactory secondary circuit continuity.... Perhaps the filament circuit is open.. This should be checked by means of a voltmeter or a continuity tester across the filament terminals of the socket by means of the conventional plug insert connected to an A.C. voltmeter or by means of the continuity tester prongs connected to a voltmeter.. It should be understood that this test is unnecessary if the tube filament lights and burns at normal brilliancy. The voltage check at the socket is not the complete test. If voltage across the filament terminals is lacking it is necessary to check the voltage at the transformer terminals or to check the continuity of the filament winding at the transformer terminals.

The same is true of the transformer secondary supplying the plate voltage. We refer to open circuits in the winding. The test for a short circuit of the plate winding or a shorted buffer condenser in eliminators employing the Raytheon tube is another item. The unit used to test the transformer output voltages in B eliminators is shown in figure 45 and the associated numerical designations refer to the parts of the systems shown in the wiring diagrams and designated by the same numbers. The arrangement prov-

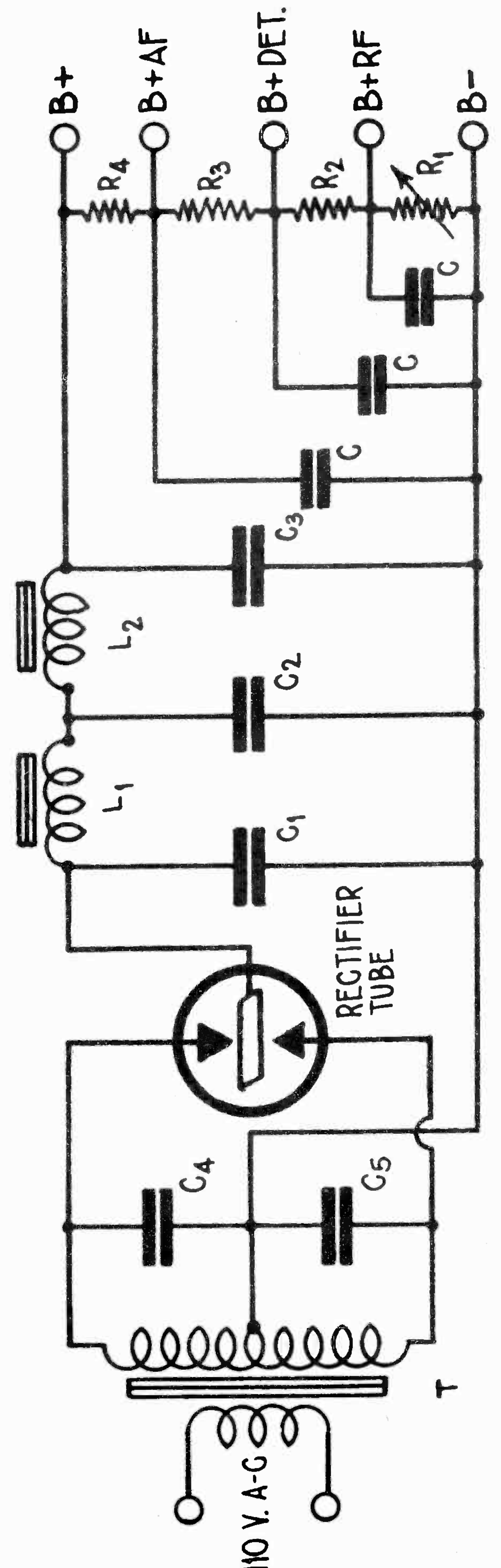

B+
B+AF
B+DET.
B+RF
B–
R4
R3
R2
R1
C
C
C
C3
C2
C1
L2
L1
RECTIFIER
TUBE
C4
C5
T
110 V. A-C

Fig.
43

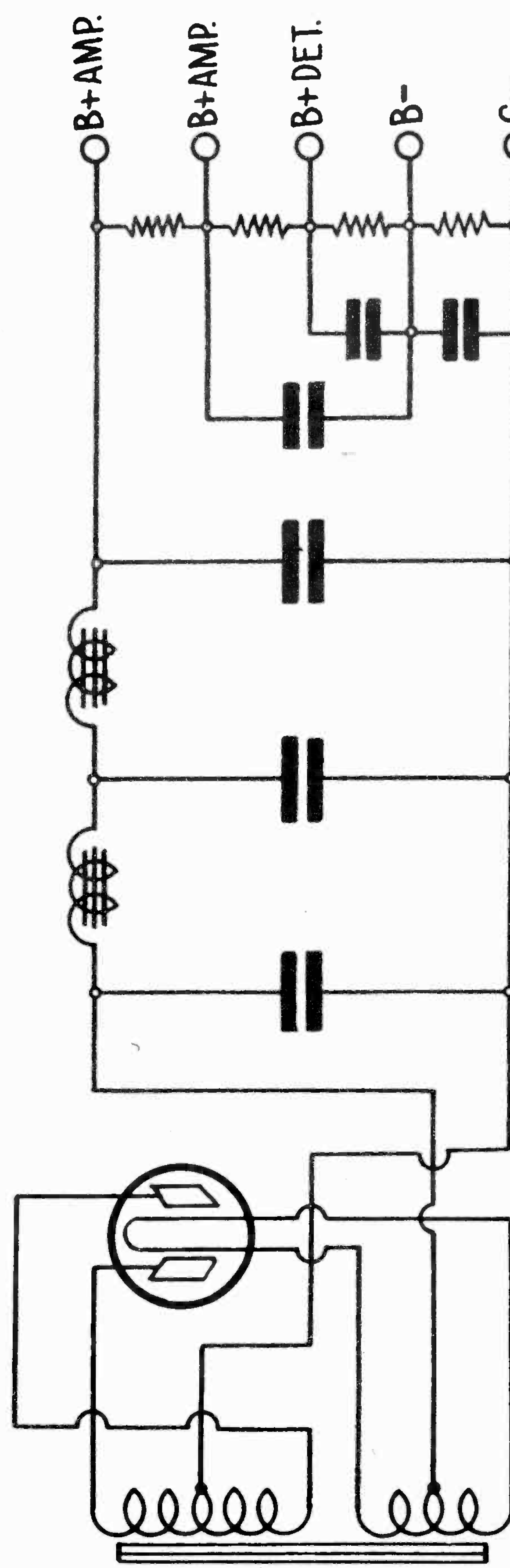
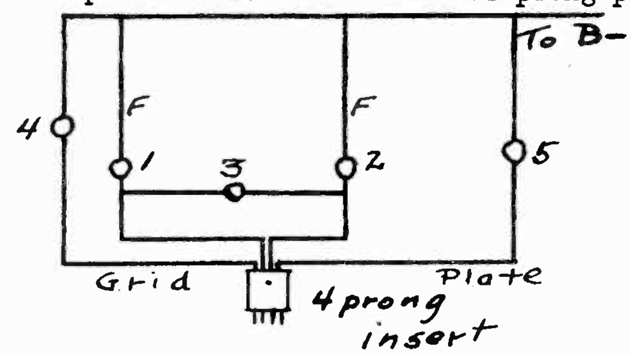
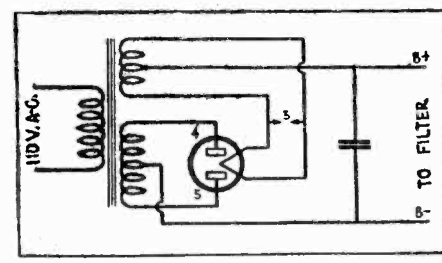

B+AMP.
B+AMP.
B+DET.
B–
C–

Fig.
44

ides a means of connecting the correct A.C. voltmeters with the proper operating ranges across the respective circuits. The four prong plug insert is placed into the rectifier

Fig.45





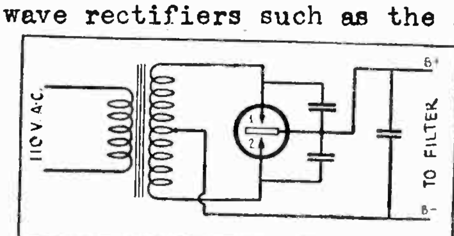
Wiring diagram of filament type rectifier. Numbers show circuits controlled by toggle switches.

Fig. 46

tube socket, the rectifier of course,being removed from the socket. The plug insert connects the socket terminals with the various terminals on the power transformer via the open circuit jacks. With one, the common terminal of the tester connected to B- the insertion of the voltmeter plug into any one of the jacks connects the voltmeter across the various power voltage circuits.

The B- terminal connects to the B- post of the eliminator if C bias voltages are not secured from the eliminator and to the maximum C- terminal of the eliminator if C bias voltages are secured from the eliminator. Jacks 3,4 and 5 are used when measuring filament and plate (A.C.) voltages in connection with filament type rectifiers and jacks 1 and 2 are used to determine the plate voltages applied to gaseous rectifiers. The filament voltage may be determined with the B- connected because the remainder of the B circuit remains open because of jacks 1 and 2.

Jacks 1 and 2 are used to measure the voltages (A.C.) supplied by the two halves of the power transformer used with the Raytheon tube. Jack 3 is used when measuring the filament voltage applied to the filament type of rectifier. Jack 4 is used to measure the plate voltage (A.C.) applied to the anode in the 280 type tube, which is connected to the grid terminal of the socket. Jack 5 is when measuring the A.C. plate voltage applied to half wave rectifiers such as the 216B and the 281.



Wiring diagram of gaseous rectifier. Numbers show circuits controlled by toggle switches.

Fig. 47

The voltmeters are connected to the conventional type of plug which is capable of withstanding A.C. potentials as high as 750 volts. It is understood of course that the line voltage is "off" when the voltmeter is plugged into the jack. If desired the arrangement may be simplified by terminating the leads from the four prong insert at four binding posts located on an external panel and connecting one, the common lead of the A.C. voltmeter to the B- and making contact with the various leads from the plug insert. In this system however, it will be necessary to remove the voltmeter connection from the B- when measuring filament voltage.

The above two arrangements will show continuity in the windings. Another arrangement is possible to determine a shorted secondary or a shorted buffer condenser. This system is recommended by the engineering staff of the Raytheon Manufacturing Co. We quote from their bulletin. " A short circuit in the secondary of the transformer can be most easily checked by connecting a 25-watt ,110-volt lamp in series with the primary. With the current "on" in the usual way but with the rectifier tube or element out of the socket, the incandescent lamp should glow with a dulll brilliancy, if at all. If it glows bright either the transformer secondary or one of the buffer condensers is broken down. With the lamp still in the primary, the rectifier tube is inserted into the socket. If the secondary connections are O.K. and the Raytheon is operative (this applies to the filament and other types of rectifiers as well) the lamp will increase in brilliancy."..... The Raytheon tubes becomes warm when operating.

Now, lack of voltage across the output circuit, the voltage divider may be due to two conditions in the filter system, an open in the choke circuit or the B- return circuit between the B- or maximum C and the rectifier and to a shorted filter condenser. A D.C. voltage test across the first filter condenser or across the input to the filter will show a shorted filter condenser and even an idea of its locati n; providing that the - return circuit is intact, i.e. the lead between the B- or the C- and the minus terminal of the power transformer secondary.

A shorted input filter condenser will eliminate all possibility of D.C. voltage measurement across the condenser. Furthermore a short in this condenser will cause overloading of the rectifiers,which in the case of the filament type of rectifier will cause overhaating of the tube plate. In the event that in a full wave system, employing two half wave rectifier tubes one plate overheats and the other appears to be normal, the defect is in the latter tube, the one with the normal plate.... In the case of the gaseous rectifier overloading due to punctured input filter condenser will cause overheating of the tube and arcing between the elements, which means that the tube is injured.

If a voltage drop is found across the input to the filter and voltage is not available across the voltage divider, it is necessary to consider the voltage available across the input filter condenser. If it is low, it means that a heavy load is being applied to the rectifier system and this load is either a short between the choke and the minus side of the system or a punctured filter condenser between the input and the voltage divider. If the voltage reading is very high, it means that the choke circuit is open or that the circuit between the output choke and the maximum B+ is open, beacuse either open will remove the load.

To locate the punctured filter condenser it is necessary to check the remaining filter condensers by measuring the voltage across the condenser. Voltage will be lacking across the punctured.unit. Continuity in the choke system is checked with a continuity tester. This method of procedure is applicable to all types of B eliminators and is independent of the type of voltage divider employed.

Let us take another instance... Voltage is not available across one output tap. The logical place to seek the cause of trouble is in the output circuit. This part of the eliminator includes the bypass condensers as well as the resistances in the network. Once again we must consider several factors. An open resistance will create one effect, whereas a shorted resistance will create another effect. Then again it is necessary to know the type of voltage divider structure. Lack of voltage at one tap in a system like that shown in figure 43 is possible with a shorted resistance. An open resistance will open the remainder of the circuit and voltage output will be lacking at several taps.

An examination of the divider network will show the truth of the above. If R3 is open voltage will not be available at B+ Det.. Neither will it be available at B+ RF.

On the other hand if R3 is shorted the voltage at B+ Det. will be the same as the voltage at B+ AF which is a definite sign that R3 is shorted and that the resistance is shorted, not the associated bypass capacity. The reason for this is that a short in the bypass condenser will short all the resistances between R3 and B-. Now, a short circuit in C connected to B+ A.F. will cause the same effect as an open in R3, that is no voltage between B+ A.F. and B- but the magnitude of voltage between the maximum B+ and the B- terminal will indicate an open in the voltage divider network, say at R3 or a short in the bypass condenser, because an open will remove the load and the maximum voltage will be high, whereas a short will increase the load and the voltage between B+ and B- will be low.

When the bypass condenser is connected across one resistance, a short in the condenser is the same as a short in the resistance, but this circuit arrangement is not used in the B voltage systems. The only location of such circuit connection is the bypass condenser across the C bias resistance. This includes the C bias resistance and bypass condenser in the B eliminator.

The situation is somewhat different when separate resistances are employed as in the eliminator used in the Atwater-Kent receiver and shown in figure 2. An open in either resistance influnces but one voltage reading, the voltage secured from that tap. A shorted bypass condenser on the other hand would either eliminate the voltage at one tap by shorting the tap with the B- or would short two of the voltage taps. For example a short in the .5 mfd. condenser connected across the detector tap would short the detector tap and B-, whereas a short in the 1 mfd. condenser connected between the detector and B+ A.F. tap would short the B+ Det and the B+ A.F., in which case the voltage at the detector tap would be the same as the voltage at the A.F. tap showing that the detector resistance is shorted.

Before we progress to other items we wish to make mention that all eliminators do not employ two chokes in the filter system and that in many cases when a dynamic speaker is employed, the fielf coil of the dynamic speaker functions as a filter choke and is energized by the eliminator current. This is shown on the accompanying page in figure 48 . The system shown is the Radio Corp. of America # 105 Power Amplifier-Speaker-Eliminator, wherein the speaker field coil is the major filter choke. The location of this choke differs from the conventional systems in that it is in the negative lead. This system and the use of a choke in connection with the resistance employed to drop the voltage from 450 volts to 90 volts as per the tap designation illustrates the variance in design. The B eliminator supplies a -3 and a -9 volt C bias .

Continuing with trouble shooting, let us imagine that the trouble is hum, in other words, excessive A.C. in the D.C. output. In many cases this condition exists with normal plate potential hence the measurement of voltages is of little value... It is more important to examine the installation to see if all the condensers are correctly connected. Incorrect placement of a filter condenser will cause hum. A short circuited choke will cause hum, hence continuity test through the chokes will prove of advantage. In this respect, the regular continuity tester is satisfactory providing that the tester realizes that the chokes possess D.C. resistance and that full reading is impossible when the voltmeter-battery continuity tester is applied. Open circuits in the bypass condenser system will cause hum... A reversed line plug will cause hum. Lack of ground in systems designed for a ground will cause hum... With respect to the chokes in the filter, continuity may be checked by deliberately shorting the choke or chokes.. If circuit continuity is satisfactory, shorting the chokes should increase the hum. Disconnecting condensers should increase the hum.

In the event that the eliminator output voltage is low and the hum is present,

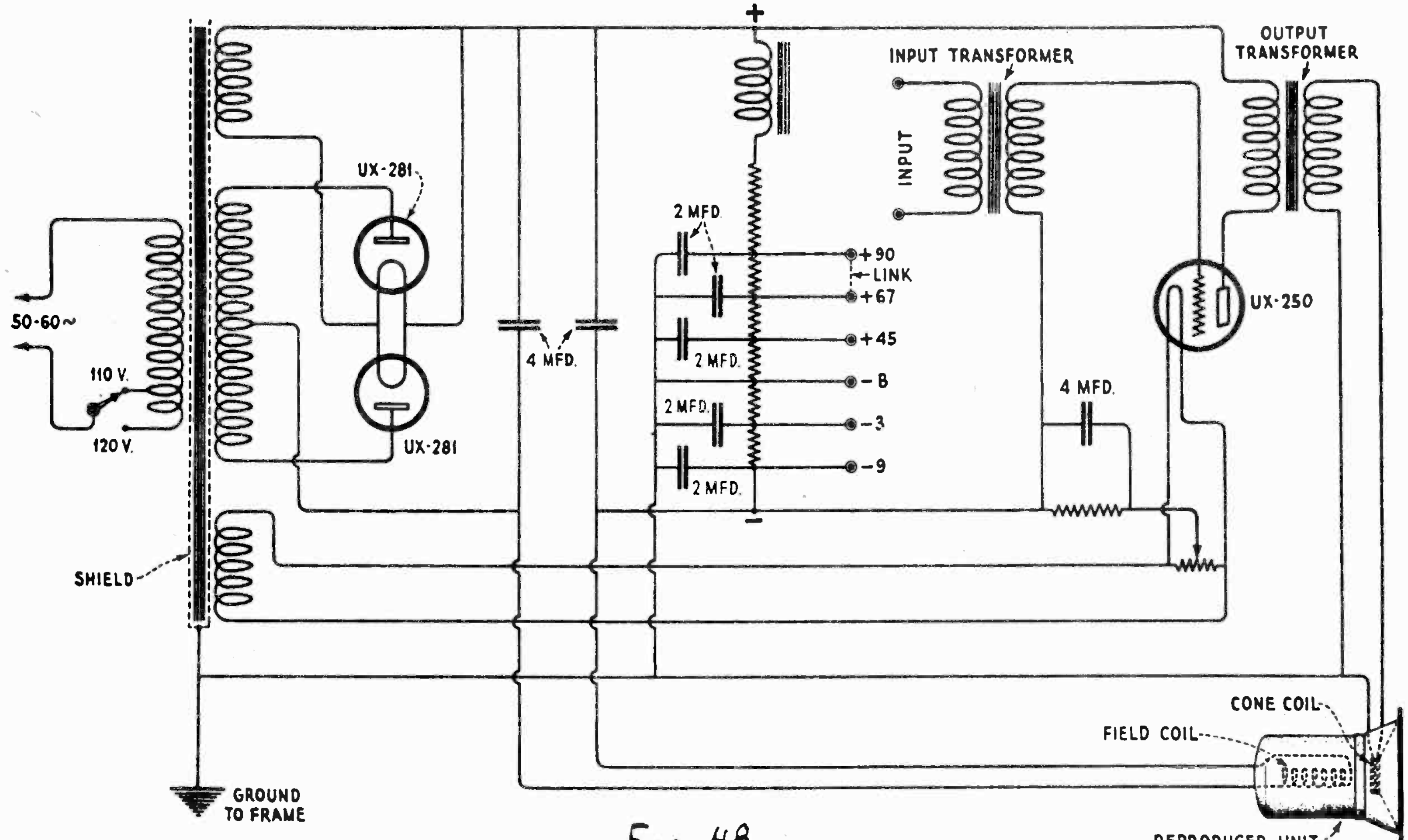


Fig. 48

Wiring Diagram of R C A #105 Power Amplifier-Speaker other factors must be considered. If the hum and the low voltage are due to the same condition. voltage will be available at all taps and across all circuits and circuit continuity with respect to the D.C. items is usually normal. The possible causes are low filter capacity or an open in the filter condenser circuit; low line voltage and defective rectifiers.

The first item requires examination; the second, requires a voltage test and the third requires consideration of the period of operation and replacement. The replacement test is better than an electronic emission test and must quicker. Reference to the curves showing the action of the various condensers in the filter illustrates the effect of low capacity. A rapid test is to add additional capacity to the first (input) and the last (output) condensers. If the original capacity was low, the additional will decrease the hum. On the other hand too much capacity in the middle condenser,if three are employed,will increase the hum.

WHEN MAKING VOLTAGE (D.C.) TESTS IN ANY PART OF THE ELIMINATOR SYSTEM, IT IS IMPERATIVE THAT A HIGH RESISTANCE VOLTMETER BE USED.

In many instances the complete design of the eliminator is such that a bad hum is found in the output.If changes in the B unit are impossible, the magnitude of hum may be reduced by adding external filter sections as shown below, a choke and a condenser in series with each tap, the choke being in series with the voltage lead and the bypass condenser connected as shown between the output voltage terminal on the set side and the B-. The choke should have an inductance of about 30 henrys and the condenser should be of from 2 to 4 mfds. The D.C. resistance of the choke should not be more than 600 ohms.

Fig. 49

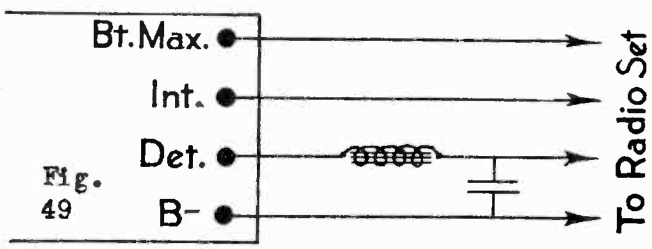


Fig. 49

The most prominent place for such audio filters is the detector tap. However, it may be applied to all the other B+ taps.

Motorboating is frequently attributed to the B eliminator, particularly poor design of the filter system. The above idea is erroneous. Many conditions contribute to motorboating, the major being excessive regeneration in the audio amplifier, due to an impedance present ine the B circuit, which is common to more than one tube circuit. The remedy includes the audio filter shown above, the abundant use of bypass capacities in the grid and plate circuits of the audio amplifier and the minimization of regeneration in the audio amplifier. Increasing the value of the bypass condensers associated with the detector tap is frequently foundto be of aid.

The eliminator is a possible source of noise. Voltage measurements are of little use in this respect and it is necessary to seek points of poor contact. This requires visual examination. Lack of ground may cause the noise because the electro-static shield in the transformer is not grounded. In many instances the noise is carried to the set through the complete eliminator and the source is the power system feeding the eliminator. If this is the case, a capacity filter such as that shown in figure 50 will prove advantageous. The condensers are of 1 mfd. each and rated at 200 volts A.C. for 110 volt systems and at 400 volts A.C. for 220 volt systems. As a matter of fact such capacity filters are found in many commercial eliminator installations.

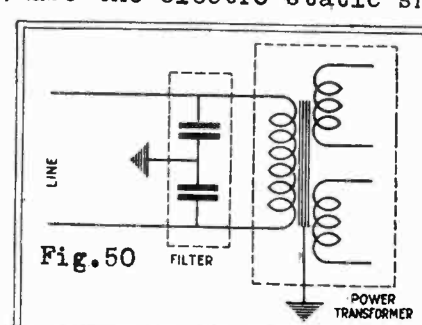


Fig.50

Overloaded voltage divider resistances will cause hissing and frying sounds and examination will show arcing if the resistances are wire wound. Settlement of dust and lint upon condensers will cause periodic flashover across the dirt. Insufficient separation between wires carrying high and low potentials may cause flashover. Overloading of the rectifier element or tube may cause intermittent arcing and noise. Defective rectifiers will cause noisy operation. In this case evidence of the trouble is found in the output voltage, the voltage fluctuating during the periods of noisy operation. Replacement of the rectifier with a new unit or tube is the best test.

Before closing this section we wish to make mention of the electrolytic condensers employed in many commercial installations. These condensers are self healing and a momentary puncture does not ruin the condensers. With respect to connection these condensers have polarity and the can is the negative electrode.

Electrolytic condensers are designed to afford high values of capacity, consequently the usual filter condenser data with respect to capacity values does not hold when electrolytic condensers are employed. In many instances single section filters are used and the capacity values of the input and output condensers are as high as 70 microfarads. The usual values are around 10 mfds.

Speakers and Types

The speakers in use today are of three types;

1. Cone (electro-magnetic)
2. Dynamic (moving coil)
3. Exponential (metal diaphragm)

Of the three types mentioned,the first and second are most popular in the radio field. The latter finds some application, but it is not prevalent and finds greater application in public address systems and in the talking movies. The type differs from 1 and 2 in both the type of structure and unit utilized to set the air into motion. However the sound unit used in the exponential horn found wide application in radio loud speakers of yesteryear. However we shall give some service data relative to trouble in such units.

Troubles in speakers are several in number;

1. Dead
2. Sound output is weak
3. Sound output is distorted
4. Speaker rattles

In connection with the cone type of speaker lack of response may be due to lack of signal input, but if we assume the speaker to be at fault the following list should cover the troubles;

1. Open cable connecting speaker to amplifier.
2. Burned out coil.

Both of these troubles may be determined by means of a simple continuity test. First test the speaker cord and second the coils with the speaker cords removed. However it is possible that the speaker cord or the coils within the speaker are shorted. To ascertain this defect, it is necessary to check the cords individually, that is, one core at a time. The meter reading when testing the coil will show the presence of a short circuit, since the usual resistance of these coils is about 1000 ohms D.C. hence the meter reading will not be a full reading when the coils are perfect.

Many cone speakers are equipped with frequency filters and an open in the filter coil will cause a "dead" speaker. Such a filter is illustrated in figure 3, the wiring diagram of the Stromberg-Carlson 635-636 receiver. The filter utilized in the RCA model 100 speaker is shown herewith. See figure 51 . As is evident a short in the condenser will short the speaker, hence when checking speakers equipped with filters, it is necessary to disconnect the complete speaker filter and to individually check the speaker and the filter components.

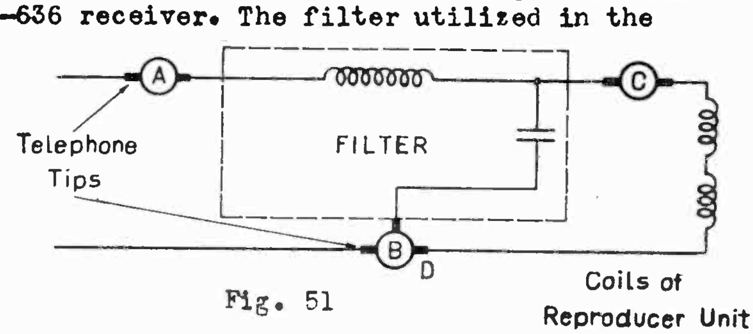


Fig. 51

The result of a continuity test applied to a condenser is the reverse of that found when a coil is tested. The perfect condenser should show an open and the initial application of potential should show a momentary charge upon the meter.

If the speaker lacks sensitivity and it is definitely established that the signal input into the speaker is normal and that the speaker cord and coils are in good condition, weak sound output is usually due to weak magnets or to a weak magnet if only one is used. The strength of the magnet is influenced by direct current flowing through the windings and if the polarity of this current flow is incorrect and the current flow maintained for quite a period the magnet will be weakened. This condition is infrequent because the average speaker is so arranged and connected to the radio set that D.C. does not flow through the speaker windings. In other cases the effect of the direct current flow is balanced in the speaker so that it does not influence the magnet.

Distorted sound output may be due to distorted input, but if the input is known to be satisfactory the possible reasons are;

1. Imperfectly adjusted armature
2. Damaged cone
3. Imperfectly centered cone
4. Defect in filter, if filter is used.
5. Incorrect coupling unit, coupling speaker to tube

Visual examination is necessary in 1,2,3 and 5. An electrical test is necessary to determine 4. The armature must be accurately centered between the pole pieces. A torn,cracked or unevenly stretched diaphragm will afford poor sound output. An imperfectly centered diaphragm will distort on loud signals.

A defect in the filter or the use of incorrect electrical constants will affect the frequency response, as for example a shorted filter choke will cause the loss of high notes if the value of the condenser is high. However the usual speaker filter is designed to cut off at a predetermined frequency, which condition will be upset by a defect in either unit.

In turn the use of the incorrect coupling unit will cause a decided loss in low frequency response.

The rattle in a speaker may be due to

1. Incorrectly centered armature
2. Loose moving parts in driving motor
3. Loose diaphragm
4. Foreign substances interfering with motion of moving elements.

The remedies are self evident and in all cases the defect is found by visual examination.

Hum is frequently a complaint. Since nothing is utilized in the speaker, which may cause the hum and if the hum is not in the amplifier output, the fault is induction between a line supplying power to the receiver or to the lights in the room, and the loud speaker cord. This is particularly true when the cord extends from one room to the next.

In some cases an output coupling unit is incorporated in the speaker housing. In this case it is necessary to add to the possible reasons for a "dead" speaker. Another possible reason is an open plate coupling choke. A second is a shorted plate coupling choke, a third, an open secondary if the output unit is a transformer and the fourth reason,a shorted secondary winding.

Lack of sensitivity may be due to

1. Insufficient excitation voltage and current
2. Partially shorted field winding
3. Partially shorted voice coil
4. Extreme rigidity of diaphragm

Rattles heard during operation may be due to

1. Incorrectly centered voice coil
2. Loose moving parts
3. Loose voice coil
4. Foreign substances between voice coil and pole piece
5. Loose frame, screws,adjusting nuts, etc..
6. Damaged cone
7. Loose grill and housing attachments.

With respect to sound units used with old horns and horn type speakers, "dead" units may be due to

1. Open cable
2. Shorted cable
3. Open coils
4. Shorted coils

Lack of sensitivity may be due to

1. Weak magnets

Distorted sounds and noises during operation may be due to

1. Bent diaphragm
2. Loose diaphragm
3. Foreign particles on pole pieces
4. Excessive signal input
5. Loose moving parts
6. Loose nuts,washers,etc..

The dynamic speaker introduces a few complications because the design of the unit involves several additional items. In some cases the apparent speaker defect is due to a defect in an auxiliary unit. Assuming the trouble to be in the speaker and its accessories, when the speaker is "dead" look for

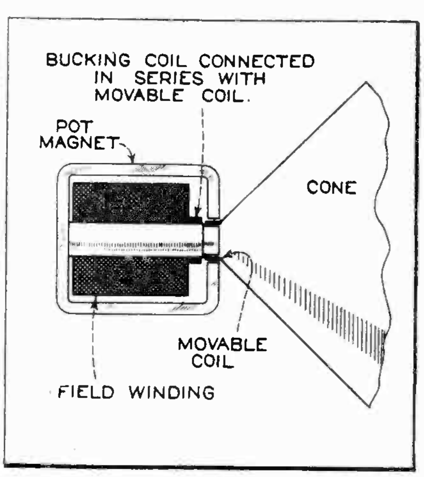
1. No signal from set
2. Lack of excitation voltage
3. Open field winding
4. Open primary of output transformer or open plate choke
5. Open voice coil
6. Disconnected voice coil
7. Shorted field winding
8. Shorted voice coil

All of the above with the exception of number 6 calls for continuity testing. In this work it is necessary to consider whether or not the correct condition of a coil means an appreciable amount of D.C. resistance. For example the voice coil in many dynamic speakers consists of a band of 1/16" copper. The D.C. resistance of this coil is less than an ordinary short circuit with #22 wire.

Distorted output may be due to distorted input, but if it is established that the input is satisfactory, look for

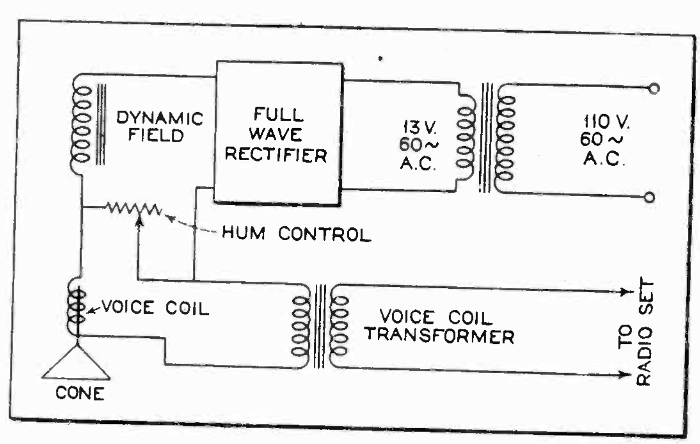
1. Incorrectly centered voice coil.
2. Incorrect coupling unit, coupling voice coil to amplifier
3. Imperfectly centered cone
4. Damaged cone
5. Excessive hum

The first four items require visual examination. The fifth item requires special consideration since the cause for hum may be poor operation of the eliminator supplying the excitation voltage. We need not dwell upon the eliminator supply since that item is covered at full length in another section. However, very satisfactory eliminators do not afford absolutely pure D.C. output, and several methods are employed to eliminate the hum generated in the speaker. These are shown below and the possible reason for hum in one case may be a shorted hum balancing coil and in the other incorrect adjustment of the hum balancing resistance. (P.G.Andres, Radio Engineering,Feb.1929.)



The bucking coil method of eliminating dynamic speaker hum.

Fig. 52



Arrangement employed for electrically counteracting dynamic speaker hum, with the aid of a variable resistance.

Fig. 53

Audio Amplifiers

Audio amplifiers in use today employ three distinct methods of coupling

1. Transformer
2. Resistance
3. Tuned double impedance

with variations of 2 and 3, where combinations of resistance and impedance and resistance and auto transformer coupling are involved. However, no matter what the arrangement the function of the system is always the same. This does not mean that the performance is the same. Our purpose is not to outline the operating characteristics of various types of audio amplifiers. Instead to concern ourselves with troubles in audio amplifiers. We take for granted and we are justified in so doing, that the audio amplifier incorporated into any receiving system is best suited for that system. Furthermore that the design of that audio amplifier is as good as can be made under existing conditions Operating on this premise we eliminate the subject of amplitude distortion in audio amplifiers, wherein is involved the frequency characteristic of the amplifier in question.

Service men do not make changes in audio amplifiers employed in finished receivers, that is, change a transformer coupled system into a resistance coupled system or vice versa, for reasons which are self evident. However, they do make tube change and change battery operated receivers into A.C. electric receivers, hence we are interested in the utility of tubes in connection with audio frequency amplifiers.

The vacuum tube employed in an audio system plays a very important role, because it manifests a great influence upon the performance of the amplifier and the attainment of satisfactory results. Unfortunately,space limits us to general discussion hence the following.

1. High mu tube or tubes designed to possess high values of amplification constant are suitable for use in two types of audio amplifiers, resistance coupled and impedance coupled and are NOT suited for use in transformer coupled systems. In this connection this type of tube is best suited for use in resistance coupled audio amplifiers.

2. The conventional type of low mu tube represented by the 201A, the 226 and the 227 is suitable for use in all types of audio amplifiers but is limited for use in all stages except the output stage. This does not mean that a power tube cannot be employed in an intermediate stage in the audio system, but it is mentioned so as to define the limits of the regular tube.

3. D.C. tubes such as the 199 and the 201A are NOT suited for operation with raw A.C. filament potential, but may be employed in series filament connection when the filament supply is D.C. secured from the A.C. power line. The same applies to the 112.

4. The screen grid tube utilized as a space charge tube is UNSUITED for use with transformer coupling. This applies to the A.C. and D.C. tubes of this type. This tube is suited for use with resistance and impedance coupling when the resistances and the chokes are specially designed for the tube.

5. The 226 and the 227 are suitable for use in audio amplifier systems operating with raw A.C. filament potential, but greater satisfaction is secured with the latter.

6. All types of tubes may be employed in push-pull arrangement providing that the system is designed for such work.

7. The utility of power tubes such as the 171,210,245 and the 250 is governed by the required output power and the amount of voltage available for application to the grid of the output power tube.

8. Output power tubes should not be interchanged unless the required operating potentials, grid,filament and plate, are available. The reason for this is that the output power is a function of the operating potentials.

9. It is necessary to remember that the operating characteristic of the output tube differs from the other tubes in the amplifier. This difference is found in the function of the output tube. Whereas the other tubes in the amplifier perform as voltage amplifiers the output tube is a power amplifier and the power output varies as the square of the input. In other words if a tube is rated at 4 watts output with a dertain value of plate potential and 40 volts applied to the grid, the application of 20 volts to the grid reduces the output power to 1/4 of the maximum output or 1 watt and NOT to 1/2 the maximum power or 2 watts.

10. The difference between the output power tubes and the other tubes in the audio amplifier is one of physical structure which permits the application of higher values of plate potential and grid bias so as to enable the application of high signal voltages to the grid of the power tube without causing overloading and distortion. Furthermore, the design of the power tube is such that it affords best energy transfer between the tube and the speaker over the normal audio frequency range, therefore affording best tone quality.

11. All tubes are suited for series or parallel filament connection, although it is not customary to employ the A.C. tubes in series connection.

12. The design of all vacuum tubes is such that operating voltage specifications must be fulfilled and adhered to. Excessive operating potentials may cause irreparable injury to the tube. This is particularly true of the filament.

13. Insufficient filament,plate or grid potentials will impair the operation of all vacuum tubes. The advent of the screen grid tube makes necessary mention of the screen grid voltage in addition to the other voltages quoted.

14. Amplification in a system should not be secured by increasing the operating potentials unless the value in use before the change is made is less than the maximum.

15. Volume control should not be in the form of reduction of operating potentials, such as the filament or plate voltages. Reducing the grid voltage is out of the question. (The above applies particularly to the audio amplifier, since plate voltage volume control is used in radio frequency amplifiers.)

16. Vacuum tubes of all types have definite operating lives, determined by the operating potentials applied to the tube. The most vulnerable part of the tube is the filament and operating life is limited by the deactivation of the filament or decrease in electronic emission. The 227 type of tube involves the cathode as the source of electrons.

17. Operating characteristics of vacuum tubes are such that certain conditions must be fulfilled inorder that the amplification be free from distortion. The first is the elimination of grid current. D.C. current must not be permitted in the grid-filament circuit since it introduces distortion and reduces amplification by varying the characteristic of the tube and the coupling device. This applies equally to all forms of audio amplification. The second is that circuit arrangement must be such that the plate current variations in the plate circuit should be faithfully amplified reproductions of the signal voltage applied to the grid circuit. This means that every increase and decrease in signal voltage should be faithfully followed by plate current variations in the plate circuit. Since these plate current variations are A.C. the D.C. plate current must be steady, hence fluctuations if D.C. plate current should not be permitted during operation. They indicate lack of balance between the plate and grid voltages. Increase in plate current during the passage of the signal indicates tube overloading, distortion or insufficient grid bias.

18. Where more than one tube is employed in a single stage, as in a parallel or a push-pull stage, it is best if the tubes are of like design and characteristics. This condition affords more stable operation. With respect to the plate current drain in push-pull stages, best results are secured if the total current drain is divided equally between the various tubes in the stage. This division of plate current is also advantageous with respect to the effect of the direct current upon the core of the coupling unit (if it employs a core) in the plate circuit.

19. Vacuum tubes may be connected into parallel and push pull arrangements when additional output is required. However the power output of two tubes in parallel is not equal to twice the output of a single tube. Empirical determinations have shown an increase of about 30 to 40%. Furthermore the use of tubes in parallel does not permit a signal voltage in excess of that permissible with one tube.

20. Push-pull arrangements afford advantages not found in parallel systems. In the first place, it is permissible to apply a greater value of signal voltage, approximately twice that permissible with one tube. Second the output is greater than that available with two tubes in parallel. Third, the operating characteristic of the tube is altered so that greater freedom from distortion is secured. Fourth, push-pull systems minimize hum due to potential variations in the grid-filament circuit due to the hum in the filament supply or induced into the grid circuit.

21. The association between the vacuum tube and the device connected into the tube plate circuit is very important, so much so that it is the difference between good quality reproduction and poor reproduction. Hence haphazard replacement of defective coupling units is impossible. When one unit is removed, the replacement should be identical.

22. With respect to the plate voltage applied to vacuum tubes, it is necessary to remember that a voltage drop takes place across the coupling unit located in the plate circuit. This means that the voltage at the tube plate is less than the voltage at the source of supply. Due to the current carrying capacity of the coupling units, plate voltage increase is definitely limited, since each increase in plate voltage increases the plate current and flow through the coupling unit. Excessive current flow will injure the plate coupling unit, regardless of its type.

23. Do not remove tubes from series filament installations unless the proper precautions are exercised to prevent overloading of the other tube filaments. The same is true of tubes in parallel connected across transformer windings.

The choice of any one type of coupling unit is a matter of like and dislike. Also of the required frequency characteristic. In this connection we can say very little since the receiver designer is the one who decides upon the type of coupling employed in the receiver and the service man or the receiver owner decides upon the type of coupling to be used in a home built receiver.

With respect to trouble however all amplifiers are alike. Not that the same trouble will be found in all types of amplifiers since different types of coupling units are afflicted with differentforms of trouble, but rather that the basic factors associated with trouble are present in all amplifiers.

To secure satisfactory operation with all amplifiers, certain requirements must be fulfilled. A defective condition means that one of the requirements has not been fulfilled. The conditions are:

1. Input signal voltage within operating limits of vacuum tubes in the system
2. That the plate potential at the tube plate be correct
3. That the grid potential at the tube grid be correct
4. That the filament potential at the tube filament be correct
5. That the coupling units be in perfect condition
6. That circuit wiring be correct
7. That connections in the circuit be perfect
8. That all the amplifier components be in good condition
9. That the filament supply be in good condition
10. That the grid supply be in good condition
11, That the plate voltage supply be in good condition
12. That the tubes be the type suited for the receiver
13. That the tubes be in good condition

A cursory analysis of the above is sufficient to show that each of the subjects is allied with the other and also associated with certain phenomena. Now if we were to discuss each of the various or rather many types of audio amplifiers available at the present time, it would be necessary to devote every page in this book. It stands to reason that this is impossible. Furthermore to expedite matters, we believe that it is better to give basic reasons for the various requirements, thereby permitting application of the data to the various types of amplifier and avoiding repetition in the book. We say without fear of contradiction that with respect to trouble all amplifiers are alike. That is to say, the conditions of overload are applicable to all types; the effect of an open is the same in all amplifiers; the effect of a short circuit is the same in all amplifiers etc.. Hence why dwell upon the individual types.

Viewed from one angle, it would be a fine thing to give an analysis of the various types of amplifiers available at the present time, but we believe that such an analysis should not be necessary. With respect to what we have in mind why should it be necessary to spend time differentiating between a resistance coupled amplifier employing a grid and plate resistance and another amplifier employing a plate resistance and a grid choke. True that the operating characteristics with respect to frequency reponse differ, but is that our concern at this time... The effect of an open grid resistance or grid leak in the audio amplifier is the same as an open grid choke....Hence we shall eliminate all that material..

We will of course discuss data which is applicable to one type of audio amplifier and not to another, but the subject matter is not lengthy. Let us start the discussion pertaining to the aforementioned requirements.

*** Bear in mind that what is to follow is applicable to all types of audio amplifiers regardless of circuit connection and the number of tubes involved, assuming that the amplifier has at least one tube.**** The numerical designations refer to the requirements as enumerated.

1. The value of grid bias employed in the reciver amplifier system limits the amount of signal voltage which may be applied to the tubes in the receiver. This is true of all types of installation, since the type of coupling does not influence the operating potentials. In other words if a 112 requires a negative grid bias of 6 volts with 135 volts applied to the plate, the same grid bias is required in transformer, resistance and impedance coupled audio amplifiers. The application of excessive signal voltage will cause tube overloading, grid current and distortion. In this connection it is necessary to consider the degree of amplification available in the system, so that overloading of the output tube does not take place. Incidently, the most frequent complaint relative to tube overloading is that in connection with the output tube. The data relative to the action of the plate current is of utility when tube overloading is the subject.

2. Incorrect plate potential causes several bad effects and may be due to several conditions. With respect to the value of potential, insufficient voltage applied to the plate will cause low amplifying level, permit overloading of the tube and consequently distortion. On the other hand, excessive plate potential will upset the balance between the grid and plate circuits and impair distortionless amplification. Also it will increase the plate current and if the increase is radical, permanent injury of the coupling unit is possible. If the injury is of such nature that it does not ruin the unit, it is possible that the damage will cause noisy operation. This is true in the case of resistances and transformer winding. In addition, it is necessary to accord detailed thought to the magnitude of plate current when the coupling unit is a transformer employing an alloy core. The design of the core is such that the permissible D.C. plate current through the transformer winding is limited. Excessive current will ruin the core electrically and impair the frequency characteristic of the transformer. The usual effect is the loss of low notes.

With respect to the causes for low plate potential, we might stress the units contained in the plate circuit, assuming correct B power unit output, and low B power unit output, assuming correct units in the plate circuit.

3. Low grid potential is a frequent cause of distortion. The operating principles of the vacuum tube demand that a certain value of grid potential be employed for each value of plate and filament potential inorder to create a state of stability between the grid and plate circuits. The attainment of distortionless amplification with the vacuum tube depends upon the elimination of grid current in the tube grid-filament circuit. This is true of all types of amplifiers without exception, transformer, resistance and impedance coupled. parallel tube filament wiring and series filament wiring. The elimination of grid current depends upon the use of the correct value of grid potential. The subject of correct grid potential, involves excessive potential, insufficient potential, lack of grid potential and incorrect polarity, consequently the source of grid potential, circuit connections and associated apparatus. The possible reasons for incorrect grid potential have been outlined in an other section, hence repetition is unnecessary, but it is necessary to mention that the grid bias controls amplification.

In connection with the grid bias potential it is necessary to mention different conditions and their effects. Insufficient grid bias of correct polarity will cause tube overloading on strong signals only, but the condition will be shown by excessive tube plate current. Incorrect polarity of grid bias will cause extremely poor amplifier operation and a great reduction in amplification. As a matter of fact it will paralyze the tube and the amplifier will be inoperative. The sign of this condition is a great increase in tube plate current in excess of the normal value. Excessive grid potential will cause distortion and if the bias is sufficient to reduce the plate current to zero the amplifier tube will be inoperative and the amplifier will be inoperative. This condition is indicated by insufficient plate current.

4. The value of filament potential governs the operation of the tube, the performance of the tube and its operating characteristics. In addition it manifests an influence upon the operating life of the tube with respect to the operating life of the filament. Excessive filament potential will cause premature deactivation of the filament and eventual burnout. Insufficient filament potential on the other hand will cause low amplification and distortion, such as tube overloading. In addition the mutual conductance value of the tube is greatly reduced and the plate impedance value greatly increased, impairing the operating characteristic of the tube with respect to the units employed in conjunction with the tube. Increased filament potential will not cause a marked effect upon the plate current, but insufficient filament potential will cause a marked decrease in plate current.

5. The condition of the coupling units in the system, regardless of type controls the amplifier performance. If for some reason the grid or plate coupling units are "open" operating potentials will not reach the tube and the amplifier will be inoperative. If the plate voltage is lacking the amplifier will appear "dead". If the grid voltage is lacking because the grid coupling unit is "open", various forms of trouble are possible. These are hum, low amplification, distortion and howling. If the coupling unit is defective insofar as the individual plate and grid units are concerned various defects will be evident, according to the type of defect. If the current flow through a transformer winding causes minute arcing between turns, crackling and frying sounds will be heard. If the core of the transformer is grounded and one of the windings comes in contact with the grounded core, hum and low amplification will be the result. In some cause possible short circuit of the operating potential may be the result. If by chance the primary and secondary windings are in electrical contact with each other distortion will be the result due to the application of a positive bias to the grid. As a matter of fact the aforementioned condition may cause total paralysis of the tube and an inoperative amplifier -- perhaps injury to the tube.

Imperfect contacts at the respective connecting terminals will cause crackling and sputtering sounds. The same is true with impedance and resistance coupling. With respect to the latter, overload of the resistance unit will cause hissing and frying sounds. Overload is usually encountered in the plate circuit and is due to excessive current flow through the resistance and the inability on the part of the resistor element to carry the plate current.

The isolating condenser employed in resistance, impedance and in combination resistance-impedance coupled audio amplifiers, between the grid and plate terminals of these coupling units is a frequent cause of distortion, noise and low amplification. A leak in this condenser will cause noise and the application of a positive bias to the grid of the amplifying tube, resulting in low or no amplification in the system; frequently a dead amplifier. The above is true in the audio amplifier employing an auto transformer in the grid circuit and a resistance in the plate circuit of the preceding tube with the isolating condenser between the two. This system will be shown later.

Certain transformer coupled audio amplifiers employ an isolating condenser in the plate circuit in conjunction with the regular transformer primary and another choke. The function of the condenser is to exclude D.C. from the transformer primary. A leak in this condenser will cause noise during the passage of signals and a short in the condenser may reduce amplification on the low frequencies. A good deal of the noise encountered in audio amplifiers is due to some imperfect condition in the coupling units and examination and diagnosis by replacement is recommended. This is particularly true of transformers operating at high potentials and resistances employed in high power audio amplifiers or resistances which are subjected to appreciable values of current load.

6. Very little need be said about circuit wiring. In the first place the receiver to be serviced was satisfactorily wired.... The possibility of wrong wiring is very remote considering the numerous tests at the manufacturing plant. Second, circuit connections do not change unless the change is made by someone. Hence it is not necessary to examine circuit connections. However, if the defect developed right after a wiring change had been made, circuit continuity test is necessary.

It stands to reason that the circuit wiring must be correct. If the receiver owner admits changes in wiring it is necessary to seek incorrect polarity of battery, reversed transformer connections, wrong placement of bypass condensers, open resistance connections, wrong tube connections, etc..

7. Much trouble in radio receivers may be attributed to poor connections between the various elements. The average radio receiver is subjected to many jars and shocks during transit, even during the short trip between the dealer and the consumer. A poorly soldered contact is jared loose. It makes contact until vibration encountered during operation opens the contact--- then trouble. In many other instances the contact is not permanently opened. Instead it breaks and makes intermittently during receiver operation. The result is electrical disturbance in the form of sputtering and crackling sounds and sometimes distortion and low amplification, depending upon the location of the poor contact.

8. We discriminate between the coupling units in the amplifier and the other parts exclusive of the tubes. We refer to the resistances employed in filter systems, the condensers employed in the filter system, the bypass condensers, the voltage reducing resistances, the tube sockets, etc.. Inorder to secure satisfactory operation, it is necessary that all these parts be in perfect condition. Shorted bypass condensers will short associated circuits, cause low amplification, short battery life, overloading of power supply devices, lack of plate potential, lack of grid potential, etc., depending upon the location of the bypass condenser. These details are of interest after the trouble has been isolated with respect to a certain stage in the amplifier or a certain section of the amplifier.

Defects in voltage reducing resistances will open the respective circuits. Defects in filter resistances carrying the tube plate current will either open the circuit, cause excessive voltage drop or will cause noise of the character mentioned in preceding sections of this chapter. Defective sockets will cause leaks between the various circuits and distortion, low amplification and sometimes stop operation of the amplifier. The latter condition involves the contact between the tube prongs and the socket prongs. Poor contact between the tube and the sockets prongs is a frequent reason for fluctuating signal strength, hum, crackling and sputtering sounds and other forms of disturbance.

Imperfections in bypass condenser with respect to an open between the connecting terminals and the active surfaces in the condenser will influence amplifier stability, increase regeneration, cause hum and sometimes howling. This is particularly true in A.C. installation.

9. The condition of the filament supply in A.C. installations plays an important role with respect to the hum in the system. Inperfect filtering in the A eliminator will cause a bad hum. Overloading of the eliminator will cause the same condition. A defect in the eliminator will cause lack of filament potential or low filament potential. In this connection we refer the reader to the section devoted to A eliminators.

With respect to battery types of filament potential sources, the condition of the battery controls the filament potential. A defective battery will cause low filament potential and in many cases sputtering and crackling forms of electrical disturbance. Such batteries have definite operating lives and after a period of time will become noisy in operation.

Transformer sources of filament potential are of interest in A.C. installations. An open transformer primary or secondary winding will cause lack of filament potential. Poor contact in the transformer will cause fluctuating filament brilliancy and fluctuating signal intensity. Insufficient current and voltage output will cause low filament potential, consequently low amplification and distortion. Incorrectly located transformer winding centre taps will cause excessive hum. Incorrectly adjusted filament shunt resistance centre taps will cause excessive hum. Open filament shunt resistances will cause excessive hum.. For further data we refer to the section devoted to filament shunt resistances.

In some cases the source of filament potential is the B eliminator; the amplifier filaments being wired in series and supplied with operating potential from the B eliminator. A defect in the B unit may cause excessive hum, distortion because of incorrect bias and lack of filament potential.

10. The source of grid potential must be perfect. If of the battery type, the electrical condition of the battery must be perfect. A defective battery will cause sputtering, crackling and other forms of disturbance. A run down battery will cause excessive regeneration, howling, squealing, hum, etc.. With respect to eliminator sources of grid potential, defective operation of the eliminator will cause a bad hum and excessive regeneration. Lack of bypass condensers will cause a bad hum and howling. Imperfections in the grid bias resistances will cause hissing and crackling sounds.

11. What has been said about the source of grid potential is applicable to the source of plate potential. Run down B batteries will cause howling and singing in addition to crackling sounds, accompanied of course, by reduced amplification. Defective B supply units will cause hum, excessive regeneration, howling and other disturbing effects.

12. The tubes employed in the system control operation and performance. If the tubes are suited to the coupling units, satisfactory performance will be secured. If however the tubes are not suited to the coupling units, amplification will be low and distortion will be very pronounced. Types of tubes suitable for use in certain types of audio amplifiers have been mentioned.

13. The condition of the tubes governs performance. If the electronic emission is low, amplification will be low, frequently accompanied by distortion. Defective A.C. tubes will cause a bad hum. In this connection certain tubes may hum badly yet show up well in tube tests. In this case replacement is the best test. Microphonic tubes will cause howling.

Troubles in Audio Amplifiers

Certain forms of trouble are associated with audio amplifiers regardless of type. Likewise certain forms of test are applicable to all types of audio amplifiers regardless of type. Now, it is impossible to segregate the various types of audio amplifying systems in use today and dwell upon the possible troubles in each system because so many arrangements are employed. Basically these systems may be divided as mentioned in the start of the section devoted to audio amplifiers. In function all systems are alike. With respect to trouble certain elements are afflicted with certain forms of ailments which are not present in other elements. Hence it is possible to divide the general run of audio amplifiers into

1. Transformer coupled systems
2. Resistance coupled systems
3. Impedance coupled systems

and to dwell upon the troubles in these systems without special reference to various modifications of either 1,2 or 3. An analysis of the many types of transformer coupled audio amplifiers in use today, shows that special reference is impossible. Some of these systems employ filters in the grid circuits, in the plate circuits, parallel feed in the plate circuits, combination push-pull arrangements, so much so that a special volume would be required to cover transformer systems alone. In view of the above we are going to consider transformer coupled systems as a unit, regardless of the actual structure of the amplifier, whether it employs battery source of filament potential, A eliminator or raw A.C. supply, parallel tubes, push-pull systems, filters in the various circuits and parallel plate supply... This does not mean that we are going to omit the schematic diagrams of the different types of audio amplifiers... All will be included, but individual discussion will be avoided.

The accompanying figure illustrates a conventional battery operated transformer coupled audio amplifier employing one straight stage and one stage arranged in push-pull fashion.Obviously it is impossible designate each part of the complete amplifier and we take for granted that the average individual who is interested in radio servicing or in the diagnosis of a faulty receiver understands symbols and is familiar with the various parts of the complete system.

Basically the A.C. operated receiver amplifier differs in but few respects from the battery operated installation. It is true that the possible faults are more numerous in the A.C. installation, but transformer connection remains unchanged. The filament circuit structure is altered, but the same is not true of the connections to the transformers. The plate,battery,grid and filament connections remain intact.

However, it is necessary to devote a little time to push-pull and parallel tube arrangements in view of the mention of these systems in the enumerated list of possible troubles. Inorder that a push-pull system operated in an amplifier perform in a satisfactory manner, it is necessary that certain conditions be fulfilled. The first of these is that the tubes employed in the two halves of the push-pull stage be of like type and whenever possible of identical characteristics. Second that the circuit continuity in the two halves of the coupling unit primaries and secondaries be identical inorder that the correct voltages be applied to the tubes. Now, in some instances, although the application is not commercial, a 210 may be used in conjunction with a 171 with of course the proper circuit arrangement so that the correct grid voltage, both operating and signal are applied. This practice is uncommon.

Reference to the second requirement means that the centre tap on the transformers must be correctly located so that equal values of signal voltage are applied to the tubes. The position of the tap governs the plate voltage applied to the tubes and in this case it is of great importance that the plate voltage and the plate current values be alike for the tubes in the system. Like values of plate current mean the elimination of the effect of D.C. upon the core of the output choke or the transformer if one is used, thus improving the operating characteristics of the output unit. The need for perfect and uniform continuity in the two halves of a push pull unit or

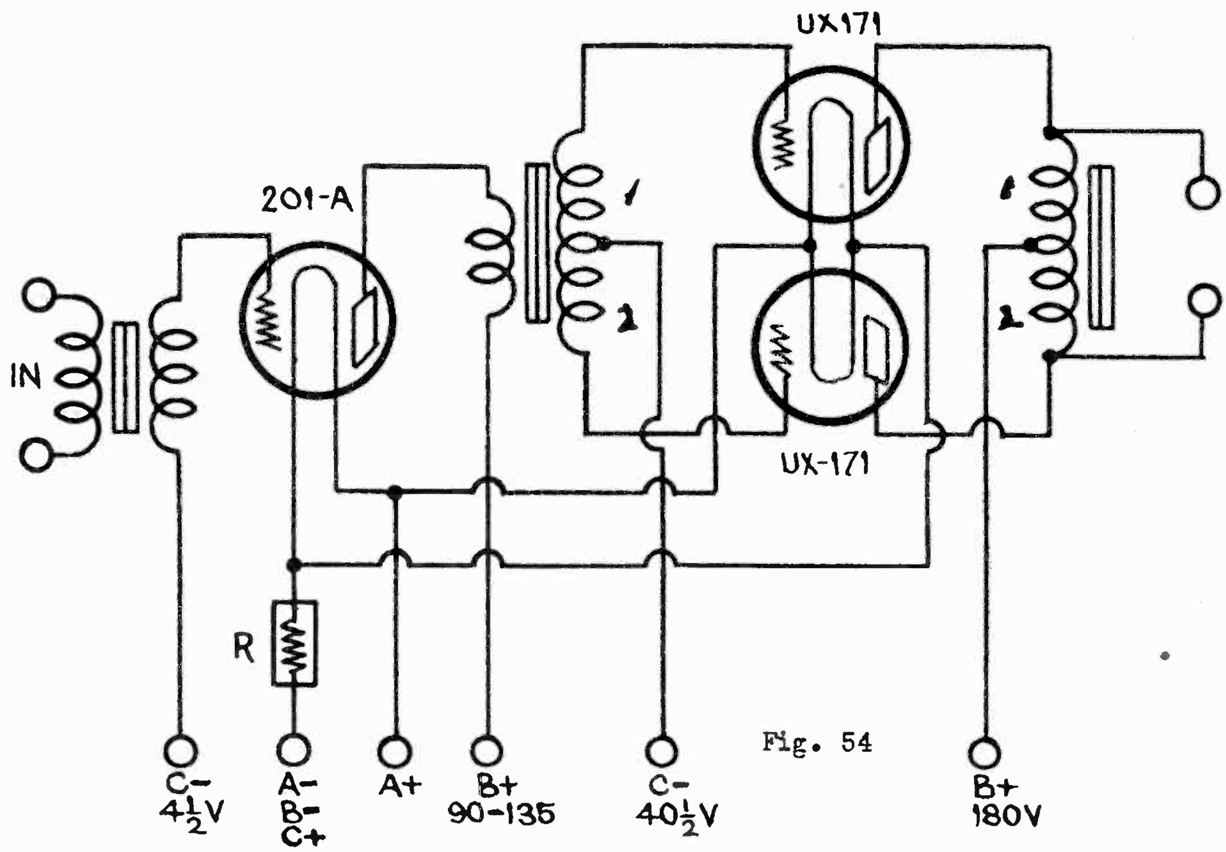


Fig. 54

winding is self evident. The two halves of such units are designated in the diagram.

The reason for push-pull systems is that the arrangement improves the tube operating characteristic, but this improvement and its associated effects are secured only if perfect balance is secured in the circuit. It is understood of course that the condition of perfect balance involves the tubes as well as the coupling units. What has been said should be borne in mind when comment is found relative to the condition of the coupling units and the tubes in push-pull systems.

Somewhat similar data is necessary relative to parallel tube arrangements but in this case, the subject matter does not encompass the coupling units. It is necessary that the tubes used in parallel combinations be of like type and characteristics otherwise performance is impaired. Of course, all the tubes must be in perfect condition

With respect to tubes employed in push-pull systems, at high values of potential, defective operation if frequently accompanied by overheating of one of the tubes, indicated by a glowing plate. This condition is not an indication of a defective tube, the one with the glowing plate. Instead, it may mean that the tube with the normal plate is defective and the one with the glowing plate is being overloaded.

An idea of a conventional A.C. audio amplifier as used in commercial receiver installations is shown below in figure 55 . The reader should disregard the radio frequency and power pack systems and note the connections to the transformers in the audio system. On distinct difference is evident in the A.C. audio amplifier... Compare the pos-

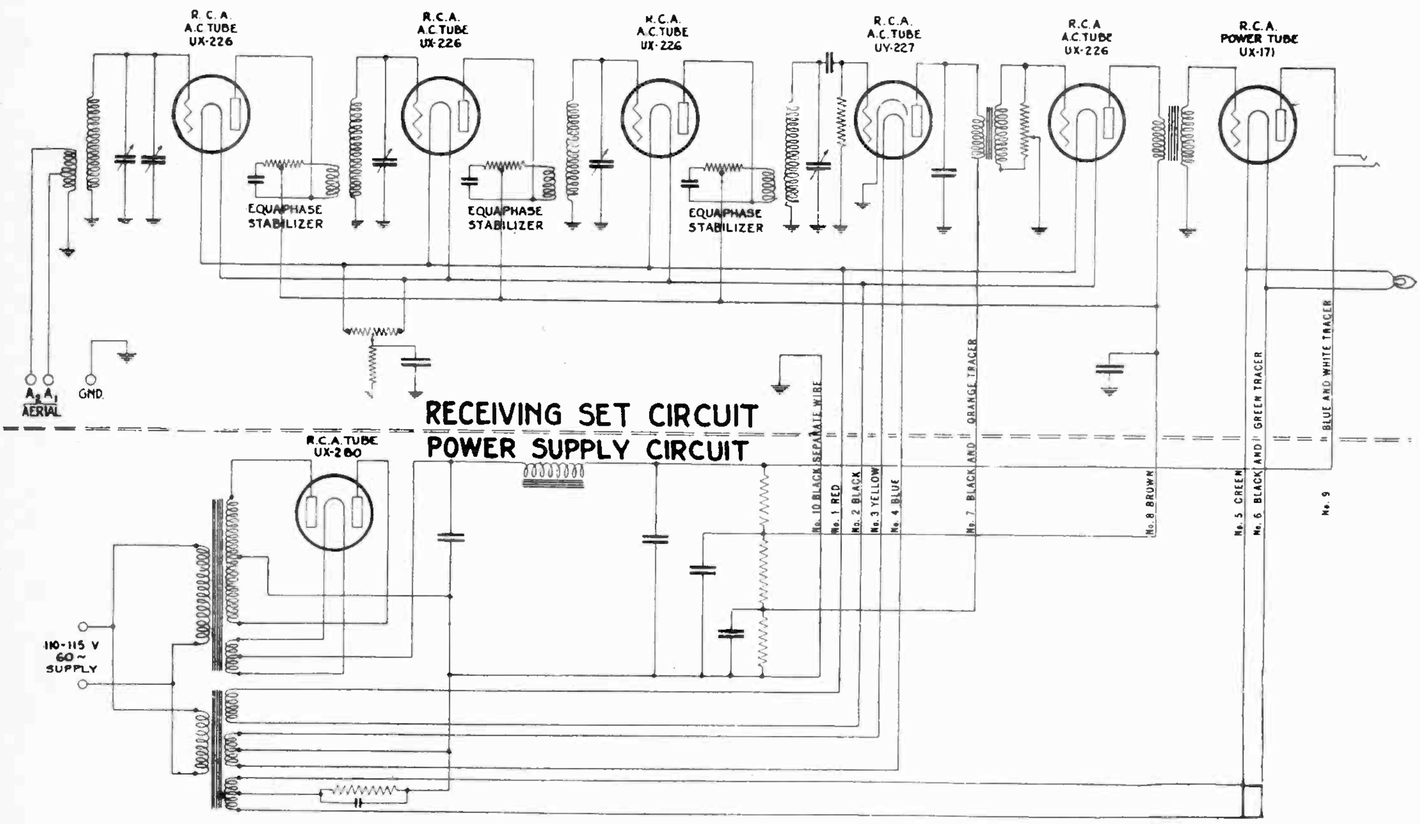


Fig. 55
Schematic diagram of Model "G" Chassis and Model G-60-S Power Supply.

ition of the grid returns. In the D.C. systems, the filament connection of the transformer is connected to the negative side of the C battery or to a resistance if the C bias is secured from the B eliminator. In any system however, the grid return does not connect to ground. In A.C. systems however the grid return or the filament lead on the audio transformers goes to ground, since it is the B minus terminal by virtue of the use of a grid bias resistance in the plate-filament circuit. If however the C bias is secured from the B eliminator, the connection is the same as in the battery operated installation.

Before entering the discussion of troubles in audio amplifiers, we wish to state some facts about filament wiring. In many instances one or more of the tubes in the audio amplifier are operated in conjunction with the radio frequency amplifier tubes, that is, as far as the filaments are concerned. Hence the filament shunt resistance associated with the audio frequency amplifier tubes is not necessarily to be found in the audio system. On the other hand, separate filament supply is used for the audio tube in other installations and the filament shunt resistance when referred to, is found in the audio amplifier. Then again, in other installations the filament shunt resistance is located in the power supply unit... These facts should be remembered when mention is made of the filament shunt resistance in connection with trouble.

One of the most frequent complaints associated with audio frequency amplifiers of all types is distortion. This condition may be accompanied by two other conditions.

First, low signal level output and second normal signal output. Since the possible reasons for distortion differ according to the two conditions mentioned, it is necessary to enumerate the faults for each condition. Now, in connection with these faults and the faults associated with other forms of trouble, we will not be in a position to discriminate between battery and A.C. operated amplifiers, hence will make mention of equipment of units associated with both and the reader must select the units involved in the defective installation. In other words if the list of faults contains the specification " low battery potential" and also the specification "low eliminator output voltage", the reader must select the item employed in connection with the amplifier. If it is a battery operated unit, the former applies, whereas if it is an A.C. unit, the latter item is of interest.

DISTORTION

A. Normal signal intensity.

1. Tube overloading. — Signal voltage excessive for tubes in system. Output voltage from detector excessive for tubes in audio amplifier.

2. Insufficient grid bias. — Grid bias correctly applied but value of potential insufficient for applied signal voltage.

3. Excessive hum in system. — Excessive hum in system will cause distortion on low notes.

4. Excessive regeneration. — See reasons for excessive regeneration.

5. Defect in speaker. — Speaker elements out of alignment or diaphragm loose.

6. Excessive B battery voltage. — Incorrect voltage tap on B battery of eliminator.

B. Low signal level.

1. Insufficient filament voltage. — Run down A battery, incorrect adjustment of filament control resistance, insufficient line voltage in A.C. systems, overloaded filament transformer winding, poor contact between tube and socket.

2. Insufficient B voltage. — Run down B battery, low B eliminator output voltage, low A.C. input into eliminator, wrong tap on battery or eliminator.

3. Incorrect grid bias. — Lack of grid bias, low grid bias, grid bias resistance defective or shorted, Incorrect polarity of grid bias.

4. Open grid circuit.. Defective grid circuit. — Transformer secondary open, open grid bias circuit,open in one half of push-pull winding (secondary), partially shorted secondary winding, wrong connections to transformer secondary, grounded secondary winding, leak between primary and secondary windings, defective resistance or condenser connected across secondary winding, defective bypass condenser in grid circuit.

5. Defective tube. — Deactivated filament or cathode, poor contact between tube and socket filament prongs, gassy tube, incorrect tube.

6. Defective units. — Shorted bypass condensers in plate and grid circuits, defective jacks, transformer primary partially shorted (push-pull), leak between primary and secondary of output transformer, grounded secondary of output transformer, non uniform tubes in pushpull and parallel arrangement, open transformer primary in parallel plate supply.

AMPLIFYING POWER WEAK

See data associated with low signal level and distortion. In addition

1. Lack of plate potential. Defective plate circuit. — Open between tube and socket,open in transformer primary,shorted transformer primary, shorted plate circuit bypass condenser,open resistance or choke in shunt plate supply, open coupling condenser in shunt plate supply,open transformer primary in shunt plate supply system,open in lead supplying plate voltage to tube.

HUM

1. Filament circuit — Incorrect adjustment of the filament shunt resistances, excessive hum in the output of the A eliminator, incorrect filament transformer centre tap, open filament shunt resistance, coupling between filament transformer or filament wiring and remainder of receiver.

2. Grid circuit. — Open grid bias resistance bypass condenser, lack of grid resistance bypass condenser, open grid circuit filter bypass condenser, lack of grid circuit filter bypass condenser, open bypass condenser,

insufficient grid bias voltage, open secondary winding,grounded secondary winding, grid bias resistance bypass condenser capacity rating too low, pick up of external hum by units in secondary circuit.

3. Plate circuit. — Insufficient plate voltage, excessive plate voltage, excessive hum in B eliminator output voltage, open primary input winding, pickup of external hum by units in plate circuit.

4. Lack of ground on core and chassis. — Transformer cores and cases are frequently grounded in A.C. installations. Also condenser cases

5. Reversed power supply plug in A.C. systems.

6. Coupling between amplifier system and detector tube system.

7. Coupling between A.C. line and speaker system cable.

8. Bad hum in detector output voltage. — Defective audio tubes.

HOWLING AND EXCESSIVE REGENERATION

1. Coupling between stages. — Transformers too close to each other, grid and plate leads of tubes too close to each other, speaker cable too close to coupling units in audio system, coupling between speaker cable and amplifier

2. Microphonic tubes. — Operation of speaker causes vibration of tubes loose in sockets, operation of speaker causes vibration of entire cabinet and tubes, moving air column from operating speaker causes vibration of tube, tube elements loose.

3. Open circuits. — Open input winding (primary of input transformer), open grid bias resistance bypass condensers, open plate circuit bypass condenser, lack of bypass condenser, open grid bias resistance,lack of grid bias.

4. Defective sources of potential. — Run down A battery, run down B battery, run down C battery, open bypass condenser in B eliminator (voltage divider network and C bias resistance), defective design in B filter system, open in ground system.

NOISE

1. Filament circuits.

Imperfect contacts, poor contact between elements of filament control resistances, poor contact between tube and socket, defective A battery, corroded terminals, arcing in A supply unit, noise in line supplying A eliminator, defective rectifier in A eliminator, intermittent contact between high voltage side and ground in A eliminator, poor ground on A eliminator.

2. Plate circuit.

Poor contact between tube and socket, defective transformer primary, excessive current flow through plate voltage control resistance, defective volume control in plate circuit, leaky bypass condenser, poor soldered connections, loose terminals, defective resistance in B eliminator, defective B battery, defective rectifier in B eliminator.

3. Grid circuit.

Poor contact between tube and socket, defective volume control, defective resistance across transformer secondary, defective transformer, leaky grid resistance bypass condenser, defective grid resistance, loose terminals and connections, poor joints, defective resistance (grid bias) in B eliminator, defective rectifier in B supply, defective filament shunt resistance.

TUBES DO NOT LIGHT

1. Defective tubes

2. Filament transformers

Line supply circuit open, transformer primary open, tap contacts open, transformer secondary open, poor contacts.

3. Batteries

Run down A battery, corroded terminals, poor contacts.

4. Filament circuit.

Defective voltage control resistances, open in wiring, poor contact between tube and socket.

TUBES LIGHT BUT NO SIGNAL

1. Lack of plate potential.

Open in plate circuit, defective B eliminator, open in cable supplying B potential, poor contact between tube and socket, shorted plate circuit bypass condenser.

2. Batteries

Incorrect polarity of A battery, incorrect

	polarity of B battery, incorrect polarity of C battery.
3. Tubes	Defective tubes, deactivated filaments, poor contact between tube and socket,
4. Coupling units	Open primary winding, shorted primary winding, shorted secondary winding, grounded secondary winding, shorted output choke or primary of output transformer, open secondary winding.

Resistance and Impedance Amplifiers

The fact that an amplifier employs resistances or impedances or combinations of both as the coupling mediums instead of the primary and secondary windings of a transformer does not divorce the system from the general discussion of transformer coupled

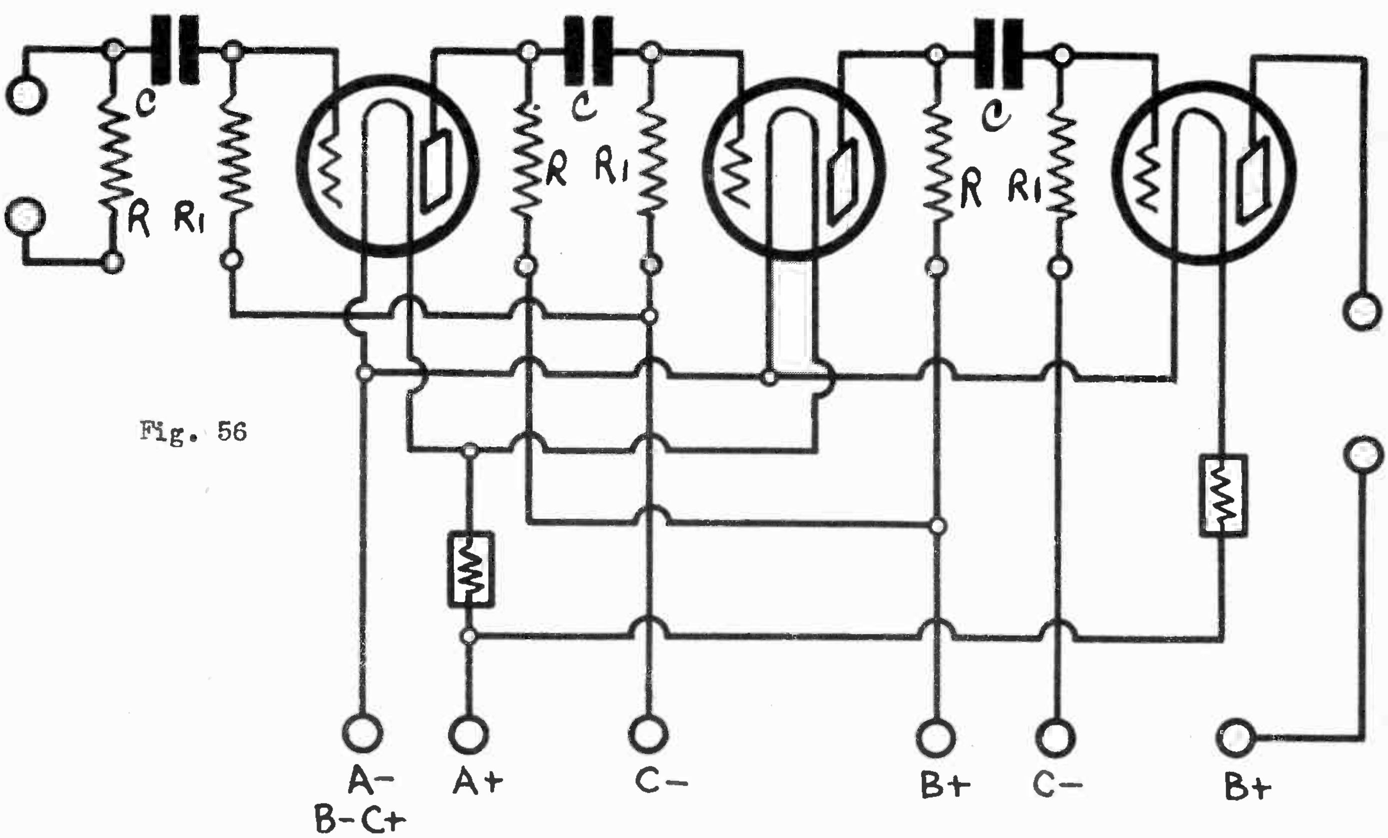


Fig. 56

audio amplifiers. The general structure of a resistance coupled audio amplifier is shown above, in figure 56. A comparison of the transformer coupled system in figure   and the resistance coupled system shown above will bring to light the similarity of the two systems. The basis difference is found in the type of coupling unit employed. Whereas in the transformer coupled audio amplifier, the coupling unit is a transformer with the primary winding connected into the plate circuit of one tube and the secondary connected into the grid circuit of the succeeding tube, the resistance coupled arrangement utilizes a resistance in the plate circuit of one tube and another resistance in the grid circuit of the succeeding tube, replacing the primary and secondary windings of the conventional transformer. The condemser C functions as an isolating condenser and also as a means of transferring the voltage across the plate circuit resistance to the grid-filament circuit of the next tube. In some cases R is replaced by a choke and in other cases R1 is replaced by a choke. The latter condition is found in such amplifiers when the amplifier is utilized in high power system. With respect to the use of a choke in place of the grid leak R1, it is essential in the coupling unit connected to the output stage when the latter is a 245,250 or a 210 tube. This consideration involves tube design and the gas within the tube.

Since the design of systems is not of interest to us, we need but mention that as far as trouble is concerned, the defects mentioned in connection with transformer coupled systems are applicable to the resistance coupled amplifier and to the various modifications of resistance coupled audio amplifiers. However it is necessary to supplement this data with additional information. It is obvious that transformer windings are not involved in a resistance coupled amplifier of the type shown, but burnout of the resistances is the equivalent. Where a choke is employed in place of the plate coupling resistance or in place of the grid leak, it is possible to apply the quoted data.

Generally speaking, resistance and combination resistance- impedance audio amplifiers are very stable in operation, but certain forms of defects are however encountered. Therefore we supplement the audio amplifier data associated with transformer coupled systems with the following:

DISTORTION

1. Open grid leak or grid choke

2. Excessive value for the grid leak resistance (designated as R1)

3. Leaky isolating condenser (designated as C in illustration)

LOW AMPLIFYING POWER

1. Excessive value for plate resistance. — A very high plate resistance or a defective resistance will cause excessive voltage drop and low plate voltage at the plate.

2. Low value for grid leak — A shorted, defective or low ohmic value grid leak will reduce the amplification available with the system.

3. Leaky isolating condenser

MOTORBOATING

1. Leaky isolating condenser

2. Incorrect C bias

3. Lack of C bias resistance bypass condenser

4. Excessive B potential

5. Regeneration in system — Defective B supply unit, lack of correct bypass condensers, coupling between grid and plate circuits.

Impedance Coupled Amplifier.

The impedance coupled audio amplifier is very similar to the resistance coupled system, as shown in the accompanying illustration. The resistances in the system are replaced by iron core chokes, one choke in place of the plate coupling resistance and another choke in place of the resistance type of grid leak. The circuit structure is the same in dual impedance audio amplifiers and in tuned double impedance amplifiers, the difference being found in the frequency response available with the individual systems.

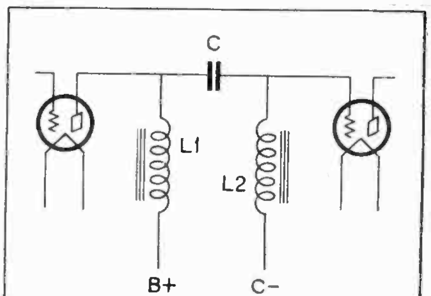


Fig. 57

Circuit diagram of single stage tuned double impedance amplifier.

With respect to trouble, the data mentioned in connection with transformer coupled audio amplifiers is applicable to the impedance coupled system. In addition it is necessary to consider the isolating or couplin condenser mentioned or rather designated as C in the resistance coupled system and above in figure 57. In the tuned double impedance arrangement this condenser plays an important role upon frequency response, the range with respect to the lower end of the audio scale increases as the value of the condenser is increased. Extensive data pertaining to the various types of coupling mentioned in connection with trouble is discussed in Volume 1 of this series, in "The Mathematics of Radio".

Auto Transformer Systems

Certain audio frequency amplifying systems make use of an auto transformer in conjunction with resistances. the transformer being in the plate circuit in one case and in the grid circuit in the other. A system employing the auto transformer in the tube plate circuit is shown in figure 58 and with the unit in the grid circuit on the next page.

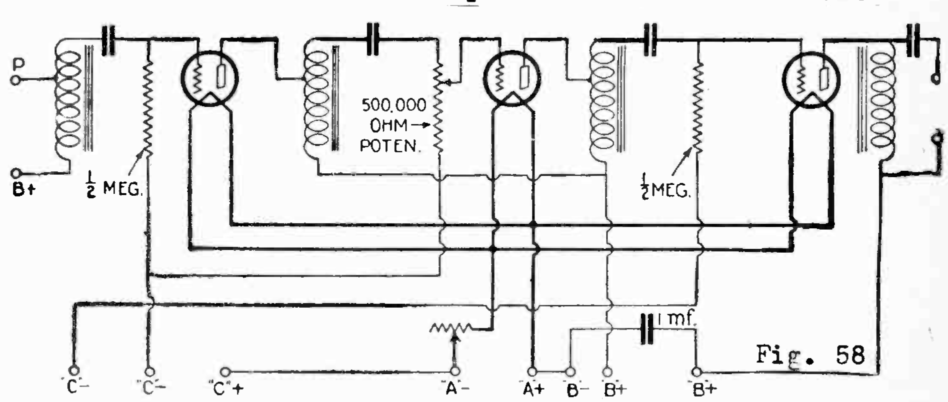


Fig. 58

What has been said about chokes and transformer windings is applicable to the auto transformer and whatever has been said about the effoct of an open in the plate circuit is applicable to the auto transformer shown in the tube plate circuits. Likewise whatever has been said about resistance type grid leaks in resistance coupled audio amplifiers, is applicable to the grid leaks shown in this system. The function of the coupling and isolating capacity C remains unchanged.

To give justice where justice is due, the manufacturer's claims for the system shown below definitely state that the function of the system differs from

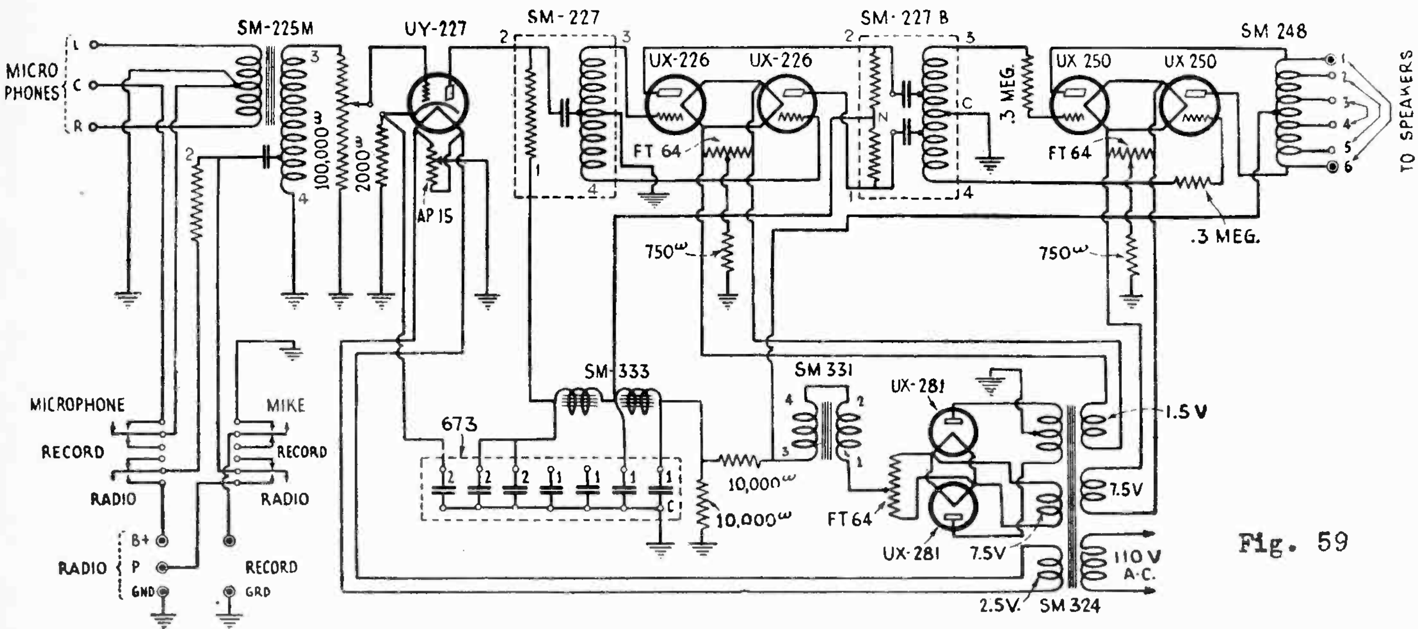


Fig. 59

conventional arrangement employing a resistance in the plate circuit and an inductance in the grid circuit. Performance proves this and this circuit is shown as an example of the use of an auto transformer in the grid circuit.

In certain respects in connection with the elimination of D.C. from the plate winding of a conventional audio frequency transformer, this arrangement shows an example of parallel plate supply and the condenser (fixed) connected between the plate end of the plate resistor and the transformer primary under normal conditions is the condenser referred to in the list of troubles and causes. It should be understood that in the example shown above, the effect of a short in the coupling condenser is the same as that of a short in the isolating capacity C employed in connection with resistance and impedance coupled amplifiers. Incidently the amplifier shown above is the Silver Marshall model 690 speech amplifier.

Modern amplifier design is a great improvement over the old systems and the need for powerful installations makes necessary every possible precaution to minimize regeneration in the system. This means that filter circuits are incorporated into various parts of the amplifier and resistances are frequently inserted into the grid circuits to create a stable condition. Such resistances are shown above in the grid circuits of the 250 type output tubes. Special mention of this nature is necessary since all of these units are possible sources of trouble and general mention cannot be made when discussing conventional arrangements. A defect or an open in one of these resistances will upset the push-pull stage balance and cause distortion.

In other cases, design engineers incorporate complete resistance-capacity filters in the grid circuits so that the A.C. potential in the grid circuit does not cause a voltage drop across the grid bias resistance, which would have the effect of balancing some of the signal voltage and reducing the amplifier output. An excellent description of work carried out upon such filters appeared in the February 1929 issue of Radio Broadcast. The author was Keith Henney. A typical circuit incorporating such filters is shown in figure 60 . This illustration accompanies the article mentioned.

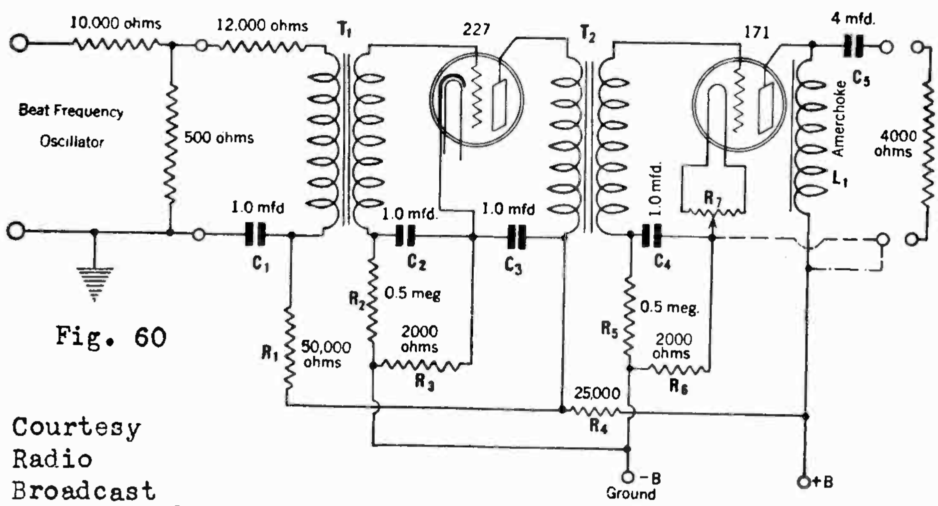


Fig. 60

Courtesy
Radio
Broadcast

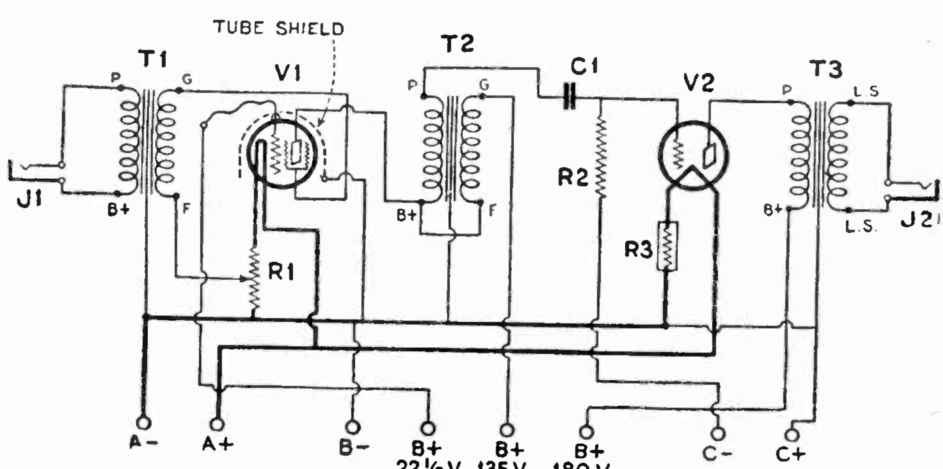
Schematic diagram of a well-filtered two-stage transformer-coupled a.f. amplifier

Such filters find application in resistance and impedance coupled amplifiers as well as in transformer coupled arrangements and have been found beneficial with respect to minimization of regeneration in the audio amplifier system.

As is evident in the illustration each filter systems involves a resistance and a condenser C2,R2,C4 and R5, hence four additional elements are possible sources of trouble. All such circuit structures must be accorded detail thought when analyzing amplifying systems. An open in the resistances mentioned will impair the application of the bias voltage. An open in the condensers mentioned will upset circuit balance. A short in the condensers will short the C bias, etc..

The reader is undoubtly aware of the use of audio chokes and condensers in the B supply leads of many audio amplifiers. These elements have been omitted from the list of possible troubles, that is,specific mention has not been made, but the choke is a part of the plate circuit, hemce reference to an open in the plate circuit involves the choke and mention of shorted or open bypass condensers in the plate circuit includes the bypass capacity used in the filter system.

The use of the screen grid tube as a space charge audio amplifier, utilizing impedance introduces but few new complications. Whatever has been said about impedance and resistanec coupled systems is applicable to this amplifier. In addition it is necessary to consider the correct connection of the tube as a space charge tube, the correct utility of the screen grid as the control grid and a biasing potential to the original control grid. In all other respects the system is identical to the types mentioned. The tube shield aids stability of the screen grid stage.



Schematic diagram of the Distant-Signal Amplifier which utilizes a 222-type tube (V1) in the first stage.

Fig. 61

Trouble Shooting in Audio Amplifiers

Shooting trouble in an audio amplifier is not as tedious as making an analysis of the amplifier.... We take for granted that the trouble shooter is certain that the faults causing the defective operation are in the amplifier and the associated equipment....

The basic troubles in audio amplifier systems may be classified under two headings

1. Operating voltages
2. Circuit continuity

The A.C. amplifier adds another possible trouble, rather another condition which will cause trouble, coupling between stages or coupling between various parts of the system, which includes the A.C. power supply. To this must be added circuit balance in connection with the filament system. The latter is of course limited to A.C. circuits.

In connection with the first classification mentioned above, it is necessary that the repair man or the man who is diagnosing the receiver know the correct operating voltages, otherwise he cannot tell conditions of excessive or insufficient operating potential. This information is usually available. A certain section in this work, is devoted to the correct operating potentials of audio amplifier tubes utilized in a number of commercial radio receivers... To continue we must assume that whoever attempts the service work knows the correct operating potentials. In this connection the average power amplifier,external of the commercial radio receiver installation, is designed for operation at the rated potentials. We make special reference to this fact because many radio receivers are designed for operation at potentials less than the manufacturer's rating.... We hope that this point is clear. By operating potentials we mean tube operating potentials.

In view of the fact that A.C. operated systems involve a greater number of possible troubles, we will devote more time to such systems; as a matter of fact,will concern ourselves with A.C. systems, since all defects other than those directly allied with the A.C. supply are representative of defects in battery operated amplifiers....

Before starting upon the actual trouble shooting, we wish to make mention of one specific requirement. Inorder that the work proceed without hindrance due to doubt, it is necessary that a headset, known to be perfect be at hand. This unit is to be employed in place of the conventional speaker when the actual condition of the speaker at hand is unknown. The winding in the head set may be protected in the conventional manner, by means of a choke and a condenser. If the speaker at hand is known to be perfect. it is unnecessary to make use of the headset, but why delay operations because a means of noting signal output is not available.In this connection an indicating system is not as satisfactory because of the possibility of hum in the output.

As an example of a commercial installation we shall discuss the audio amplifier in the Stewart-Warner model 801A Series B receiver. This unit and the power pack are shown on the accompanying page. The fact that the radio frequency amplifier is shown is of little consequence. .It should be ignored. An analysis of the system shows that the amplifier consists of two stages and three tubes, a conventional stage an one stage of push-pull with an output transformer. Judging from the voltage indications, the first stage tube is a 226 and the output stage tubes are 171s or the equivalent... It is best to analyze each wiring diagram before service work is attempted. According to the wiring diagram, the filament supply for the audio tubes is independent of the supply for the radio frequency tubes, a separate transformer winding being employed for the 226 tube in the audio amplifier. A separate winding supplies the 5 volts required for the filaments of the output tubes... All grid returns in the audio system connect to B- and ground... All C bias voltages are secured by means of a drop across a resistance con-

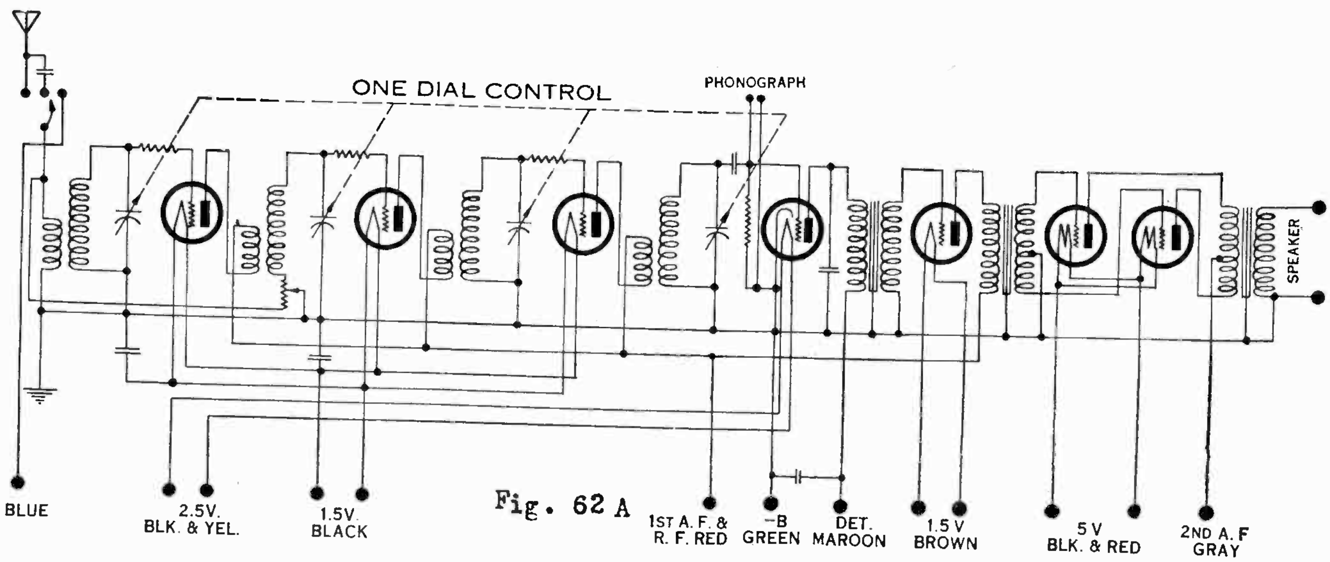


Fig. 62 A

MODEL 801, 801-A, 811, 811-A SERIES B

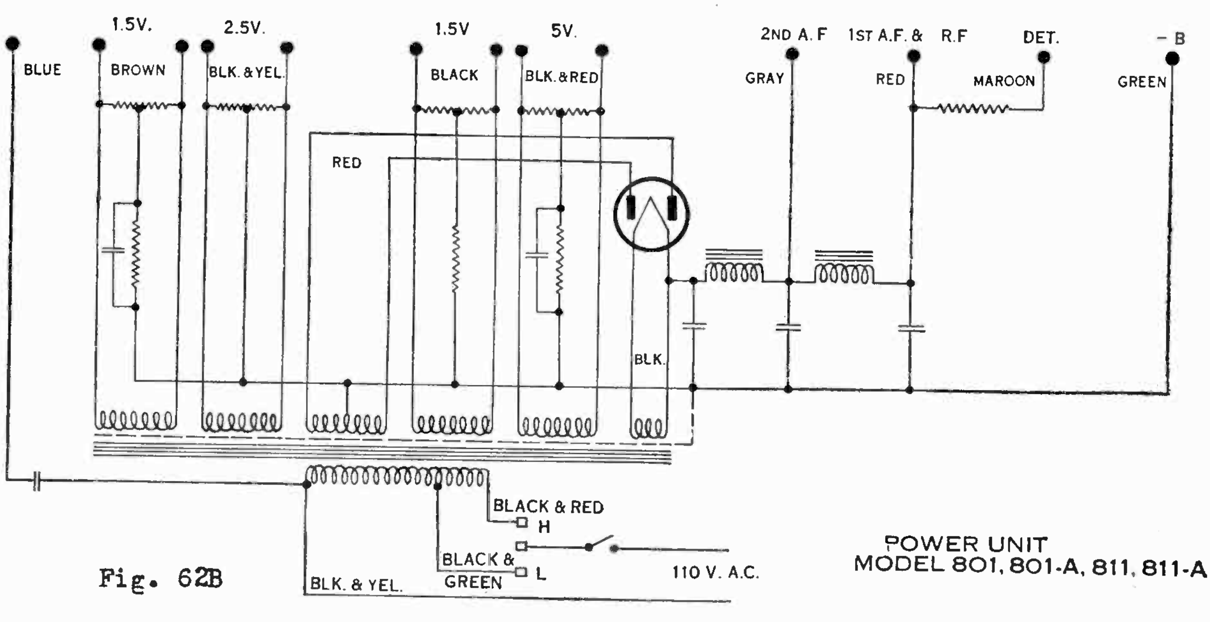


Fig. 62B

nected into the plate filament circuit...All audio frequency transformer cores and cases are grounded.

Let us imagine that the radio frequency and detector systems are perfect. The audio amplifier however is defective. The amplifier output signal is fair but distorted.... What now?.....

The fact that the signal output is fair is resonable evidence that circuit continuity is normal.

We must consider several items. First are the tubes. Since the signal output is fair with respect to intensity, it is safe to assume that the tubes are in good condition. This conclusion is not definite, but inorder to proceed it is necessary to assume certain conditions. This method of progress saves time in the long run.. Second, is the condition of the speaker. Once again we shall assume that the speaker is perfect. ... The trouble is in the audio amplifier.

According to the possible reasons for distortion and normal intensity in audio amplifier, we must consider a definite number of items, viz;

1. Tube overloading.
2. Incorrect grid bias (insufficient).
3. Excessive hum in the system.
4. Excessive regeneration.
5. Defect in speaker.
6. Incorrect B battery voltage (excessive)

A previous conclusion eliminates number 5. To determine the truth of number 1 we reduce the signal being fed to the amplifier and find that the distortion is still present, hence the trouble cannot be tube overloading. The amount of hum audible in the output is negligible, hence item number 3 is eliminated. The remaining items are allied with operating voltages and since a test for operating voltages when carried out with a set tester will show circuit continuity, the correct test is self evident, namely operating voltages.

The set tester is applied to the first audio tube, the 226 and plate,grid and filament voltages are found intact. These determinations do not mean that circuit continuity through the audio frequency transformer in that stage is correct, other than that the circuit is continuous. However, since the voltage measurements show values identical with or close to the values known to be the correct figures, it is safe to proceed to the other tubes in the system. The set tester is now applied to the second tube in the amplifier, one of the push-pull stage tubes. The plate voltage is found to be higher than normal.. The filament voltage is normal...The plate current is excessive and the grid bias is less than normal.. It is evident that the trouble, whatever it may be is in the push-pull stage.. Let us analyse the conditions found in this stage.

Excessive plate potential cannot be due to increased output from the B unit, since the plate potential applied to the 226 in the audio system is normal. A decrease in voltage drop across the filter choke is likewise impossible since the drop across this choke would display an effect upon the plate voltage supplied to the 226 tube. The increase in plate current is attributable to the high plate voltage and to the low grid bias. The latter item is of importance..

According to the wiring diagram, the grid bias applied to the tubes in the push-pull stage is the voltage drop across the resistance R, due to the TOTAL current flow (plate current) of the two output tubes. Apparently the amount of current required to produce the necessary grid bias voltage is not secured despite the fact that the plate voltage applied to the tube tested is excessive and the plate current in that stage is excessive. The logical conclusion is that the remaining pushpull tube is inoperative. .. With this tube in the circuit, the total plate current flow through R would be greater, and because of the additional current drain, the plate voltage applied to the plate of the tube tested would approach normalcy...The next logical test is the other push-pull tube.

The set analyzer is applied.. The filament voltage is normal. Plate voltage and plate current readings are absent..The condition bears out the deduction previously made in connection with the other output tube.. Let us determine the cause for lack of plate voltage and plate current... The possible reasons are three in number.

1. Open winding in output transformer
2. Defective tube
3. Poor contact or no contact between receiver tube socket and tube or tube insert.

1A. An open in the plate voltage feeder cable is impossible since the same cable supplies plate voltage from the B power unit to the other output tube. Hence an open is possible in only one half of the output transformer winding, the half connected to the plate of the tube being tested.

2A. A defective tube may cause lack of plate current, but it should not limit the application of plate potential. This fact points towards the possible trouble mentioned in the last half of the preceding paragraph.

3A. Poor contact between the tester insert and the receiver tube socket is possible and must be determined by means of a voltage test between the socket plate prong and the maximum B+ terminal.

To check 1A, the open in one half of the transformer primary a battery-voltmeter continuity tester is applied. The tester consist ofa 22.5 or a 45 volt battery block in series with a voltmeter with satisfactory voltage range as shown in figure 63 . The tester is connected across the tube plate terminal on the socket and the B+ cable feeding the output transformer primary. The meter indicates 0 or an open in that half of the transformer winding. The winding is shorted by means of a piece of wire and the tube inserted into the tester socket and the tester insert is plugged into the receiver tube socket. .. Plate voltage is observed and plate current flows through the system indicating that the tube is satisfactory.

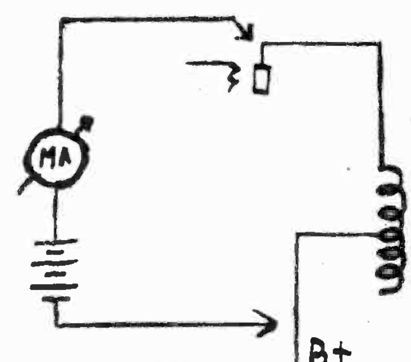


Fig. 63

As is evident from the above, the set analyzer as a unit will not indicate all conditions. It will, by aiding in the isolation of the trouble into a certain part of the receiver or indicating that the trouble is in one part of a tube circuit, help diagnosis, but absolute location of the trouble is beyond the device. In addition to the set analyzer, every man interested in servicing should have a continuity tester of the type shown which may be employed to indicate an open, a short, a partial short or satisfactory continuity. If the set analyzer is designed for continuity testing, all the better, but the continuity tester should be an inherent part of every service kit.

The set analyzer is of little utility when the trouble is of such nature that it concerns one resistance in parallel with the other, since a voltage test across one of the resistances will show potential even if the second resistance is open. We refer to the filament shunt resistance connected across the tube filament. A voltage test across the filament will show potential when the shunt resistance is open and the aural trouble is hum in the receiver amplifier.

Suppose that the trouble is excessive hum. If the signal output is normal, which condition is very possible, it stands to reason that circuit continuity must be satisfactory. This of course does not mean that all bypass condensers are correctly connected, since an open bypass condenser across a C bias resistance will not interfere with the amount of amplification available in the system, but it will cause a bad hum. If however the output signal is weak, it is necessary to trace the items allied with low signal intensity. In all probability the reason for the low signal output is the reason for the hum. The revers may be true, but we are not interested in which came first, the chicken or the egg.

It is possible however to segregate the possible reasons for hum with various degrees of amplifying power available in the system. For example the design of the A.C. vacuum tube makes necessary certain filament, grid and plate voltages inorder that the hum in the tube output circuit be minimum. Hence the first requirement in the quest for hum troubles is

1. Operating voltage

It is needless to stress the methods of determining the correct operating voltages, since explicit directions accompany each testing unit sold on the market and the man who constructs his own set analyzer is undoubtly familiar with the application of the device.

The determination of operating voltages will expedite the location of the trouble, since continuity is involved in the test, just as the open transformer primary showed up in the voltage test previously described. Here we find the difference between hum when the signal is normal and when the signal is weak. If the weak signal is due to an open circuit, the open will be isolated when the voltage test is made. This is why the possible reasons for hum, as mentioned in the section devoted to "Troubles in Audio Amplifiers" are minimized, since an open grid circuit will make normal signal intensity impossible, yet will cause hum in many installations.

On the other hand, the application of incorrect operating voltages is possible with continuity through all circuits. If the hum is due to this condition it is necessary to determine the reason for the incorrect operating voltage. The possible reasons for incorrect operating voltages have been mentioned in a preceding chapter.

Supplementing this is lack of balance in the filament circuit. This condition cannot be determined by means of the set analyser and an examination of the filament circuit is necessary. If the filament resistances are adjustable, the task is much simpler..... Adjustment or manipulation naturally follows... If the adjustment is of little aid, it is necessary to examine continuity of these filament shunt resistances or to seek perfect continuity between the transformer centre tap and the remainder of the filament circuit.

In this connection we must again mention that accurate adjustment of the filament shunt resistance is necessary when 226s are employed. Accurate adjustment is not necessary with the 227, but operation is improved if the adjustment is accurate. Hence the second important item is

2. Filament circuit balance

Trouble shooting for hum is unfortunately more complex than we would like it to be. We make mention of the possibility of a large A.C. component in the plate voltage. This involves the design of the eliminator and the rectifying tube. The same is true of the filament voltage, if the source of filament potential is an A eliminator. Hence in the quest for the possible reasons for hum, it is necessary to consider the operating life of the rectifying system in the B unit and the rectifying system in the A unit. If both of these devices have been in operation for a long period, specific attention must be paid to the possibility of worn out rectifiers. In this connection an indication will be available in the form of reduced operating potentials.

A reversed line plug will frequently cause hum in A.C. installations.

Coupling between the power unit andthe remainder of the receiver need not be considered in a commercial receiver, particularly if the receiver has been in operation for a period and the results have been satisfactory and physical changes have not been made. However, such trouble may develop if the ground is lacking on a core or case of one of the units in the installation. This is quite frequent and we make the third major possible reason

3. Lack of correct grounding of units in the installation

With respect to coupling between the A.C. power circuit inclusive of the filament wiring and the remainder of the receiver, particularly the audio amplifier, it is necessary to give detailed consideration to this item, when the receiver proper and the power system are assembled at home or when changes have been made in physical location.

When hunting trouble in grouned circuits, to locate an open ground or lack of ground and an incorrect location of a ground, it is necessary to disconnect the regular ground and trace continuity after studying the wiring diagram, by disconnecting some of the grounded circuits. For example a ground in the secondary of the first audio stage of the Stewart-Warner 801A receiver shown in figure 62 would not be evident as long as the grid return terminated in the B- and ground. It would therefore be necessary to seek a ground in this transformer and a possible short by disconnecting the regular ground through the grid return and then test for the ground by means of the continuity tester.

A gradual increase in hum indicates the gradual failure of a unit which might cause the hum and the units within this category are

1. The tubes in the amplifier
2. The rectifier in the A eliminator
3. The rectifier in the B eliminator
4. The filter condensers in the A eliminator

Querying the customer should guide the repair man.

A sudden increase in hum means a sudden failure of a part. It is not characteristic of tubes to fail suddenly unless the failure of the tube is due to application of excessive potential at that moment. Such failures invariably mean injury to the tube and discontinuation of function. Furthermore the failure of certain units will not only cause hum but will stop operation of the amplifier. The latter includes puncture of the grid bias resistance bypass condensers and shorting of the grid bias resistance. Such condition will cause lack of grid bias and if in the output stage, the amplifier will appear "dead".

When the advent of hum is sudden look for

1. Open grounds to the set and the cores and cases
2. Open filament shunt resistances
3. Open filament transformer centre taps
4. Short circuits of filament shunt resistances
5. Open bypass condensers
6. Open grid circuits
7. Grounded grid circuits

in the amplifier and

1. Lack of ground
2. Open filter condensers
3. Open bypass condensers

in the associated eliminators.

As is evident the search for hum troubles is more difficult than for a defect in circuit continuity. The same is true of noise troubles. Once again operating voltages have very little to do with the possible troubles.

Noise is usually accompanied by normal signal intensity, hence circuit continuity may be considered perfect. With the exception of noise due to induction from external sources and noise passed to the receiver from the A and B eliminators, noise may be classified under two headings,

1. Poor contacts or all kinds
2. Defective windings or resistances caused by passage of excessive current flow

A visual examination is necessary in the first case and replacement is necessary in the second. Replacement is recommended because it is much faster than a test of the device to determine the exact location of the defect in the unit. With respect to isolation of the fault, the method of procedure applies to the hum trouble and to the noise trouble. The most rapid and effective method of isolating the fault to at least a part of the amplifier, is to remove one tube at a time, thus removing a stage at a time. It is of course necessary to start with the tube furthest from the output stage.

If the hum is present when all but the output tubes have been removed it is safe to assume that the hum does not originate in the stages preceding the output stage. It is possible that the trouble is due to an open filament shunt resistance, but this consideration applies only when all the tubes in the amplifier are fed from the same transformer winding. This is seldom the case.

It is possible that the hum is to be found in all stages, hence is present when all but the output tubes are removed. In that case, the hum is undoubtly due to excessive A.C. component in the plate voltage. It is, however, necessary to add the possibility of some condition in the output stage such as a defect in the grid bias system. Also excessive hum in the filament voltage supply if an A eliminator and induction between the filament circuit and the remainder of the amplifier, if the filament supply is A.C.

If the hum disappears when one of the intermediate audio amplifying tubes is removed, the origin of the hum is in that stage or in some part of the amplifier preceding that stage and check-up of the possible reasons mentioned, is in order.

The same method of progression is applicable when searching for the causes for noise.. Remove one tube at a time...... then examine the various elements in the respective circuits.

Suppose that the trouble is low volume --- poor amplification. According to the list of possible reasons for this condition, we have many items to consider... But the problem is not as difficult as it appears upon the surface because one test, say the operating voltage test will clear up or eliminate many of the items mentioned in the list of possible troubles. For example, if the filament voltage is normal, it eliminates all the items connected with the filament voltage. If the plate voltage is very low, it eliminates all factors not associated with plate voltage. In connection with voltage measurements, we suggest that when making grid bias voltage tests, the unit in the grid circuit be included. In other words, the grid be the - terminal for the voltmeter and the + terminal be the cathode or the filament centre tap, as the case may be. This method of measurement will show continuity through the unit in the grid circuit. This test should supplement the regular grid voltage test, the latter showing the correct voltage in the circuit. This is illustrated in figure 64 . Test A is across the entire circuit and test B across the unit producing the voltage drop. This circuit shows a resistance between the filament centre tap and the B-.

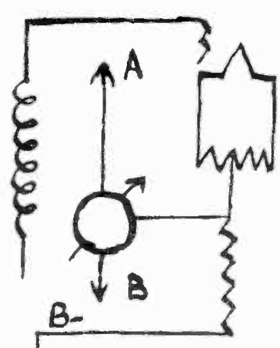


Fig.64

The application of the set analyzer to determine operating voltages and respective values of plate current will afford an idea of the condition of the vacuum tubes in the system, since a deactivated tube will have no or very little effect upon the plate voltage measurement, but the plate current consumption will be less than normal. The other significant data available with the plate current measurement have been enumerated and the reader is referred to that chapter on voltages.

We can therefore decide that the first test is that for operating voltages. Now, in connection with the voltage test, it is necessary to remember that a deactivated tube when used in a system, such as the first stage in the Stewart-Warner receiver shown in figure 62 , will show normal or slightly higher than normal plate potential, less than normal plate current and less than normal grid bias, since the grid bias is a function of the magnitude of plate current. This condition must be differentiated from a condition resulting in a similar effect, when the plate voltage is less than normal or when the grid bias resistance is less than normal.

With but one exception, the operating voltage test accompanied by the plate current test will show the location of the defect, at least as far as a part of the complete circuit is concerned. The only exception is a short across the primary or plate coupling unit or a short across the secondary or grid coupling unit. Short circuits will permit continuity but will impair the passage of the signal voltage; consequently will permit D.C. voltage observations. Hence after all voltage tests have been made and after tube tests show satisfactory condition, tests for short circuits in the units mentioned are necessary.... However, the method of measurement shown above, where the grid bias voltage is measured between the grid and the cathode or filament centre tap will show normal continuity through the secondary of an audio transformer, a grid choke or the grid leak, by reduced grid voltage due to the current consumption of the meter used. The reduced voltage indication does not mean that the grid voltage is likewise reduced because of the coupling unit in the grid circuit. The voltage drop is due to the current flow in the circuit when the meter is connected into the circuit. The normal circuit arrangement when the meter is omitted and the grid bias is applied means lack of current, hence lack of voltage drop (D.C.) across the grid.

In the plate circuit we check the measured value against the rated value. We refer to the plate voltage at the tube element.... Primaries or transformers are more apt to burn out than short and a "blown" winding will show an open in the plate circuit. To check a punctured bypass condenser across the plate winding it is necessary to check the voltage drop across the plate coupling unit, with the condenser "in" and "out".

"Dead" amplifiers are of various types and a rapid test is the removal and replacement of the tubes. Starting with the tube or tubes in the output stage a click should be heard in the speaker if the operating potentials are applied and circuit continuity is normal in the output stage. If the click is lacking, the fault may be located in the output stage in the form of an open, or the plate potential circuit is open It is understood of course that the filament circuit is normal and that the tubes are lighted. If the click is heard, the tube constituting the amplifying stage nearest the output stage is removed and replaced. If the click is audible, we progress to the subsequent tube moving backwards. If however the click is not audible, investigation of the operating potentials is in order. The same is true of the continuity of the coupling unit between this tube and the output stage.

An open primary or plate circuit will cause a "dead" amplifier. A deactivated tube will cause a similar condition. Poor contact between the tube and the socket will cause a similar condition.... The status of an amplifier may be determined by tapping the detector tube or the first audio stage tube with the finger nail or a light solid object. If the amplifier is normal a ringing sound will be heard...

For accurate work, operating voltage tests must be made, but if the set analyzer is not available, the above method of progress supplemented by a continuity tester will permit diagnosis.

In many instances "dead" amplifiers are caused by the simplest of defects. ...It is not necessary that the trouble be complex. A broken battery cable connection, a poorly soldered B- joint, a loose binding post top, poor contact between the tube and the socket.... etc., and the amplifier is "dead".

In all of this work we have devoted very little space to the actual sources of potential. The reasons for this are simple. If the tube filaments do not light, it is needless to consider the amplifier "dead" until it has been found inoperative with the filament lighted, i.e. after the defect in the filament supply or circuit has been remedied. The same is true of the source of plate potential. If the operating voltage test shows no voltage from the source of potential, the trouble in the latter must be remedied before further tests may be made upon the amplifier. And since we devote separate chapters to the A and B supply units we deem it unnecessary to consider the A and B supply when shooting trouble in audio amplifiers... We believe that comprehension is facilitated by individual discussion of the various systems. It is for this reason that we have omitted reference to special power amplifiers which are part and parcel of spec-power packs. These units will follow after the discussion of B eliminators.

Troubles in Detector Systems

The grid circuit of the detector is really a part of the radio frequency amplifying system, but we shall discuss this part of the receiver as an individual unit. What are the possible troubles in detector circuits?.. Let us see.

1. Distortion
2. Lack of sensitivity
3. Noise

Although few in number, these three faults cover a good deal of ground, for example:

The consideration of distortion involves several factors, such as operating voltages, excessive regeneration, tube overloading, incorrect value of grid leak, etc..

Lack of sensitivity involves a defective tube, a poor,unsuited tube, incorrect operating voltages, lack of resonance in the tuned stage, poor or incorrect grid leak, etc..

Noise involves a defective tube (microphonic), induction into the detector stage, defective grid leak, poor or defective sources of potential, open circuits and poor contacts.

Each one of the items mentioned above may be discussed at length, since the each subject is worthy of discussion. Experience in the field has shown that distortion in the detector stage is seldom due to a defective tube, unless the defect is deactivation of the filament, in which case the distortion is accompanied by low sensitivity or low signal level. However, excessive regeneration is a frequent complaint, particularly so when the detector stage is regenerative, and in this case distortion is usually accompanied with increased sensitivity rather than lack of sensitivity. However, in some instances, the regeneration control is unsatisfactory and the distortion in the stage is due to this condition. If this be true, it is necessary to investigate the regeneration controls. Perhaps the required plate circuit bypass condenser is not connected into the circuit... Perhaps the grid leak is incorrect or the plate voltage is excessive.

Distortion accompanied by low volume or sensitivity, and when investigation shows the detector tube to be in good condition is usually the result of low plate voltage or incorrect grid bias. Here too, we find a distinct difference between the respective reactions. Low detector plate voltage frequently gives rise to a hum, whereas a low resistance grid leak will,reduce sensitivity without an accompanying noise of the hum variety. With respect to low plate potential, we should qualify the statement to include all operating potentials, although incorrect bias with the grid leak and condenser system will not cause a hum. Low filament potential however may give rise to a hum and cause a reaction similar to that due to an open plate circuit.

Tube overloading is a probable reason for distortion in the detector stage. The use of three and four stages of tuned radio frequency amplification, sometimes with screen grid tubes, gives rise to a healthy voltage which is applied to the detector. To secure maximum sensitivity the grid leak-condenser detector arrangement is employed and this tube cannot handle the input voltage possible with the grid bias system. The consequence is tube overloading.

The use of a high value of grid leak or a normal grid leak which has developed a defect, makes the above mentioned condition even worse, since the charge upon the grid cannot leak off in time... The result is tube blocking. A detector tube may be overloaded because the plate potential applied is insufficient and when this potential is increased operation is normal.

Incorrect operating potentials involves the use of incorrect polarity of grid bias in the grid bias detector or excessive negative grid bias. This subject involves distortion with lack of sensitivity, particularly when the grid bias is excessive, in which case weak signals will have very little effect upon the detector tube.

Lack of sensitivity is usually accompanied by low signal level, but when local station response is satisfactory and distance is lacking, the cause of the condition is seldom located in the detector tube. However, lack of resonance in the detector stage is a possible fault. Incorrect adjustment of the regeneration control or insufficient regeneration is another. Incorrect operating potentials are seldom involved since they would cause distortion on the local signals. A low value of grid leak would cause low sensitivity level without distortion on strong signals. An unsuited detector tube rather than a defective tube is a probable cause since a defective tube would indicate its condition when strong signals are received.... In all of this discussion we take for granted that the radio frequency stages and the antenna are satisfactory..... A leaky bypass condenser in the plate circuit would diminish signal strength... A defect in the radio frequency coupling unit would do likewise, but it would also impair local reception. Incorrect polarity of the bias with grid leak-condenser systems would impair distance reception.

We do not stress the repairs in the above cases since they are obvious when the fault is mentioned.

Correct adjustment of the grid bias in grid bias detector systems is of great importance with respect to receiver sensitivity. Lack of grid bias will impair operation on all stations but excessive grid bias (negative) will greatly diminish receiver sensitivity. The locals will come through but the distant stations will be lacking. Referring again to the grid leak-condenser arrangement, we exclude a shorted grid condenser since it will show its condition when listening to local stations. The response will be distorted.

With respect to noise in the detector stage, the faults are of two types, defective units and poor contacts. The first classification includes leak bypass condensers, defective grid leaks, partially shorted tuning condensers, leaky grid condenser, defective sources of potential when batteries and noise in the A and B eliminators, a gassy tube. The second classification involves poor contacts, corroded terminals, electrolysis in cables, poor contact between tube and socket prongs, partial shorts in the radio frequency coupling units,---- wherever contacts are involved.

Howling and hum are separate. The former involves microphonic tubes and excessive regeneration. The latter involves, assuming otherwise satisfactory detector operation, induction from other power circuits, hum voltage present in the filament supply, hum voltage present in the plate supply. Hum present in the detector due to modulation in the radio frequency plate circuits must be eliminated by removing the hum from the radio frequency system.

Radio Frequency Amplifiers

Radio frequency amplifiers in use at the present time are of several types. Each design engineer selects the type he prefers and builds his receiver around his pet system. It is not within our scope to describe each of these systems; as a matter of fact we do not deem it necessary. If we were to devote space to each type of tuning system in use today, to each type of input circuit in use to day, to each type of volume control system in use today, we could write a book with more than 1000 pages, which would not cover everything that may be said about the systems.

Therefore let is suffice to say that some means is employed to tune the radio frequency stages so that they are resonant to a predetermined frequency. This means that we must consider two specific systems;

1. With a band pass filter preceding a number of untuned stages
2. With the band pass filter in the tuned stages

The second classification in turn has two categories,

1. Conventional tuned stages
2. Tuned stages arranged to constitute band pass filter stages.

The function of the radio frequency amplifier in a receiver, irrespective of type is to provide the required amount of receiver sensitivity and to provide the required selecting powers, so that the receiver owner may choose between the stations available for reception without interference between stations. If the above two requirements are fulfilled, the type of radio frequency amplifier used is of little consequence.

As it happens, the same result may be achieved with more than one system, because the complete receiver is designed around the system used, hence our interest is not the actual system, but trouble associated with the radio frequency amplifier. An examination of the wiring diagrams shown in this book will clearly illustrate the numerous systems in use, but no matter what the circuit structure one fact is definite, ---- that circuit continuity must be perfect. In addition, resonance must be uniform in the respective stages.

Considered from the point of circuit continuity, the actual circuit structure is obviously unimportant. Be it a tuned transformer or an untuned transformer, the continuity through these items must be perfect. However, perfect continuity is possible even whan a defect is present, hence we must amend, by addition of the stipulation that the units used must be perfect. It is logical that the last statement does not refer to an open, since an open circuit will prevent continuity. Hence, examination for shorts in windings, leaks between windings ---etc...

All tuned grid circuits do not consist of a single winding and a tuning condenser. The exact number of components in a system may be twice as many as the number mentioned, depending upon the circuit structure, but no matter what the elements in the circuit, each performs a certain function. If all function in normal manner, the circuit as a unit, will perform in a normal manner. If however, one unit fails, it will evidence that failure in one form or other --- in some way which will indicate the presence of the defect. What we mean is best illustrated by an examination of the radio frequency circuit structure of the Grebe A.C. 6 Synchrophase receiver shown on the next page.

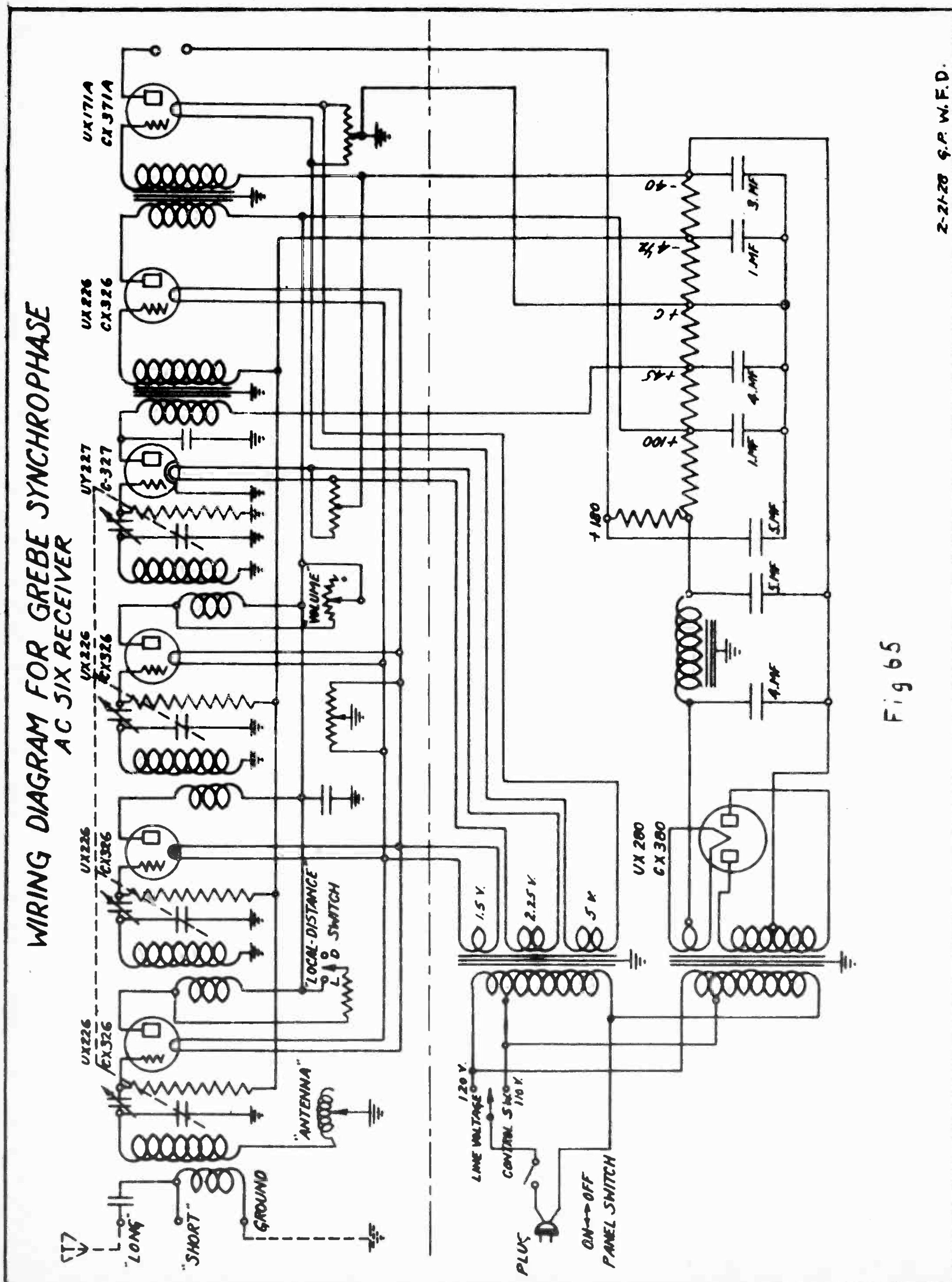

WIRING DIAGRAM FOR GREBE SYNCHROPHASE
AC SIX RECEIVER
UX171A
CX371A
UX226
CX326
UY227
C-327
UX226
CX326
UX226
CX326
UX226
CX326
"LOCAL-DISTANCE" SWITCH
L D
VOLUME
"ANTENNA"
"LONG"
"SHORT"
GROUND
-40
-4½
+C
+45
+100
+180
3. MF
1. MF
4. MF
1. MF
.5 MF
.5 MF
4. MF
UX 280
CX 380
1.5 V.
2.25 V.
5 V.
120 V.
110 V.
LINE VOLTAGE
CONTROL SW.
PLUG
ON-OFF
PANEL SWITCH
2-21-28 G.P. W.F.D.

Fig 65

The radio frequency amplifier differs from the conventional systems, but the difference is not radical... The tuning to a frequency or a wave is accomplished in the normal manner. However, the grid bias applied to the radio frequency amplifying tubes is not applied in the normal manner, through the transformer secondary. Instead it is passed through a resistance located in the grid circuit. If this resistance opens, the C bias circuit is open. If however the small variable condenser located in the grid circuit becomes shorted. the C bias resistance will be come shorted because one side of the tuned radio frequency transformer secondary connects to ground and the other side of the transformer secondary connects to the C bias resistance.... Here is a circuit different than the conventional, yet certain conditions will cause certain effects, which when the circuit is analyzed indicate the position of the fault.

The number of elements in any one circuit influence the possible number of sources of trouble, but troubles are usually singular with respect to number and measurements made to prove determinations will indicate satisfactory performance of certain units and this eliminate these units as possible sources of trouble.... If the reader bears the above in mind, trouble shooting will be greatly simplified.

We cannot lay too much stress upon circuit analysis, upon examination of the wiring diagram of the receiver to be serviced. This work is of infinite importance, as a matter of fact servicing cannot be carried out as it should be conducted unless the man repairing the receiver is familiar with what parts comprise the circuit. This is particularly true of radio frequency amplifiers because of the varied design.

As an example we have the receiver employing a separate tuned band pass filter preceding the untuned stages. Lack of selectivity due to a defect in the band pass filter will not be evident when tube circuits are tested because the band pass filter mentioned is not in the tube circuit, unless the output of the filter is the input for the first radio frequency amplifying tube..... The condition mentioned must be known before servicing is attempted.

With very few exceptions, troubles in radio frequency amplifiers are attributable to similar conditions, irrespective of the number of elements in any one circuit. However, it is necessary to know the units used in each circuit, so as to coordinate the unit and its location when the trouble is attributed to any one unit. As an illustration of what we mean, the volume control in the Grebe receiver shown,is a variable resistance across one of the radio frequency transformer primaries. In some other receivers, the volume control is a variable resistance in the antenna circuit. Hence mention of a certain trouble associated with the volume control means one thing when the volume control is located as shown and when it is in the aerial circuit, the type of trouble is different. In the former instance, an open volume control will impair control of volume, whereas in the second case, an open volume control will impair signal strength, cause hum in A.C. receivers, etc..

With a final recommendation to study the wiring diagram we pass on to the possible troubles in radio frequency amplifiers.

Troubles in Radio Frequency Amplifiers

If we were to discuss each type of radio frequency amplifier in use today and each special type of circuit structure as employed by the various receiver manfacturers, it would be possible to fill several volumes. Fortunately however the subject matter permits of generalization, because many causes of troubles are common to all radio frequency amplifiers. Furthermore if a cause is mention in connection with one system and that particular unit is not employed in that system, it is possible to forget its mention and seek the other causes as quoted in the text. For example if we list a defective volume control located in the aerial circuit as a possible reason for poor signal strength and the receiver in question does not employ such a resistance, the quotation is simply overlooked and the other causes considered.

A general expression of trouble in radio frequency amplifiers would include

1. Broad tuning
   a. Normal signal strength
   b. Low signal level

2. Poor amplification

3. Excessive regeneration

The items allied with these three forms of trouble encompass practically everything associated with radio frequency amplifiers.

Broad tuning is a frequent complaint. Recognizing the type of trouble it is possible to at least limit the fault to location in one part of the receiver installation, the radio frequency amplifier and aerial system. However, it is impossible or rather unsafe to come to a rapid conclusion, because it is necessary to consider circuit structure.... Are the tuned stages of conventional form?... Are the radio frequency amplifying stages of the tuned type or the untuned type?.... Does a band pass filter precede the regular amplifying stages?... These are some of the questions which must be answered prior to the analysis because they influence the findings. Fortunately few commercial radio frequency amplifiers utilize a band pass filter series preceding the regular radio frequency stages... Most of the commercial receivers employ conventional tuned stages, although some of these stages constitute band pass filters. This involves very little extra work or thought, which fact will become evident as we move along.

Every reader of these pages is familiar with the fact that the tuning of stations or the selecting power of a radio receiver is located in the radio frequency amplifier. The detector makes the signal audible and the audio frequency amplifier magnifies the signal to the required intensity. Therefore no matter what the complaint just so long as it is associated with tuning or selectivity, the location of the fault is in the radio frequency amplifier, its associated accessories or the aerial system.

In connection with broad tuning, this state may exist with low signal level and with normal signal level. Recognition of this difference has much to do with the final result. If the state is the former, the possible troubles are many; if however the state is the latter, the possible troubles are much less in number.... Let us consider the latter state.... The signal level is normal but the set tunes broadly.

The fact that the signal level is normal, is ample proof that the amplification available with the system is normal, which in turn means that circuit continuity and operating potentials must be normal. This is so because a short of an open in one of the circuits would impair signal strength. Likewise any discrepancy in operating voltages would reduce signal strength, because the amplification available in each radio frequency amplifying tube would be reduced.

To all appearances, the operating characteristic eliminates the tubes, circuits and sources of operating potential... What can the trouble be?.... Very simple although many do not wish to admit it. The lack of selectivity in such cases is usually limited to one section of the radio receiver tuning dial, which condition in turn may be due to two actions, diagnosis making necessary consideratiom of both these actions. The first is excessive signal strength in any one location and broad tuning accompanied by excessive signal strength when the receiver is tuned to that station. In this connection the trouble may be present on more than one wave, if the receiver is located in a spot very favorable to several local transmitters. The second action, is the operating characteristic of some tuned band pass filters, which have a tendency to increase the band pass width as the frequency is increased, as the tuning is adjusted for the low wavelengths. Amplification suffers very little but the band pass has been increased to 20 and 25 kilocycles instead of the required 10 K.C.

Wherein lies the solution is the next question?.... Perhaps the high input signal level is attributable to the antenna system.... This is very likely if the receiver is located within a few miles of power transmitters and the aerial is very long. Powerful broadcasting stations located near a receiver system,(by near we mean within 10 miles,) will cause decided interference if the aerial is too long. Perhaps the volume control located in the aerial system is defective in such a manner that the signal input into the tuned stages cannot be reduced. Now we come to the subject mentioned in the previous section. The latter condition would be manifest by lack of volume control when the volume control unit was being varied. Under the circumstances the possible reasons for broad tuning with normal signal level would be

1. Excessive signal strength due to location of transmitters
2. Excessive aerial length
3. Operating characteristic of inductively coupled or conductively coupled band pass filters, when the radio frequency stages are of the band pass filter type.

Broad tuning over a certain portion of a dial may be due to lack of resonance in the tuning system, but lack of resonance should cause a drop in signal level, because the various stages in the system are not tuned to the same frequency or wavelength. If the discrepancy is not sufficiently great to cause this drop, for example a variation of 2 kilocycles, the variation is not sufficiently great to cause broad tuning.

We have another consideration encountered where the screen grid tube is used. Perfect shielding and grounding of all shields is necessary for satisfactory tuning with these tubes as radio frequency amplifiers. Incorrect shielding and grounding will cause broad tuning and other faults, which we shall discuss later. Shielding of the control grid lead is of utmost importance, as is the grounding of this shield.

Recognition of the possible reasons for broad tuning with normal signal intensity eliminates the tubes, batteries,eliminators,resistances, condensers,etc..

Elimination of the tubes, batteries and other such items cannot mean the elimination of the design characteristics of the radio frequency amplifying system particularly when the screen grid tube is employed. The characteristic of many radio frequency stages utilizing the screen grid tube is to overamplify on the low wavelengths, i.e. to afford greater amplification as the wavelength is reduced (by tuning), thus causing broad tuning on the lower end of the tuning dial. The only way to oversome this trouble is to reduce the signal input.

Suppose that the condition is reversed. The radio frequency amplifier tunes broadly and the signal level is low, less than normal... What now?.... The possible troubles are now much more numerous. As far as the antenna system is concerned we need consider but few items;

1. Insufficient length
2. Poor aerial design, leaks to ground
3. Shorted aerial, short in lightning arrestor, leadin, etc..
4. Lack of ground
5. Poor ground

Let us eliminate the aerial ... Let us say that it is electrically perfect and of the correct length... The trouble now is not only broad tuning but also low signal strength. The two are not interlocking. Whereas the cause for the broad tuning may cause the low signal level, the cause for the low signal level need not be the reason for broad tuning, because the lower the energy level in the radio frequency stages, the less should be the tendency towards broad tuning. Under the circumstances we may segregate the possible reasons for broad tuning and also the possible reasons for low signal level or amplification and note which items associated with broad tuning will cause low amplification ---- low signal level.

The items which might cause broad tuning and low signal level or poor sensitivity, when particularly allied with tuning are

1. Defective aerial circuit (in receiver) resistance, choke or condenser
2. Defective radio frequency transformers
3. Lack of resonance between stages, condensers out of alignment
4. Defective volume control when located in aerial or first stage
5. Open grid circuit
6. Excessive stabilization
7. Open tuning condensers
8. Shorted tuning condensers
9. Open bypass condensers
10. Shorted bypass condensers

Each one of the above influences either tuning or the signal in the tuned circuits,hence broad tuning and low signal level.

An analysis of the factors which govern the degree of amplification in the tube will show that they cannot cause broad tuning. This should be qualified somewhat, although, under certain conditions the defect will stop operation of the receiver. We refer to incorrect polarity of C bias, as the possible defect which will reduce amplification and cause broad tuning. We mean + to the grid when the normal connection is - to the grid. The other factors

1. Low filament potential

2. Low plate potential
3. Low grid potential
4. Deactivated filament
5. Defective tube

will not react upon the tuning. They will influence amplification but not the selecting powers of the radio frequency system.

In view of the fact that the causes for low amplification will not cause broad tuning, it is necessary when broad tuning is the trouble, to locate the reason for the broad tuning before attempting to determine the reason for the low amplification level. The basis cause for broad tuning is most frequently the reason for the low signal level. When the former is remedied, the latter is automatically remedied.

Let us consider another situation,--- low signal output with satisfactory selectivity.... Now, the above statement does not mean that circuit continuity may be assumed to be perfect, because the degree of selectivity available with a system increases as the signal input into the system decreases. Hence it is possible that circuit continuity is not normal, but appears normal because the signal level is low. The proper method of attack in this case is to first locate the reason for the low signal level. If anything is wrong with the tuning circuits, it will become evident after amplification has been brought to the normal level. A condition such as we have mentioned noted when listening to a local station does not afford a definite clue... It is possible that the trouble lies in the antenna system. Again we have the list of possible troubles allied with the aerial and ground.

1. Insufficient aerial length
2. Poor aerial design, shielded, leaks to ground
3. Shorted aerial,short in lightning arrestor,leadin, etc.
4. Lack of ground
5. Poor ground

Suppose we eliminate the aerial!.....Then we are obliged to consider all of the items allied with amplification and ooeration of the vacuum tubes in the radio frequency amplifier; for example

1. Incorrect operating potential at the tube plate
    a. poor batteries
    b. poor power B supply
    c. excessive voltage drop in plate circuit
    d. incorrect battery or power B unit output potential
    e. incorrect line voltage input to power B unit, etc..
2. Incorrect operating potential at the tube filament
    a. defective battery
    b. poor A eliminator
    c. incorrect filament transformer operation or load
    d. insufficient or excessive voltage drop in filament circuit
3. Incorrect grid bias
    a. defective battery
    b. defective or incorrect grid bias resistance
    c. defective grid bias resistance bypass condenser
4. Defective tube
    a. deactivated filament (low electronic emission)
    b. gassy tube

5. Excessive stabilization
    a. incorrect adjustment of stabilizing agent
    b. excessive reduction of regeneration
    c. defective stabilizing resistances
6. Poor contact between tube and socket

So much for the tubes. Suppose that the operating potentials are satisfactory and the trouble is attributable to circuit condition and adjustment... It is not necessary that the defect be highly technical. Many service man are too prone to overlook simple defects, yet a simple defect will cause a major trouble. The adjustment of the tuning circuits is of great importance and several items present themselves, for example;

1. Adjustment of the local-distance switch
2. Adjustment of the long-short aerial switch
3. Adjustment of the loop and associated contacts

We omit all mention of open circuit in the tuning circuits because these defects will become evident when operating voltage tests are made --- PROVIDING that the tuning circuit is so arranged that the operating potentials are caused to pass through the tuning system...This is not always the case, as for example in the Grebe receiver mentioned in the preceding section. However, an open grid circuit or an open plate circuit will cause a great reduction in signal intensity, as a matter of fact will frequently stop operation of the receiver, and the condition will be different than that mentioned. We shall mention the possible reasons for extremely low signal output from a radio frequency amplifier and a"dead" or apparently "dead" radio frequency amplifier. Checking open circuits is continuity testing, which should follow after the operating voltage test has been made. Where the operating voltage and current flow through the radio frequency transformer primary and secondary windings, continuity testing will be unnecessary, because the operating voltage test will show the open circuit... Not necessarily the position of the open, but its location in a certain part of the receiver. The continuity tester is then applied to locate the exact point of open.

However where the tuning circuits are not in the path of the operating potentials, continuity testing will be necessary to determine the possibility of an open in one of the circuits... It is now necessary to seek and open, rather than to determine the location of a known open in the wiring.

Excessive regeneration in a radio frequency amplifier is a frequent complaint. Fortunately the reasons therefore are not mysterious and applicable to practically every type of radio frequency amplifier, irrespective of manufacture. In this connection it is of course necessary that the reader appreciate, that all manufactures of radio receivers do not employ similar methods of securing stability of operation, but no matter what the system, the statement relative to stabilization applies with equal facility to the circuit used in the receiver at hand. In certain respects excessive regeneration is allied with the factors which control amplification, viz;

1. Excessive plate voltage
2. Excessive grid voltage
3. Excessive filament voltage
4. Excessive signal voltage
5. Inductive coupling between various radio frequency coupling units
6. Imperfect shielding, lack of correct ground
7. Insufficient or incorrect stabilization
    a. incorrect adjustment of neutralizing condenser and system

b. shorted grid suppressor
c. insufficient resistance for grid suppressor
8. Lack of bypass condensers or open bypass condensers
9. Incorrect radio frequency amplifying tube

Where the screen grid tube is used, it is necessary to add

10. Excessive screen grid voltage

Note that the electrical design of the various coupling units, the transformers and the condensers has very little to do with the problem. The operating potentials influence feed back because they alter the tube characteristic, increase amplification and consequently the amount of energy fed back from one circuit to the other. The increase in plate voltage reacts upon the grid circuit and increases regeneration between the grid and plate circuits of that tube.

Excessive signal strength means greater feedback from one circuit to another, since more energy is fed back from one circuit to the other circuit under any one condition. Insufficient stabilization permits the presence of excessive regeneration. Lack of bypass condensers increases regeneration because the proper paths are not provided from the signal voltages. The wrong radio frequency tube is apt to increase feedback because the stabilization employed in the receiver does not compensate for the increased grid-plate capacity of the new tube.

The greater the amplifying power of a radio frequency amplifier, the greater the tendency towards feedback, because the signal voltage in the circuit is much greater and because the voltage fed back in the respective stages is amplified to a great extent. This is the reason for the extreme care required when the screen grid tube is used. Particular attention must be paid to shielding of the control grid lead. Lack of shielding of this lead is frequently the difference between satisfactory operation and annoying lack of stability

Excessive regeneration may be present in a radio frequency amplifier without causing heterodyne squeals when tuned to resonance. Instead it is a direct cause of distortion in the form of sideband suppression. This fault is manifest by extreme selectivity, a hissing sound at resonance and an apparent loss of high notes, or the upper audio register.

Excessive regeneration in a radio frequency amplifier is frequently due to causes which are foreign to the amplifier, namely the B batteries and the B eliminator, when these units are defective. Last but by far not the least contributory cause is the aerial system, inclusive of the ground. Unless the receiver has been specifically designed for a short aerial, a short aerial will increase regeneration and cause squealing. The same is true if the ground is removed.

Dead amplifiers are usually due to lack of plate potential, assuming normal filament potential, open grid circuits and shorted tuning controls. The reasons for lack of plate potential are numerous, viz;

1. Open plate circuit
2. Shorted plate circuit bypass condenser
3. Open lead supplying plate potential to receiver amplifier

An idea of plate circuit continuity may be secured by adjusting the receiver for maximum sensitivity and removing one radio frequency tube at a time, starting with the tube neasrest the detector. As each tube is removed and replaced into the receiver socket a distinct click shouàd be audible in the speaker or headset connected to the receiver.

Noise may originate in the radio frequency amplifier and the probable reasons are ;

1. Imperfect contact between the tubes and the sockets
2. Imperfect contact in volume controls
3. Imperfect contact at battery or potential terminals or posts
4. Partial shorts in the tuning condenser
5. Loose contacts in the amplifier system
6. Corroded battery terminals

Series Filament Receivers

We devote a special section to series filament receivers because the subject has been found to be very confusing to many men who have had occasion to work upon such installations. Unfortunately space does not permit a full resume of design but if any one is interested, we refer him to the May and June, 1927 issue of Radio Broadcast, to two articles by Roland F. Beers. These two articles describe the design of series filament receivers and are the most comprehensive and explanatory articles upon this subject, which have come to the attention of this writer.

As far as servicing is concerned, the series filament receiver is no different than the regular parallel filament arrangement. However the units employed in some series filament receivers and the method of filament circuit arrangement makes necessary mention of certain precautionary measures which must be followed during the process of servicing.

Inorder to apply these precautionary measures it is essential that the service man study the receiver wiring diagram. The reason for this is that all filament circuit arrangements in series filament receivers are not alike, and these differences cover voltage tests, grid bias voltages and the possible causes of trouble. Another excellent story covering the various types of filament circuit structure and grid bias systems in series filament receiver was published in Radio Engineering,June 1928. The author is William P. Lear.

The first consideration involves the current flow through the tube filaments. Without plate potential, the filament current in each tube is the rated current and the value determined by whatever resistance is used to govern filament potential and current. But when the plate voltage is applied, the plate current must needs flow through the filament inorder to reach the B- terminal of the B supply, hence the current through the filament is the filament current and the plate current. While the magnitude of plate current is not excessive when considered without other items, the total current through the filaments of the various tubes may become excessive because in certain positions the plate currents of various tubes in the system are addative, so much so that a 20 and 30% overload is possible.

Such overload is of particular importance when the 199 type of tube is used and the method of bypassing the excessive current is to place a resistance in shunt with each filament as in the Varion receiver shown in figure 66. The value of this resistance is determined by application of Ohm's law for resistance R = E ÷ I, where E is the tube filament voltage and I is the excess current. Since these resistances, designated as R1,R2,R3 and R4 are protective resistances, it stands to reason that an open in one of the resistances may cause burnout of the tube filament. In turn a short circuit in this resistance will short the

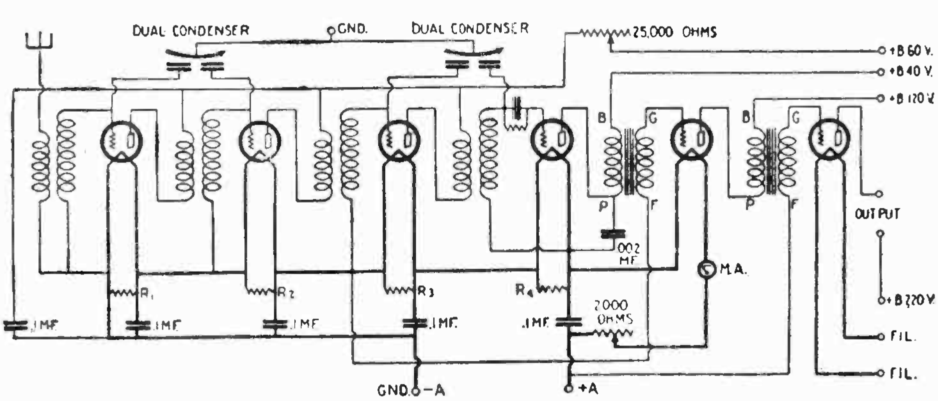


Fig.66

tube filament, remove the filament as a load upon the remainder of the filament system and cause excessive current flow in the filament circuit, perhaps burnout of some other tube filament.

Now, such protective resistances are not standard in all receivers, particularly when 201A type tubes are employed and when the plate voltages applied to the various tubes in the series combination are of such magnitude that the plate current values are within a certain range. Hence it is necessary that the filament circuit structure be known. When the resistance is used, it is essential that it be capable of carrying the required amount of current present in the system in the event that the tube is withdrawn from the socket. In this connection filament voltage tests must be made with the tube in the tester socket.

The second important item is the grid bias. Here it is necessary to examine the design of the radio frequency circuit, whether or not the tuning condensers utilize a common rotor shaft. Individual controls for each tuning condenser rotor or isolation of each rotor simplifies matters to a very large extent as shown in figure 67 . Each tube filament produces a voltage drop hence it is possible to secure the required negative or positive bias by connecting to the proper side of the filament circuit. Or if so desired separate resistances may be incorporated into each filament circuit, the voltage drop across this resistance being employed as the grid bias, it being necessary of course, to locate the resistance in the proper leg of the circuit. This arrangement is shown below in figure 67 68 , the grid bias resistances being designated as R1. It is quite obvious that this grid circuit arrangement cannot be employed when the tuning condensers have a common rotor, because such connection would short some of the filaments. To overcome this difficulty the tuning condenser rotors connect to ground and the radio frequency transformer secondaries are connected to the proper biasing terminals. A second fixed condenser is then connected between the radio frequency transformer secondary (filament end) and ground, thus providing a closed oscillatory circuit. This system is shown in several of the series filament receiver wiring diagrams listed in this book.

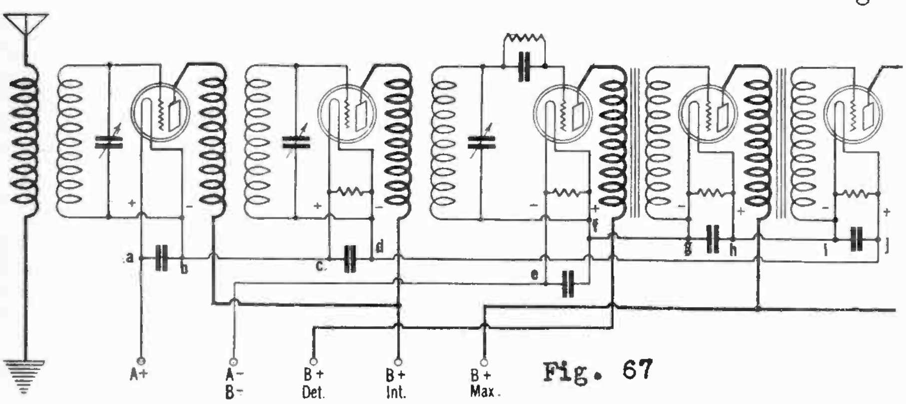
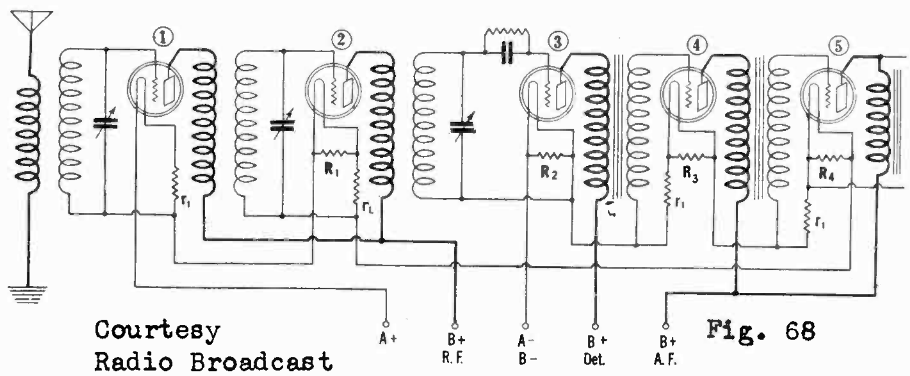


Fig. 67

Courtesy Radio Broadcast.



Courtesy Radio Broadcast

Fig. 68

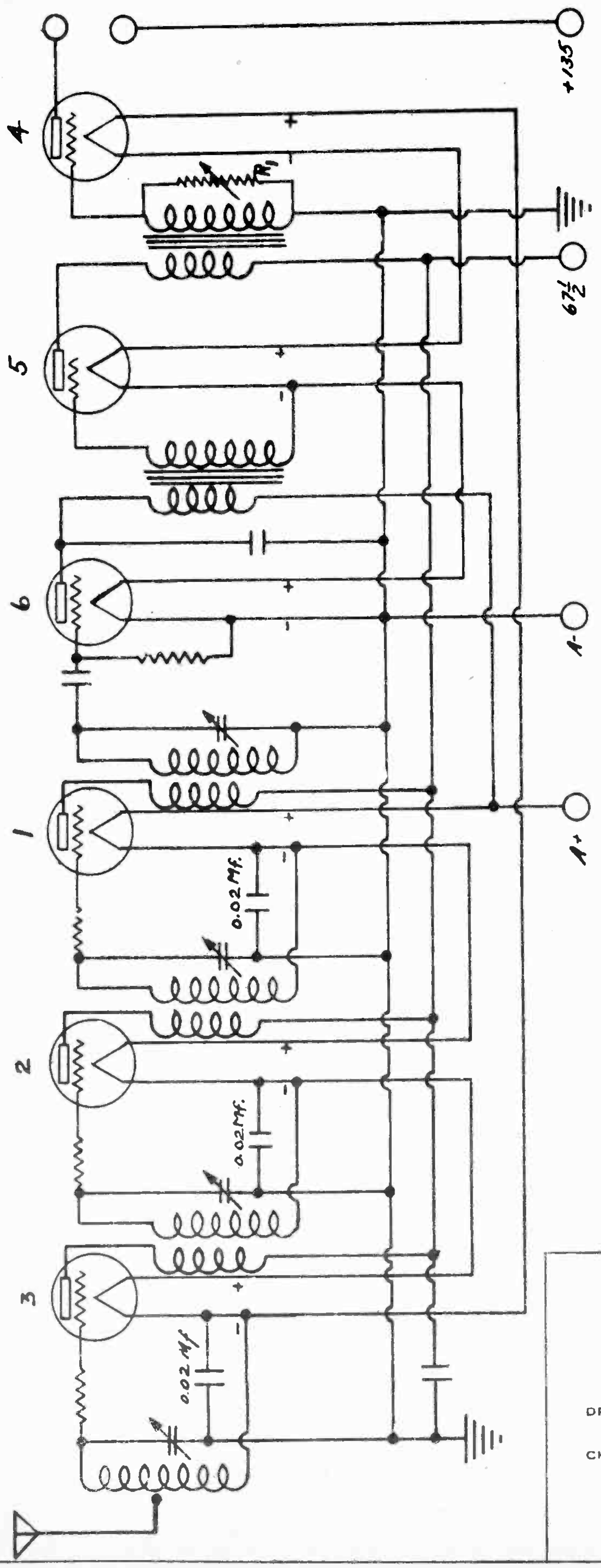
With respect to troubles in series filament receivers, all the items mentioned in connection with the conventional types of receivers are applicable. In addition it is necessary to add open bypass condensers in the filament circuits as possible reasons for excessive regeneration and howling. Open bypass condensers as possible reasons for broad tuning, when the grid bias resistances are in the circuit, and shorted bypass condensers as possible reasons for filament circuit overloading when the bypass condensers are in shunt with the protective resistances.

Overloading of the power supply unit will cause motorboating and fluctuation of filament brilliancy. Incorrect bias adjustments will likewise influence filament briliancy by virtue of the effect upon the plate current and the final effect upon the source of power.

A short circuit in the fixed condenser utilized to close the oscillatory circuit in the tuning system and to eliminate the effect of the filament circuit resistance will impair reception so that signals are not received.

The method of wiring or changing battery operated receivers into series filament receivers operated in conjunction with the Raytheon BA tube is shown in the section devoted to wiring diagrams.

Another few words about motorboating. Increasing the value of the output filter condenser will be found helpful. The use of audio filters in each audio plate lead, between the B+ of the eliminator and the B+ terminals of the plate circuit resistance, choke or transformer primary will be helpful. Such filters consist of a 3 henry choke in series with the B supply lead and a 2 mfd. fixed condenser between the B+ terminal of the audio coupling unit and the B- terminal of the receiver.



ES-54

ATWATER KENT MODEL-33 RADIO RECEIVER CIRCUIT WITH SERIES FILAMENT CONNECTIONS FOR OPERATION WITH RAYTHEON "BA" POWER SUPPLY

Tube #1 - UX 201A
2 - UX 201A
3 - UX 201A
4 - UX 171A
5 - UX 201A
6 - UX 200A

Additional Apparatus:

3 - .02 mfd. condensers

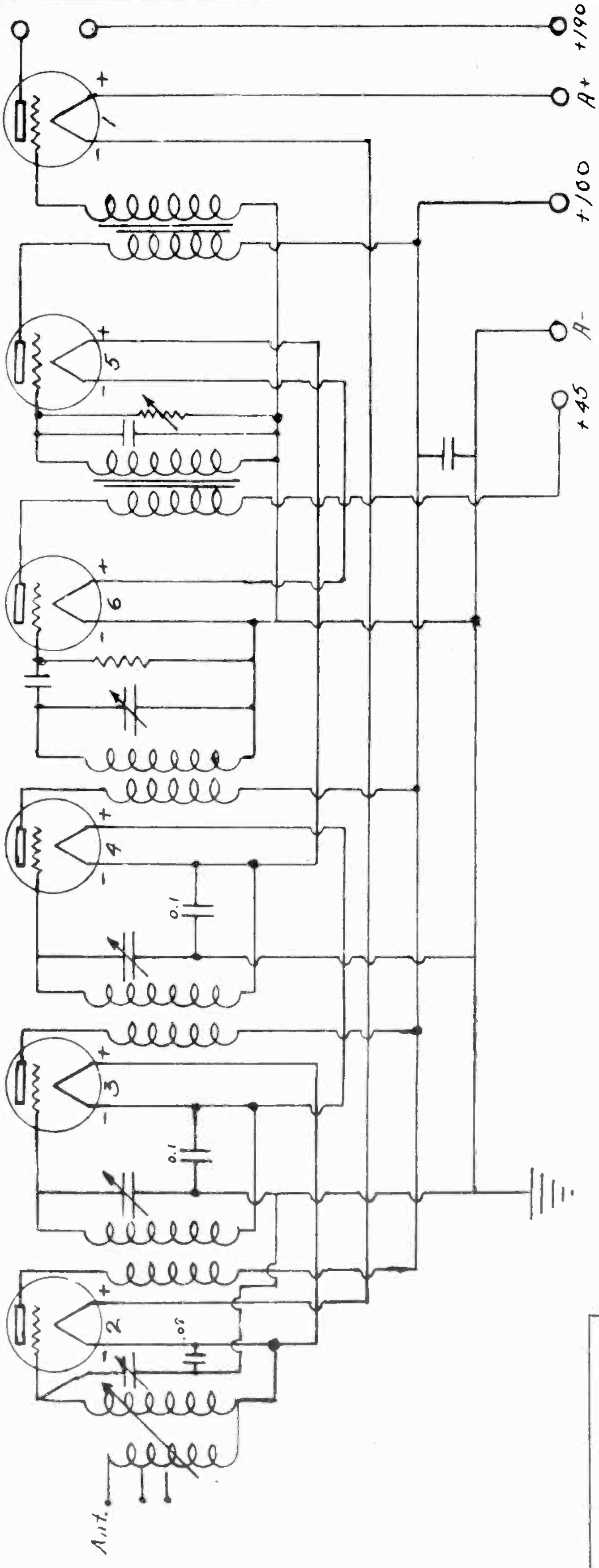
1 - 0-100,000 ohm (R_1)

ATWATER KENT MODEL-33 SERIES FILAMENT RADIO RECEIVER.

DRAWN BY G.R. DATE 11-3-27

CHECKED BY B.J.A. DATE

RAYTHEON MANUFACTURING CO.
CAMBRIDGE, MASS.



ES-62

SPLITDORF SIX TUBE RADIO RECEIVER CIRCUIT SHOWING CONNECTIONS FOR SERIES FILAMENT OPERATION USED IN CONJUNCTION WITH RAYTHEON TYPE "BA" SUGGESTED POWER SUPPLY.

Tube #1 - UX171A
2 - UX-201A
3 - UX-201A
4 - UX-201A
5 - UX-201A
6 - UX-200A

ADDITIONAL EQUIPMENT:

2 .1 mfd condensers

1 .02 mfd condenser

1 0-200,000 ohms variable resistance

The voltages indicated are the potential above ground.

SPLITDORF SIX TUBE RADIO RECEIVER CIRCUIT

DRAWN BY R.F.A. DATE 11-10-27

CHECKED BY B.J.A. DATE

RAYTHEON MANUFACTURING CO.

CAMBRIDGE, MASS.

Continuity Tester

The simplest testing device which finds application in radio service work is the continuity tester employed to determine an open or a short circuit in a coil or winding such as a radio frequency transformer, an audio frequency transformer, a filter choke, etc., and a short circuit due to puncture or some other cause in condensers of various types.

The construction of such devices is very simple. One type utilizes a battery and a high resistance voltmeter connected in series as shown below in figure 69

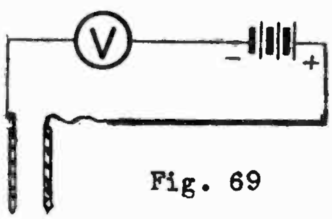


Fig. 69

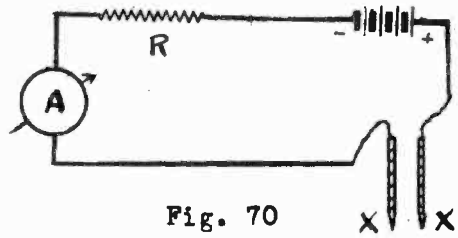


Fig. 70

and another type utilizes a low range milliammeter, a battery and a resistance connected in series fashion as shown above in figure 70.

The first type is a general utility instrument where it is necessary to decide whether a unit is open or shorted. The arrangement when applied to a device such as a transformer winding affords an idea of the presence of an appreciable amount of resistance in the circuit. The second arrangement, however, is of greater utility because it is possible, within a certain ohmic range, to determine the approximate DC resistance of the unit being tested. In this manner, it is possible, providing that the D.C. resistance of the unit is known, to determine the presence of a partial short circuit.

Therefore, the second arrangement is preferred for all types of continuity testing. The current indicating instrument designated as A is 0 to 1 Weston D.C. milliammeter. The resistance R is a 22,500 ohm accurately calibrated fixed resistance. The battery is a 22.5 volt Block. In view of the fact that an approximate value of the resistance being measured is satisfactory and because the maximum current drain in this circuit is 1 milliampere, the gradual deterioration of the battery is of little consequence. The drain is small and a long period will elapse before the battery voltage decreases to a value where it upsets the readings.

With respect to utility, we need not stress the fact that the unit to be tested or the circuit to be tested is connected across the test prong terminals X and X1. However, it is important to bear in mind the type of unit being tested. With the resistance and battery voltage values mentioned, it stands to reason that a short across X and X1 will cause the maximum current reading upon the meter A, that is, .001 ampere or 1 milliampere. The introduction of an appreciable amount of resistance across or between the terminals X and X1 will reduce the deflection upon A, hence any unit with an appreciable amount of resistance such as a fixed resistor of 500, 1000 or 5000 ohms, will show a current deflection less than the maximum. The same is true if the unit to be tested is a coil with a large number of turns such as a filter choke or a transformer primary or secondary. If these units are shorted and the winding is connected across X and X1, the equivalent effect upon the continuity tester circuit will be a direct short and the maximum reading will be observed. If, however, the unit does possess an appreciable amount of resistance, it is possible to determine the value of this resistance by means of the following. Let us assume that the two test prongs have been connected across a resistance in the plate circuit of a tube. The meter indicates a current flow of .1 milliampere or .0001 ampere. What is the resistance of the unit being tested? According to Ohm's law, the total resistance in the circuit is

$R = E \div I$ and substituting we have

$R = 22.5 \div .0001 = 225{,}000$ ohms.

From this we subtract the original resistance of 22,500 ohms and the resistance of the unknown is therefore 202,500 ohms. Let us take another example which will illustrate a lower value of resistance. We are testing a resistance utilized in a B eliminator and rated at 6,500 ohms. The set tester is applied and the current flow indicated upon the meter is .95 milliampere. What is the resistance of the unknown? Proceeding as we did above, we have

$R = 22.5 \div .95$

$R = 23{,}684$

From this we subtract the original resistance and find that the unknown is 1,184 ohms instead of supposed 6,500 ohms. The above should suffice to illustrate the utility of the tester. As a matter of fact the circuit combination shown may be used to measure resistances as high as 4 megohms. With respect to continuity, it is understood that lack of indication when the test prongs are connected across a winding, signifies an open circuit in the winding. The use of the low resistance meter and the low current range meter affords a means of testing high resistances.

Testing condensers is somewhat different than testing coil windings. The result should be the contrary. The condenser when perfect should show an open, that is no reading upon the meter, but sign of perfection is an initial "kick" of the meter needle when the tester is first applied, after which action the meter needle again returns to the zero position. An indication of an appreciable current flow through all condensers with the exception of the electrolytic wet condenser and the dry A condenser signifies a defective condenser.

The above data applied to the specific application of the continuity tester. However, its utility is not limited to these items. As a matter of fact, it may be used wherever mention of a continuity tester is made in the servicing information discussed in subsequent chapters.

Neutralizing is an important operation and to do a good job, it is necessary that it be carried out in a methodical manner. The first important item is the "dummy" or "balancing" tube which is necessary for neutralizing. In view of the fact that three types of tubes, the 201A, the 226 and the 227 are utilized in radio frequency systems, it is necessary to have a dummy tube of each of these types. The balancing tube is normal in every respect, with the grid, filament and plate elements intact and in correct position. In order to be certain that the space between the tube electrodes is normal, it is necessary to employ a new tube, of each type which has been tested in a radio receiver and found perfect in every respect.

Only one change is made upon these balancing tubes. One of the filament prongs is cut off at the base and the filament wire re-soldered. This is done in order that the filament should remain unlighted when the tube is placed into the receiver socket and the filament wire should be intact as a tube element.

Re-neutralization or balancing of a receiver requires a source of modulated

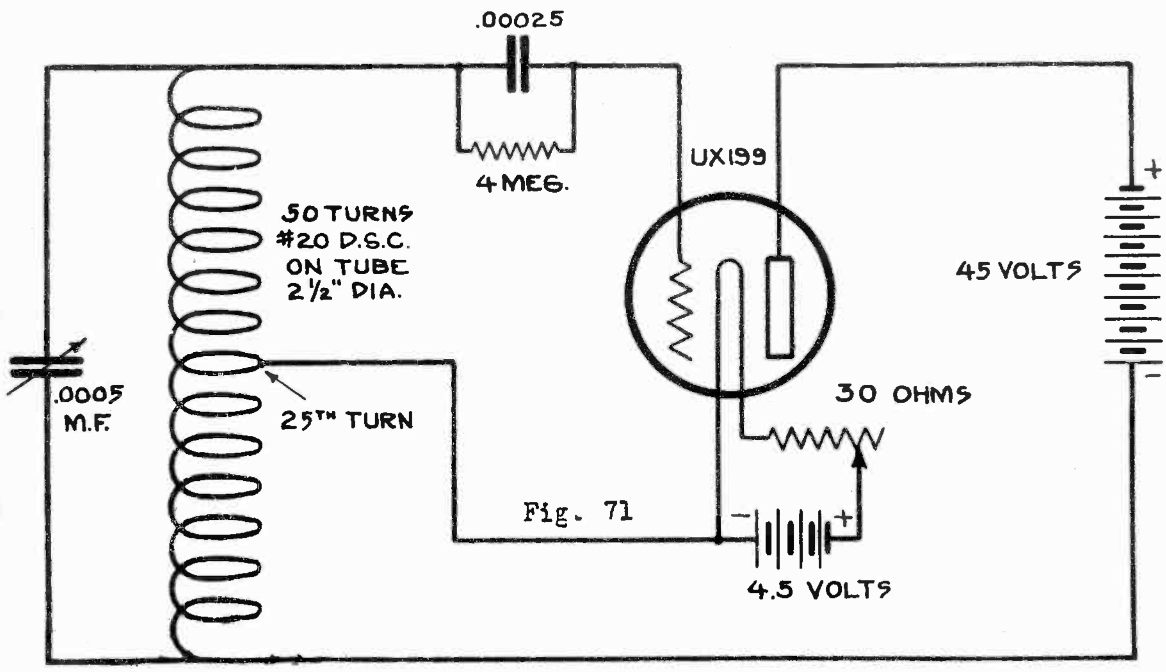


Fig. 71

Modulated Oscillator Recommended in RCA Service Sheets

radio frequency. Regular broadcasting is satisfactory for this purpose but better results are secured when the intensity of the carrier is constant and when the tone of the signal or the modulation is likewise constant at one frequency. Hence we show the wiring diagram of the oscillator recommended by the Radio Corp. of Amer. for use when neutralizing and balancing receivers. In view of the fact that the electrical constants of the various units constituting the modulated oscillator are shown in the diagram, it is unnecessary to repeat. With respect to operation, the .0005 variable condenser controls the wavelength or frequency of the generated radio frequency wave and grid leak-grid condenser combination modulates the output. Various values for the grid leak afford various modulating frequencies.

Relative to the actual balancing, the balancing tube used in the work is governed by the types of tubes employed in the receiver radio frequency system. If the radio frequency amplifier employs 227 type tubes, the balancing tube should be the 227. If the receiver employs 226 type tubes, the 226 balancing tube is used,etc.

The process of balancing and neutralizing is practically identical. Proceed as follows:

1. Set the receiver into operation with normal ground and aerial.
2. Place oscillator about two feet distant from receiver. Adjust oscillator to about 300 meters.
3. Start oscillator and tune receiver to resonance with oscillator. The oscillator and receiver adjustments should be off local operating wavelengths.
4. Remove first radio frequency tube from receiver socket and place similar type balancing tube in that socket.
5. Note if any signal is heard. In order that best adjustment be available, volume control should be on full. If no signal is audible, that stage is neutralized. If however signal of decreased volume is heard, neutralization of that stage by means of adjustment of the neutralizing condenser is necessary.
6. The process of adjustment is critical and requires extreme care.
7. The adjustment of the neutralizing condenser is satisfactory when the signal is the absolute minimum or when no signal is heard.
8. When the first stage is properly neutralized, the balancing tube is withdrawn, the regular tube inserted and the process repeated with the other radio frequency stages.

Balancing the radio receiver is carried out along the lines mentioned above with the exception that the trimmer condensers are adjusted for each stage with the regular tube in the socket and it is unnecessary to use the dummy tube. It should be understood that reference to balancing does not mean neutralization, instead we refer to the alignment of the tuning condensers.

When neutralizing and balancing the receiver, it is best to do both on more than one wavelength. For example, on 230, 350 and 500 meters, making tests after the completion of the operation at each wavelength.

Adjustment of the trimmer condensers produces a result different from that found when the neutralizing condenser is adjusted. The trimmer condenser is varied until the signal output is maximum and in order to enable most accurate adjustment it is best to make use of some indicating system rather than to judge output by aural observation.

An output indicating system finds application for all sorts of work wherein it is necessary to compare output signal intensity, determine condition of balancing, efficacy of tubes, types of amplifiers, types of coupling units, etc. The systems we show on the following page are suitable for this sort of work. As is evident, one unit makes use of the rectifying action of a crystal and the other makes use of the rectifying action of a three element vacuum tube. The DC milliammeter in the tube circuit measures the rectified current, the greater the indication, the greater the AC signal applied across the input of the indicating system. The filament rheostat is used to adjust the meter deflection so as to permit operation within the meter range.

The variable resistance connected across the input enables adjustment of the input signal and provides a control against overload. The second system makes use of a transformer connected when so desired to the output of the receiver, a crystal and a low range DC milliammeter. The last two units are connected in series across the output winding of the transformer. The crystal, preferably of carborundum rectifies the signal in the transformer secondary circuit so that the current flow through the meter MA is uni-directional and consequently will produce a deflection upon the meter. The milliammeter has a range of from 0 to 5 milliamperes D.C. Its range may be increased in the event that the signal deflection extends beyond the scale by shunting the meter with a 500 ohm variable resistance.

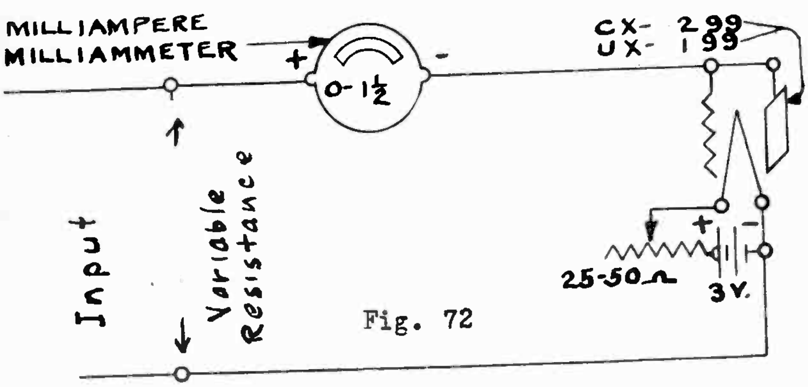


Fig. 72

A system of determining relative degrees of efficiency of the entire system preceding the audio amplifier is shown below in figure 74. This unit is designed for use in superheterodyne receivers, but is applicable under definite conditions; first in home built receivers and second, when the peak frequency of the intermediate frequency amplifier is the same as the peak frequency of the intermediate frequency transformer used in the indicating system.

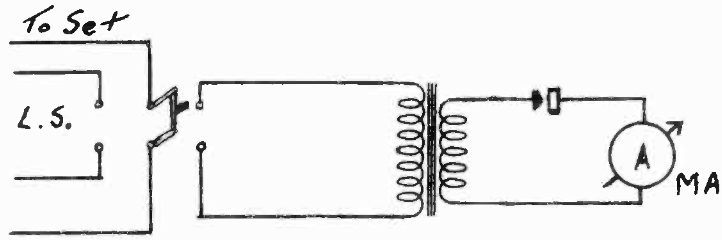


Fig. 73

The rectifier tube burns at subnormal brilliancy, and may be a 199 or a 201A. The plate voltage is secured by connecting the plate return to the positive leg of the filament supply. The voltage applied to the rectifier or indicating tube is the voltage induced in the secondary of the designated intermediate frequency transformer because of the radio frequency component in the plate circuit of the detector (2 nd) which passes through the primary of the intermediate frequency transformer. The greater the defelcetion upon the 0 -1 D.C. milliammeter marked G, the greater the input to the second detector. If the unit is to be employed with various superheterodyne receivers, it is necessary to arrange for a variable peak in the intermediate frequency transformer used in the indicating system.

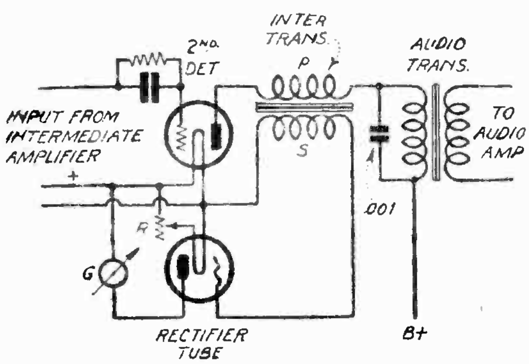
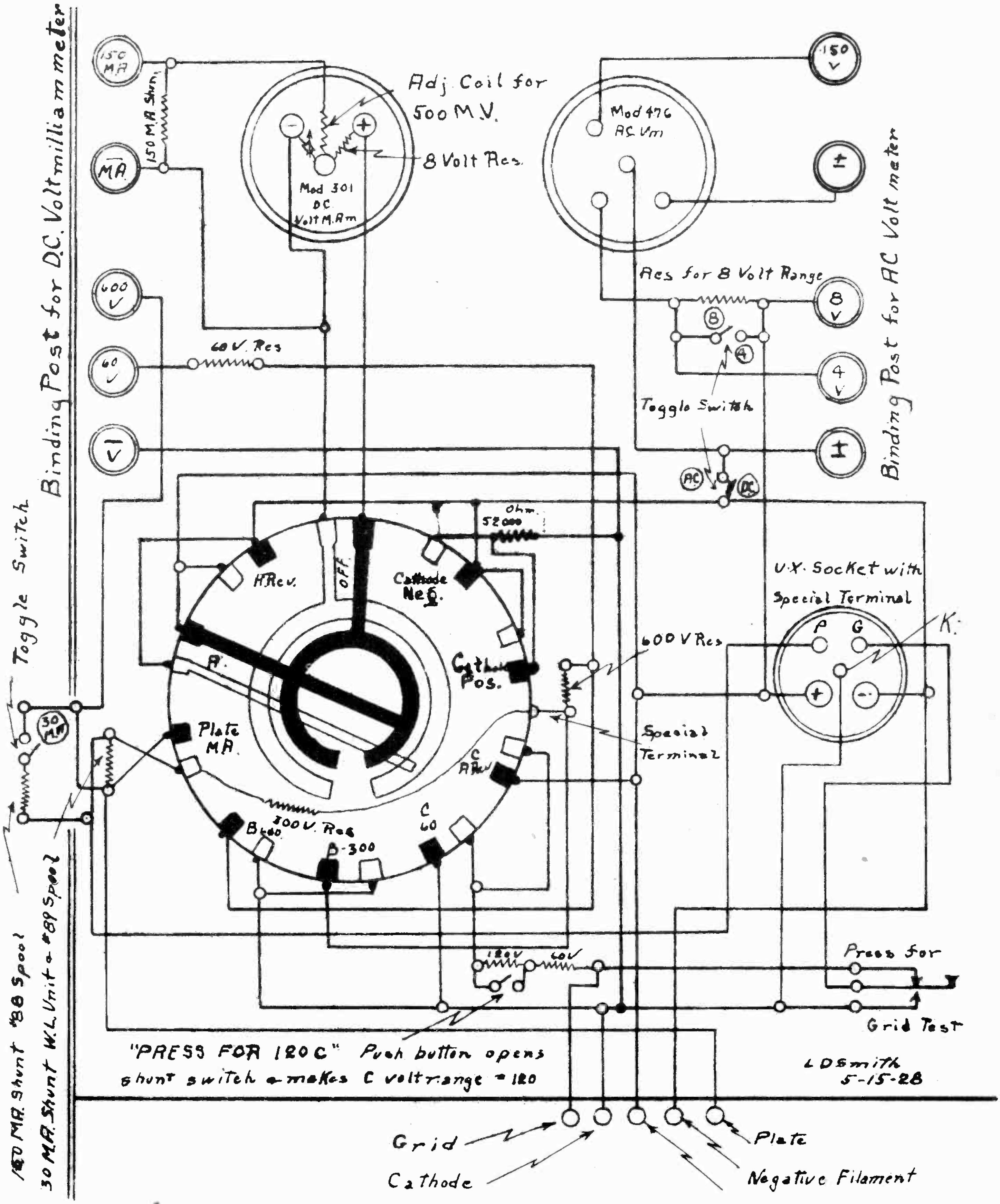
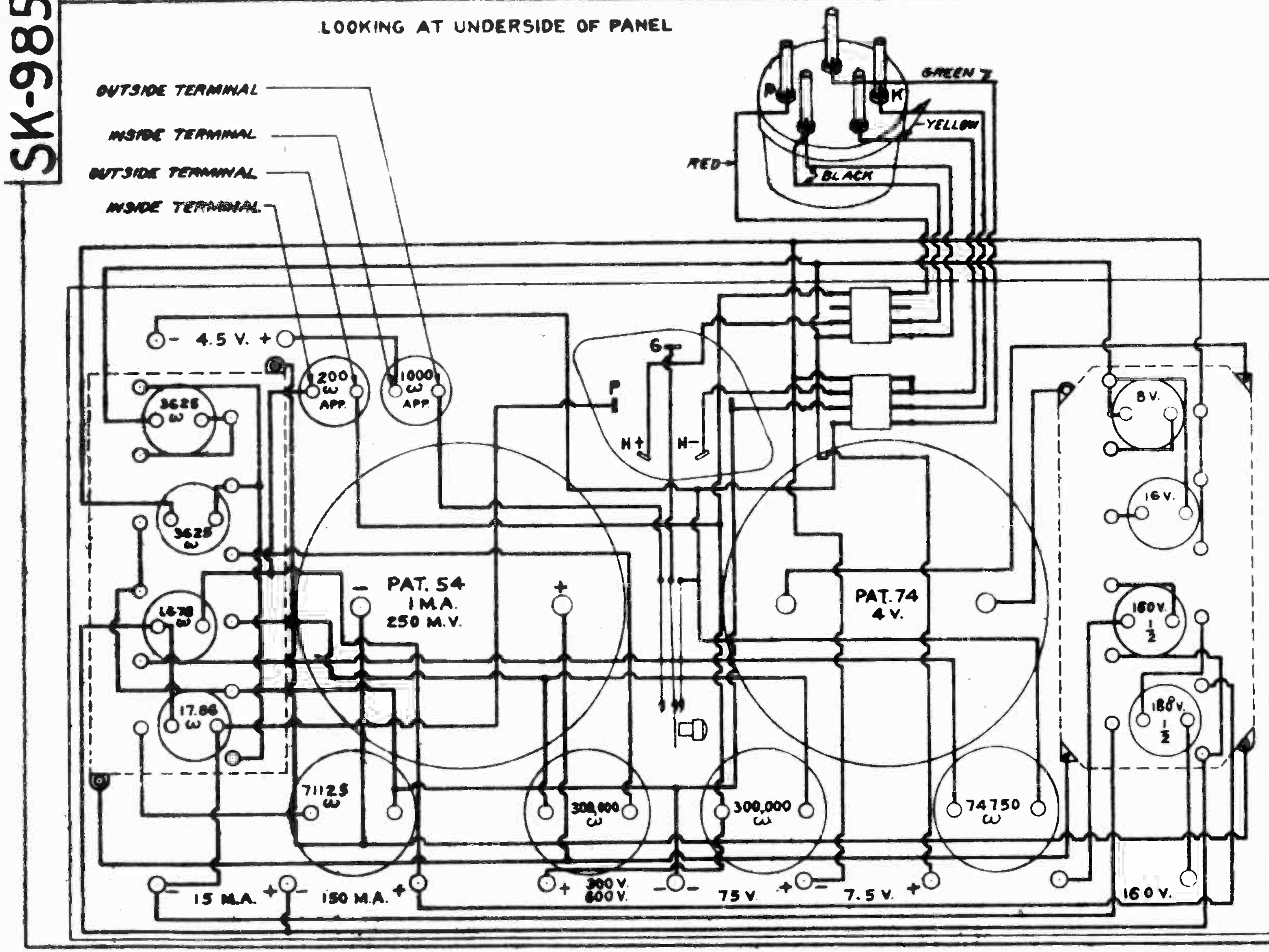


Fig. 74



Wiring Diagram of Weston 537 AC-DC Receiver Tester

SK-985



REQ.	NAME OF PART	NO.

SK-985

JEWELL ELECTRICAL INSTRUMENT CO

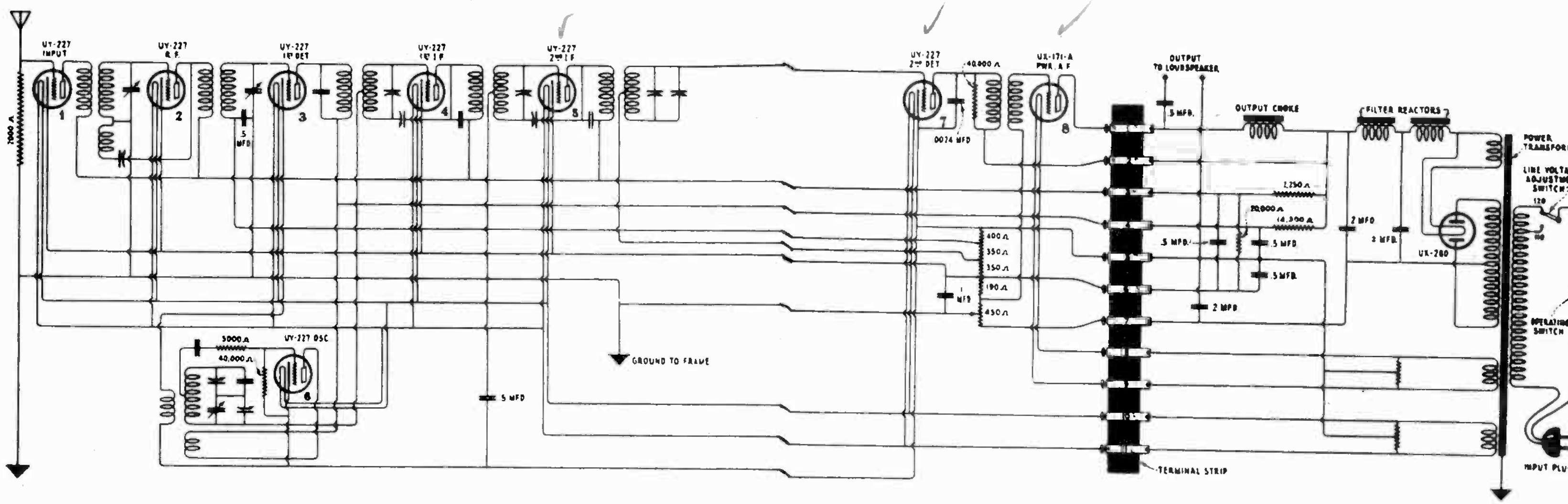
WIRING DIAGRAM

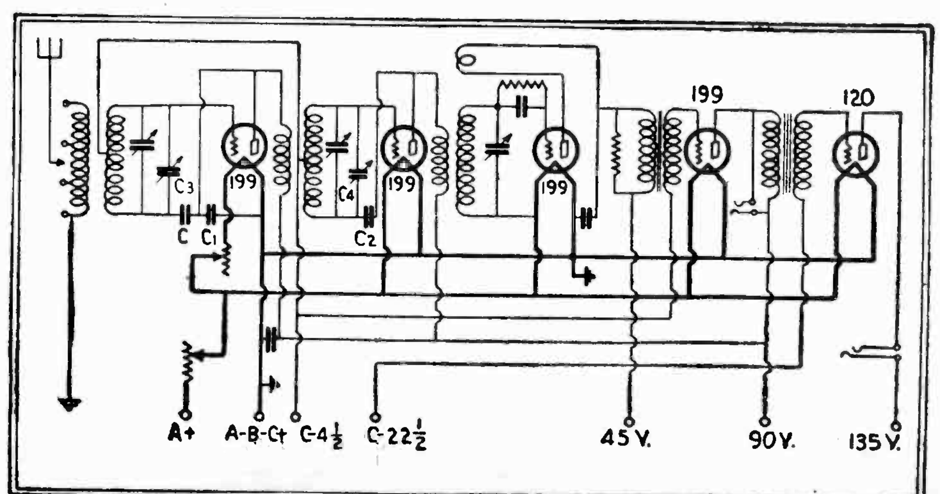
DRAWN		TRACED	
W.T.	4-11-28	W.T.	4-17-28
CHECKED		APPROVED	

ISSUE-1	4-17-28	DATE
OUTSIDE & INSIDE TERMINAL WAS NOT SPEC. FOR 200 ω & 1000 ω COIL. W.R. 5-2-28 ISS 2		

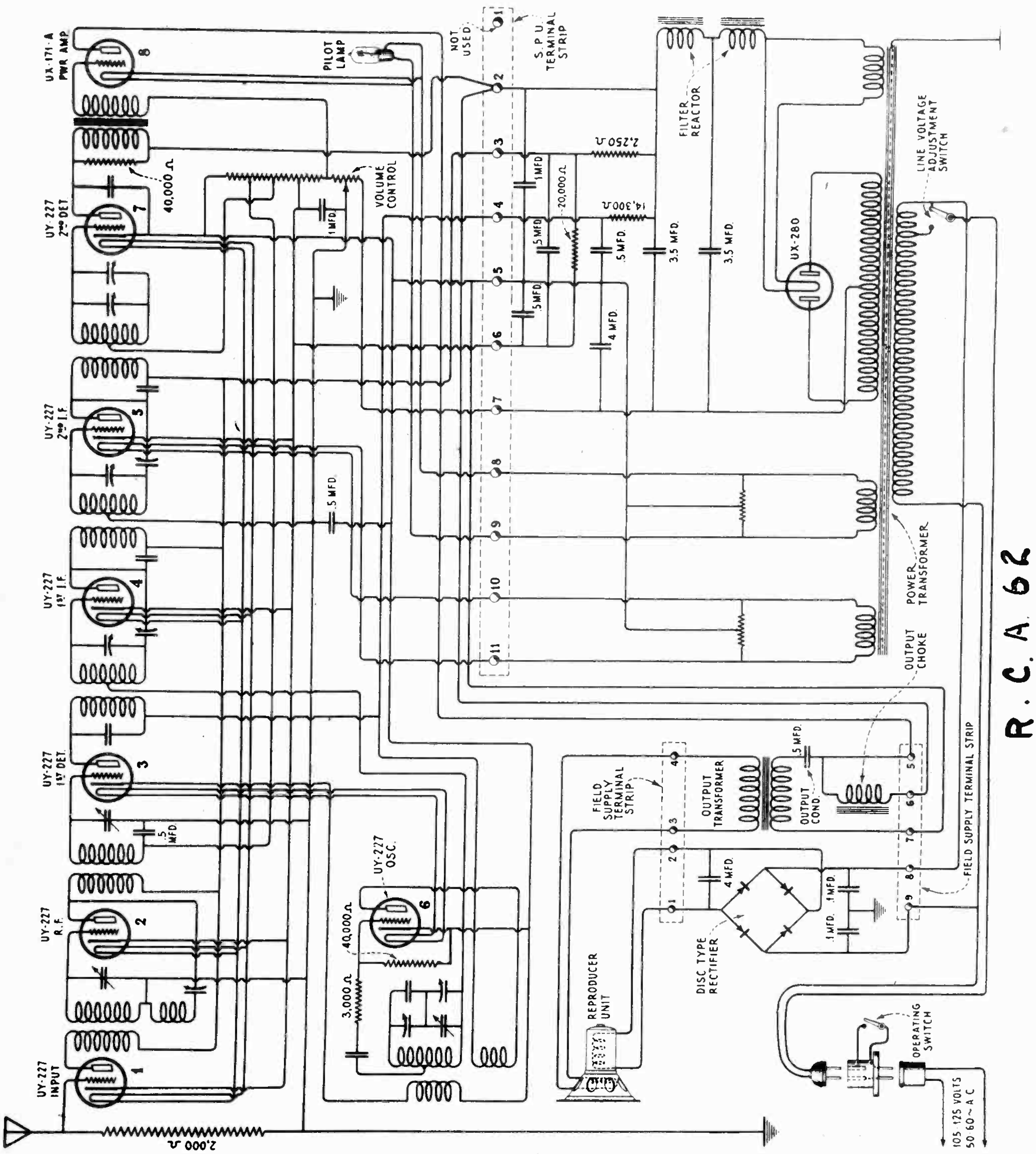
PAT. 199			
USED ON			DWG
MATERIAL			
SIZE	KIND	SHAPE	TEMPER

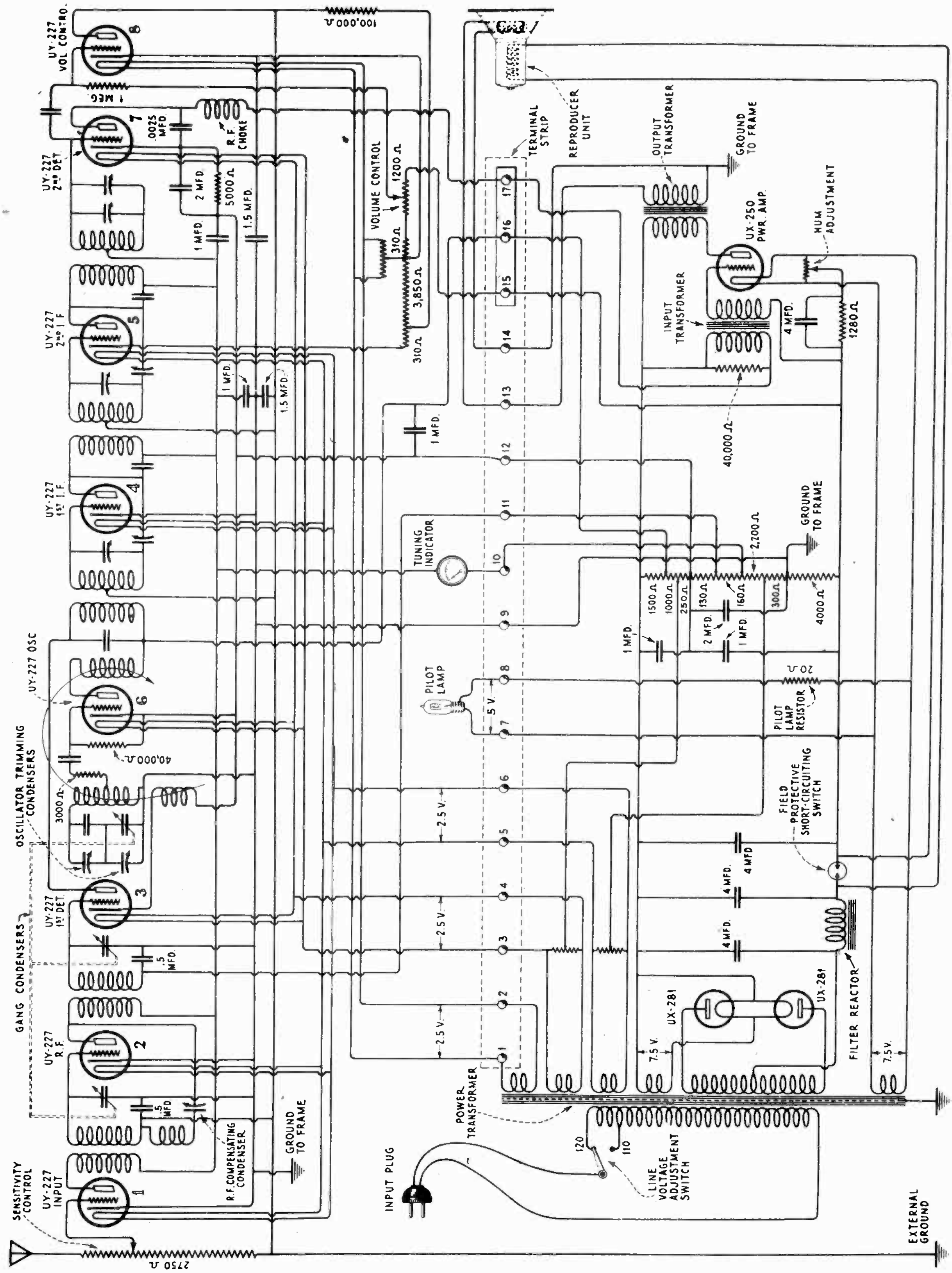
Radiola 60



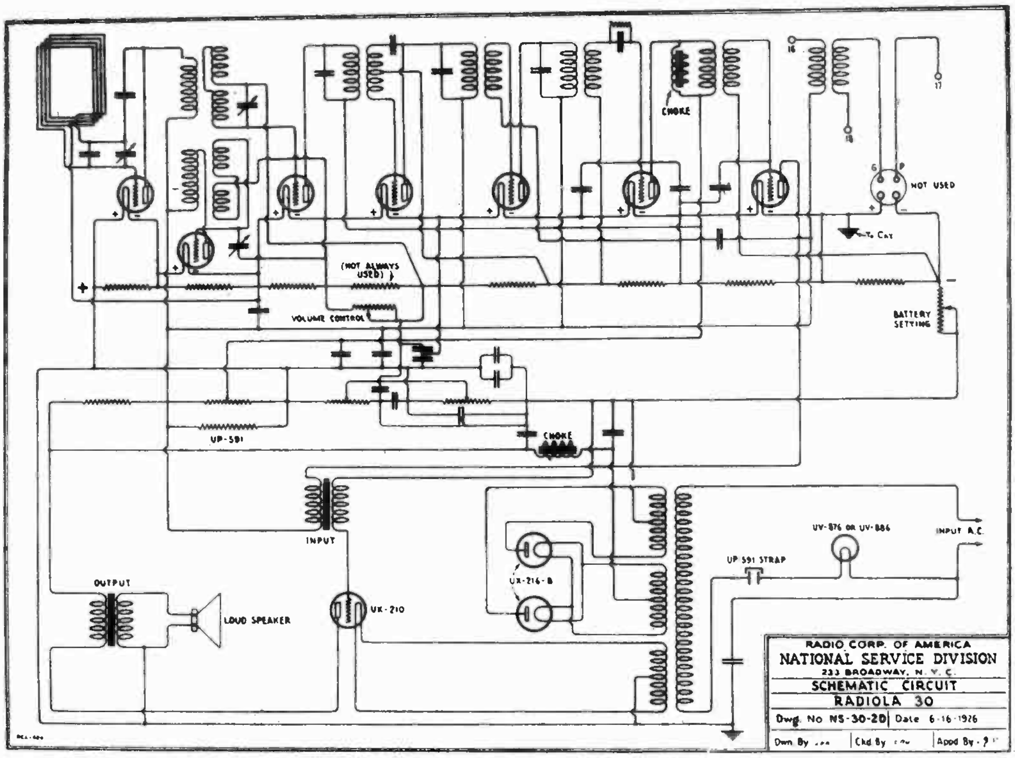


Circuit diagram of the popular "Radiola 20" five-tube receiver. Two stages of balanced radio frequency, with a regenerative detector, provide unusual sensitivity.

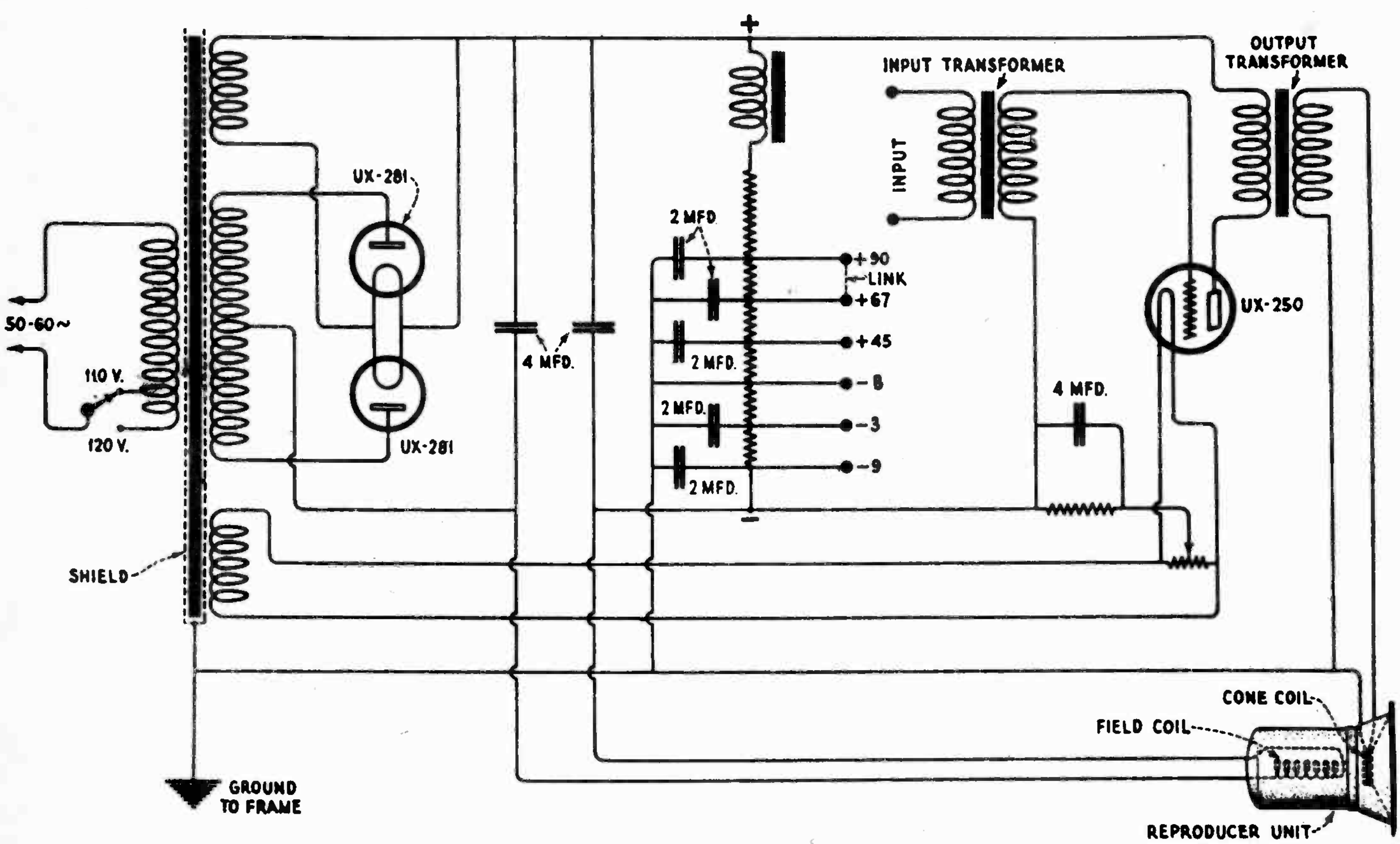

UX-171-A PWR AMP
8
UY-227 2ND DET
7
40,000 Ω
UY-227 2ND I.F.
5
UY-227 1ST I.F.
4
UY-227 1ST DET.
3
.5 MFD
UY-227 R.F.
2
UY-227 INPUT
1
2,000 Ω
UY-227 OSC.
6
40,000 Ω
3,000 Ω
PILOT LAMP
VOLUME CONTROL
1 MFD
NOT USED
S.P.U. TERMINAL STRIP
2,250 Ω
1 MFD
20,000 Ω
14,300 Ω
.5 MFD
.5 MFD
.5 MFD
4 MFD
3.5 MFD
3.5 MFD
FILTER REACTOR
UX-280
LINE VOLTAGE ADJUSTMENT SWITCH
POWER TRANSFORMER
OUTPUT CHOKE
FIELD SUPPLY TERMINAL STRIP
OUTPUT TRANSFORMER
OUTPUT COND.
4 MFD
.1 MFD
.1 MFD
DISC TYPE RECTIFIER
REPRODUCER UNIT
OPERATING SWITCH
105-125 VOLTS 50-60 ~ A C
R.C.A. 62


UY-227 INPUT
SENSITIVITY CONTROL
2750 Ω
UY-227 R.F.
GANG CONDENSERS
R.F. COMPENSATING CONDENSER
GROUND TO FRAME
UY-227 1ST DET.
OSCILLATOR TRIMMING CONDENSERS
UY-227 OSC
3000 Ω
40,000 Ω
UY-227 1ST I.F.
UY-227 2ND I.F.
UY-227 2ND DET.
.0025 MFD
R.F. CHOKE
2 MFD
5000 Ω
1 MFD.
1.5 MFD.
1 MEG.
UY-227 VOL CONTROL
100,000 Ω
VOLUME CONTROL
1200 Ω
310 Ω
3,850 Ω
TUNING INDICATOR
PILOT LAMP
5 V
2.5 V.
TERMINAL STRIP
REPRODUCER UNIT
OUTPUT TRANSFORMER
GROUND TO FRAME
UX-250 PWR. AMP.
HUM ADJUSTMENT
INPUT TRANSFORMER
4 MFD.
1280 Ω
40,000 Ω
2,200 Ω
1500 Ω
1000 Ω
250 Ω
130 Ω
160 Ω
300 Ω
4000 Ω
20 Ω
PILOT LAMP RESISTOR
FIELD PROTECTIVE SHORT-CIRCUITING SWITCH
UX-281
FILTER REACTOR
7.5 V.
POWER TRANSFORMER
INPUT PLUG
120
110
LINE VOLTAGE ADJUSTMENT SWITCH
EXTERNAL GROUND

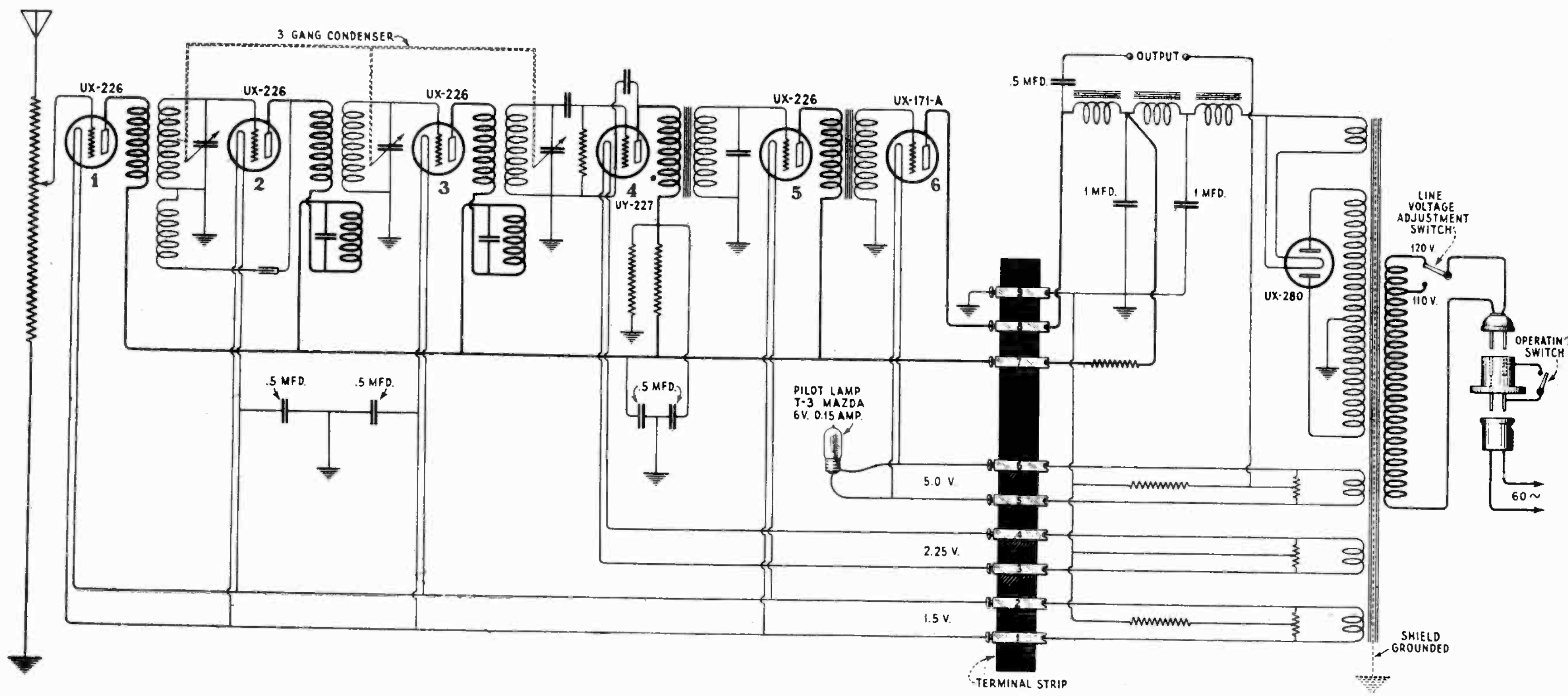
R. C. A. 64



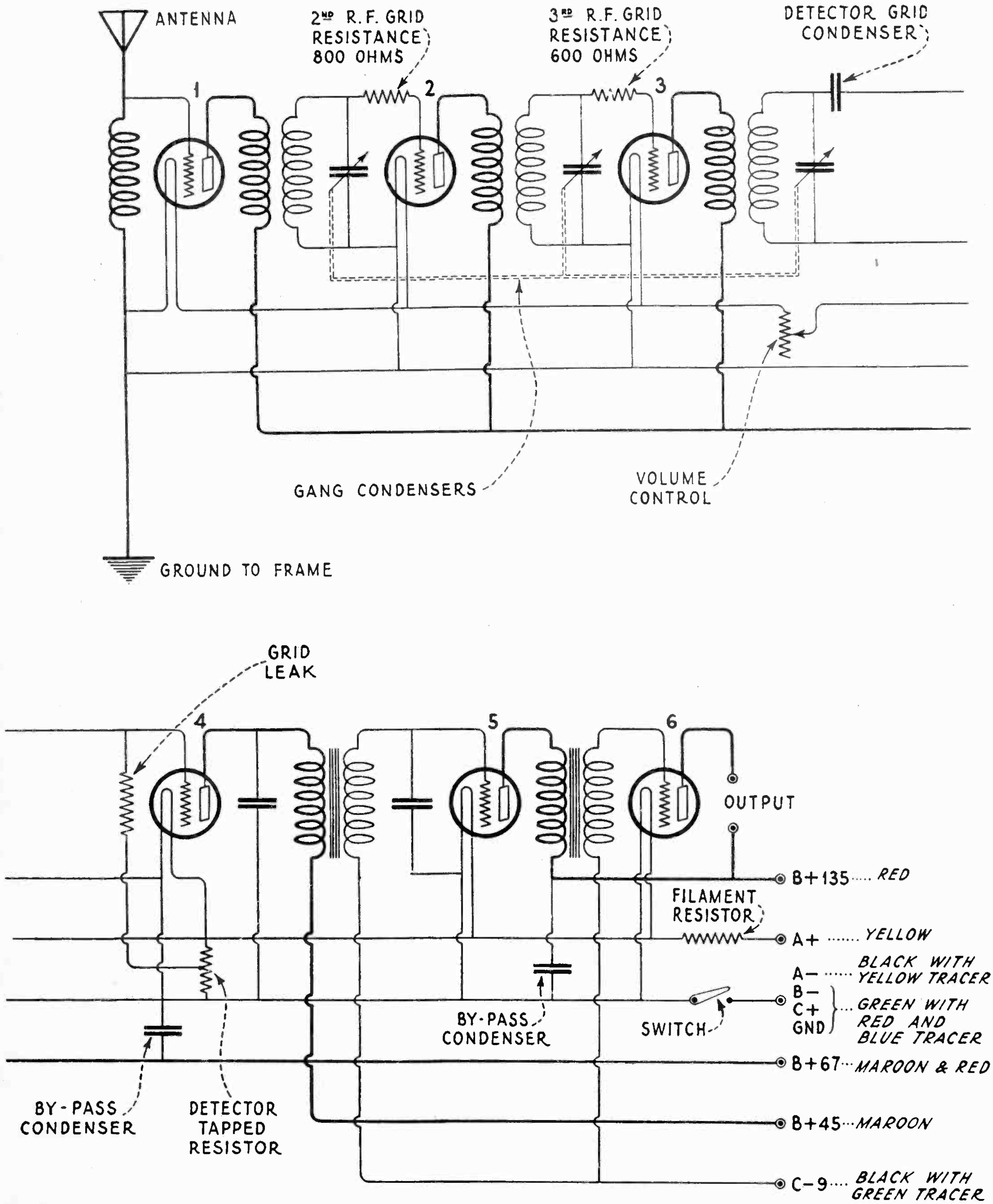
—*Schematic circuit diagram of Radiola* 30



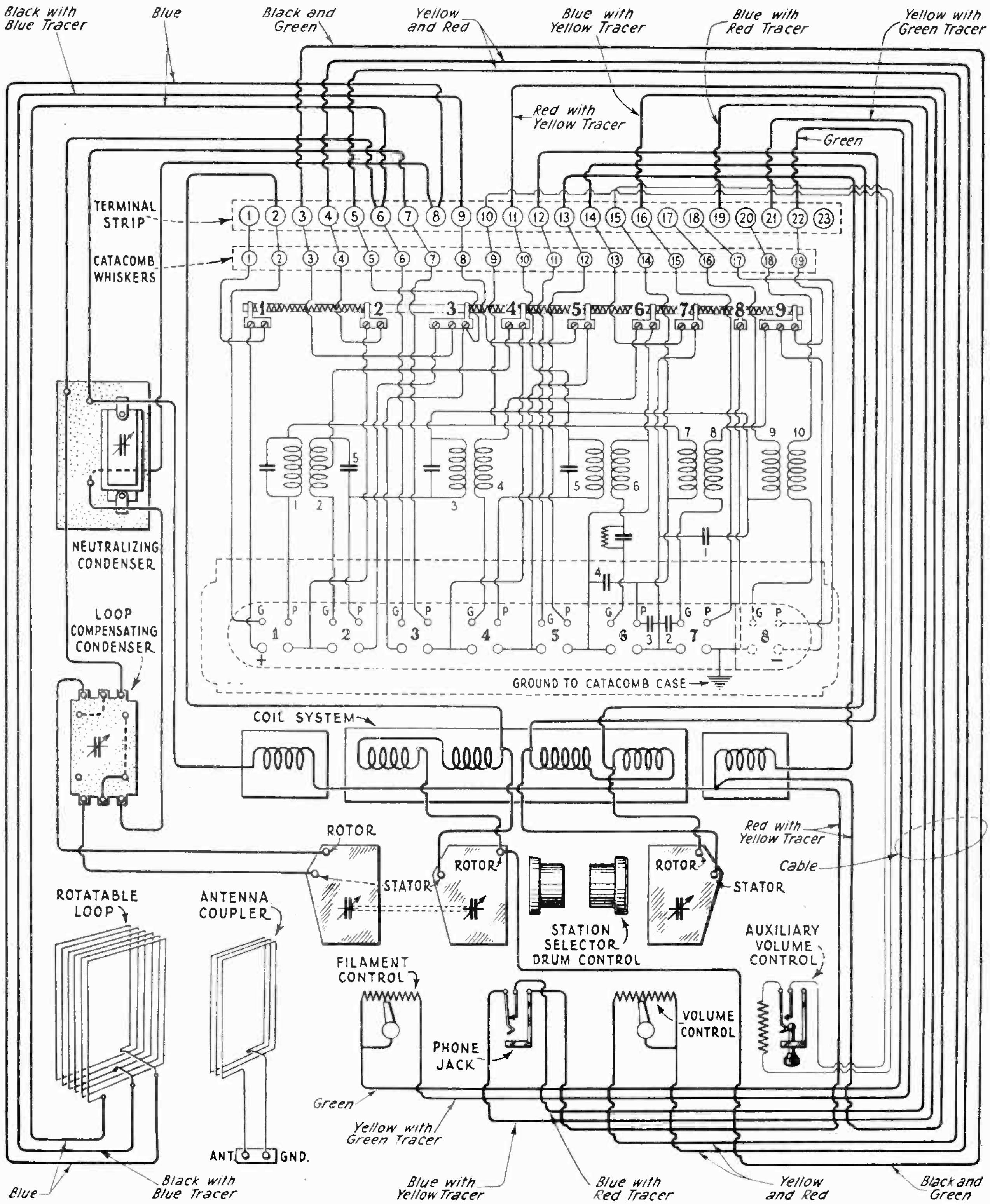
R.C.A. 105



-Schematic circuit diagram of the receiver and socket power unit of Radiola 51

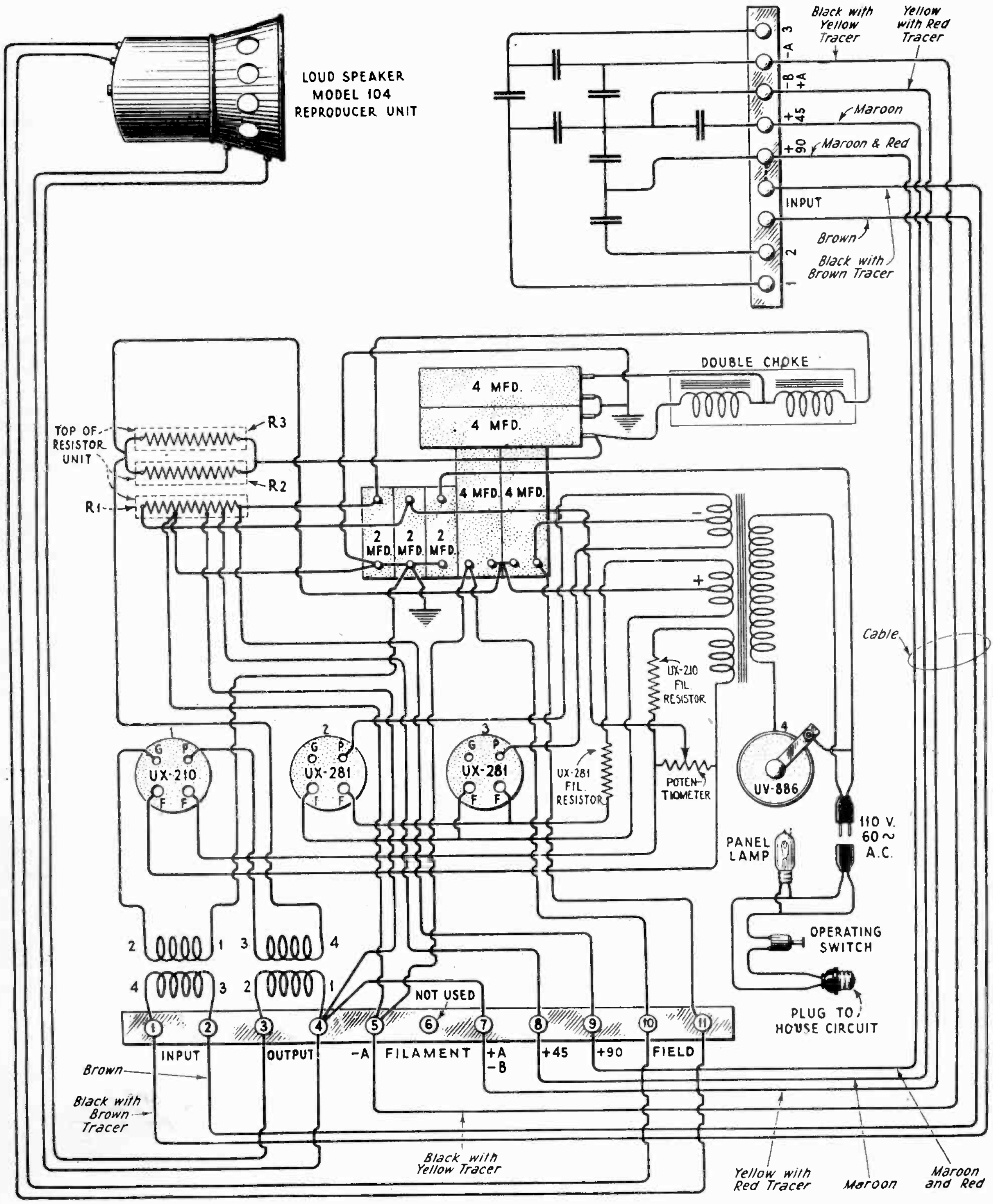


—*Schematic circuit diagram of RCA Radiola 16*



—Panel and loop assembly continuity wiring diagram

Radiola 32



—Rectifier power amplifier and reproducer unit continuity wiring diagram

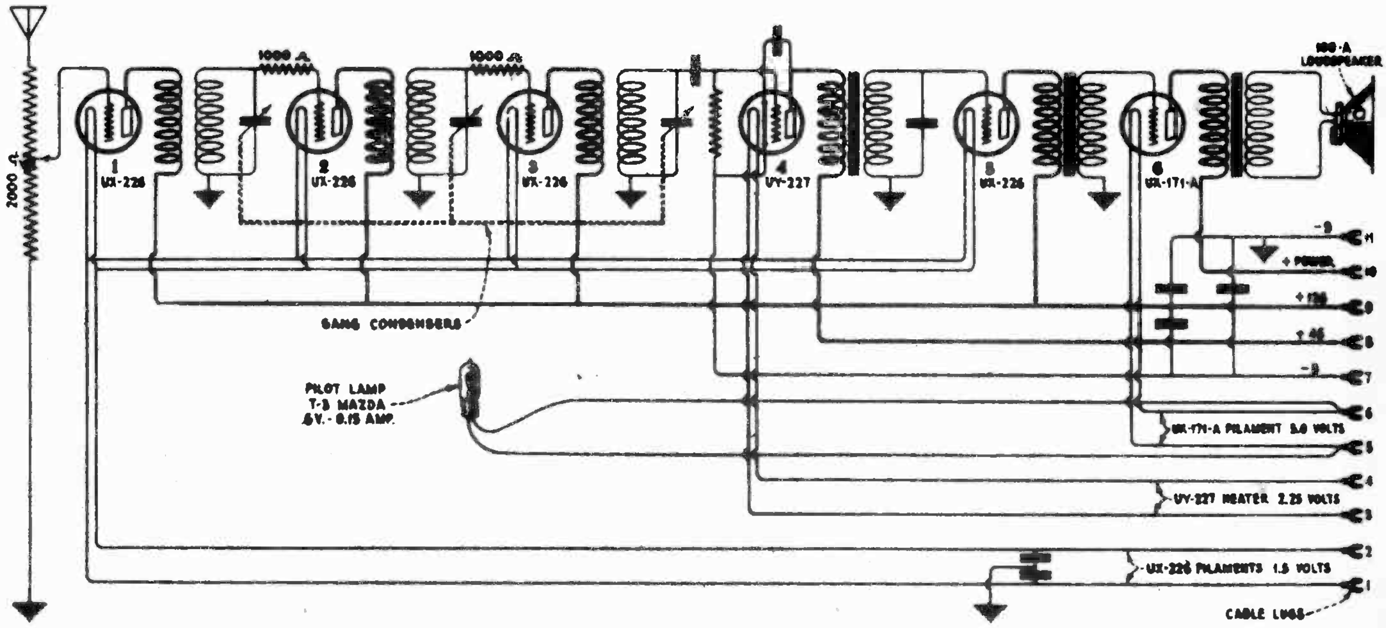
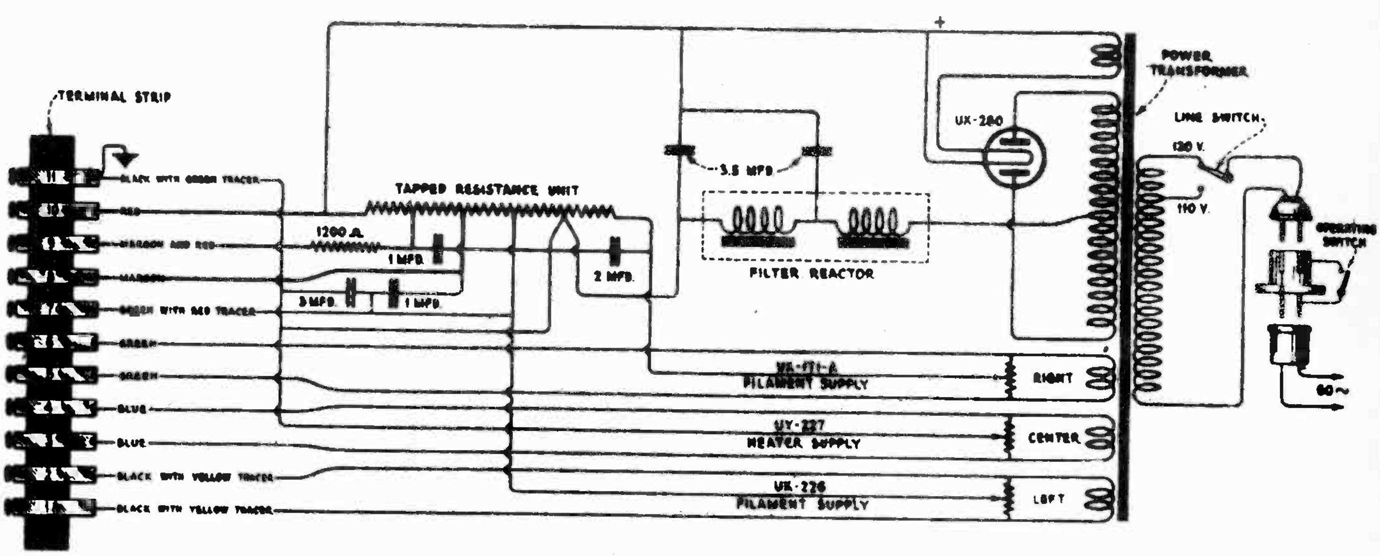
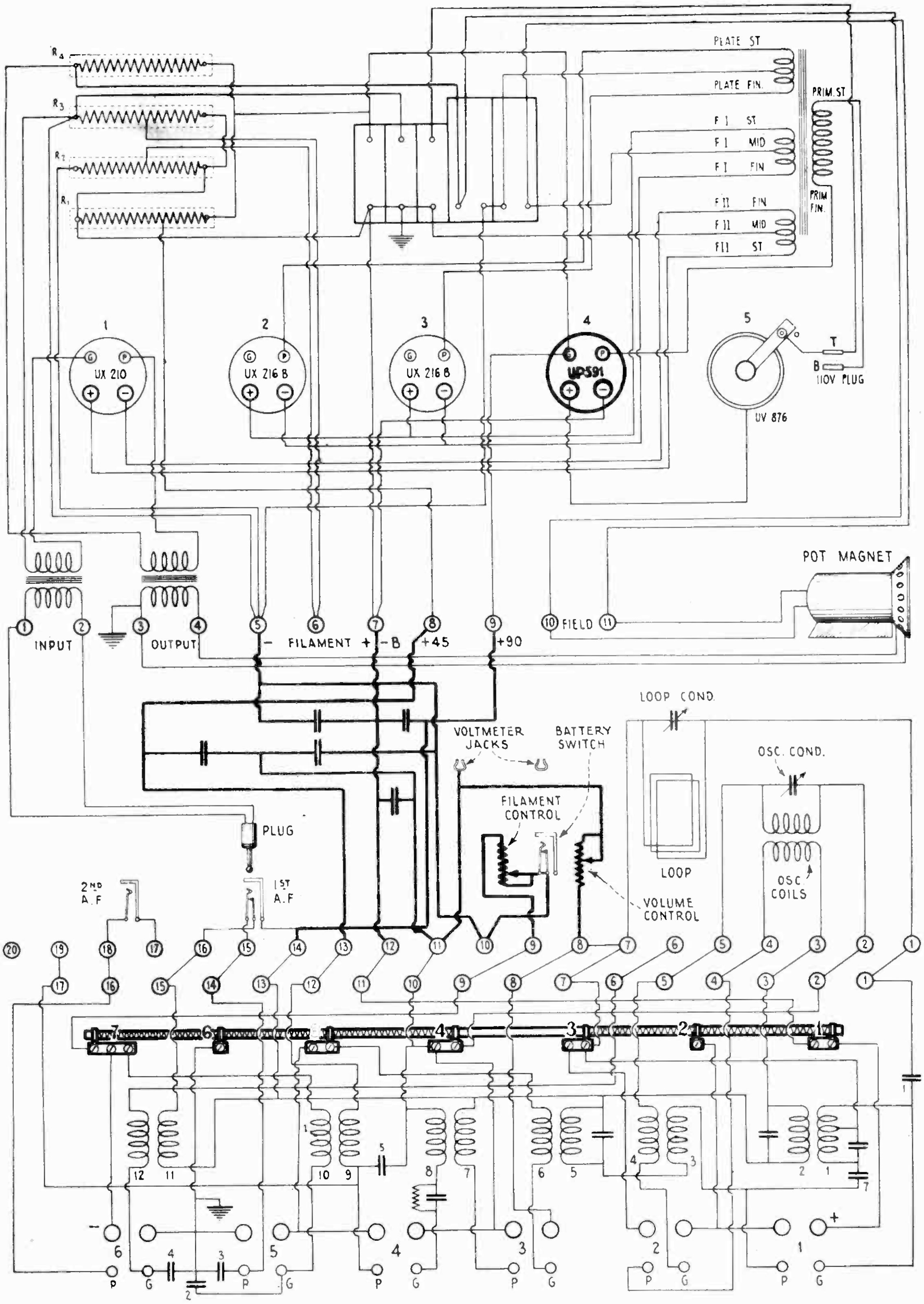


Figure 4—Schematic circuit diagram of the receiver assembly of RCA Radiola 50

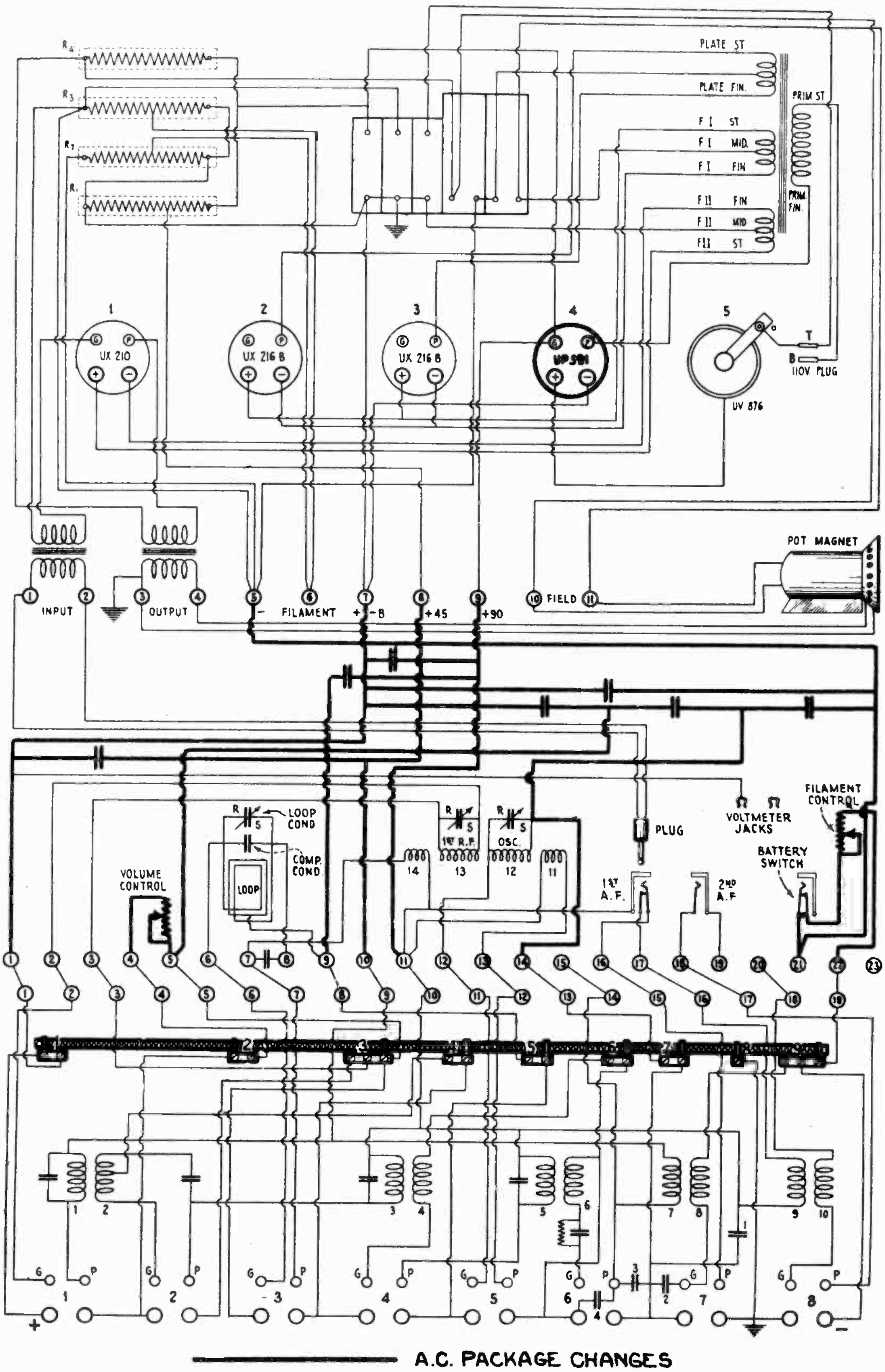


—Schematic circuit diagram of the Socket Power Unit of RCA Radiola 50

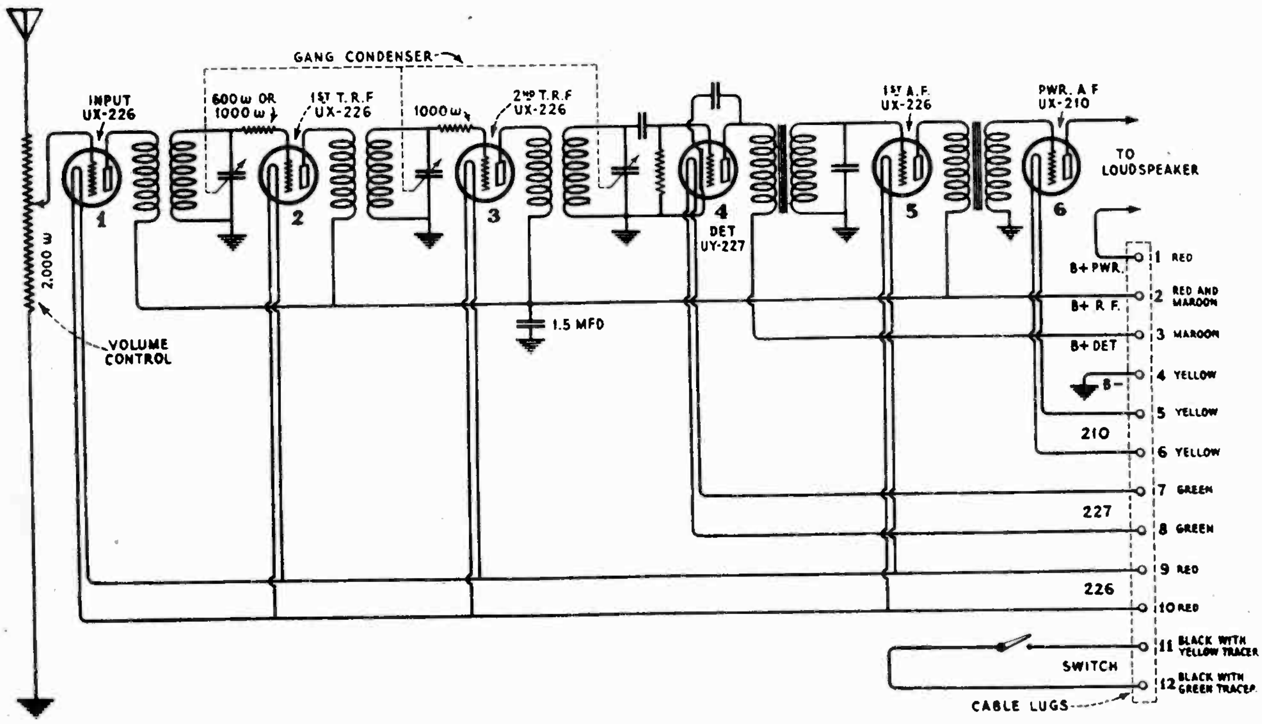


A.C. PACKAGE CHANGES

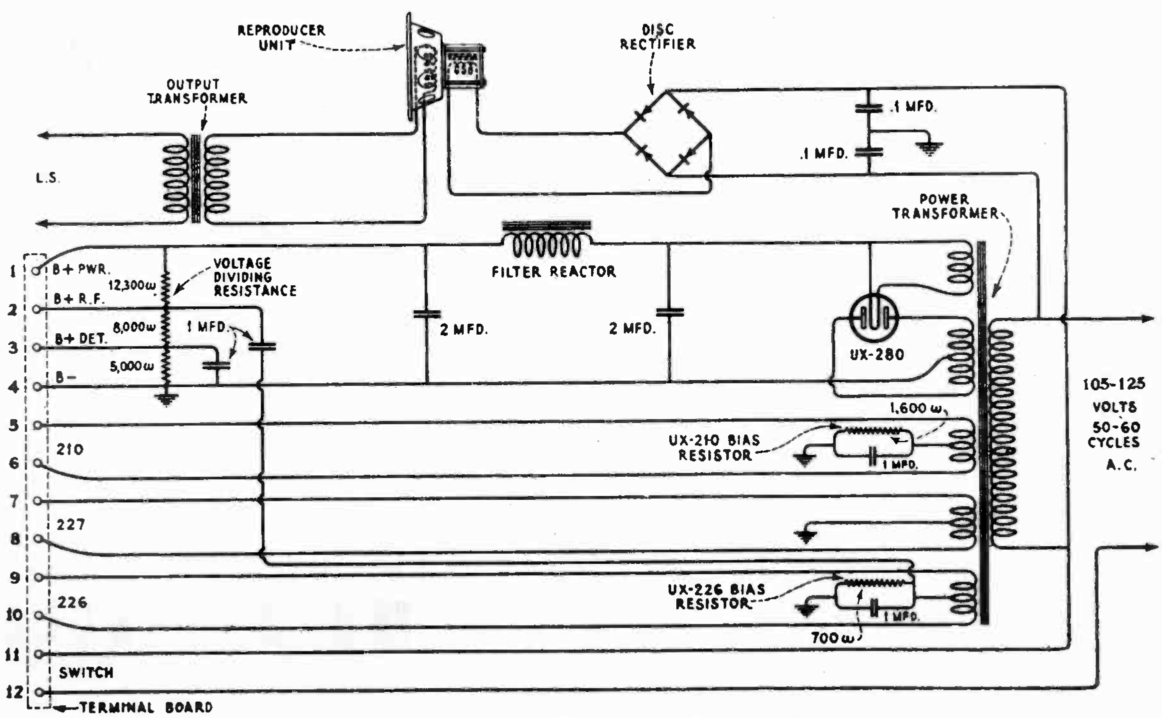
—Radiola 25 A.C. operated continuity circuit diagram



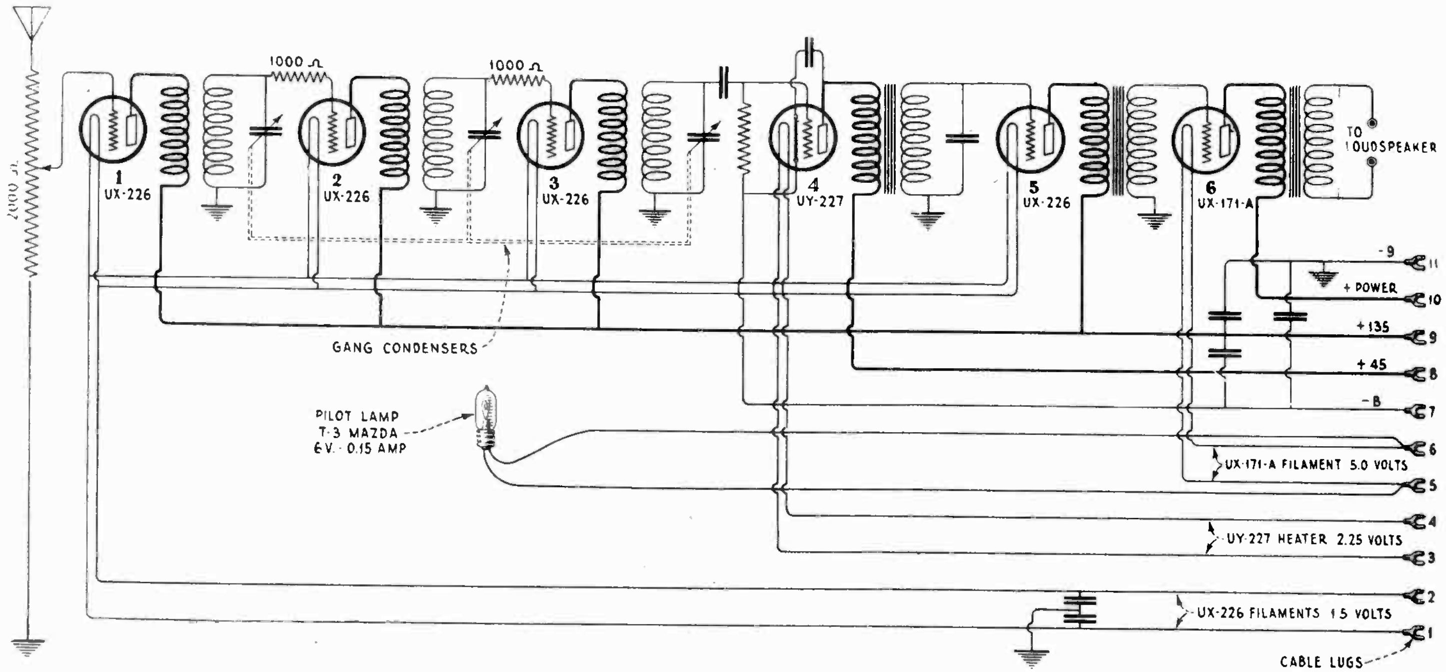
—*Radiola 28 A.C. operated continuity circuit diagram*



–Schematic circuit diagram of the receiver assembly in Radiola 41

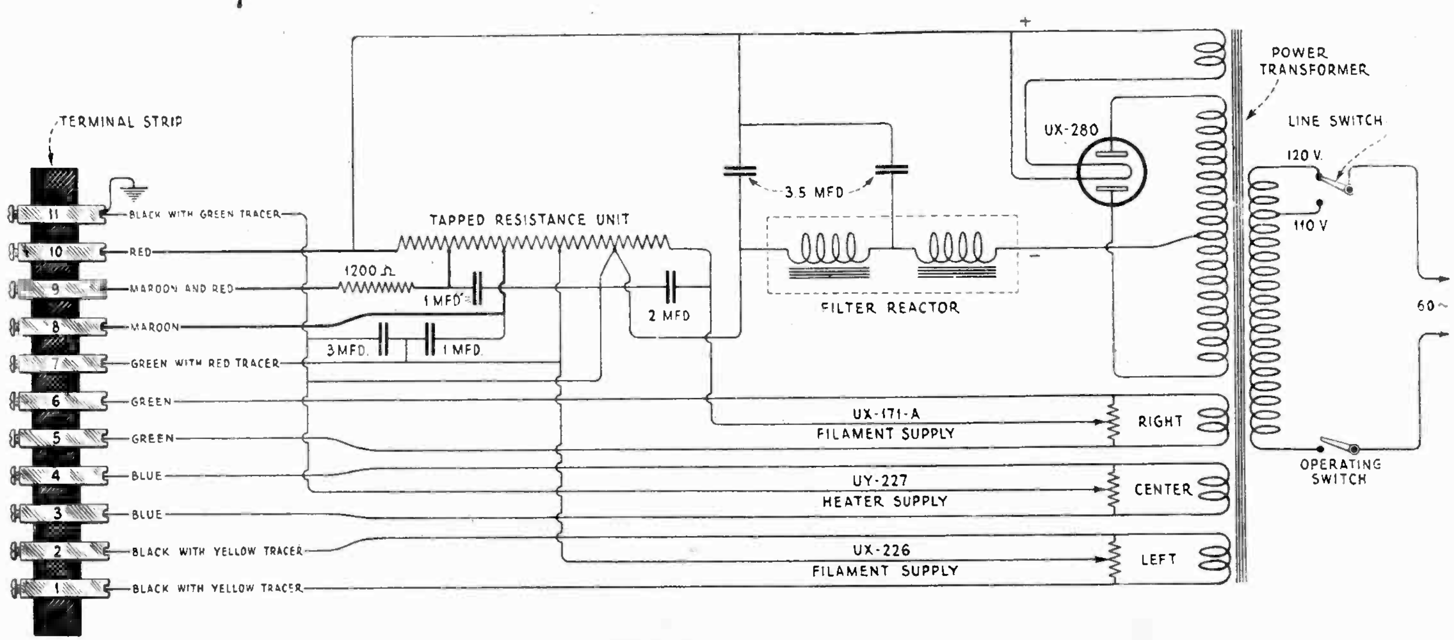


–Schematic circuit diagram of Receptor S. P. U.

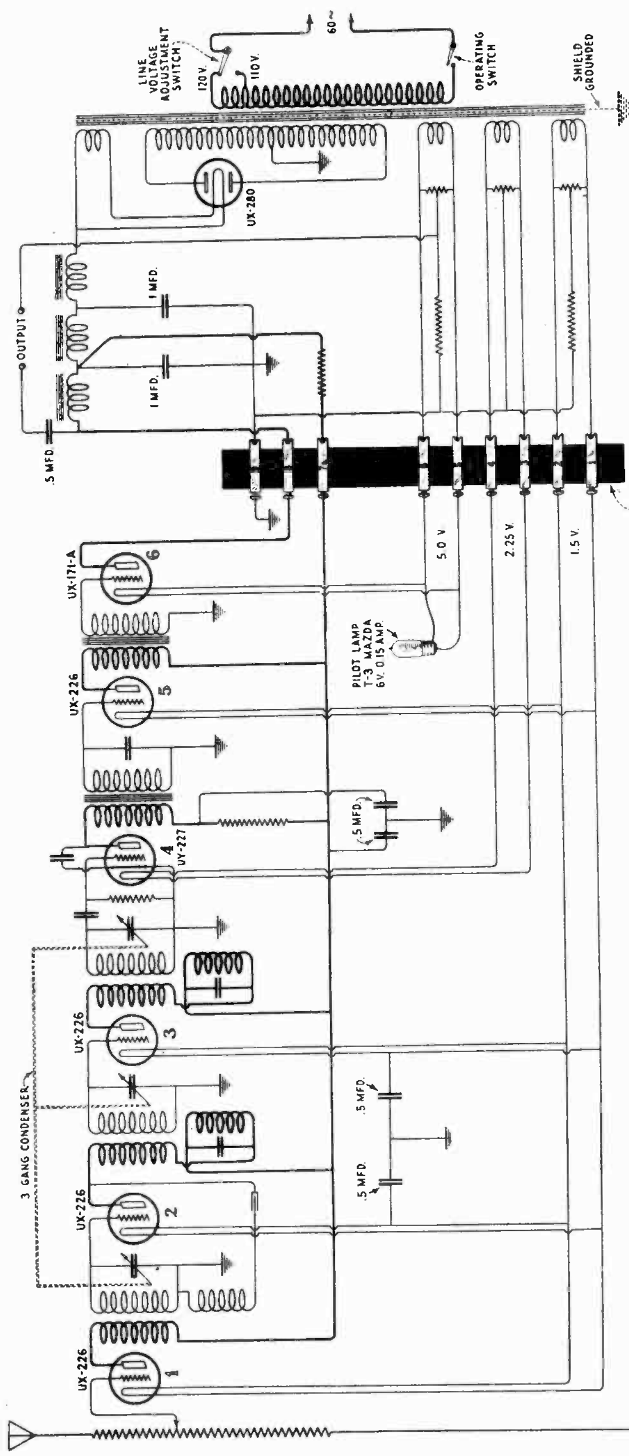


—*Schematic circuit diagram of receiver assembly.*

R.C.A. 17

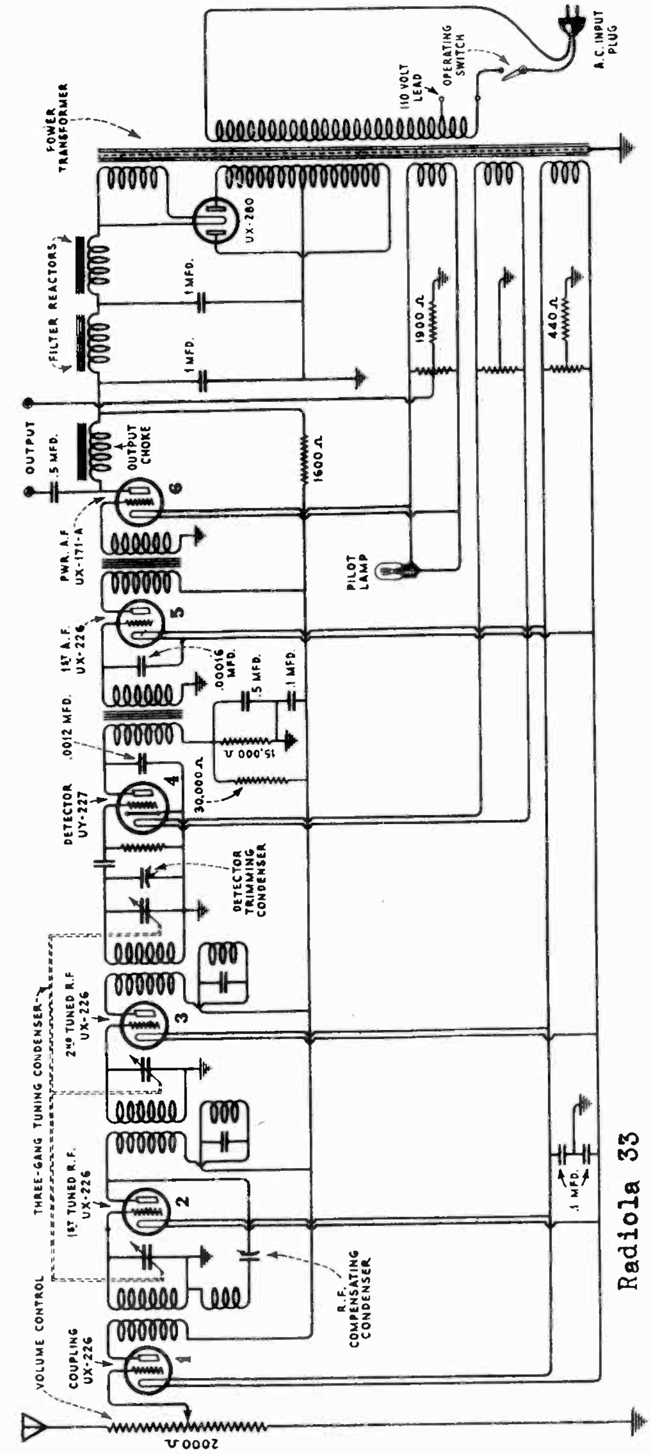


—*Schematic circuit diagram of socket power unit.*

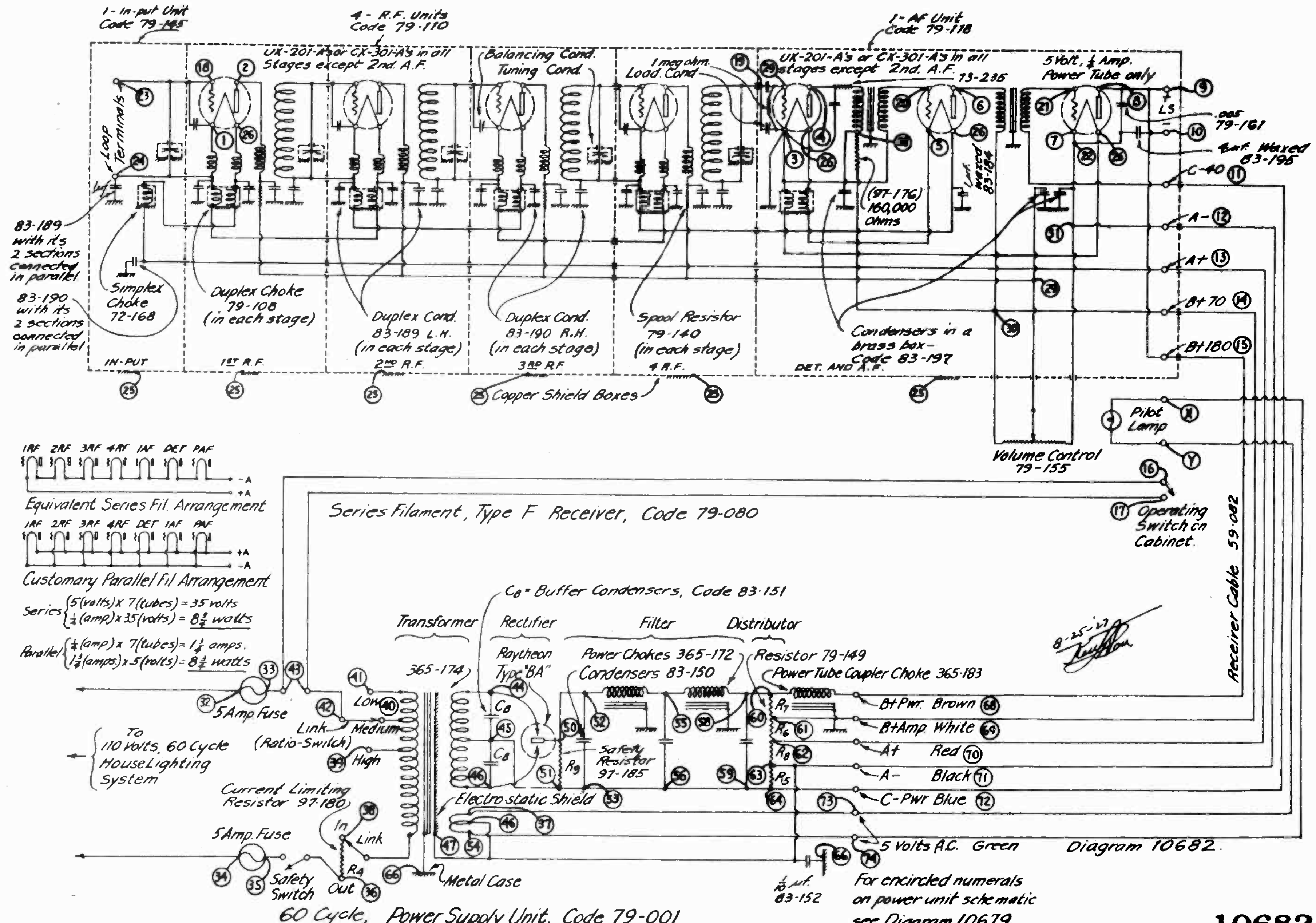


Radiola 18

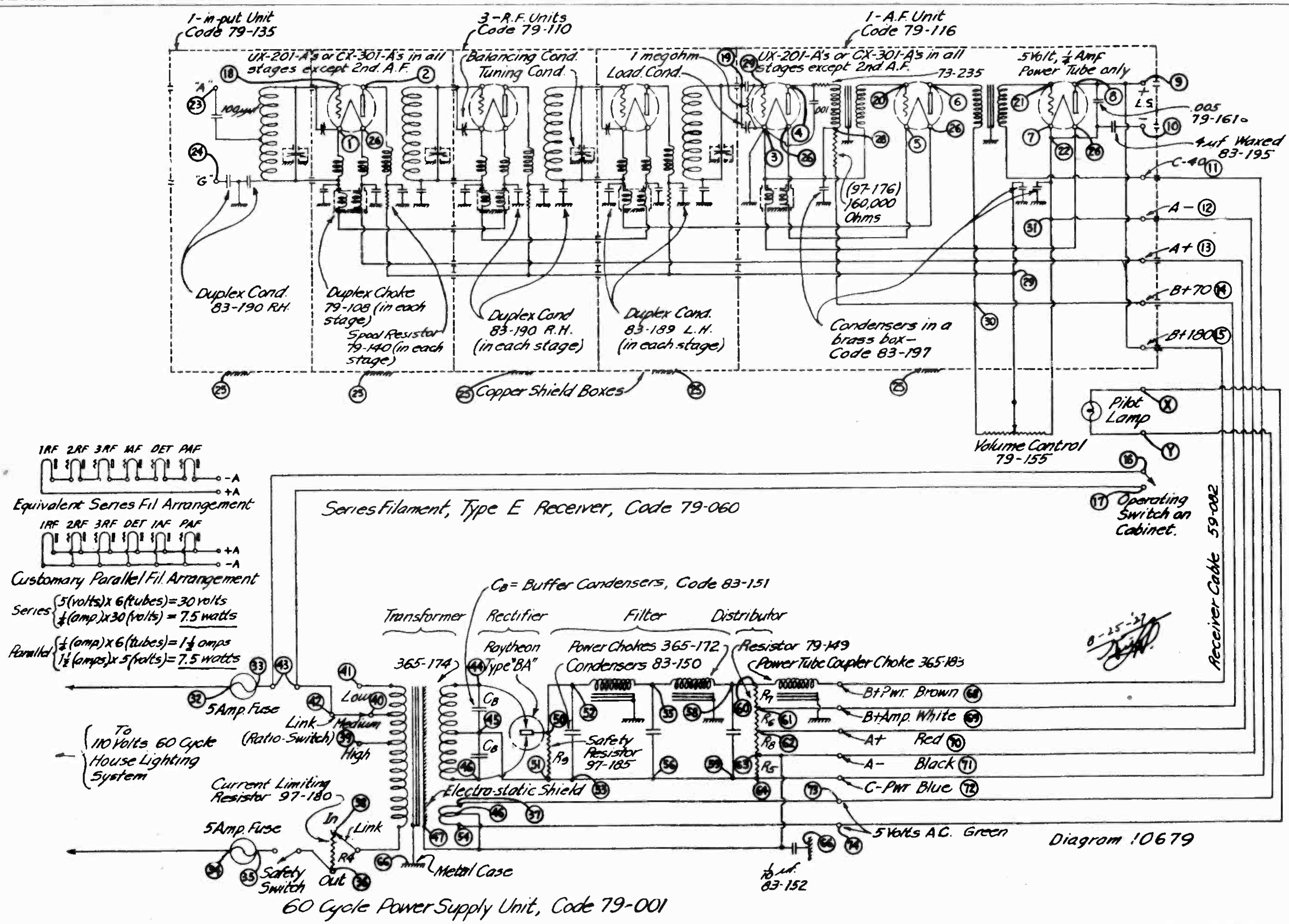
Schematic diagram of receiver and socket power unit.



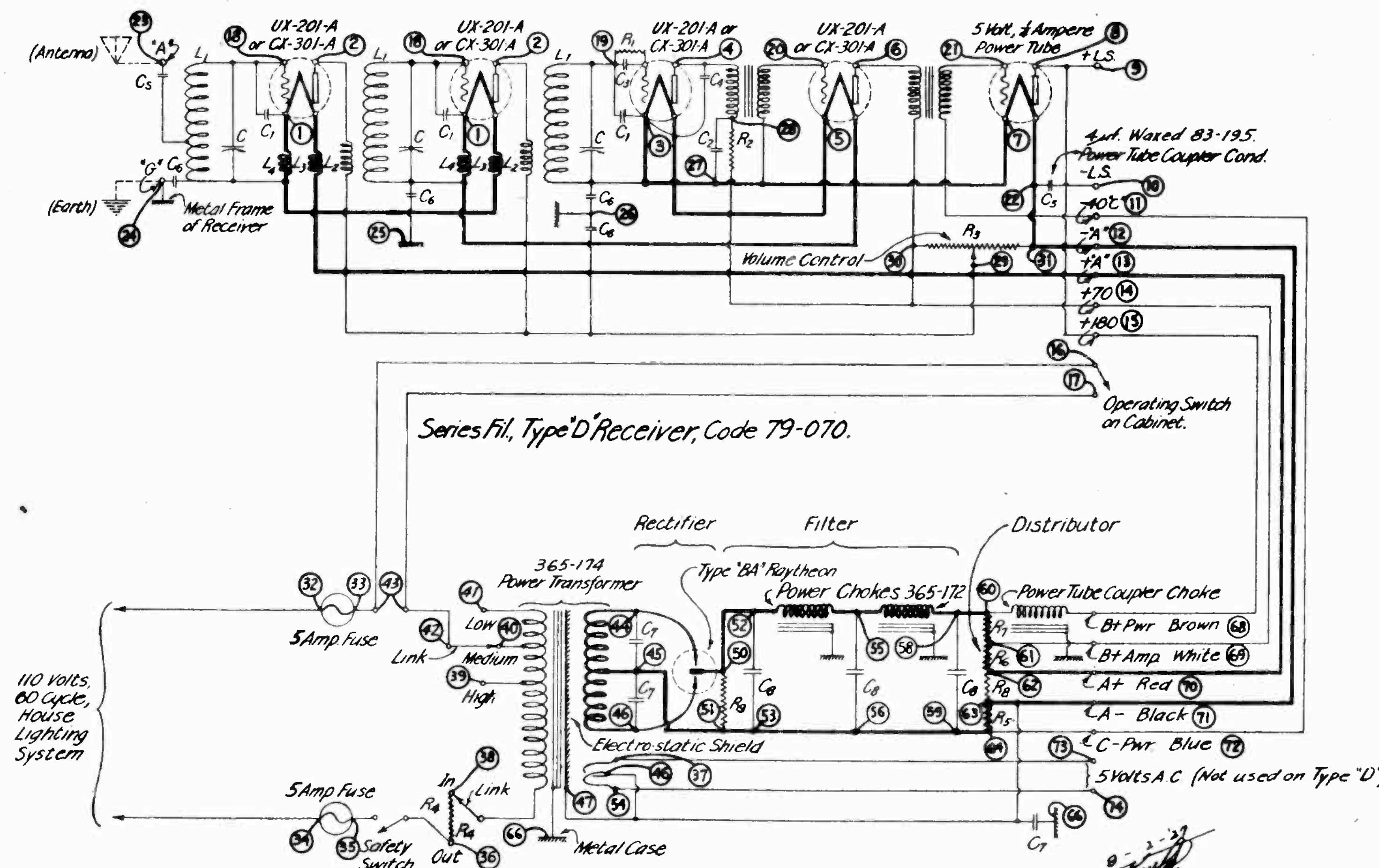
Radiola 33


1 - In-put Unit Code 79-145
4 - R.F. Units Code 79-110
UX-201-A's or CX-301-A's in all Stages except 2nd A.F.
Balancing Cond.
Tuning Cond.
1 meg ohm. Load Cond.
UX-201-A's or CX-301-A's in all stages except 2nd A.F.
1 - AF Unit Code 79-118
73-235
5 Volt, ½ Amp. Power Tube only
LS
.005 79-161
Buf. Waxed 83-195
C-40
A-
A+
B+70
B+180
Loop Terminals
83-189 with its 2 sections connected in parallel
83-190 with its 2 sections connected in parallel
Simplex Choke 72-168
Duplex Choke 79-108 (in each stage)
Duplex Cond. 83-189 L.H. (in each stage)
Duplex Cond. 83-190 R.H. (in each stage)
Spool Resistor 79-140 (in each stage)
(97-176) 160,000 Ohms
Condensers in a brass box - Code 83-197
IN-PUT
1st R.F.
2nd R.F.
3rd R.F.
4 R.F.
DET. AND A.F.
Copper Shield Boxes
Pilot Lamp
Volume Control 79-155
Operating Switch on Cabinet.
Receiver Cable 59-082
1RF 2RF 3RF 4RF 1AF DET PAF
Equivalent Series Fil. Arrangement
1RF 2RF 3RF 4RF DET 1AF PAF
Customary Parallel Fil. Arrangement
Series {5 (volts) x 7 (tubes) = 35 volts; ¼ (amp) x 35 (volts) = 8¾ watts
Parallel {¼ (amp) x 7 (tubes) = 1¾ amps.; 1¾ (amps) x 5 (volts) = 8¾ watts
Series Filament, Type F Receiver, Code 79-080
C8 = Buffer Condensers, Code 83-151
Transformer
Rectifier
Filter
Distributor
365-174
Raytheon Type "BA"
Power Chokes 365-172
Condensers 83-150
Resistor 79-149
Power Tube Coupler Choke 365-183
Safety Resistor 97-185
Electro-static Shield
5 Amp Fuse
Link
Low
Medium
High
(Ratio-Switch)
To 110 Volts, 60 Cycle House Lighting System
Current Limiting Resistor 97-180
In
Out
5 Amp. Fuse
Safety Switch
Metal Case
B+Pwr. Brown
B+Amp White
A+ Red
A- Black
C-Pwr Blue
5 Volts A.C. Green
1/10 μf. 83-152
Diagram 10682.
For encircled numerals on power unit schematic see Diagram 10679.
60 Cycle, Power Supply Unit, Code 79-001

10682


1-in-put Unit Code 79-135
3-R.F. Units Code 79-110
1-A.F. Unit Code 79-116
UX-201-A's or CX-301-A's in all stages except 2nd A.F.
Balancing Cond.
Tuning Cond.
1 megohm
Load Cond.
73-235
5 Volt, ¼ Amp Power Tube only
.005 79-161
4 µf Waxed 83-195
C-40
A –
A +
B+70
B+180
Duplex Cond. 83-190 RH.
Duplex Choke 79-108 (in each stage)
Spool Resistor 79-140 (in each stage)
Duplex Cond 83-190 R.H. (in each stage)
Duplex Cond. 83-189 L.H. (in each stage)
(97-176) 60,000 Ohms
Condensers in a brass box – Code 83-197
Copper Shield Boxes
Pilot Lamp
Volume Control 79-155
Operating Switch on Cabinet.
Receiver Cable 59-082
Series Filament, Type E Receiver, Code 79-060
1RF 2RF 3RF 1AF DET PAF
Equivalent Series Fil Arrangement
1RF 2RF 3RF DET 1AF PAF
Customary Parallel Fil. Arrangement
Series 5 (volts) x 6 (tubes) = 30 volts; ¼ (amp) x 30 (volts) = 7.5 watts
Parallel ¼ (amp) x 6 (tubes) = 1½ amps; 1½ (amps) x 5 (volts) = 7.5 watts
C$_B$ = Buffer Condensers, Code 83-151
Transformer
Rectifier
Filter
Distributor
365-174
Raytheon Type "BA"
Power Chokes 365-172
Condensers 83-150
Resistor 79-149
Power Tube Coupler Choke 365-183
Safety Resistor 97-185
Electro-static Shield
B+Pwr. Brown
B+Amp. White
A+ Red
A– Black
C-Pwr Blue
5 Volts A.C. Green
5 Amp. Fuse
Low
Medium
High
Link (Ratio-Switch)
To 110 Volts 60 Cycle House Lighting System
Current Limiting Resistor 97-180
In
Link
Out
Safety Switch
Metal Case
1/2 µf 83-152
60 Cycle Power Supply Unit, Code 79-001
Diagram 10679

10679



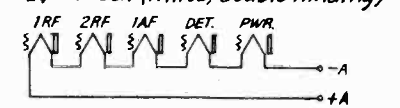
Series Fil, Type "D" Receiver, Code 79-070.

60 Cycle Power Supply Unit, Code 79-001.

(Filament Circuit in Heavy Lines)

Code Numbers on Diagram 10667

C	73-130
C_1	Balance Cond.
C_2	83-184 1 µf.
C_3	73-287 .0002 µf.
C_4	72-299 .001 " .
C_5	83-195 4 µf.
C_6	83-189 and 83-190 .5 µf. each.
C_s	72-238 .0001 µf.
R_1	1 Meg ohm (not shown 10667)
R_2	97-176, 160,000 ohms.
R_3	79-155 50,000 ohms.
L_1	71-223 and 79-124
L_2	Plate Coil (Green, Single Winding)
L_3	+F Coil (Green, Double Winding)
L_4	-F Coil (White, Double Winding)



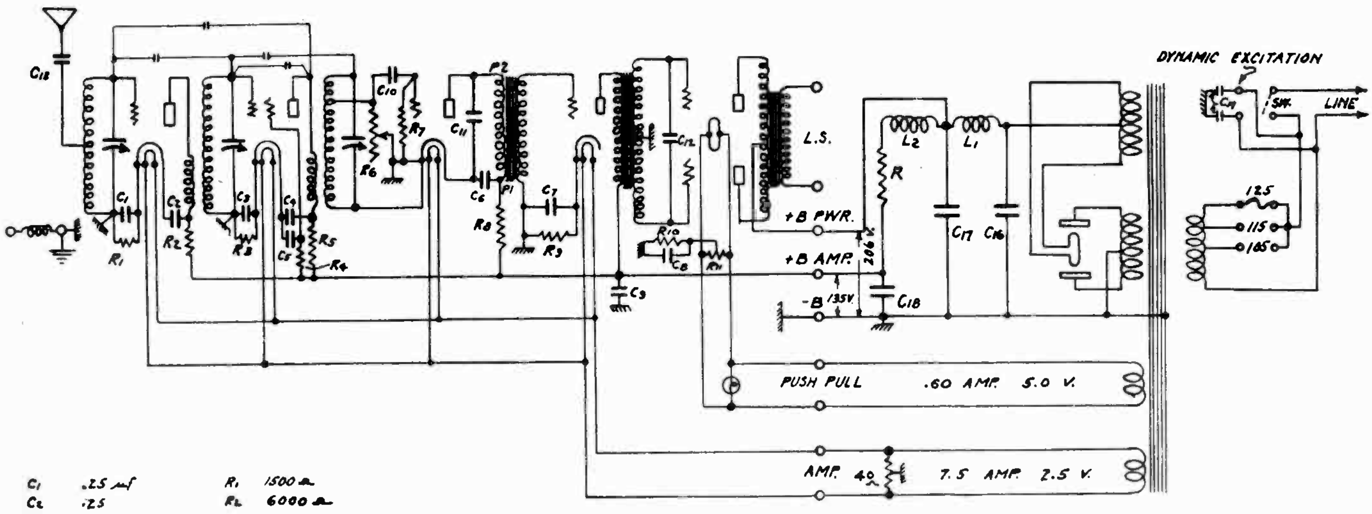
Equivalent Series Filament Arrangement

Code Numbers on Diagram 10669

C_7	83-151 (2 - ½ µf.)
C_8	83-150 4 µf.
R_4	97-180 4 ohms
R_5	79-149 135 ohm section
R_6	79-149 200 " "
R_7	79-149 350 " "
R_8	79-149 2000 ohm section
R_9	97-185 20,000 " "

Diagram 10673

10673

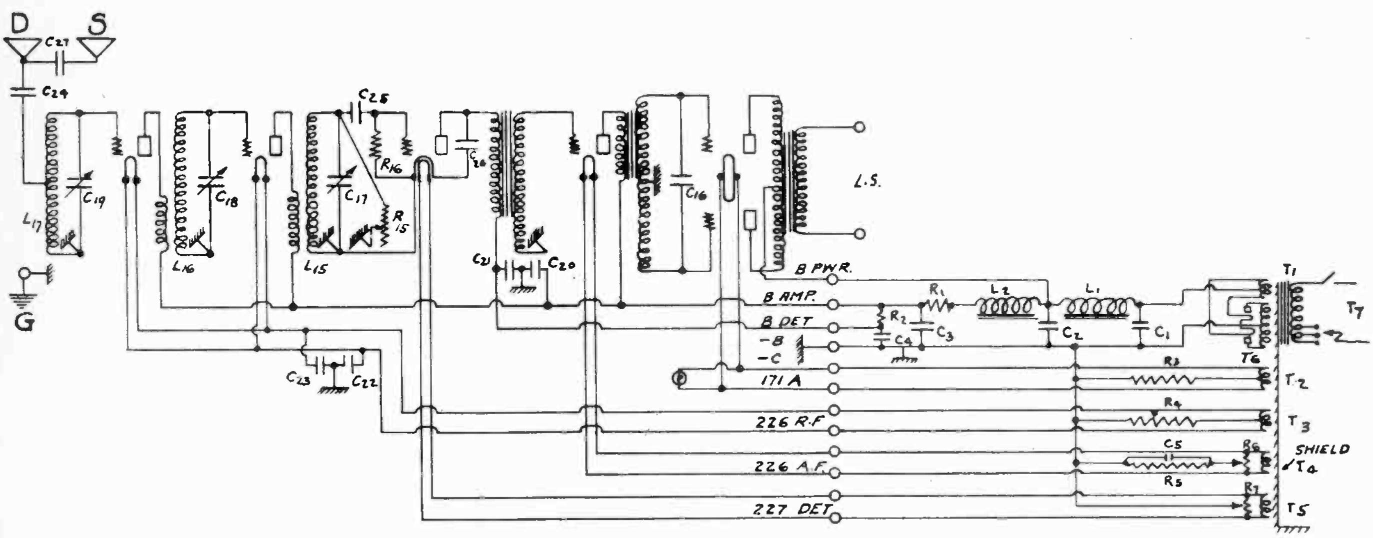


C_1	.25 µf
C_2	.25
C_3	.25
C_4	.25
C_5	.25
C_6	.25
C_7	.25
C_8	.25
C_9	.25
C_{10}	.0002
C_{11}	.001
C_{12}	.0002
C_{13}	.0001

R_1	1500 Ω
R_2	6000 Ω
R_3	300 Ω
R_4	40,000 Ω
R_5	6,000 Ω
R_6	700,000 Ω
R_7	2 MEG
R_8	13,000 Ω
R_9	1500 Ω
R_{10}	1500 Ω
R_{11}	40 Ω

Federal Model K

25 CYCLE		60 CYCLE
1300 Ω	R	1300 Ω
15 H. 285 Ω	L_1	15 H. 285 Ω
60 H. 1570 Ω	L_2	60 H. 1570 Ω
2 M.F.	C_{16}	1 M.F.
4 M.F.	C_{17}	1 M.F.
4 M.F.	C_{18}	2 M.F.
0.1 M.F.	C_{19}	0.1 M.F.



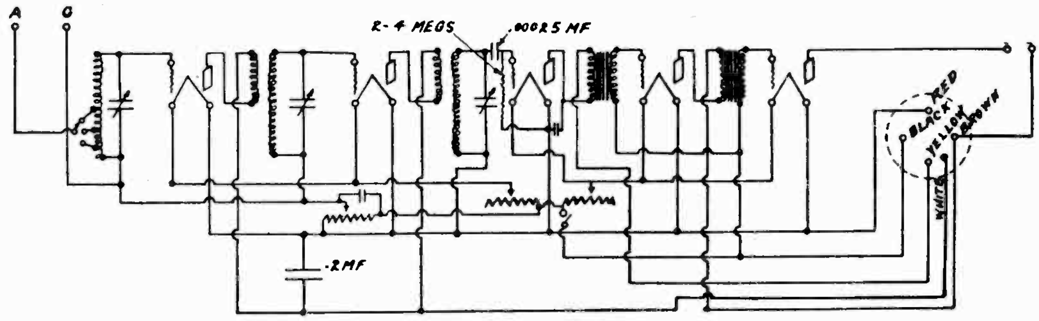
PARTS LIST FOR REC.

C_{16} = .0002 µf	L_{15} = 262 µh		
C_{17} = .0003 µf	L_{16} = 262 µh		
C_{18} = .0003 µf	L_{17} = 262 µh		
C_{19} = .0003 µf			
C_{20} = ½ µf			
C_{21} = ½ µf	R_{15} = 500,000 Ω		
C_{22} = 1/10 µf	R_{16} = 2 Meg		
C_{23} = 1/10 µf			
C_{24} = .0001 µf			
C_{25} = .0002 µf			
C_{26} = .001 µf			
C_{27} = 50/35 µµf.			

Federal Model H

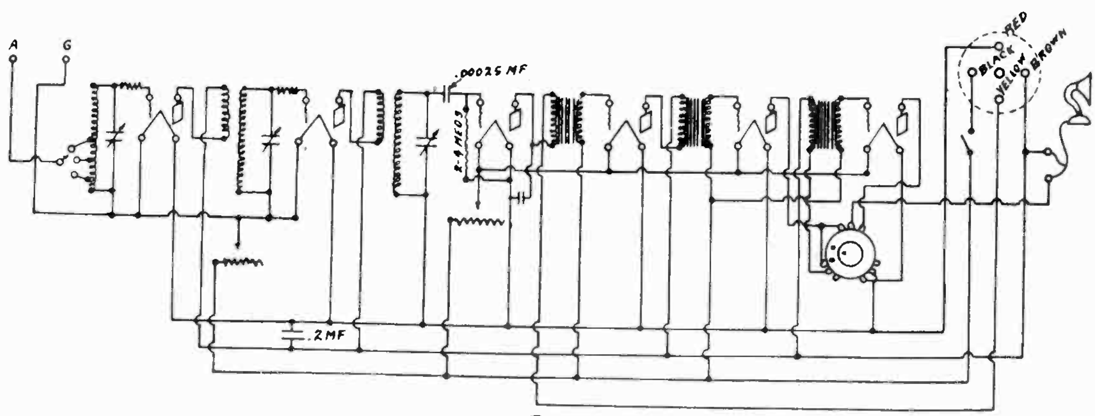
PARTS LIST FOR POWER UNIT

C_1 = 1 µf	R_1 = 3500 Ω	L_1 = 15 h - 285 Ω	T_1 = 24
C_2 = 1 µf	R_2 = 13,000 Ω	L_2 = 55 h - 1600 Ω	T_2 = 24
C_3 = 2 µf	R_3 = 1300 Ω		T_3 = 8
C_4 = 1 µf	R_4 = 1400 Ω		T_4 = 8
C_5 = ½ µf	R_5 = 2500 Ω		T_5 = 12
	R_6 = 40 Ω		T_6 = 2390
	R_7 = 40 Ω		T_7 = 573



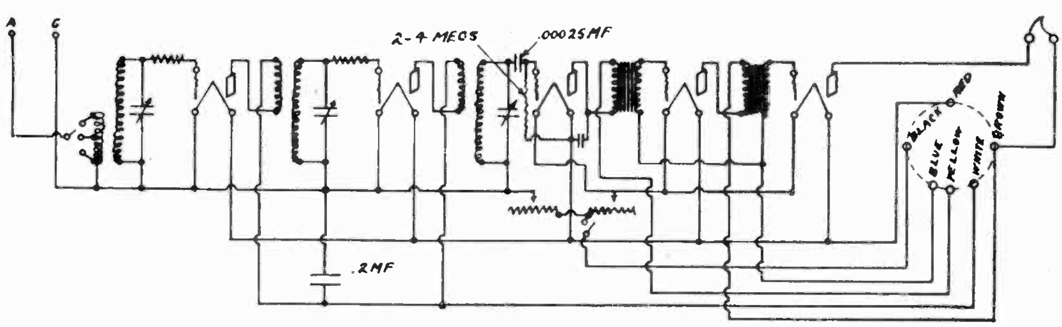
1 D B

Note.—This set has two R.F. rheostats (one for each R.F. tube). —F1R connects to the slider lead of the 1st R.F. rheostat instead of to —F2R.

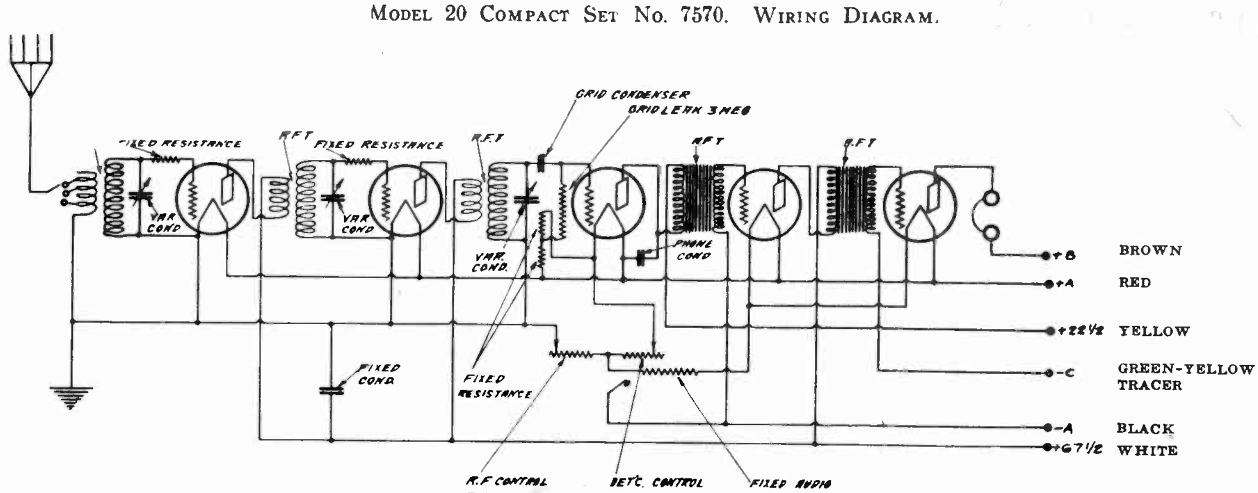


12

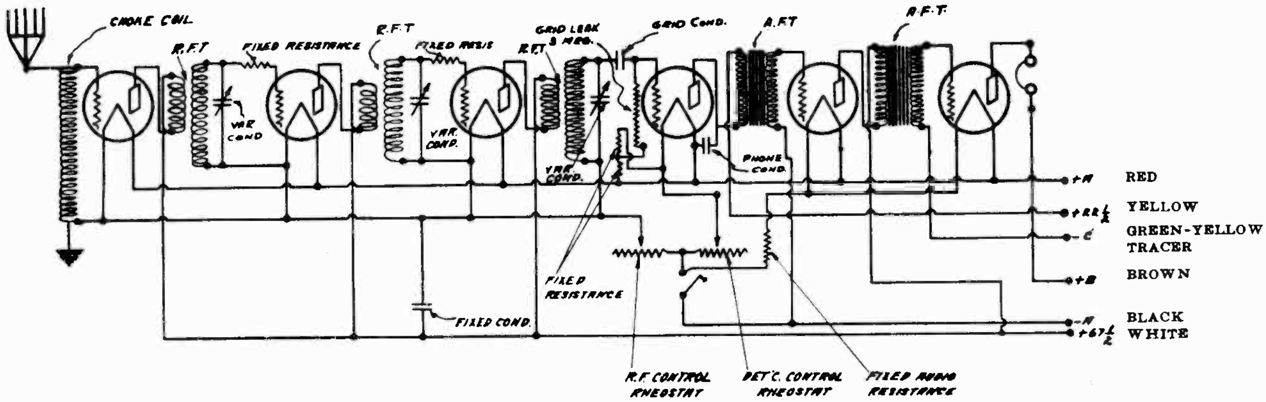
(Diagram shows one rheostat controlling detector and all three A.F. tubes. In actual set, rheostat controls detector and 1st audio only, 2nd and 3rd audio tubes being on separate fixed resistances.)



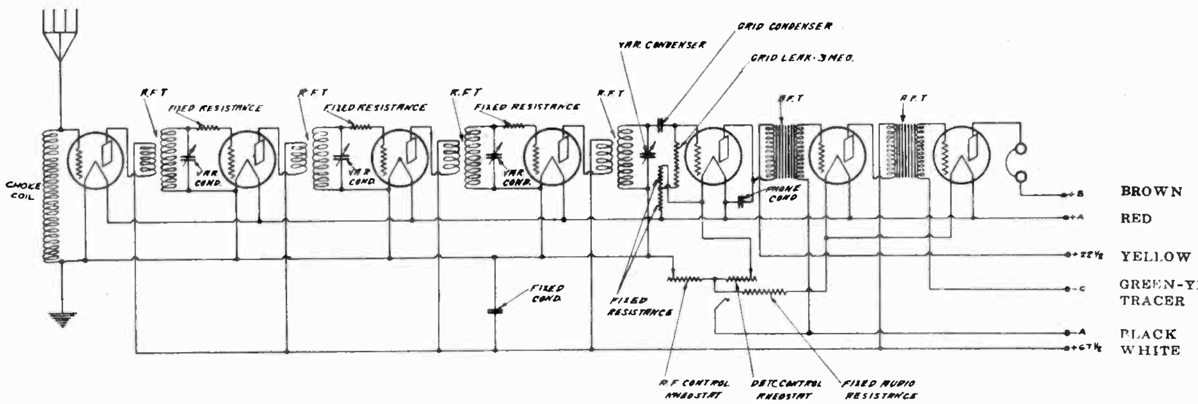
Model 20 Compact Set No. 7570. Wiring Diagram.



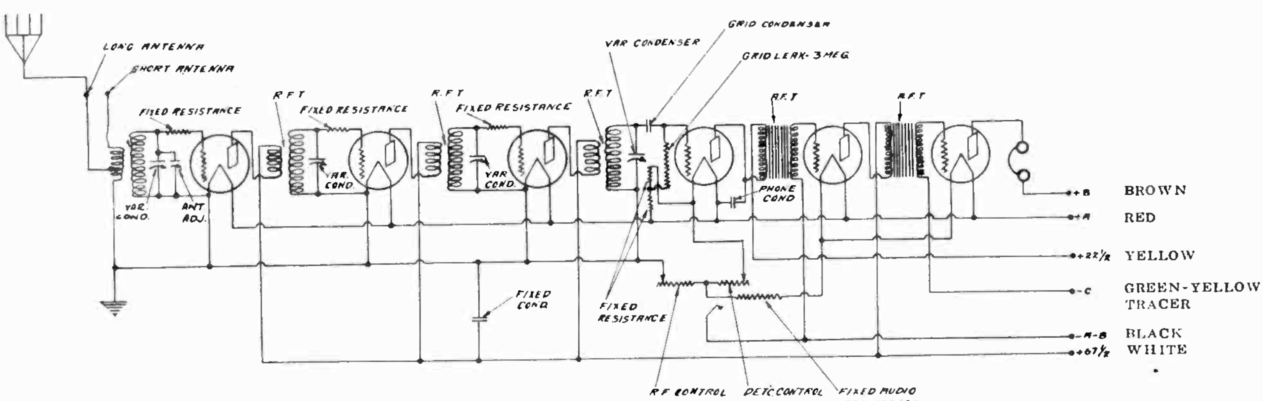
Model 20 Compact Set No. 7960. Wiring Diagram.



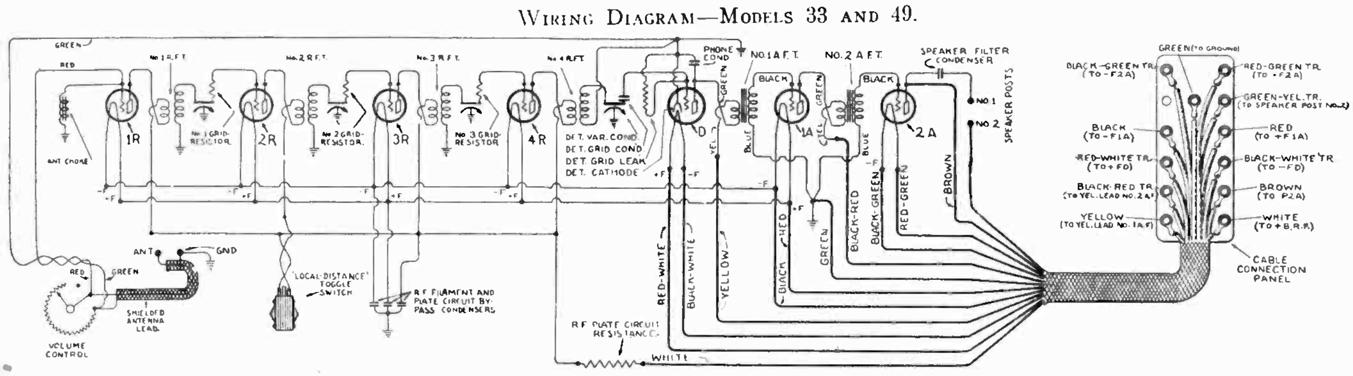
Wiring Diagram of Models 30, 35 and 48. (In Model 35, one rheostat controls the three R.F. filaments and a fixed resistance is connected in series with the detector and two A.F. filaments.)



Wiring Diagram of Model 32.

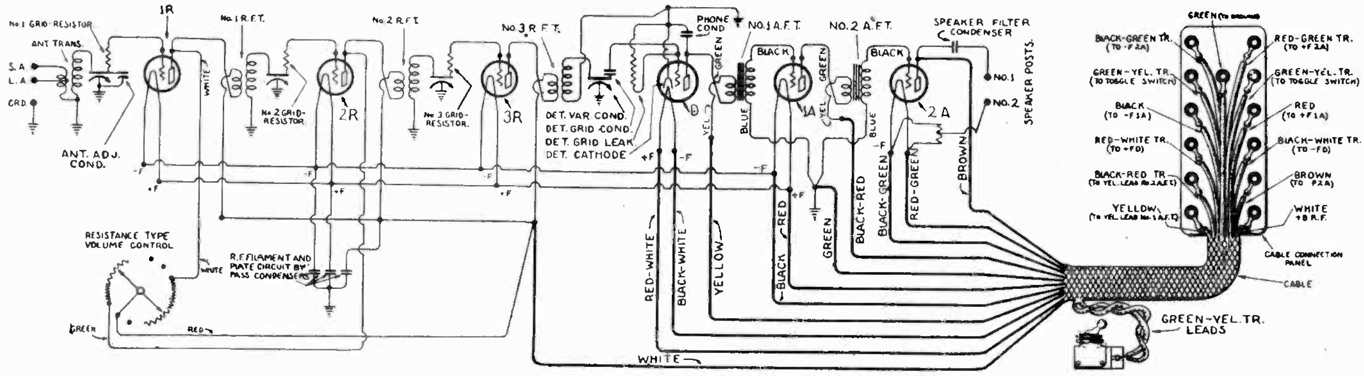


Wiring Diagram—Models 33 and 49.

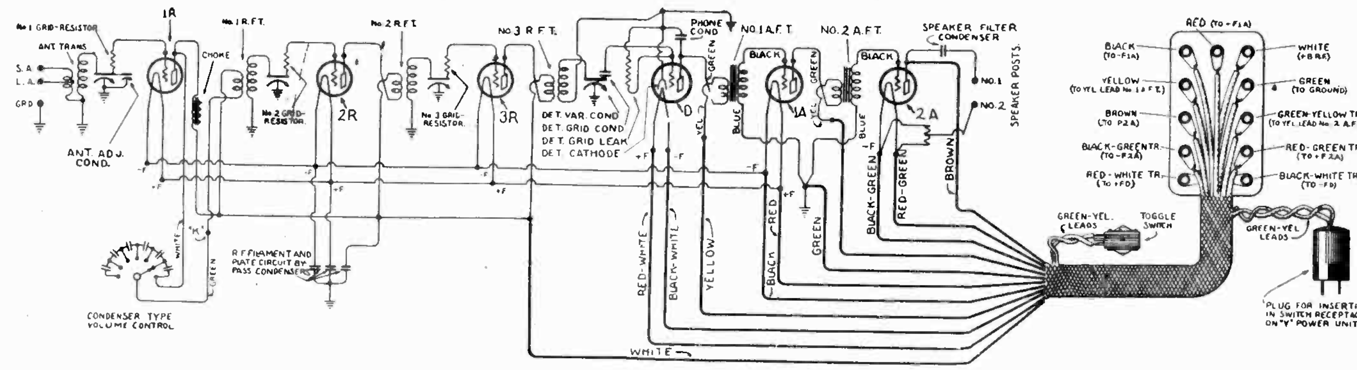


Wiring Diagram of Model 38

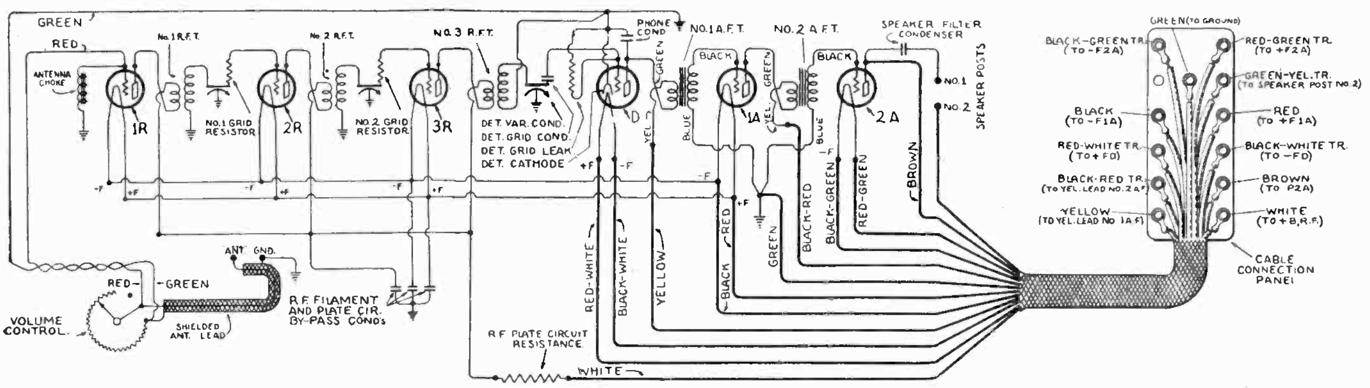
A 2nd A. F. filament shunt resistance is used before Serial No. 1,752,000 and the green-yellow tracer cable lead is not used. Connections for this resistance are shown in dotted lines in the diagram on page 71. Note that the black and the red cable leads feed the R. F. filaments as well as the 1st A. F. filament. A schematic diagram of the volume control is shown in Fig. 60.



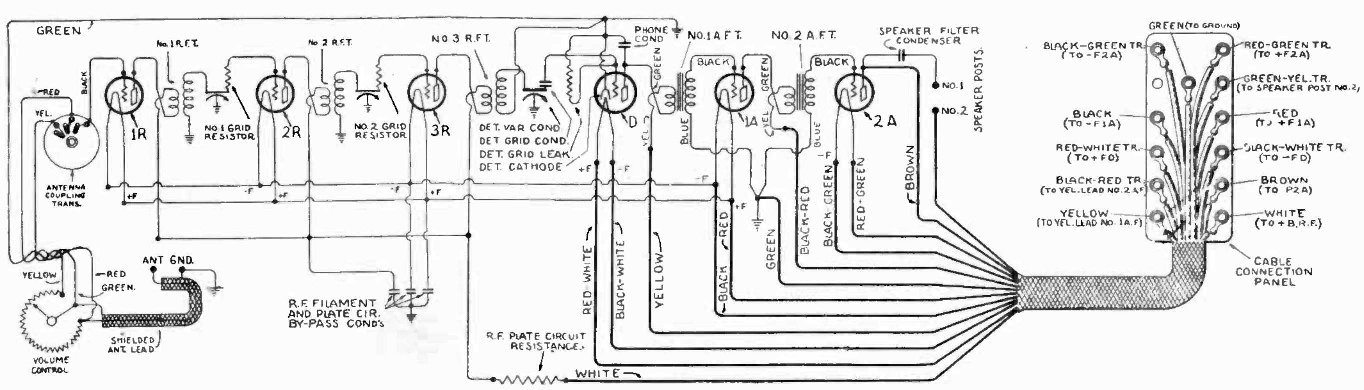
Wiring Diagram of Model 36 With Resistance Type Volume Control and Cable Connection Panel for Later Model "Y" Power Unit. (Note that the red and the black cable leads feed the R.F. filaments as well as the 1st A.F. filament. In some Model 36 sets the +B 1st A.F. cable lead is green with a yellow tracer.)



Wiring Diagram of Model 36 With Condenser Type Volume Control and Cable Connection Panel for Early Model "Y" Power Unit. (Note that the +B 1st A.F. cable lead is green with a yellow tracer. In some Model 36 sets, and in all other Atwater Kent A.C. receivers, a black-red tracer is used for this connection.)



Wiring Diagram of Model 37. (A 2nd A.F. filament shunt resistance is used before Serial No. 1,385,000, in which case speaker post No. 2 connects to the centre-tap of this resistance, and the green-yellow tracer lead is not used. The R.F. plate circuit resistance is used after Serial No. 1,385,000. Note that the red and the black cable leads feed the R.F. filaments as well as the 1st A.F. filament.)



Wiring Diagram of Models 40, 42 and 52

Model 52 does not have the shielded antenna lead, but is provided with two twenty-foot leads which are connected to the volume control, black for antenna and black-green tracer for ground.

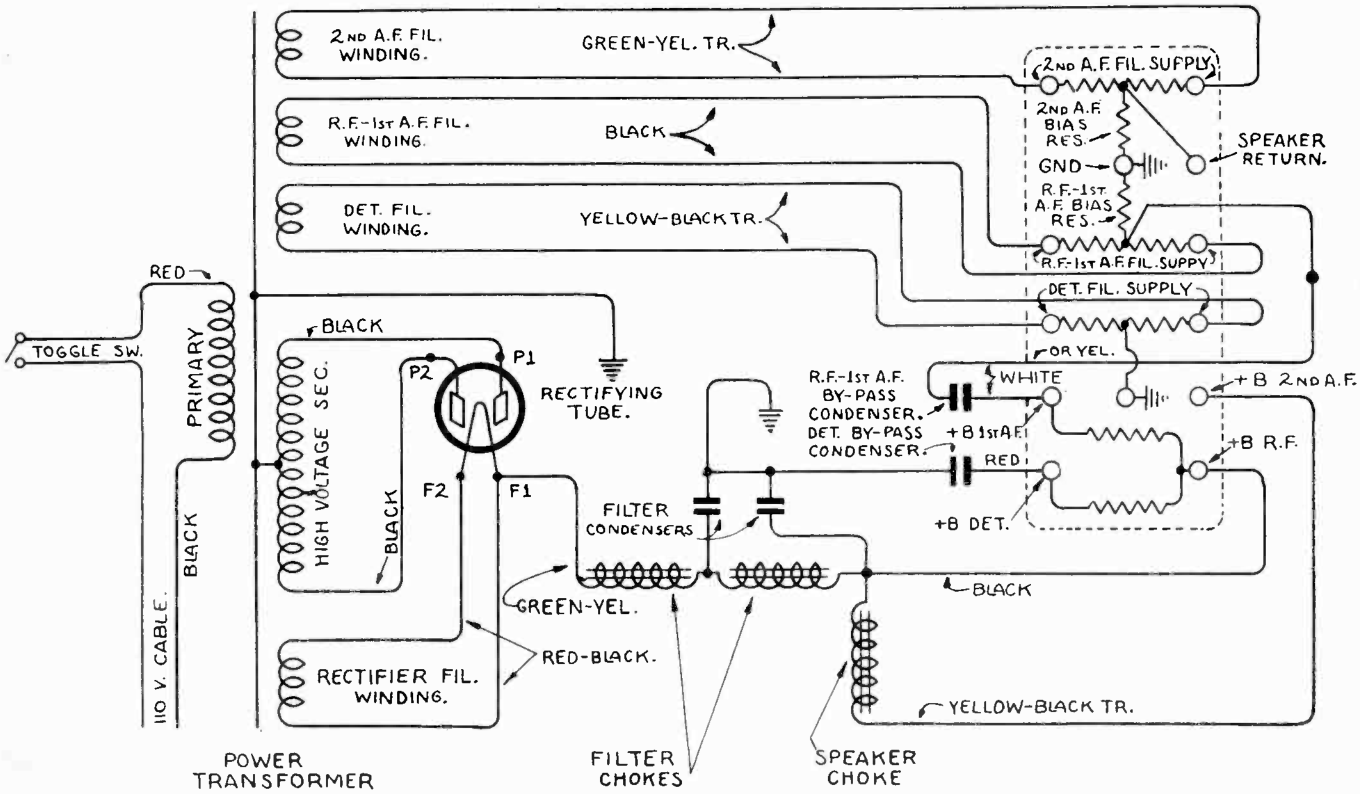
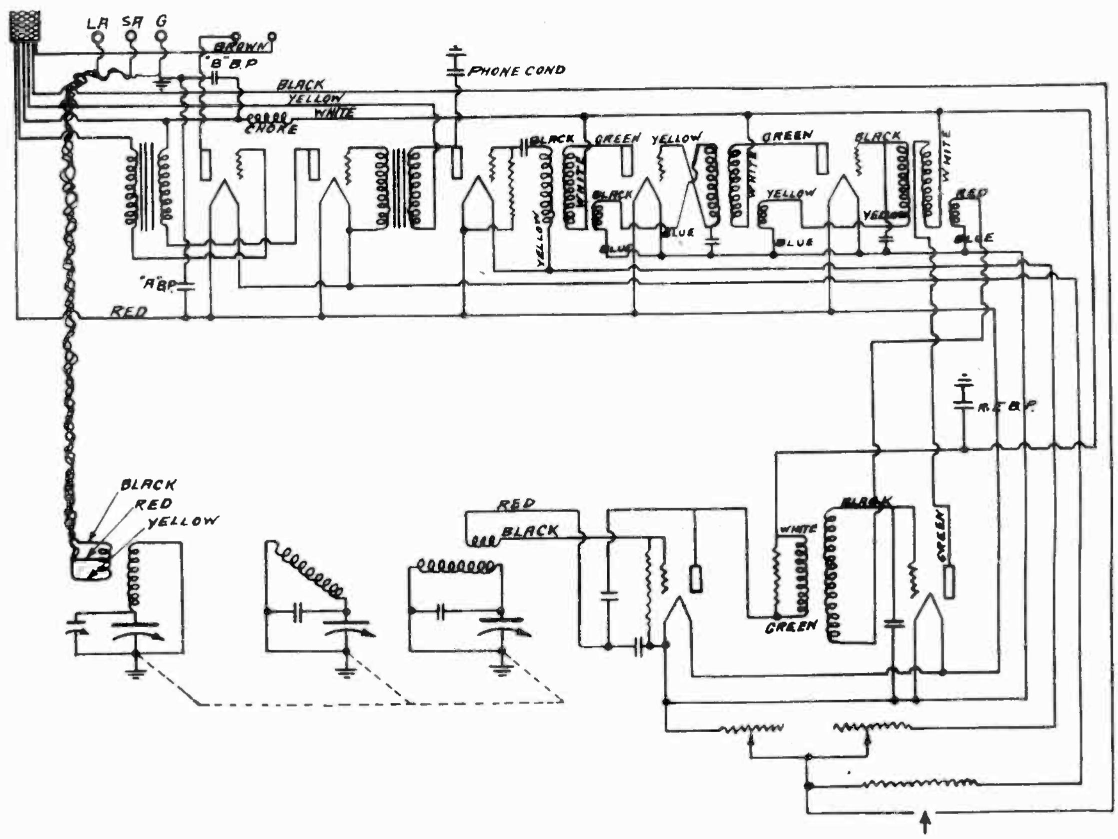


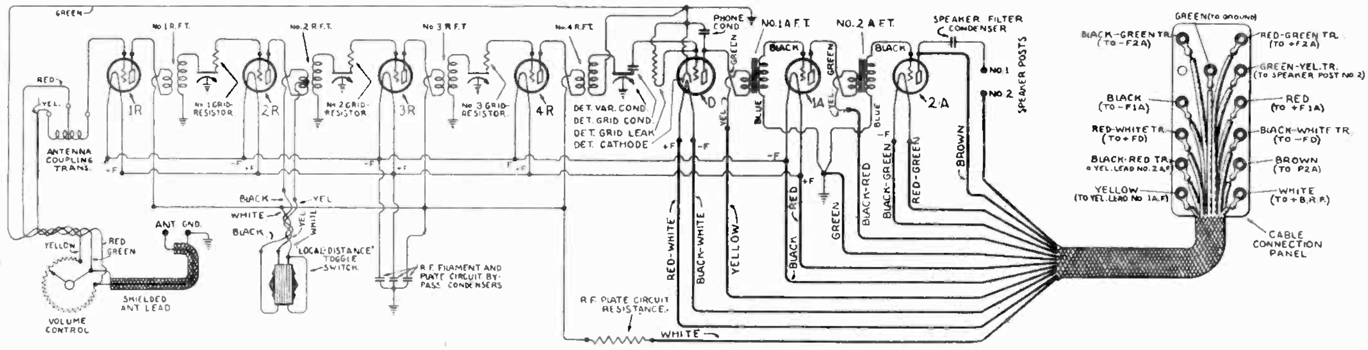
Diagram of Power Unit in Models 37 and 38

The diagram of the power unit in Models 40, 42, 44 and 52 is similar to that shown above with the following exceptions: A regulating resistance is connected in series with the primary circuit in Models 42, 44 and 52. A filter condenser is connected between F1 and ground. The junction point of the bias resistance is connected to the lower instead of the upper ground eyelet. The color scheme is different and is shown in Fig. 77.

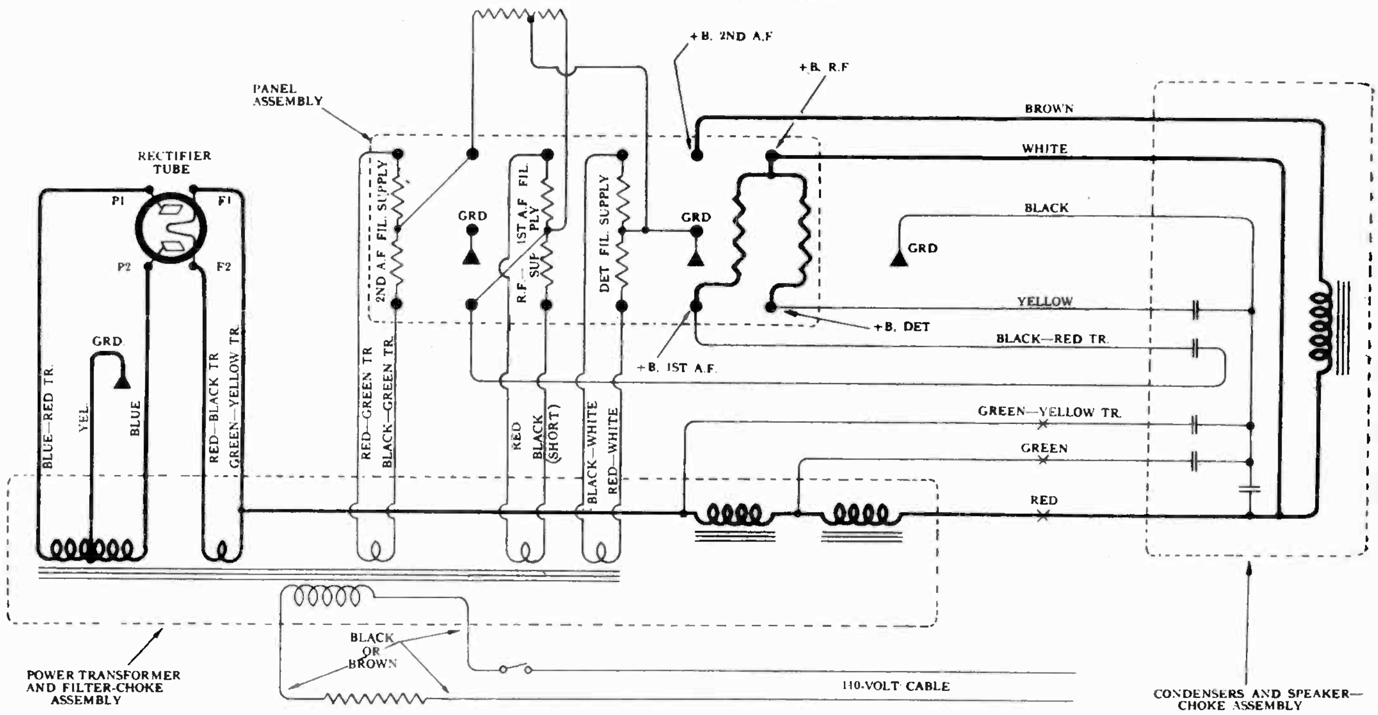


Wiring Diagram of Model 50.

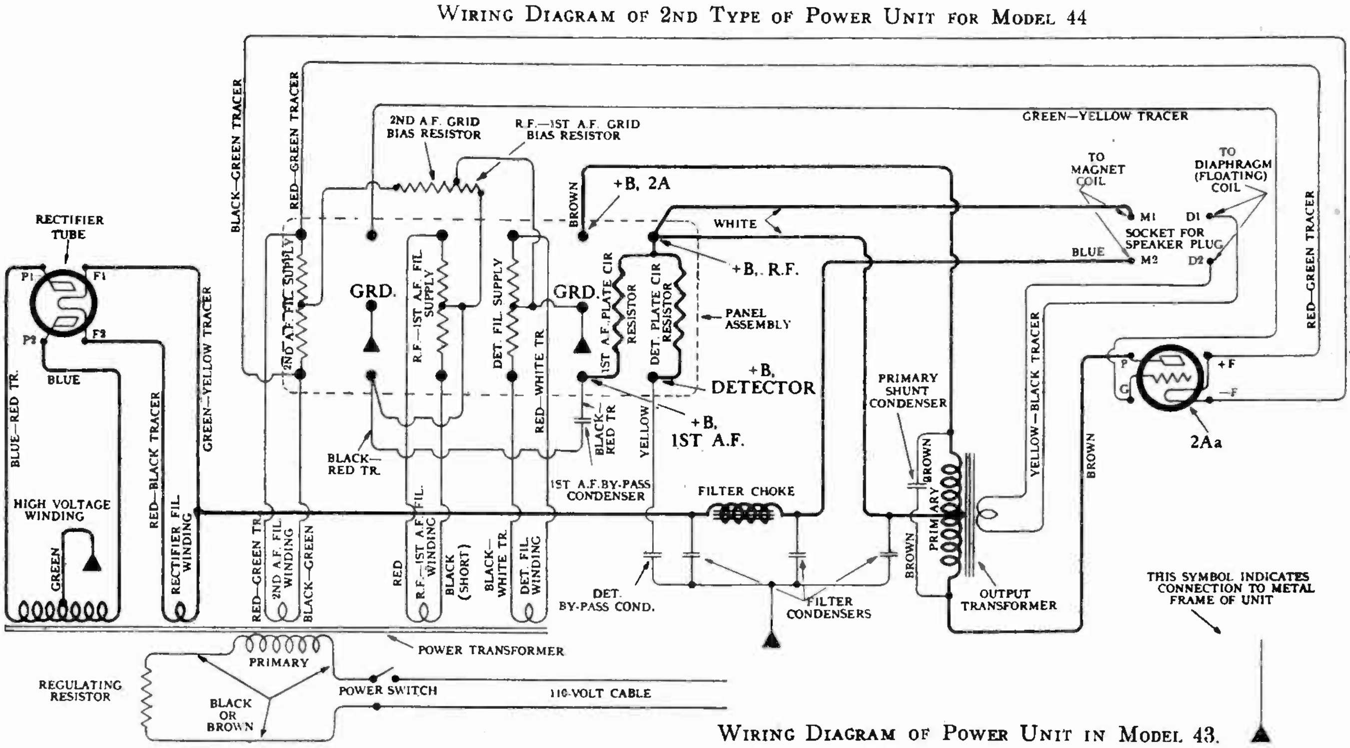
Note.—Black lead (—F) is grounded—not shown in diagram. Most of Model 50 Sets also have an R.F. choke between plate of second audio tube and speaker post No. 1.



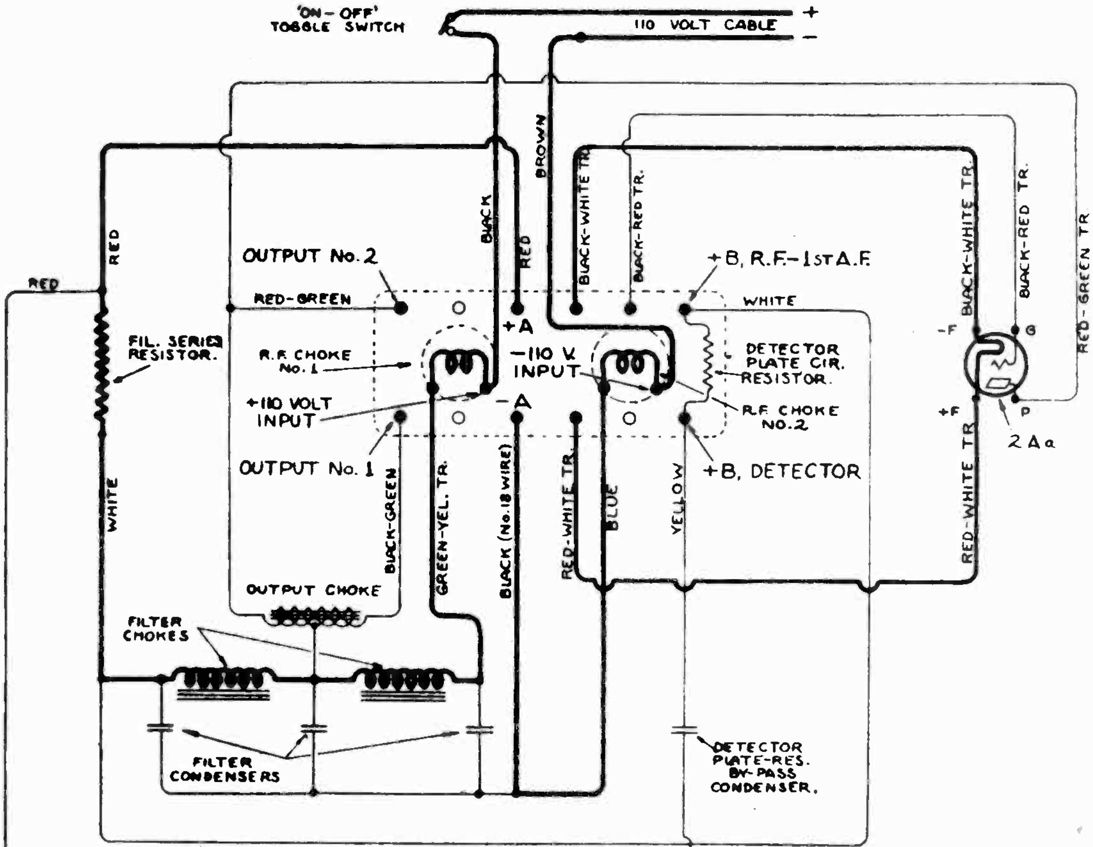
Wiring Diagram of Model 44



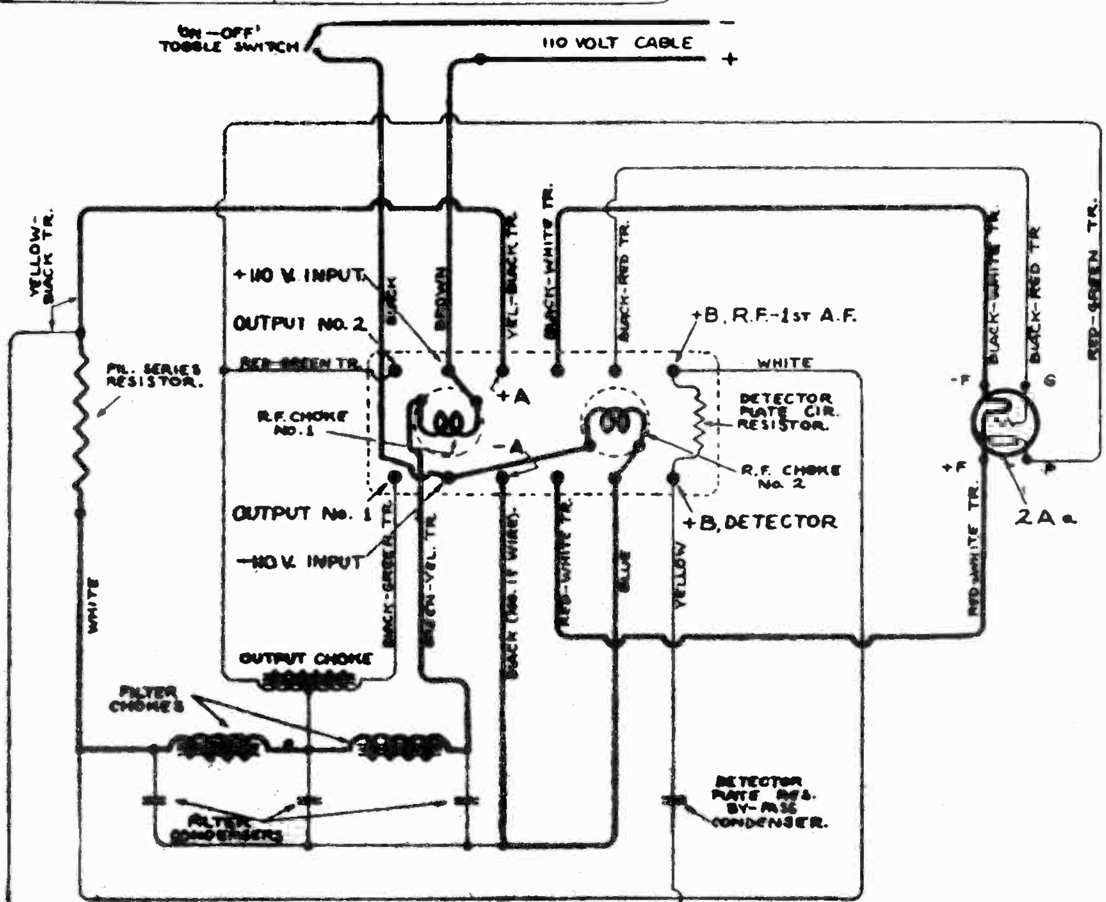
Wiring Diagram of 2nd Type of Power Unit for Model 44



Wiring Diagram of Power Unit in Model 43.



WIRING DIAGRAM OF 1ST TYPE OF POWER UNIT FOR MODEL 41.



WIRING DIAGRAM OF 2ND TYPE OF POWER UNIT FOR MODEL 41.

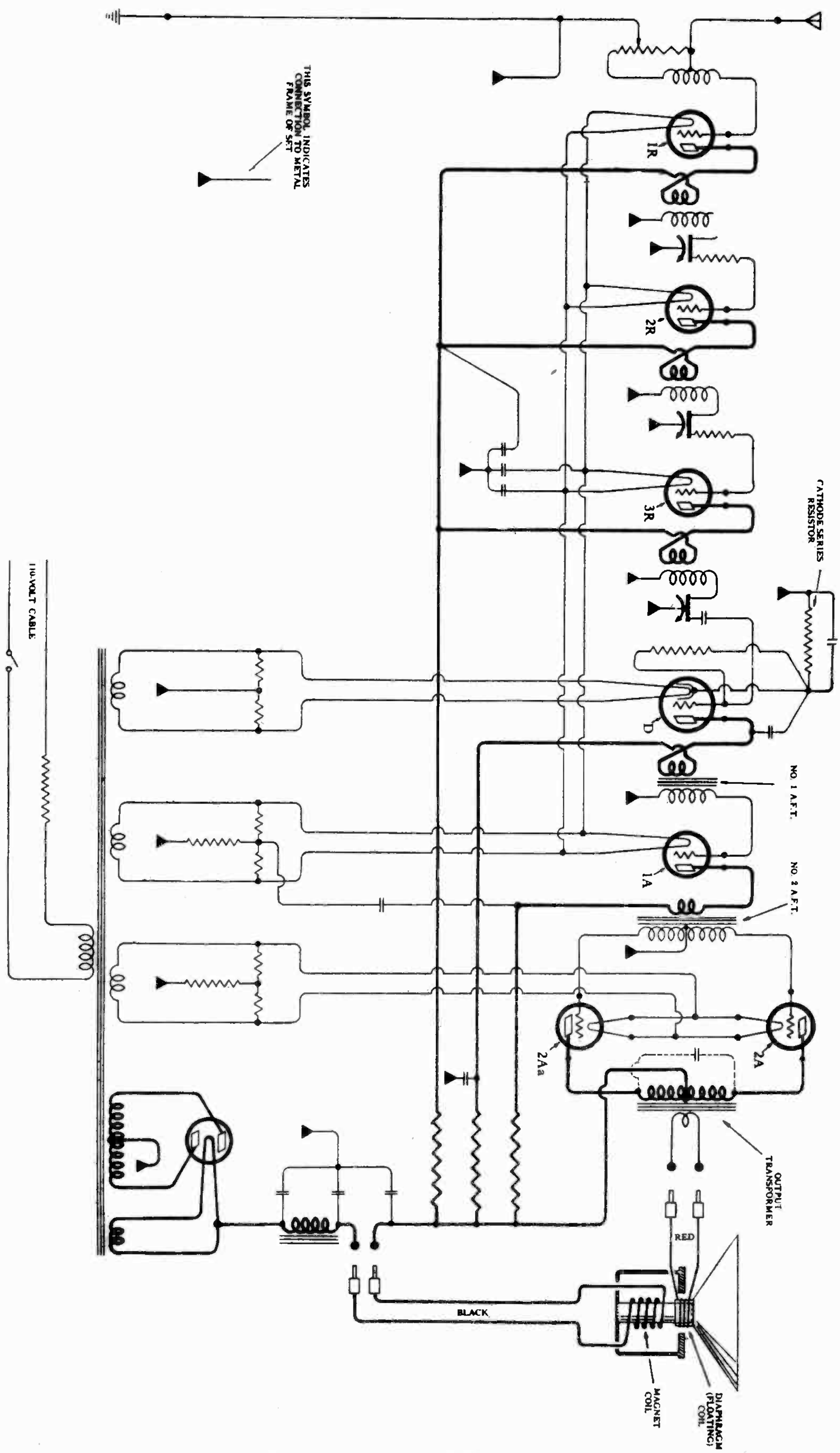
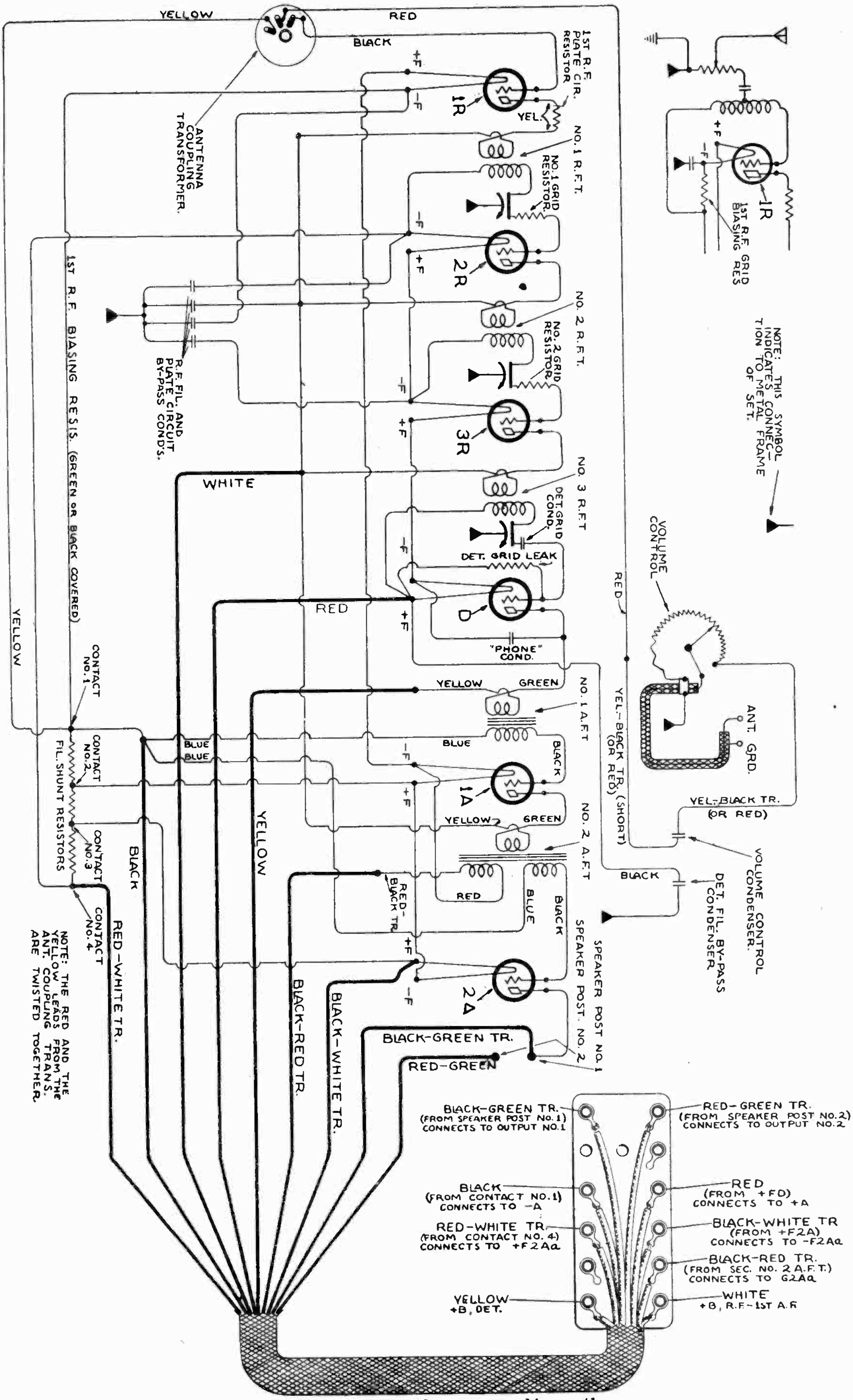
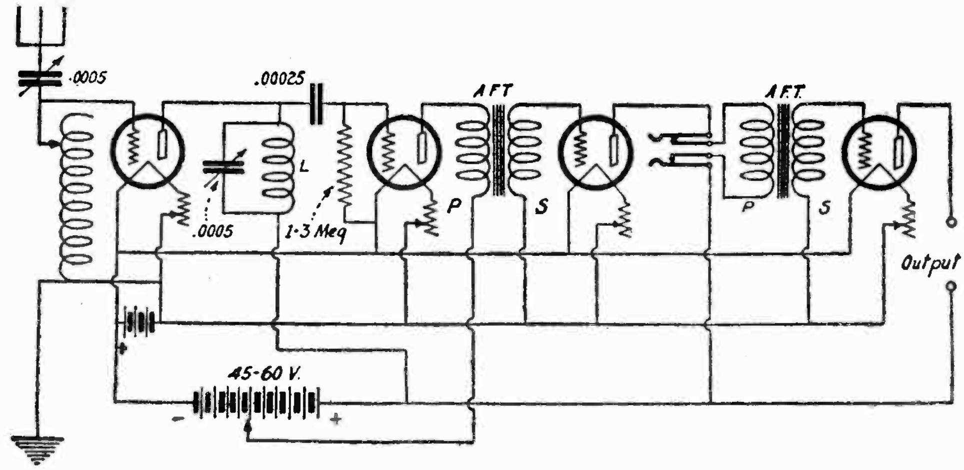


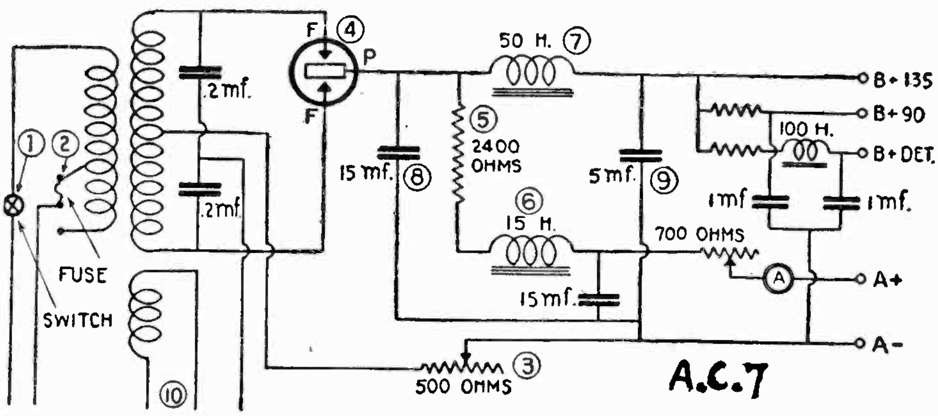
Diagram of Model 43 Set and Power Unit.
The output transformer is sealed in the power unit.



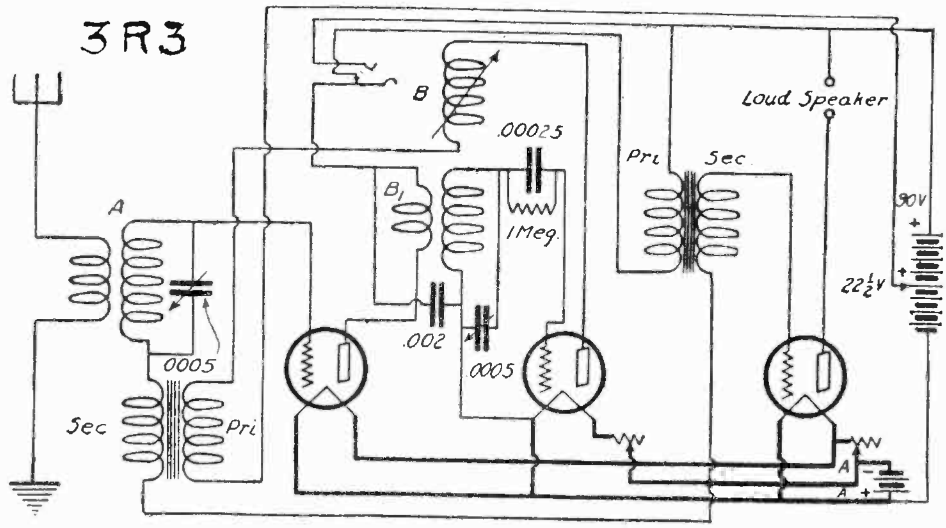
Wiring Diagram of Model 41.



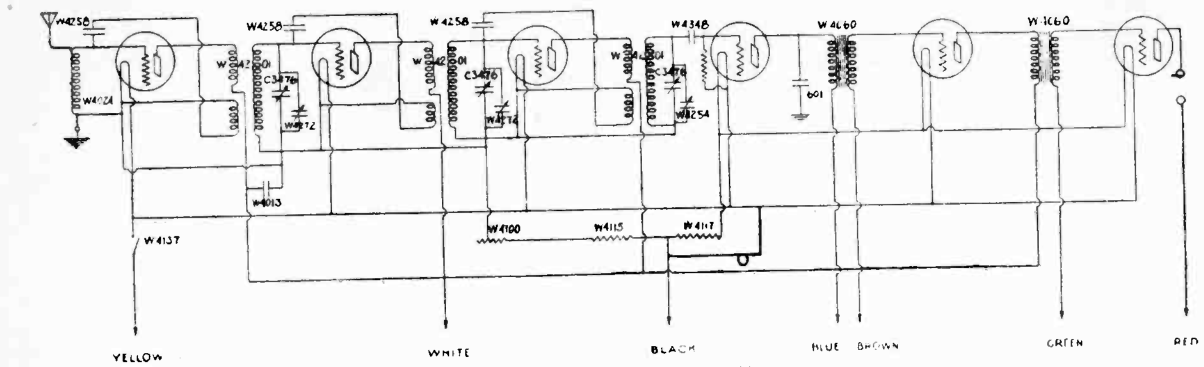
The Crosley XJ Receiver is Similar to the Well-Known Model X.



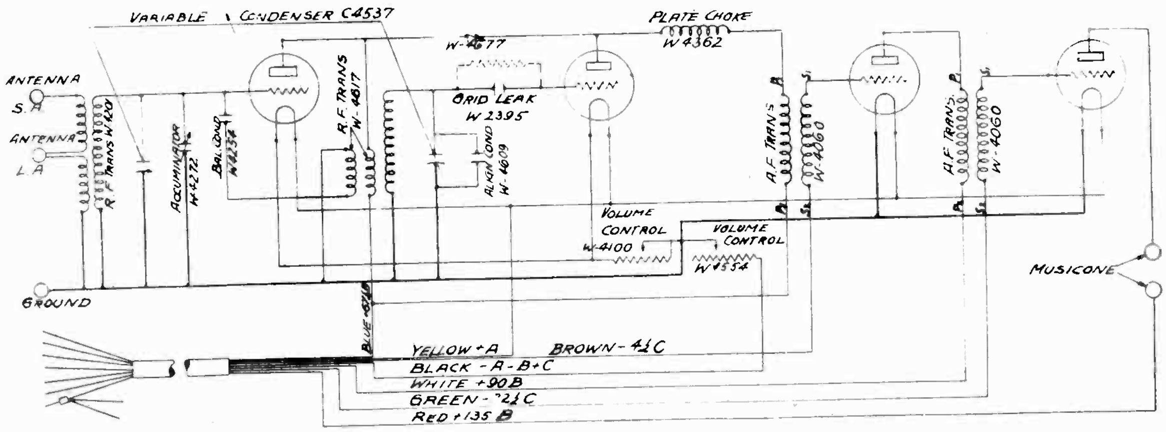
-Schematic diagram of the Crosley A.C. Power Unit.



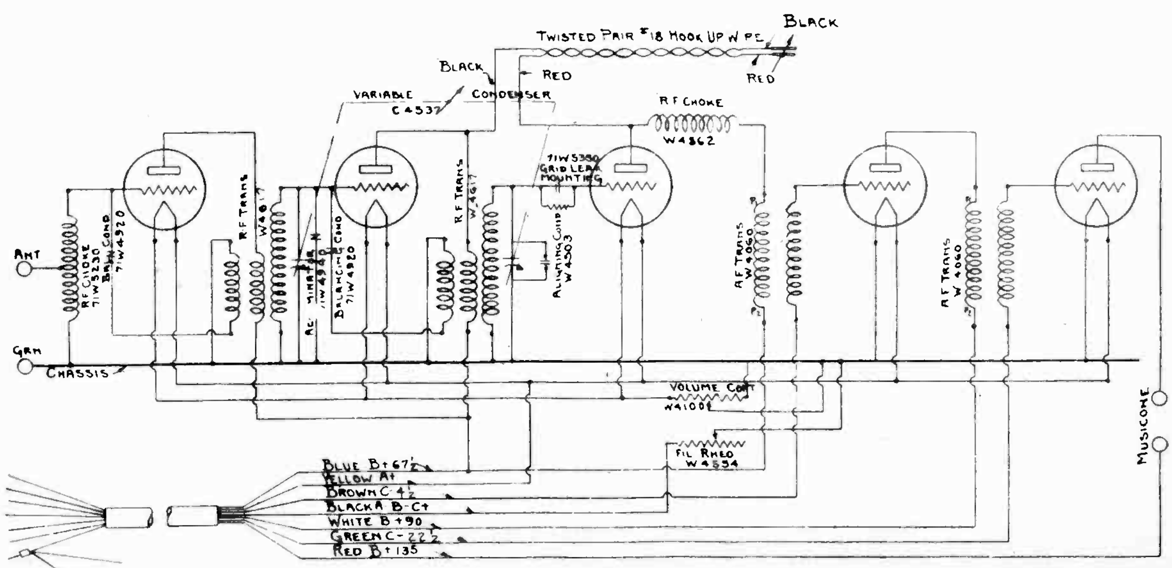
The 3-control Trirdyn circuit is capable of high amplification.



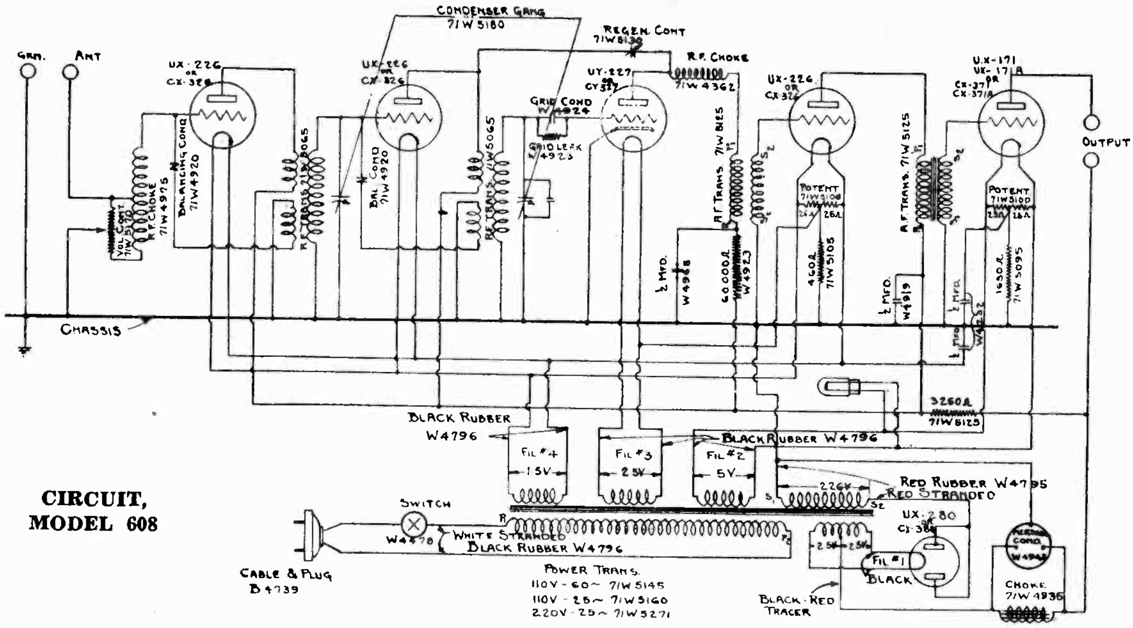
CIRCUIT OF MODEL 601



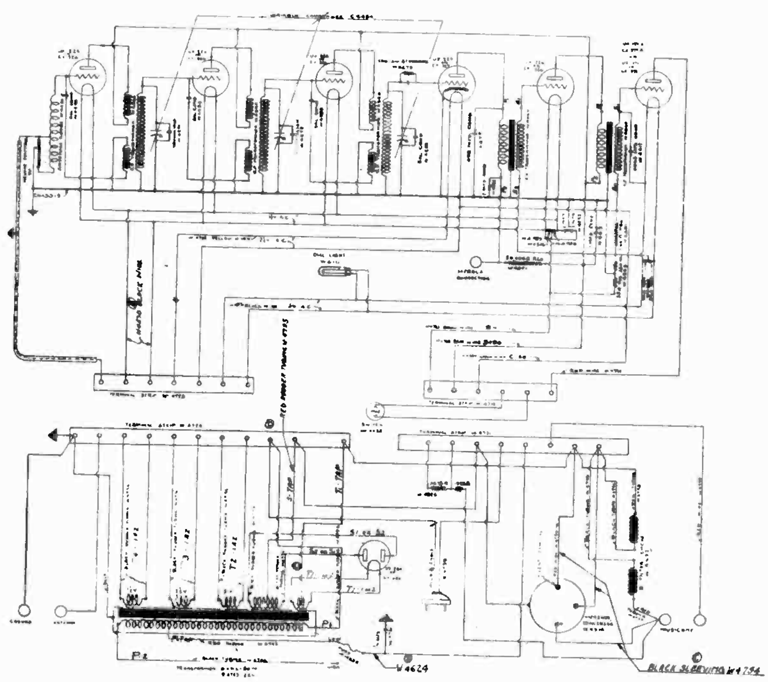
CIRCUIT, MODEL 401



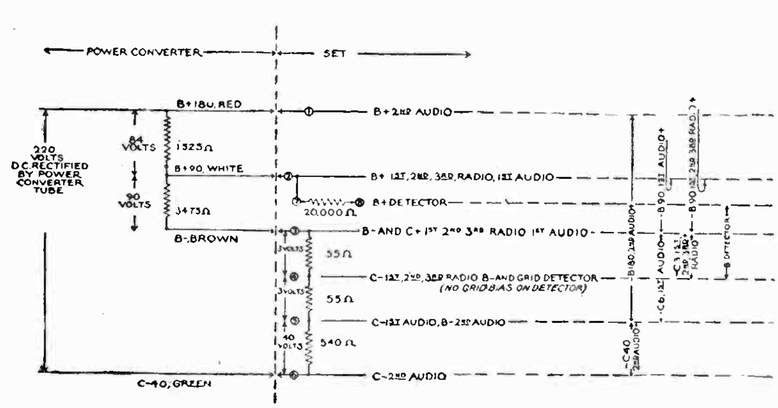
CIRCUIT, MODEL 401-A



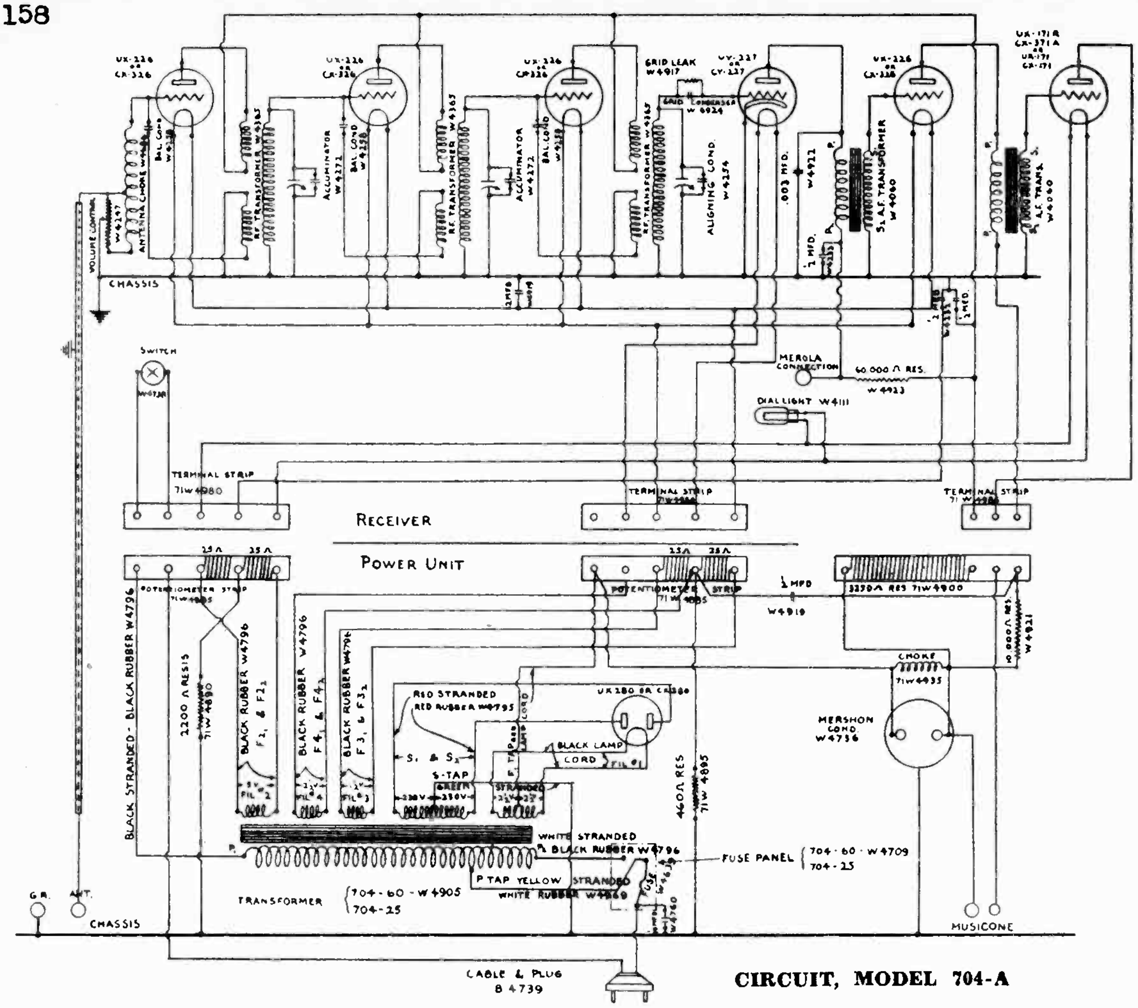
CIRCUIT, MODEL 608



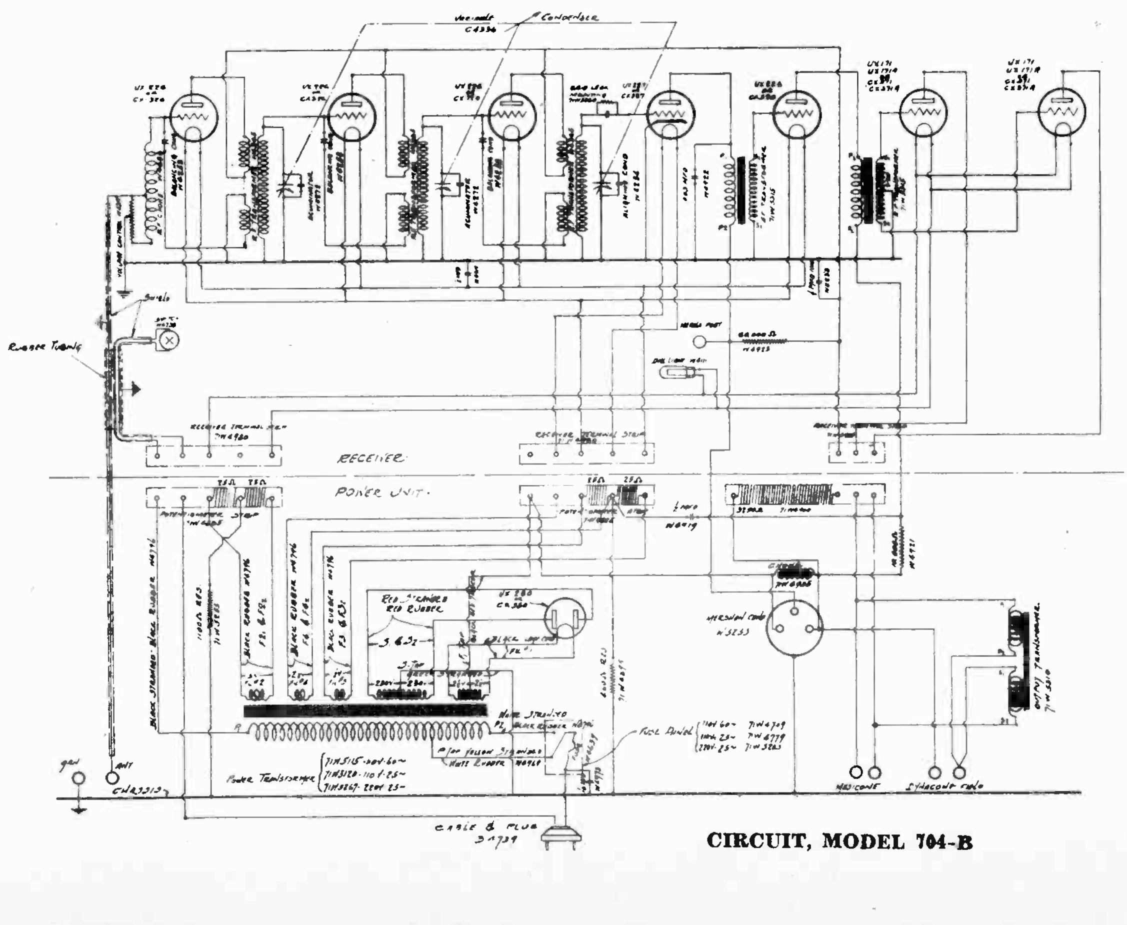
CIRCUIT, MODEL 704



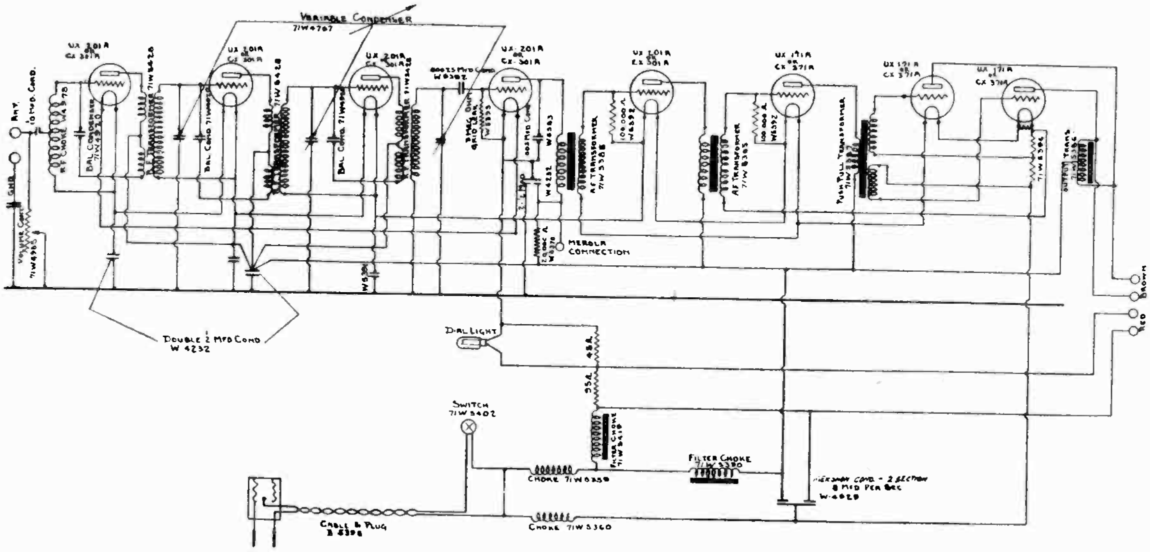
"B" AND "C" SUPPLY MODEL 704



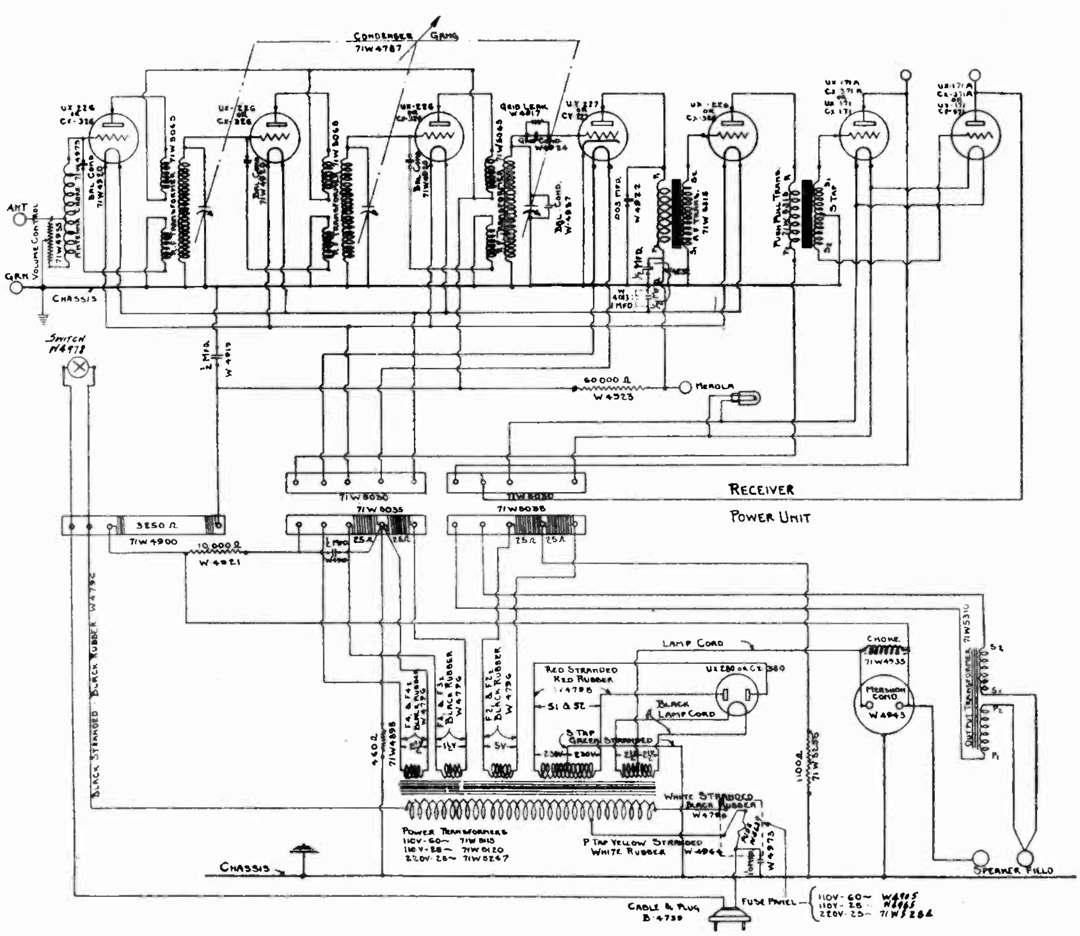
CIRCUIT, MODEL 704-A



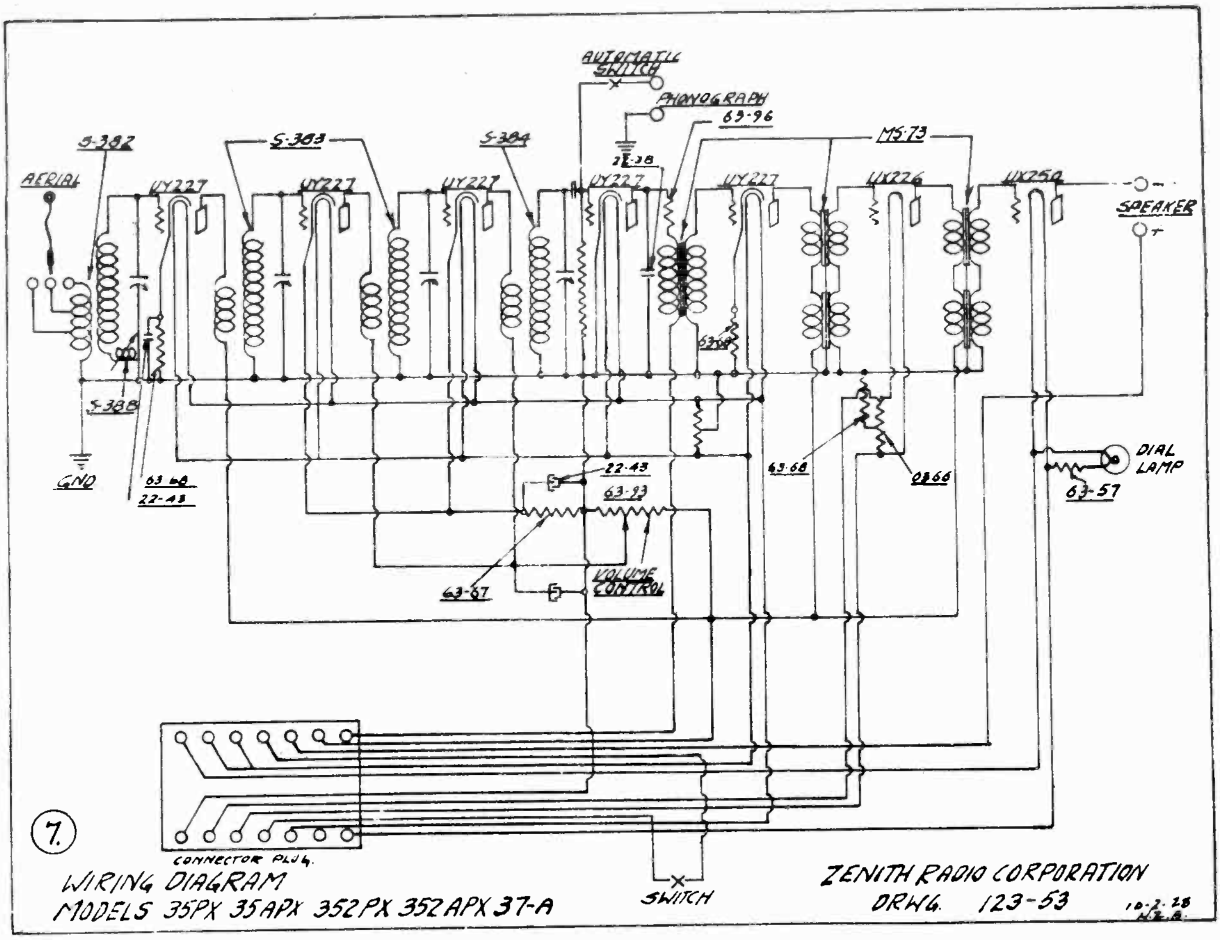
CIRCUIT, MODEL 704-B



CIRCUIT, MODEL 705

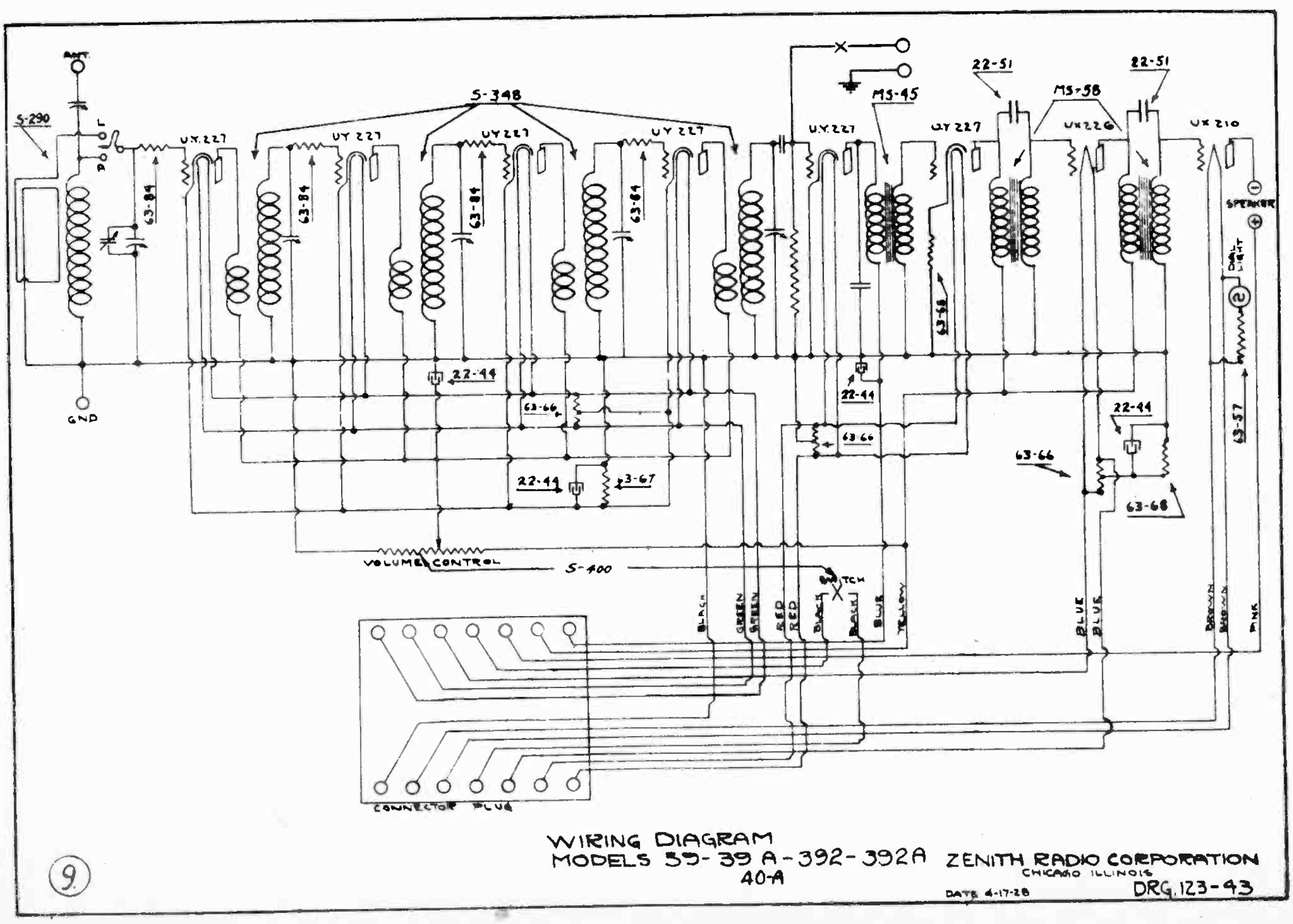


Crosley 706



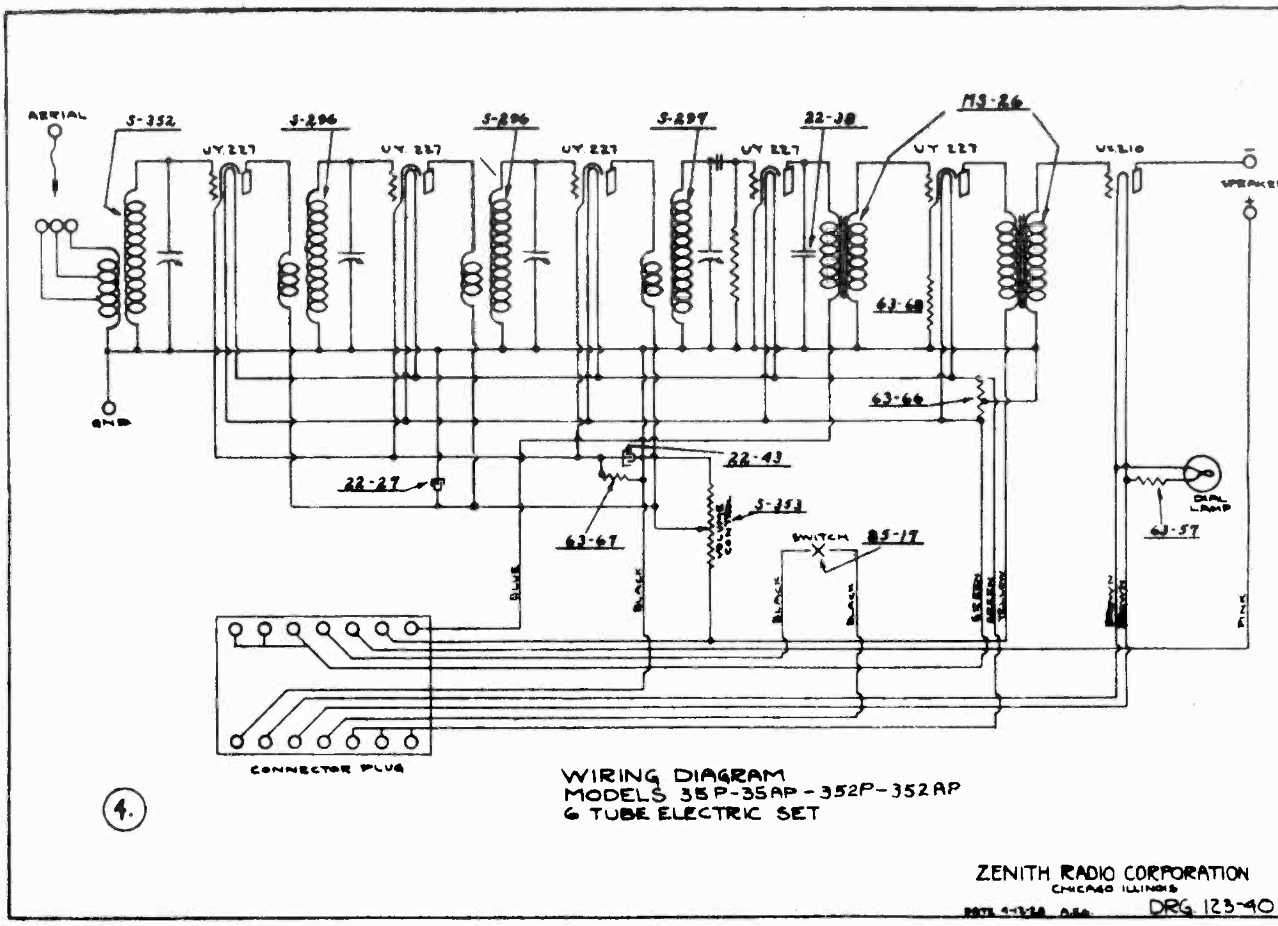
WIRING DIAGRAM
MODELS 35PX 35APX 352PX 352APX 37-A

ZENITH RADIO CORPORATION
DRWG. 123-53
10-2-28



WIRING DIAGRAM
MODELS 39-39 A-392-392A
40-A

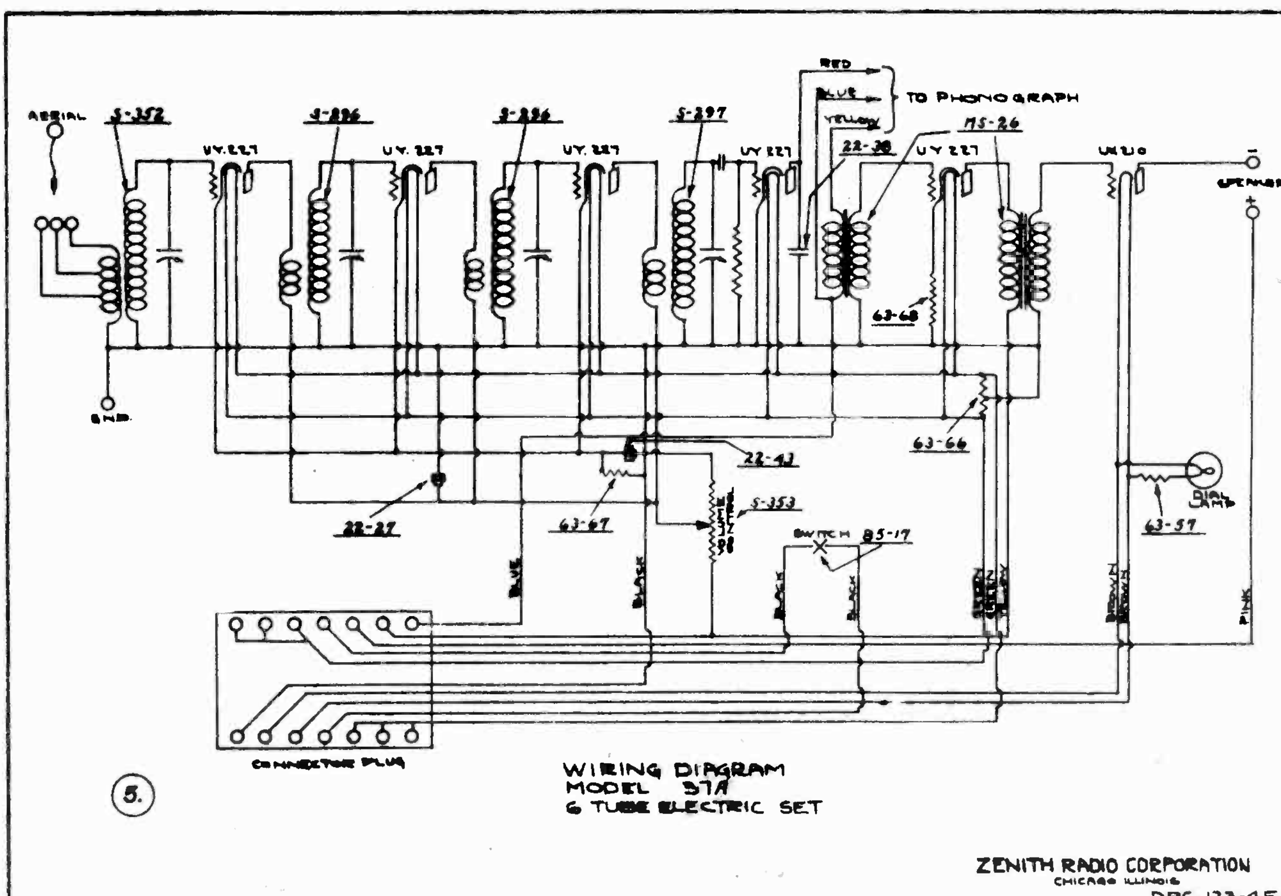
ZENITH RADIO CORPORATION
CHICAGO ILLINOIS
DATE 4-17-28
DRG. 123-43



(4.)

WIRING DIAGRAM
MODELS 35P-35AP-352P-352AP
6 TUBE ELECTRIC SET

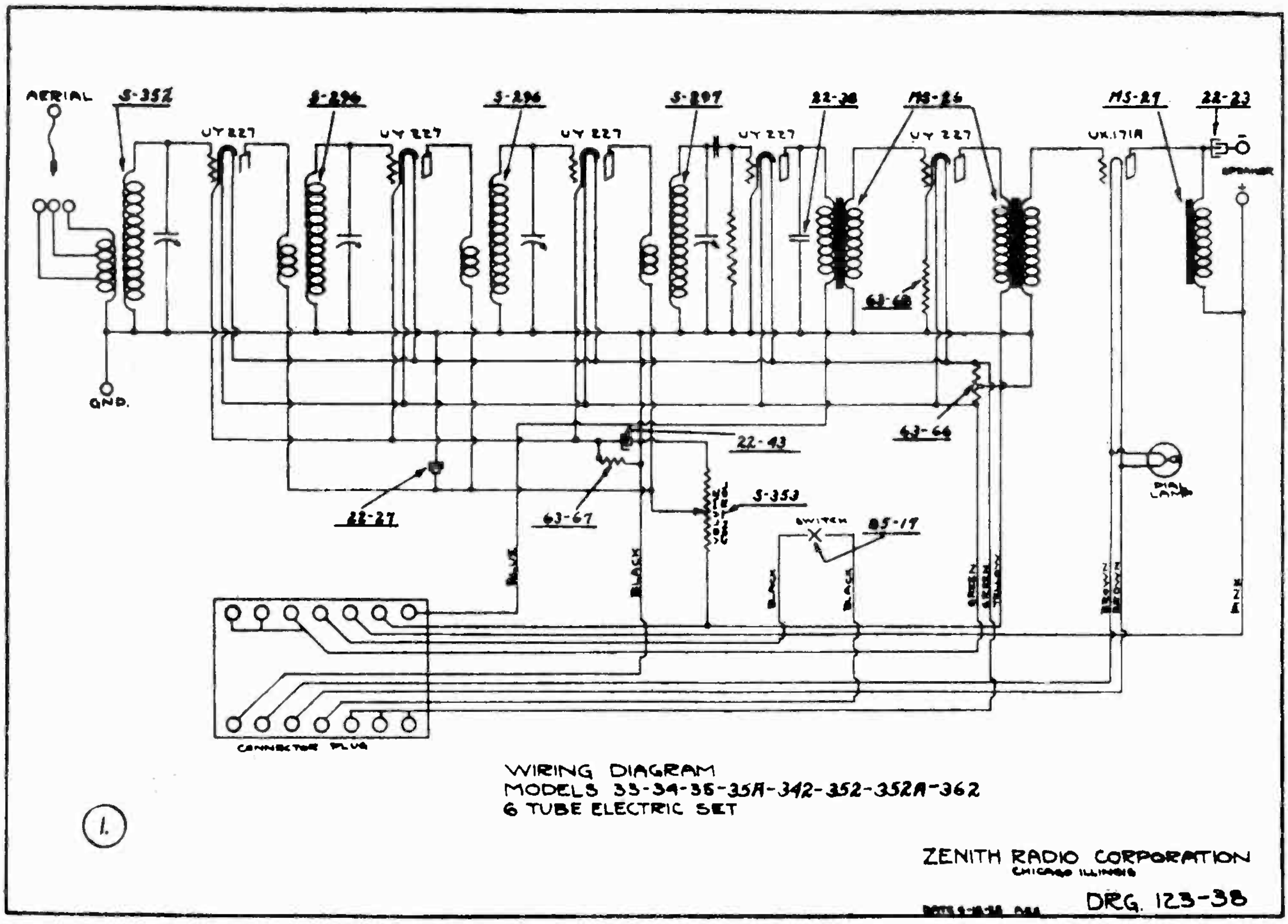
ZENITH RADIO CORPORATION
CHICAGO ILLINOIS
DRG. 123-40



(5.)

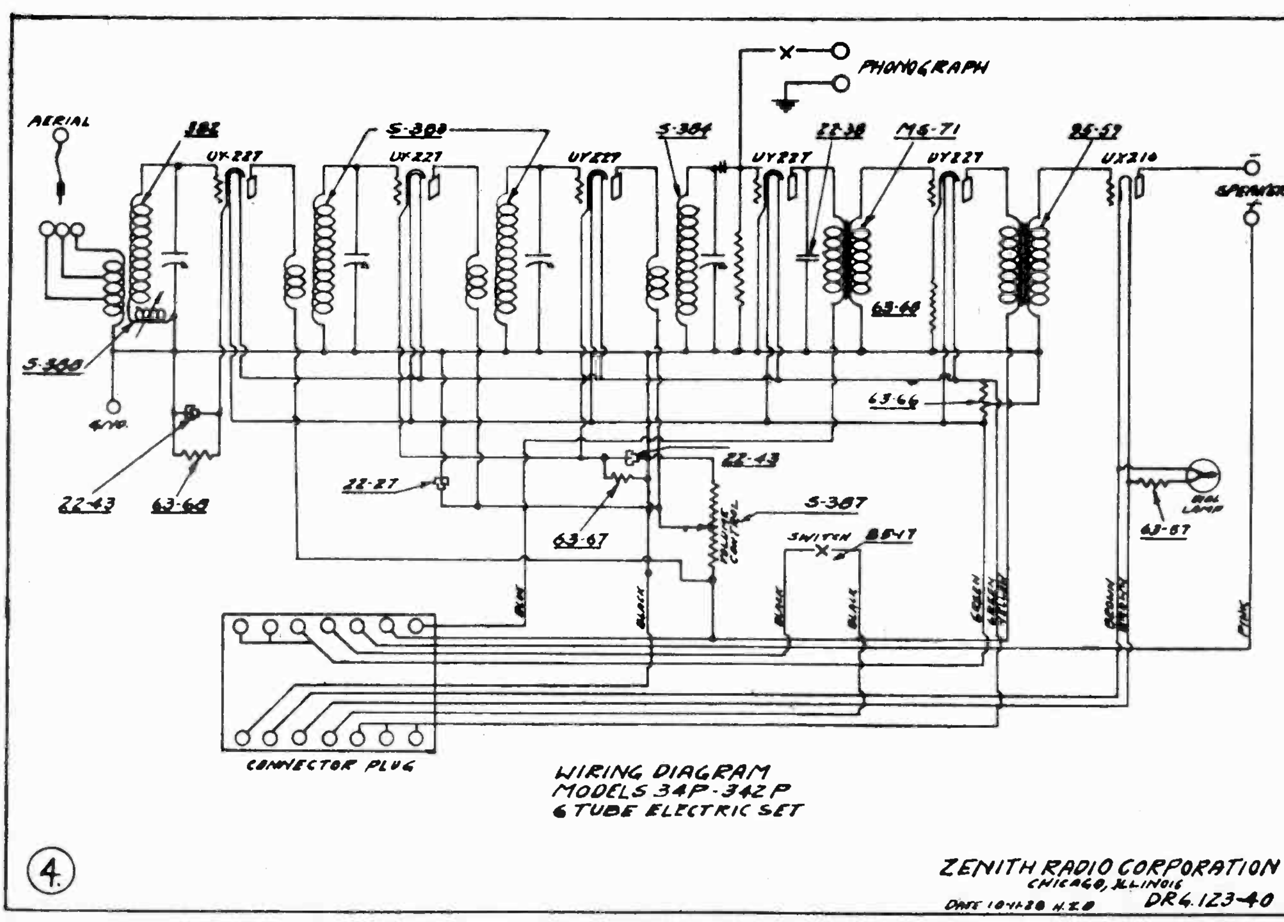
WIRING DIAGRAM
MODEL 37A
6 TUBE ELECTRIC SET

ZENITH RADIO CORPORATION
CHICAGO ILLINOIS
DRG. 123-45



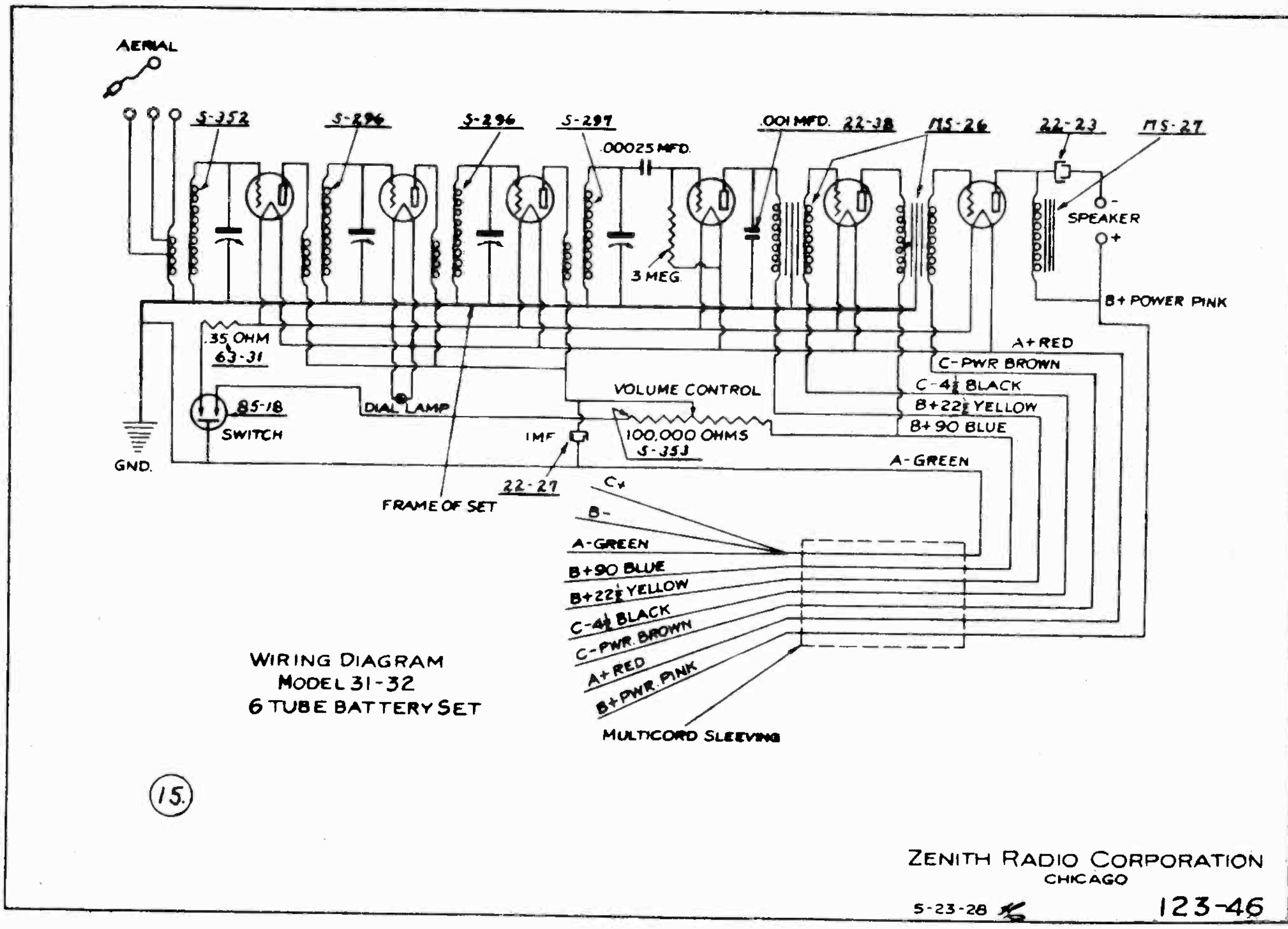
WIRING DIAGRAM
MODELS 33-34-35-35A-342-352-352A-362
6 TUBE ELECTRIC SET

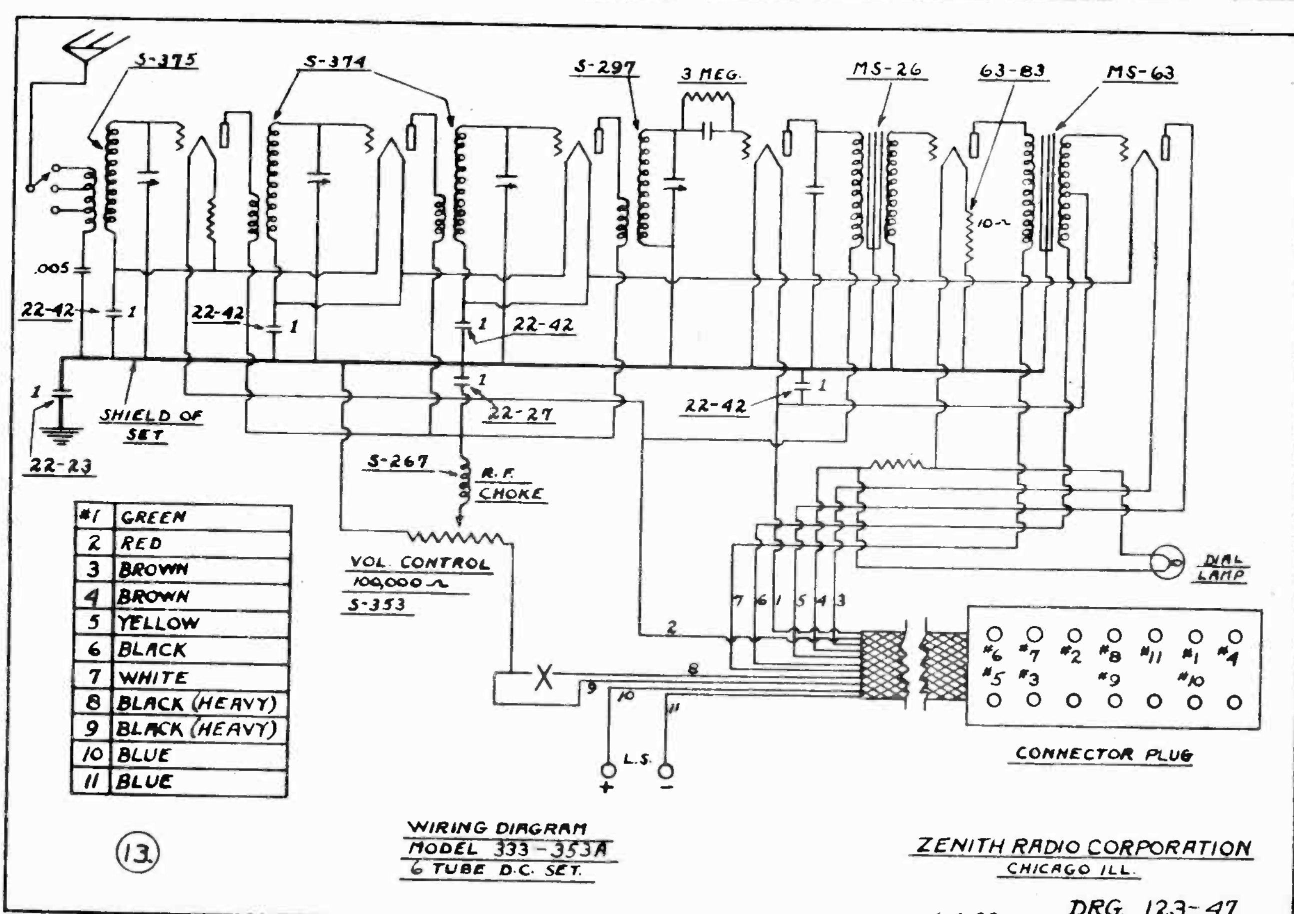
ZENITH RADIO CORPORATION
CHICAGO ILLINOIS
DRG. 123-38



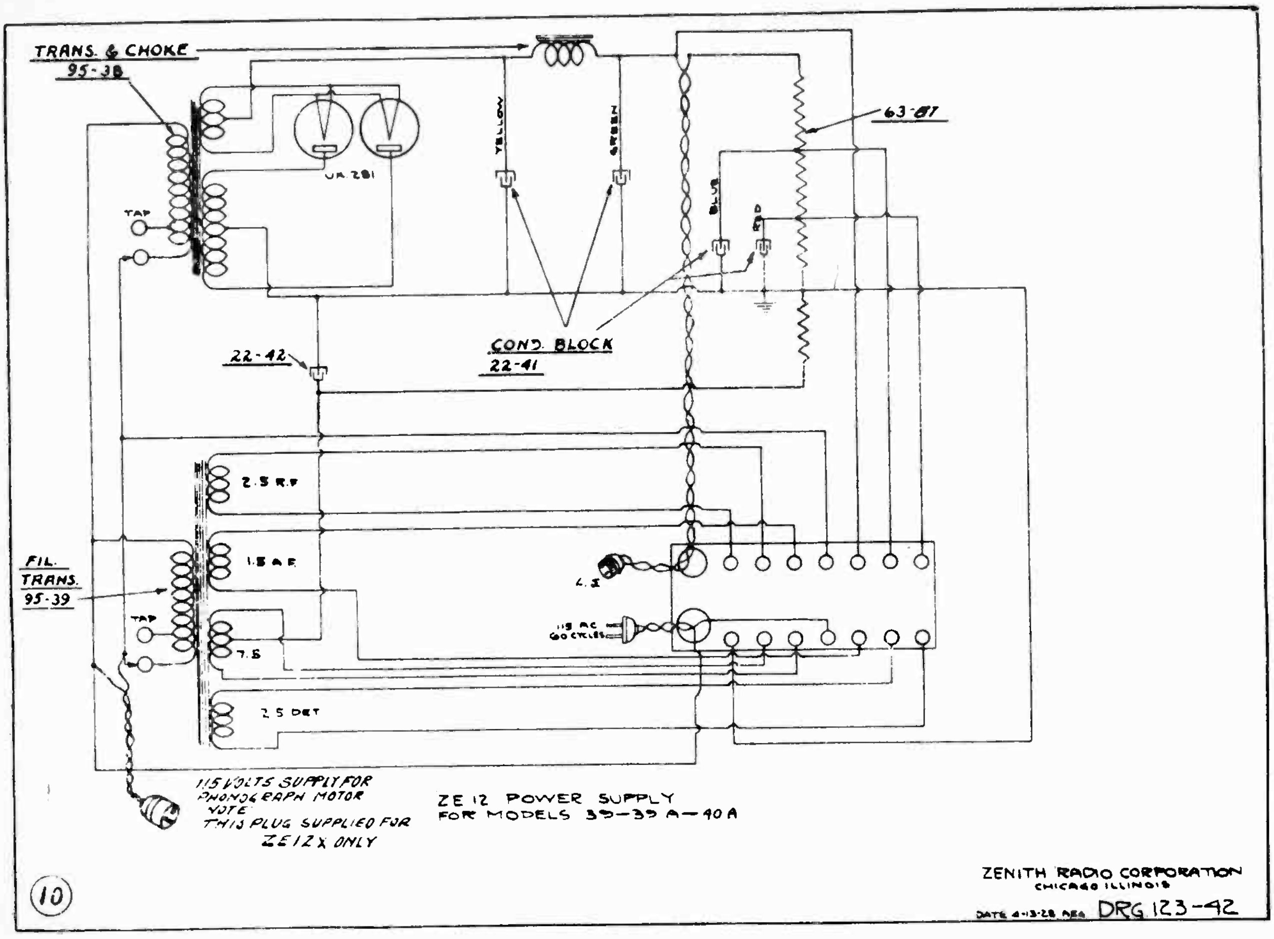
WIRING DIAGRAM
MODELS 34P-342P
6 TUBE ELECTRIC SET

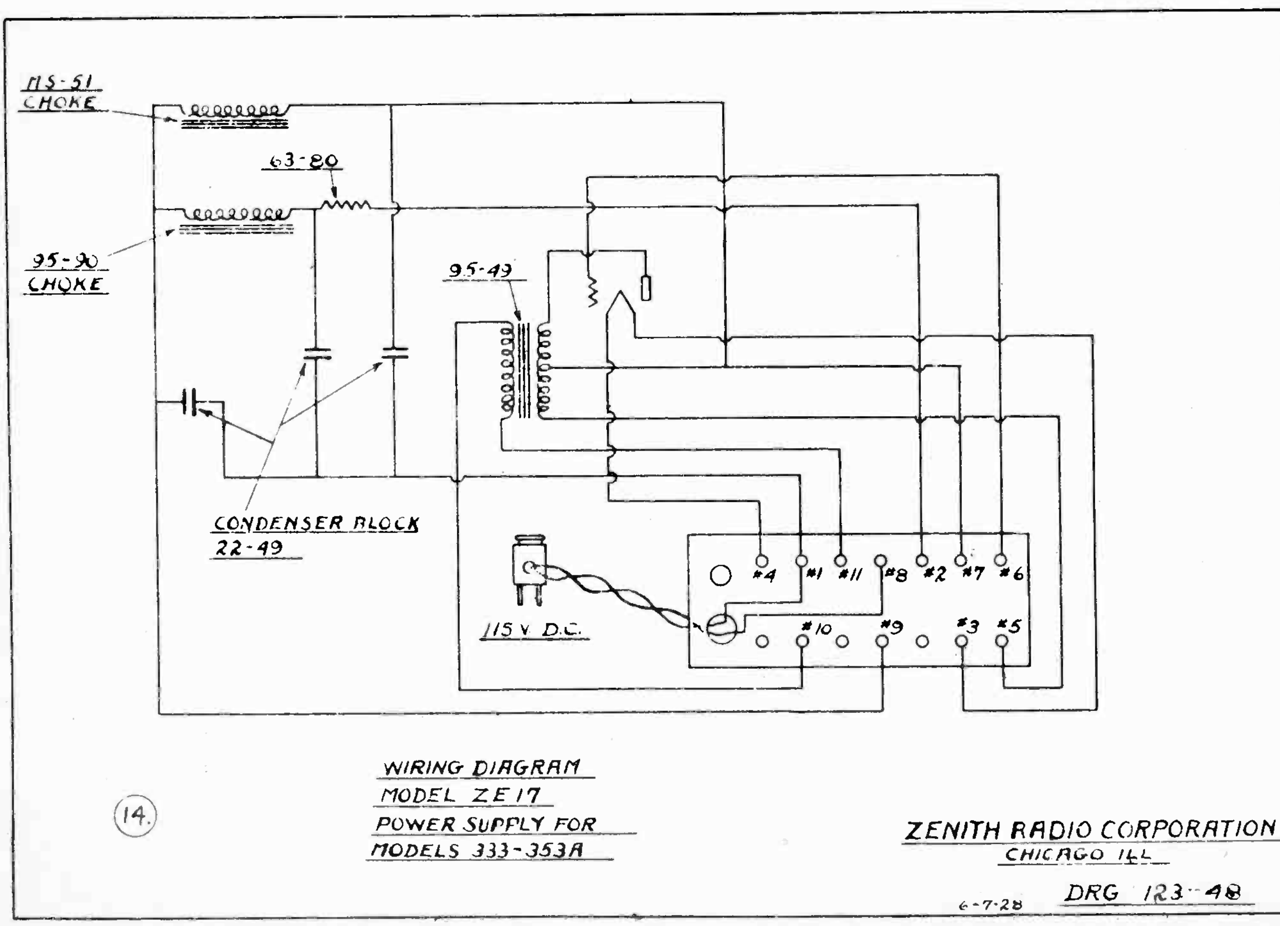
ZENITH RADIO CORPORATION
CHICAGO, ILLINOIS
DATE 10-4-28 H.Z.B
DRG. 123-40



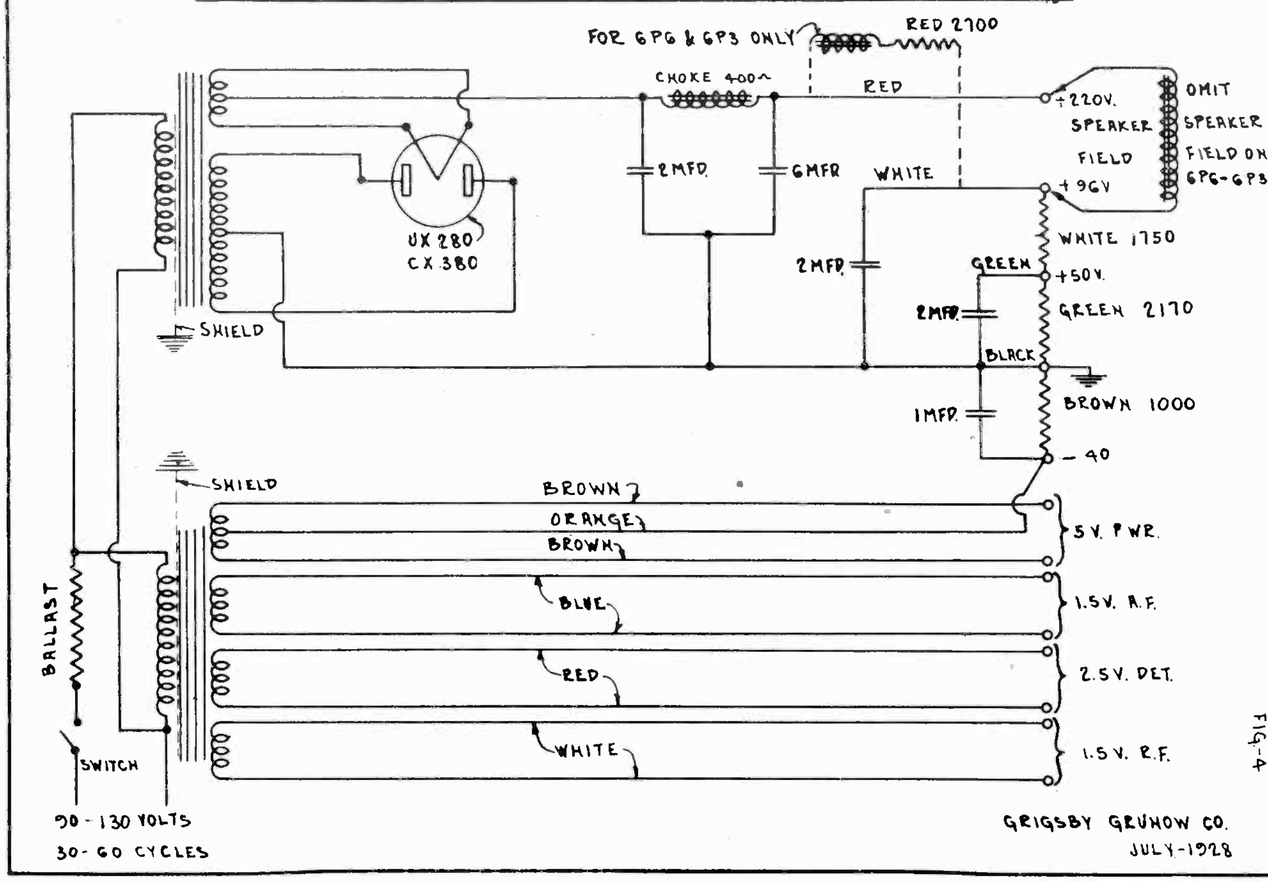


#1	GREEN
2	RED
3	BROWN
4	BROWN
5	YELLOW
6	BLACK
7	WHITE
8	BLACK (HEAVY)
9	BLACK (HEAVY)
10	BLUE
11	BLUE


TRANS. & CHOKE
95-38
UX 281
YELLOW
GREEN
63-87
BLUE
RED
TAP
22-42
COND. BLOCK
22-41
2.5 R.F
1.5 A.F
7.5
2.5 DET
FIL.
TRANS.
95-39
TAP
115 AC
60 CYCLES
115 VOLTS SUPPLY FOR
PHONOGRAPH MOTOR
NOTE
THIS PLUG SUPPLIED FOR
ZE12X ONLY
ZE 12 POWER SUPPLY
FOR MODELS 35—35 A—40 A
ZENITH RADIO CORPORATION
CHICAGO ILLINOIS
DRG 123-42
(10)

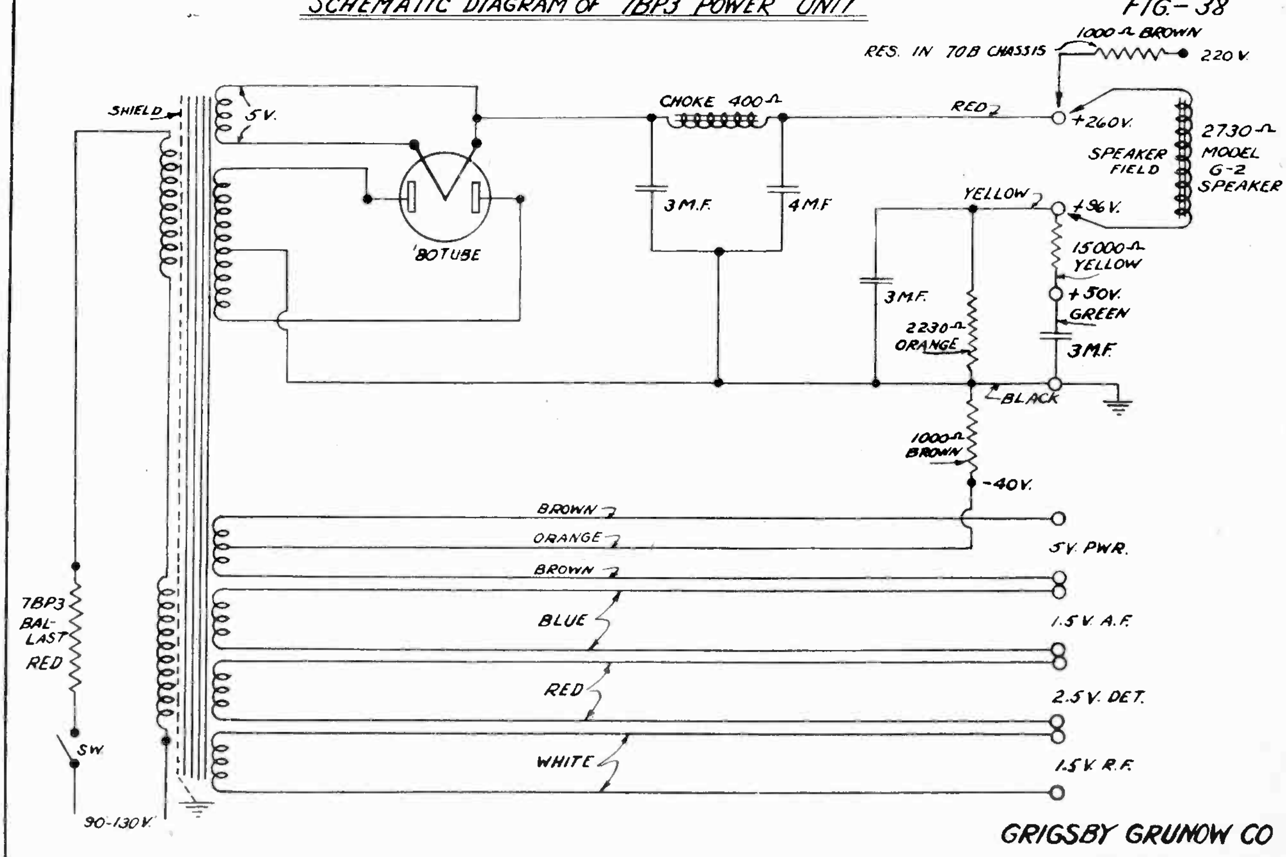

MS-51
CHOKE
63-80
95-90
CHOKE
95-49
CONDENSER BLOCK
22-49
115 V D.C.
#4
#1
#11
#8
#2
#7
#6
#10
#9
#3
#5
WIRING DIAGRAM
MODEL ZE17
POWER SUPPLY FOR
MODELS 333-353A
(14)
ZENITH RADIO CORPORATION
CHICAGO ILL
6-7-28
DRG 123-48

SCHEMATIC DIAGRAM OF 7P6-7P3 POWER PACK (OLD WIRING)



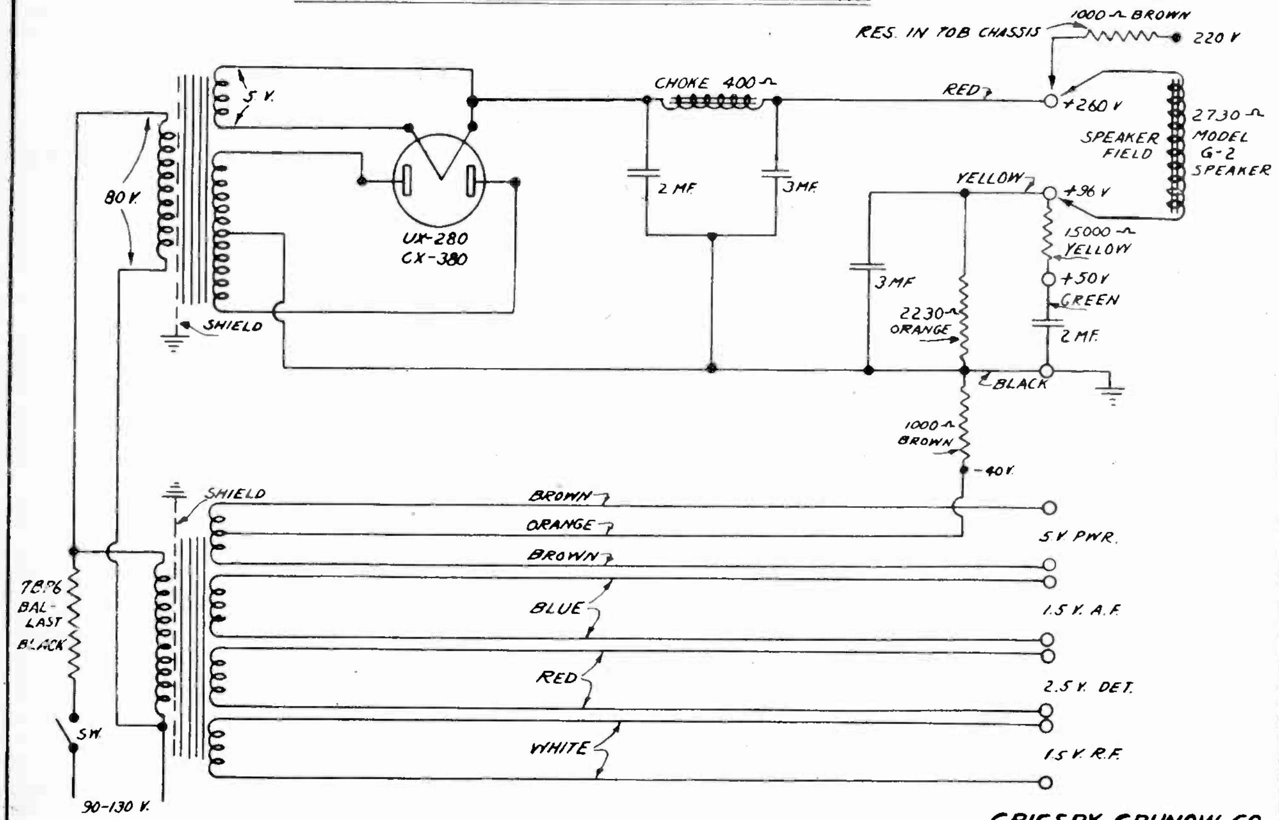
SCHEMATIC DIAGRAM OF 7BP3 POWER UNIT

FIG.-38



SCHEMATIC DIAGRAM OF 7BP6 POWER UNIT

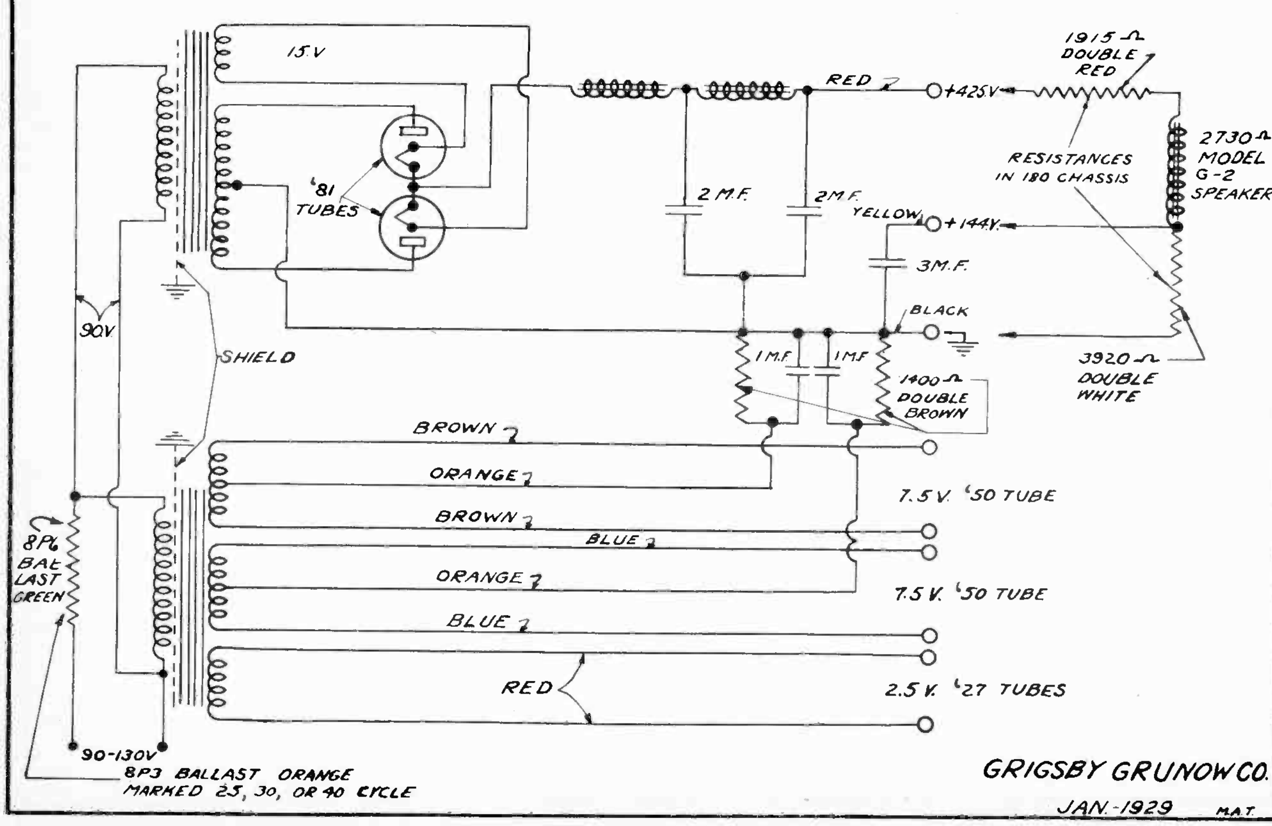
FIG. 27



GRIGSBY GRUNOW CO.
JAN.-1929 T.W. JR.

SCHEMATIC DIAGRAM OF 8P6 & 8P3 POWER UNITS

FIG.-31.



GRIGSBY GRUNOW CO.
JAN.-1929 M.A.T.

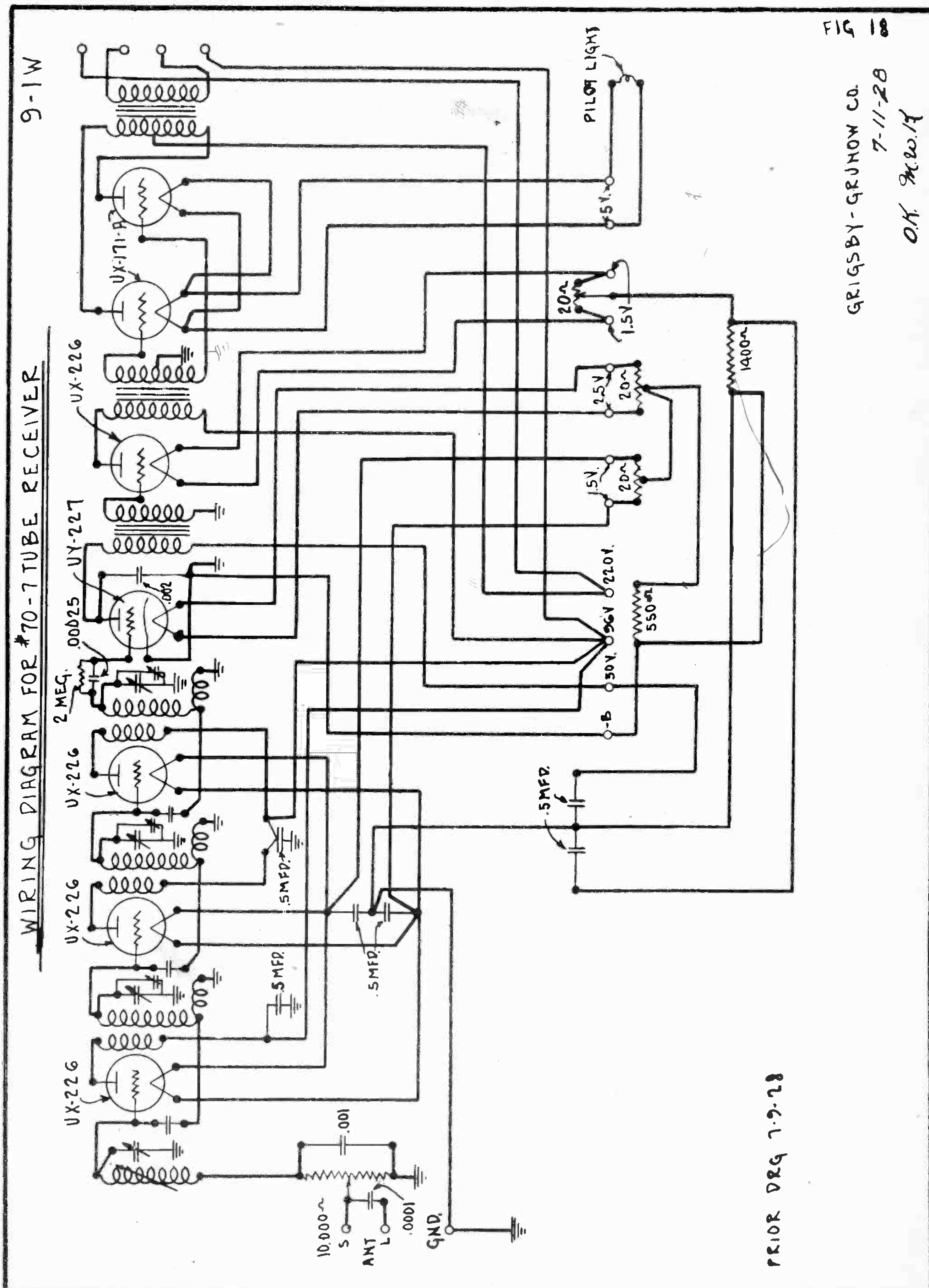
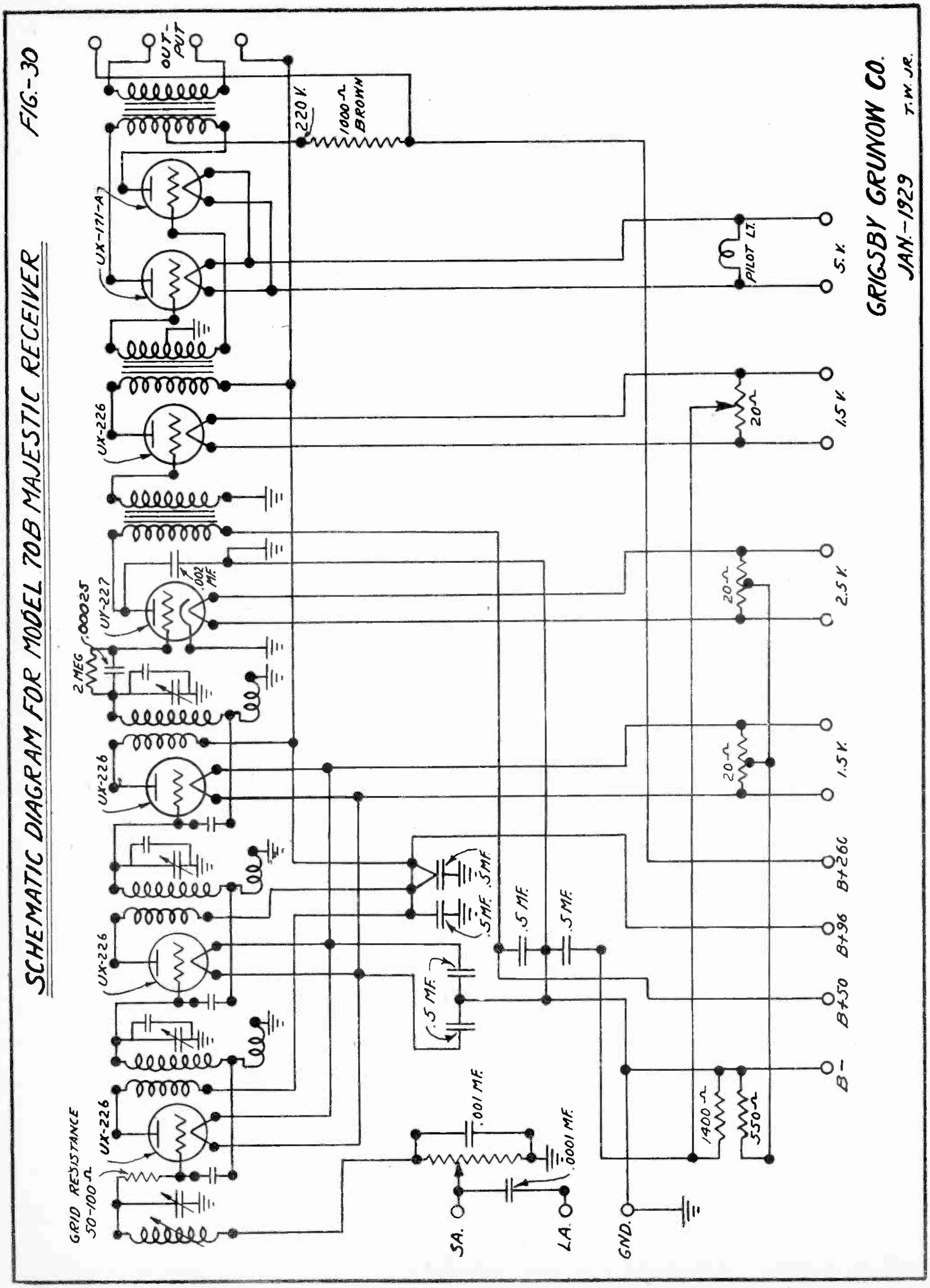
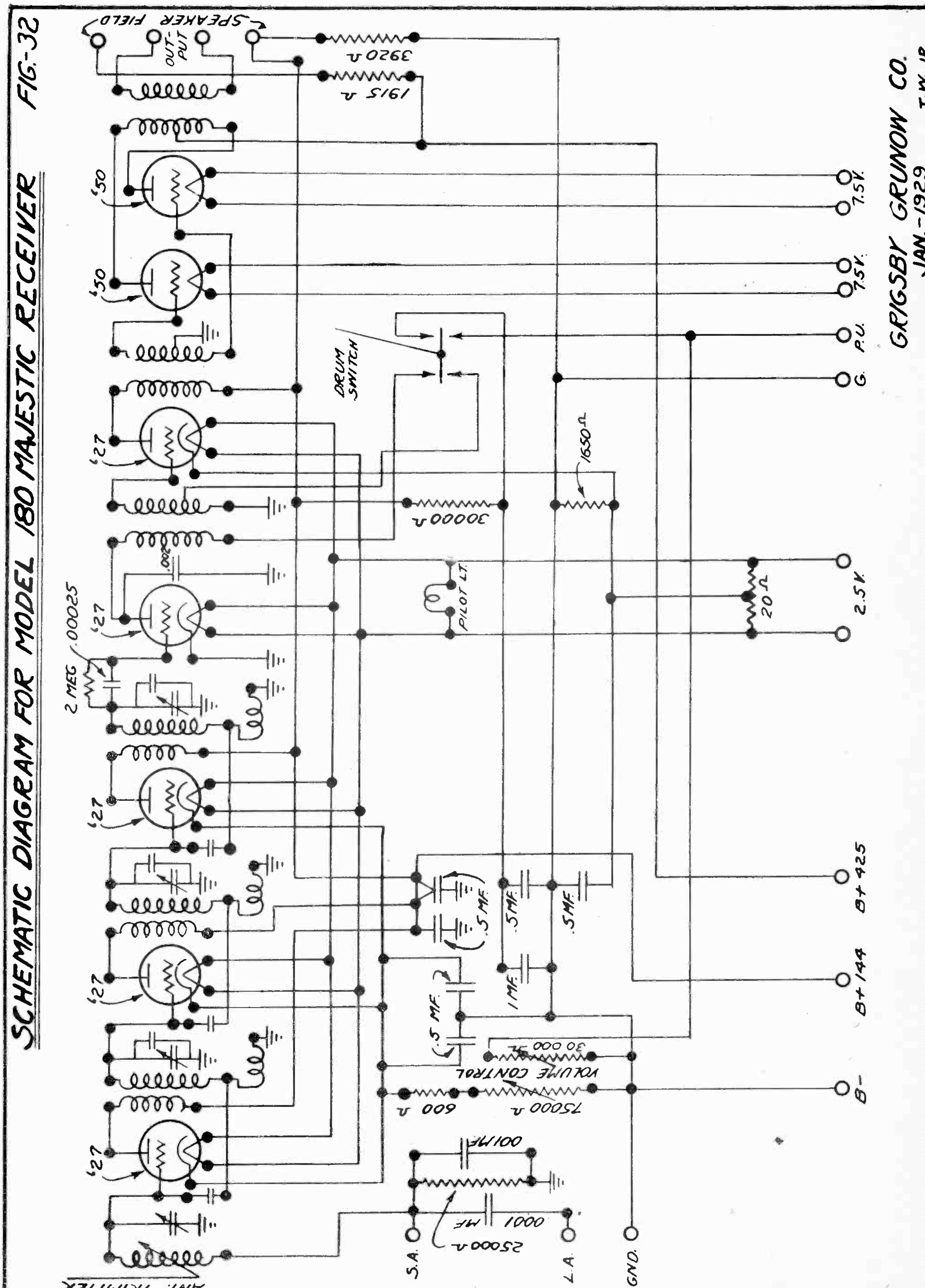


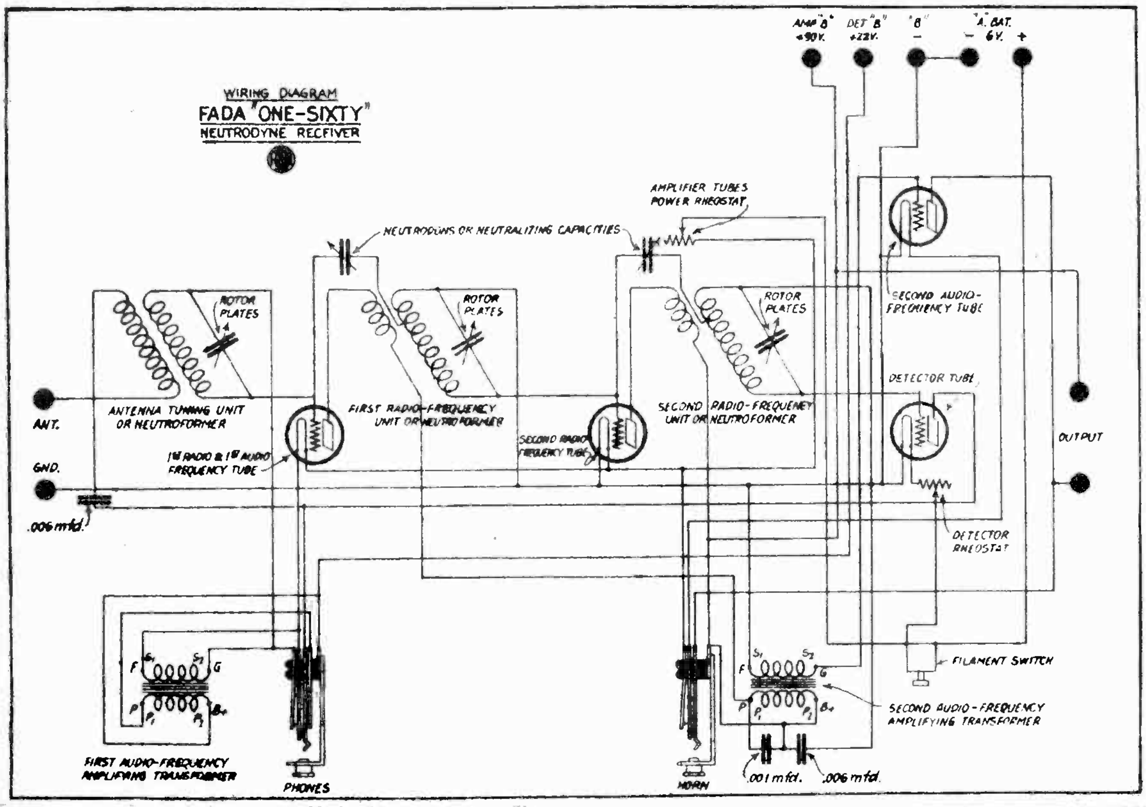
FIG 18
9-1W
WIRING DIAGRAM FOR #70-7 TUBE RECEIVER
GRIGSBY-GRUNOW CO.
7-11-28
O.K.
PILOT LIGHTS
UX-171-A
UX-226
UY-227
UX-226
UX-226
UX-226
.00025
.002
2 MEG.
.5MFD.
.5MFD.
.5MFD.
.5MFD.
.001
.0001
10,000~
S
ANT
L
GND.
5V.
20~
1.5V
2.5V
20~
1.5V
20~
1400~
220V.
96V.
550~
30V.
-B
PRIOR DRG 7-9-28

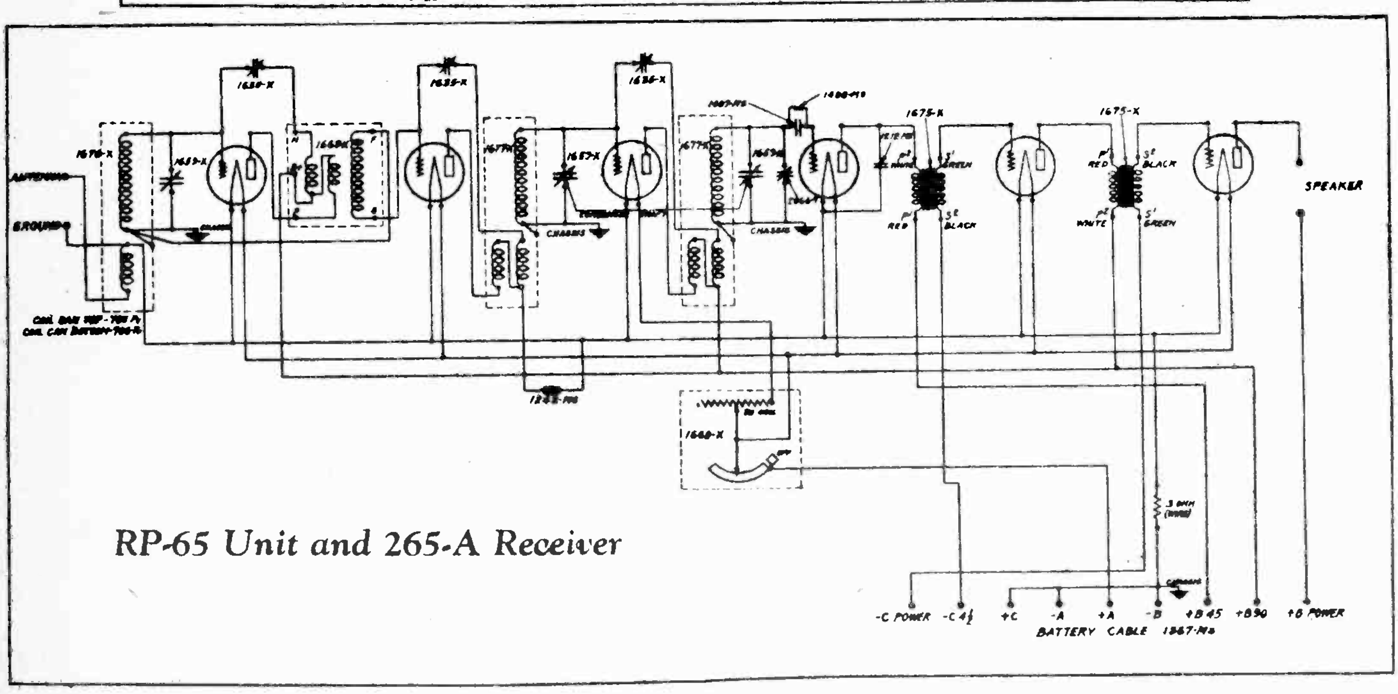


SCHEMATIC DIAGRAM FOR MODEL 70B MAJESTIC RECEIVER

FIG.-30


SCHEMATIC DIAGRAM FOR MODEL 180 MAJESTIC RECEIVER
FIG-32
SPEAKER FIELD
OUT-PUT
3920 Ω
1915 Ω
'50
'50
'27
'27
'27
'27
'27
DRUM SWITCH
1650 Ω
30000 Ω
PILOT LT.
20 Ω
2 MEG
.00025
.5 MF.
.5 MF
.5 MF
1 MF.
.5 MF.
30 000 Ω
VOLUME CONTROL
600 Ω
75000 Ω
.001 MF
.0001 MF
25000 Ω
ANT. TRIMMER
S.A.
L.A.
GND.
B-
B+144
B+425
G.
P.U.
7.5V.
7.5V.
2.5V.
GRIGSBY GRUNOW CO.
JAN.-1929
T.W. JR.





RP-65 Unit and 265-A Receiver

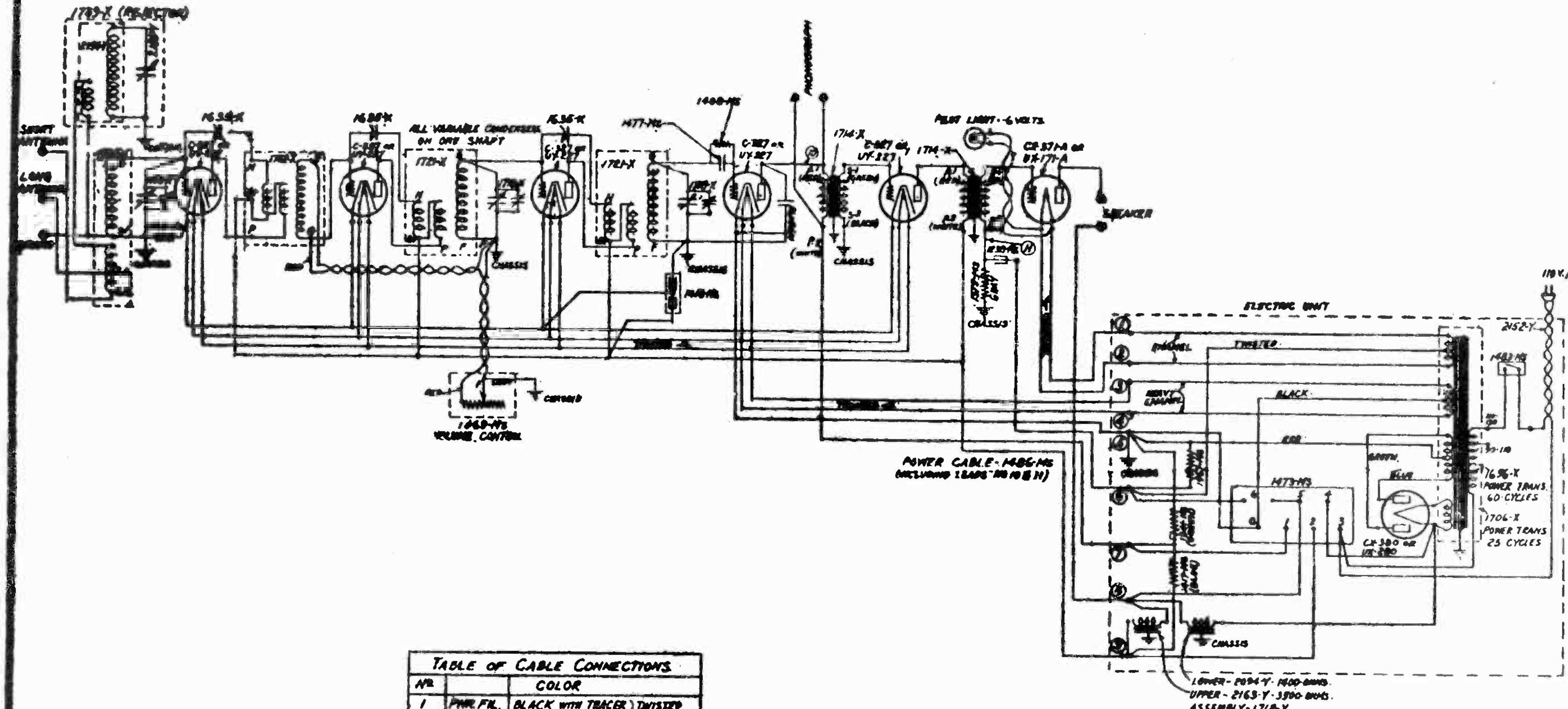
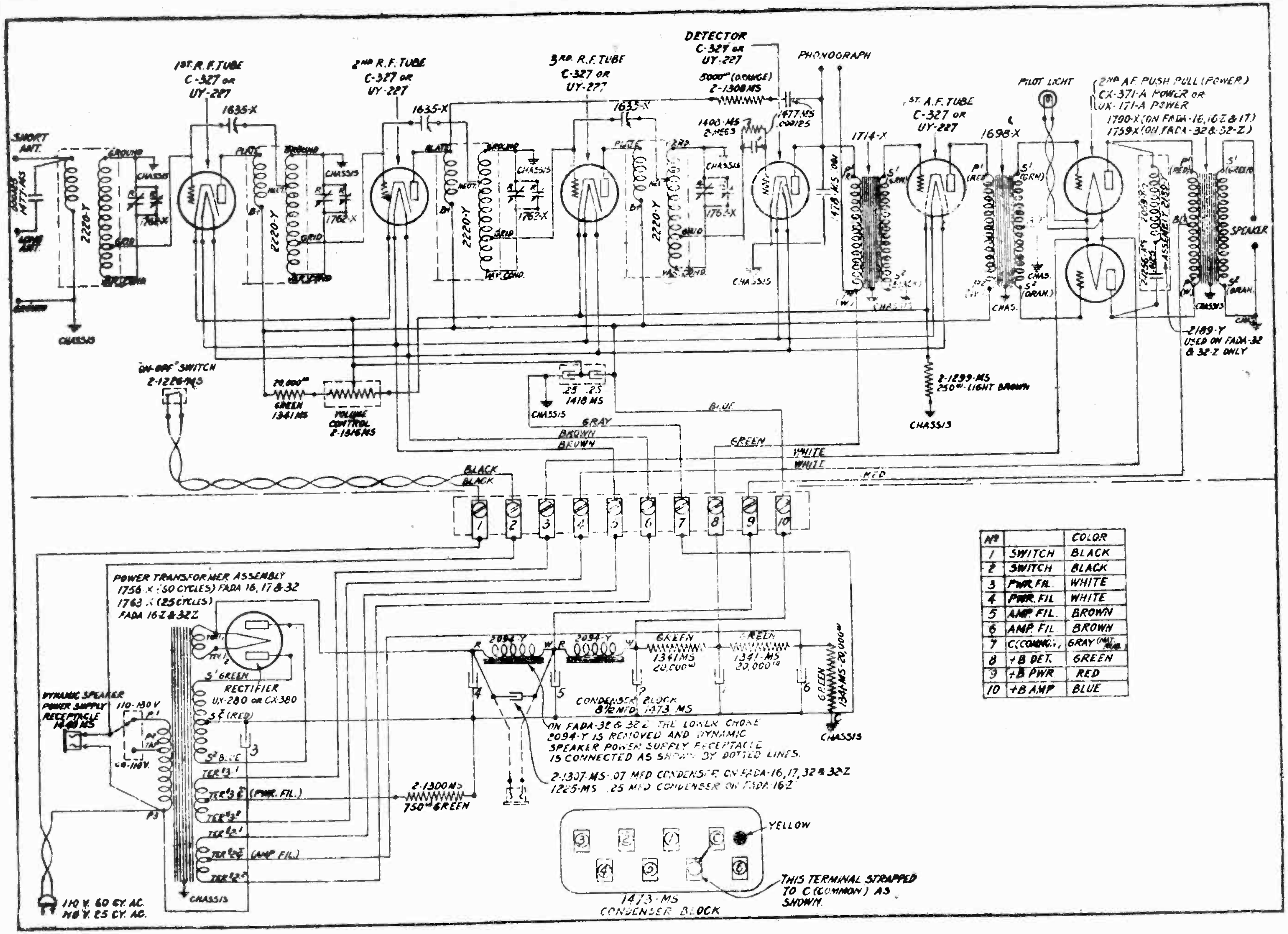


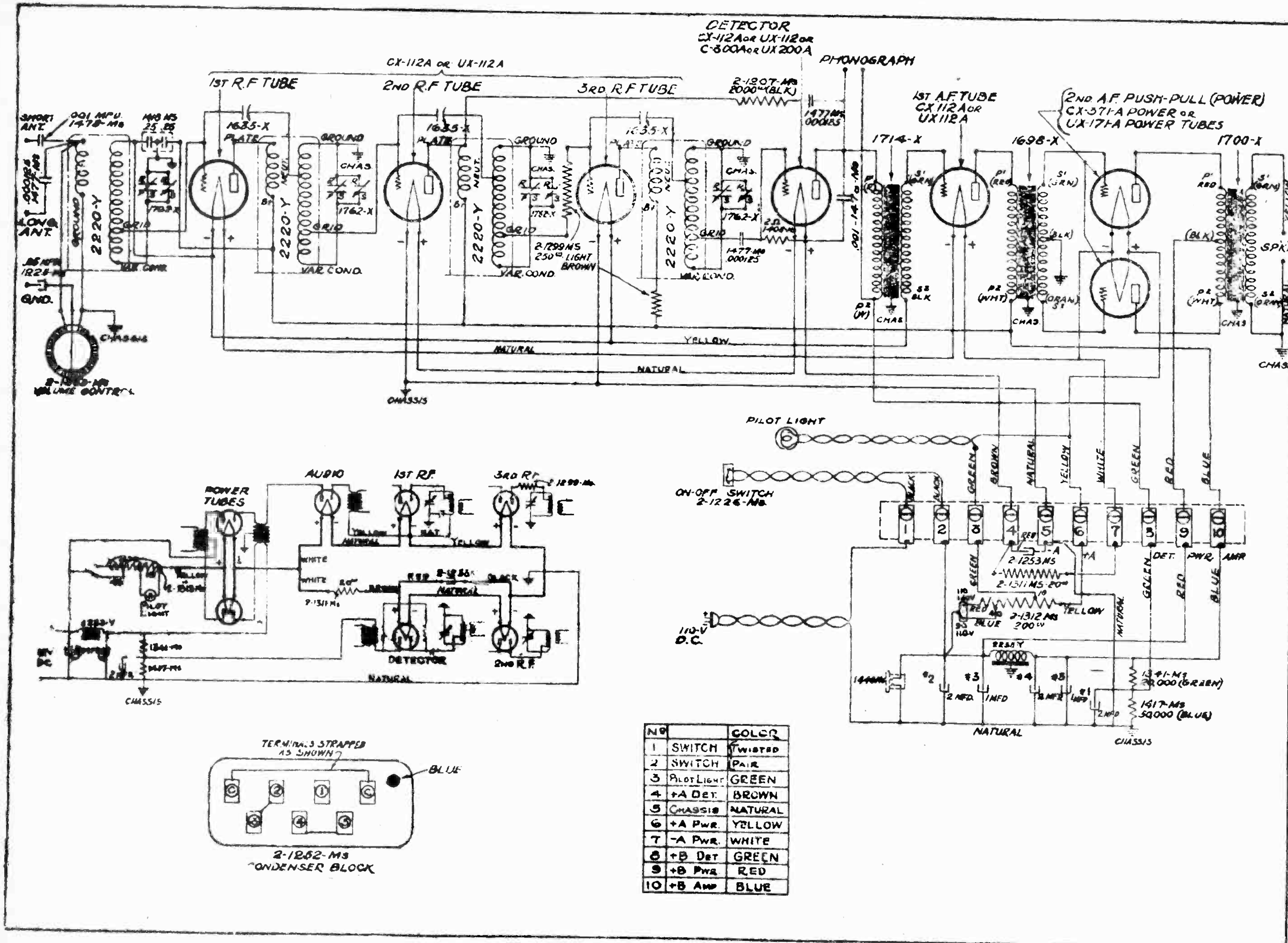
TABLE OF CABLE CONNECTIONS

NO		COLOR	
1	PWR. FIL.	BLACK WITH TRACER	TWISTED PAIR
2	PWR. FIL.	BLACK " "	
3	AMP. FIL.	BLACK " "	TWISTED PAIR
4	AMP. FIL.	BLACK " "	
5	C (COMMON)	GREEN	
6	C PWR	BROWN WITH WIDE GREEN TRACER	
7	+B DET.	MAROON	
8	+B PWR.	RED	
9	+B	RED WITH WIDE BLACK TRACER	
10		BLACK	
11		BLACK	

Fada 10, 11, 30 and 31 Receivers—60 cycles
Fada 10Z, 11Z, 30Z and 31Z Receivers—25 cycles

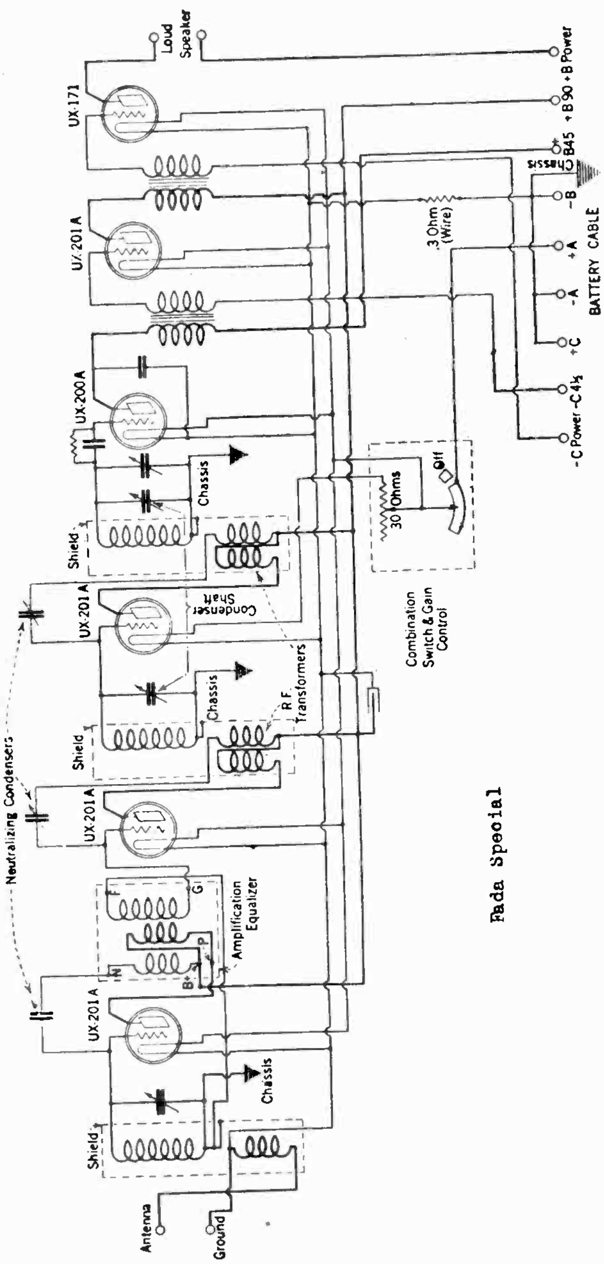


Fada 16, 17 and 32 Receivers - 60 cycles
Fada 16-Z and 32-Z Receivers - 25 cycles

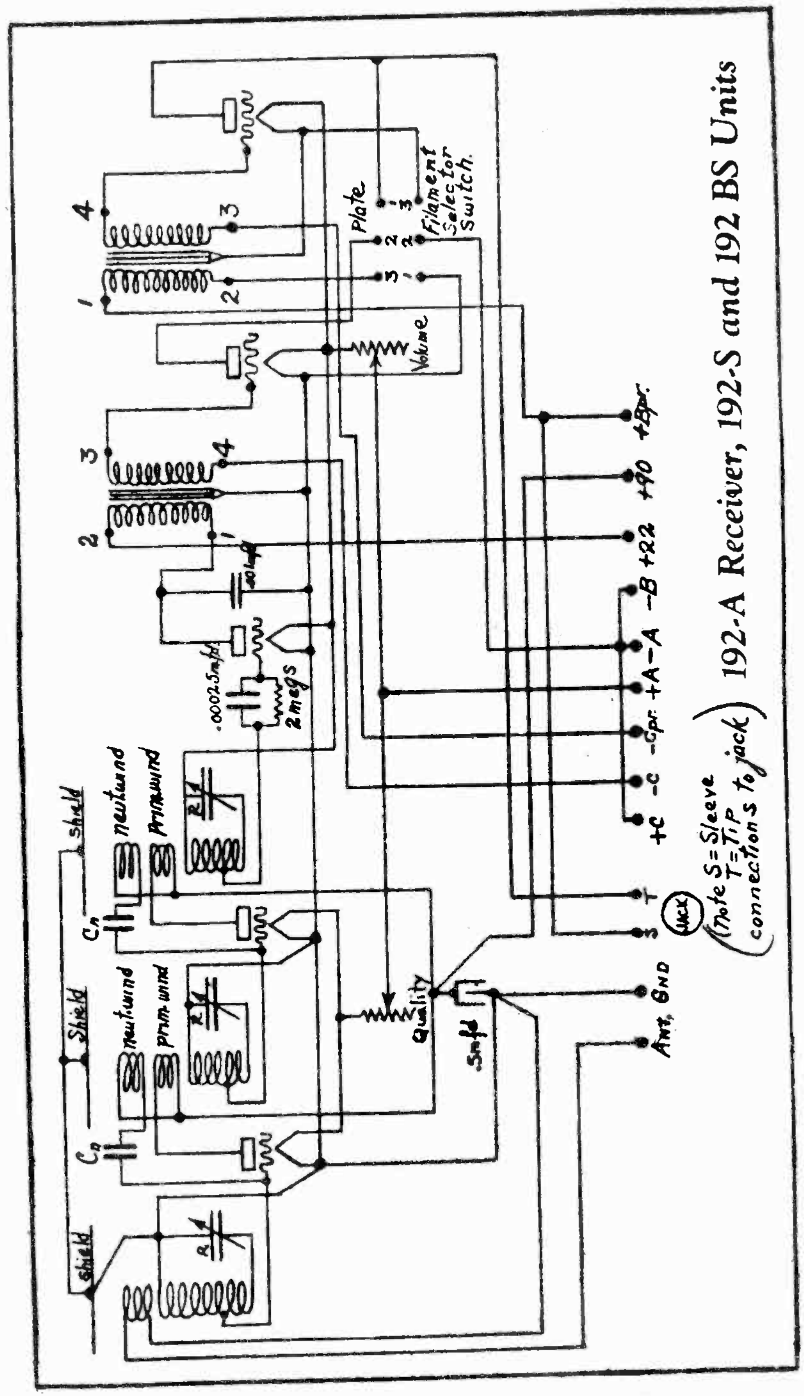


Nº		COLOR
1	SWITCH	TWISTED
2	SWITCH	PAIR
3	PILOT LIGHT	GREEN
4	+A DET.	BROWN
5	CHASSIS	NATURAL
6	+A PWR.	YELLOW
7	-A PWR.	WHITE
8	+B DET	GREEN
9	+B PWR.	RED
10	+B AMP	BLUE

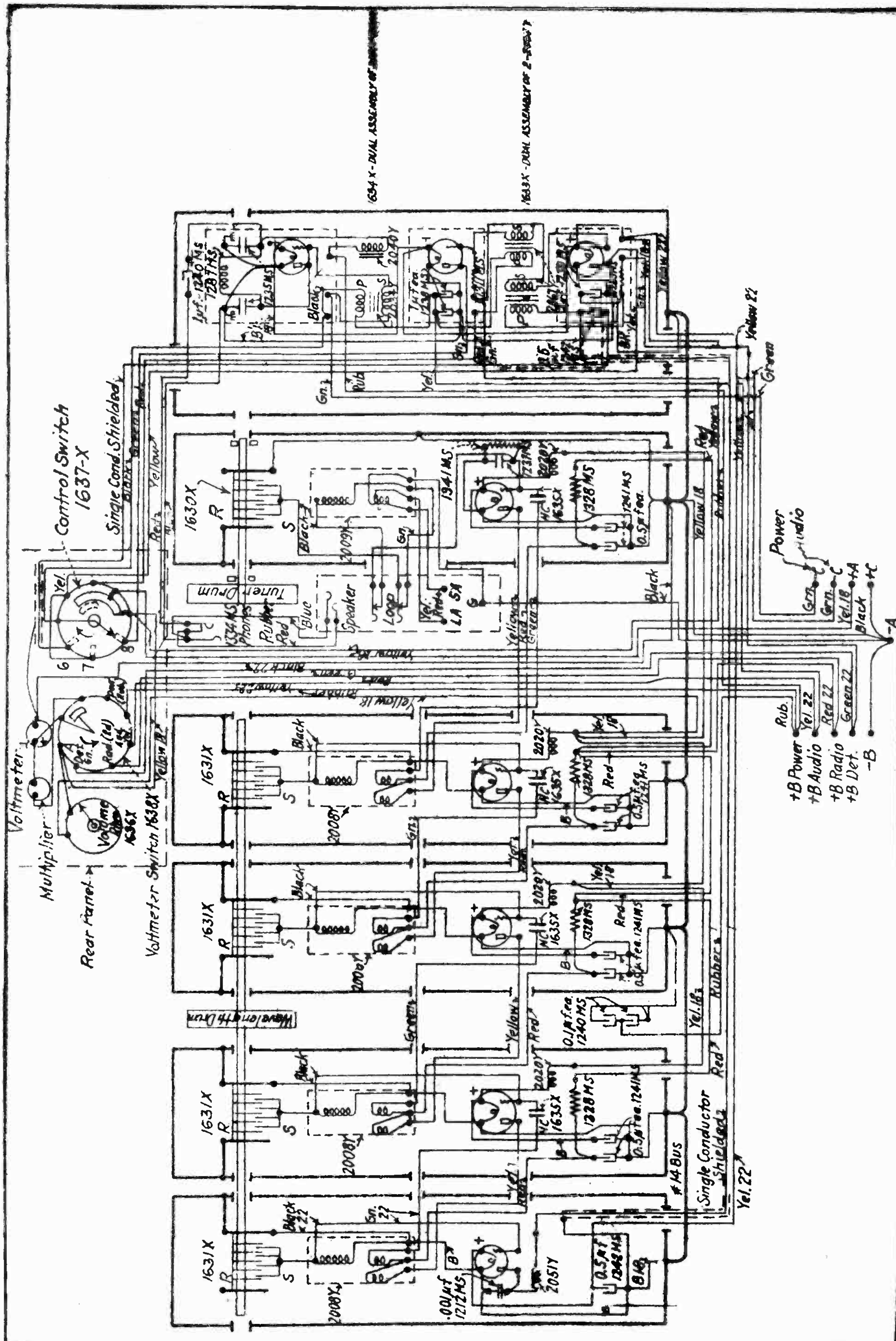
Fada 18 DC Receiver
for use with direct current only



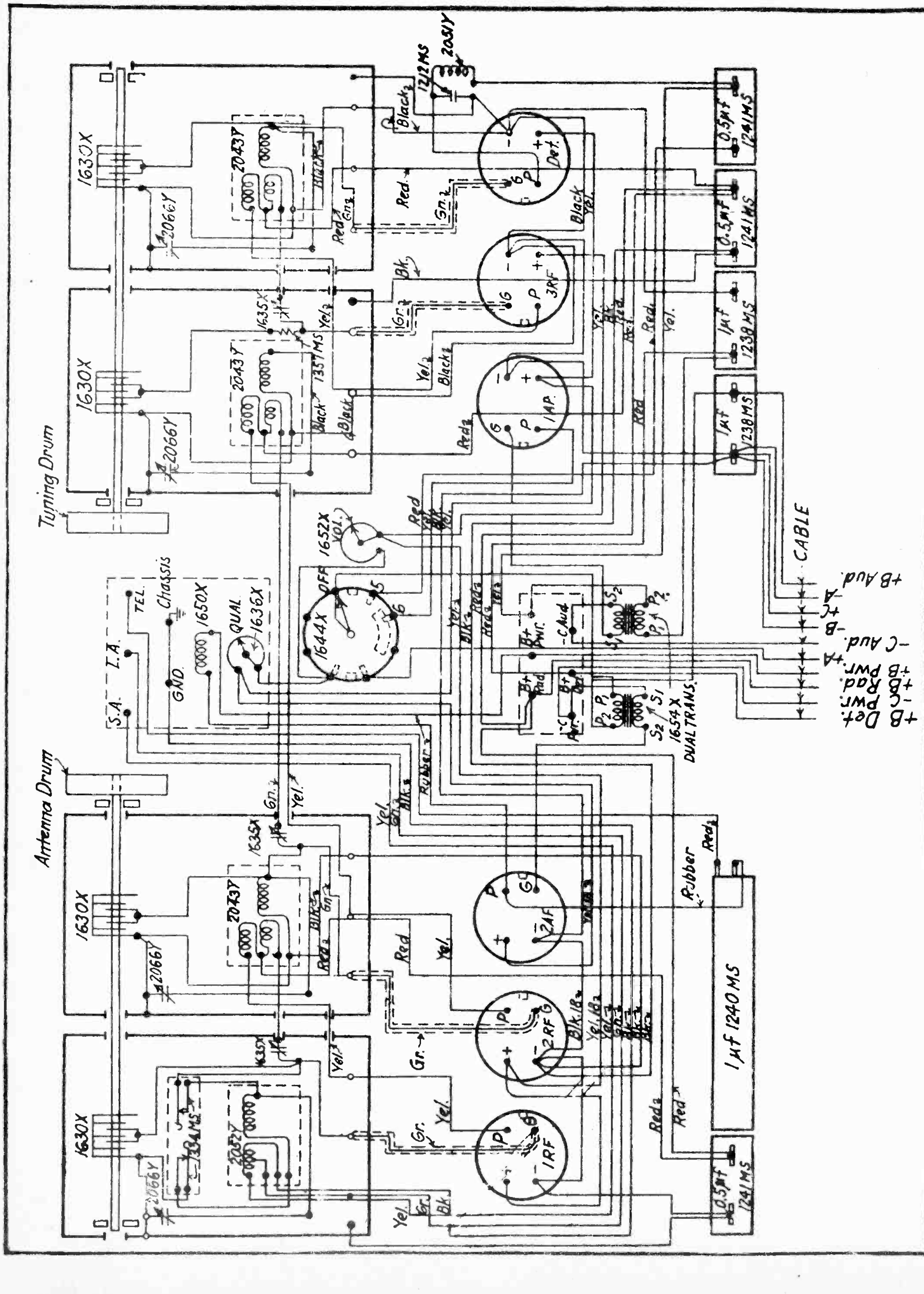
Fada Special



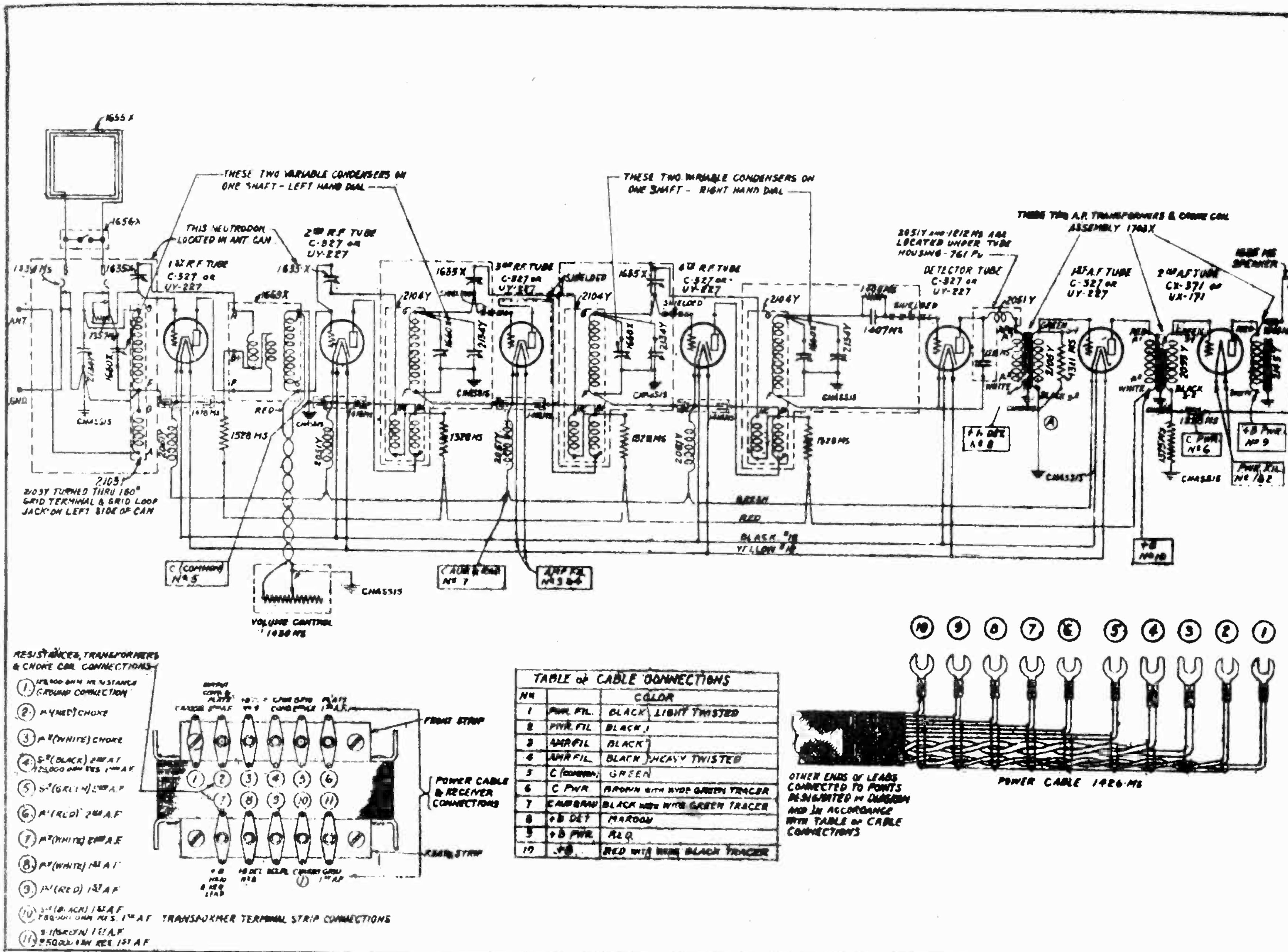
192-A Receiver, 192-S and 192 BS Units



R-80-A Unit, 480-A and SF 50/80-A Receivers



460-A Receiver and R-60 Unit



“7” AC Receiver 475-UA or CA and SF45/75-UA or CA
472-UA or CA and SF45/72-UA or CA

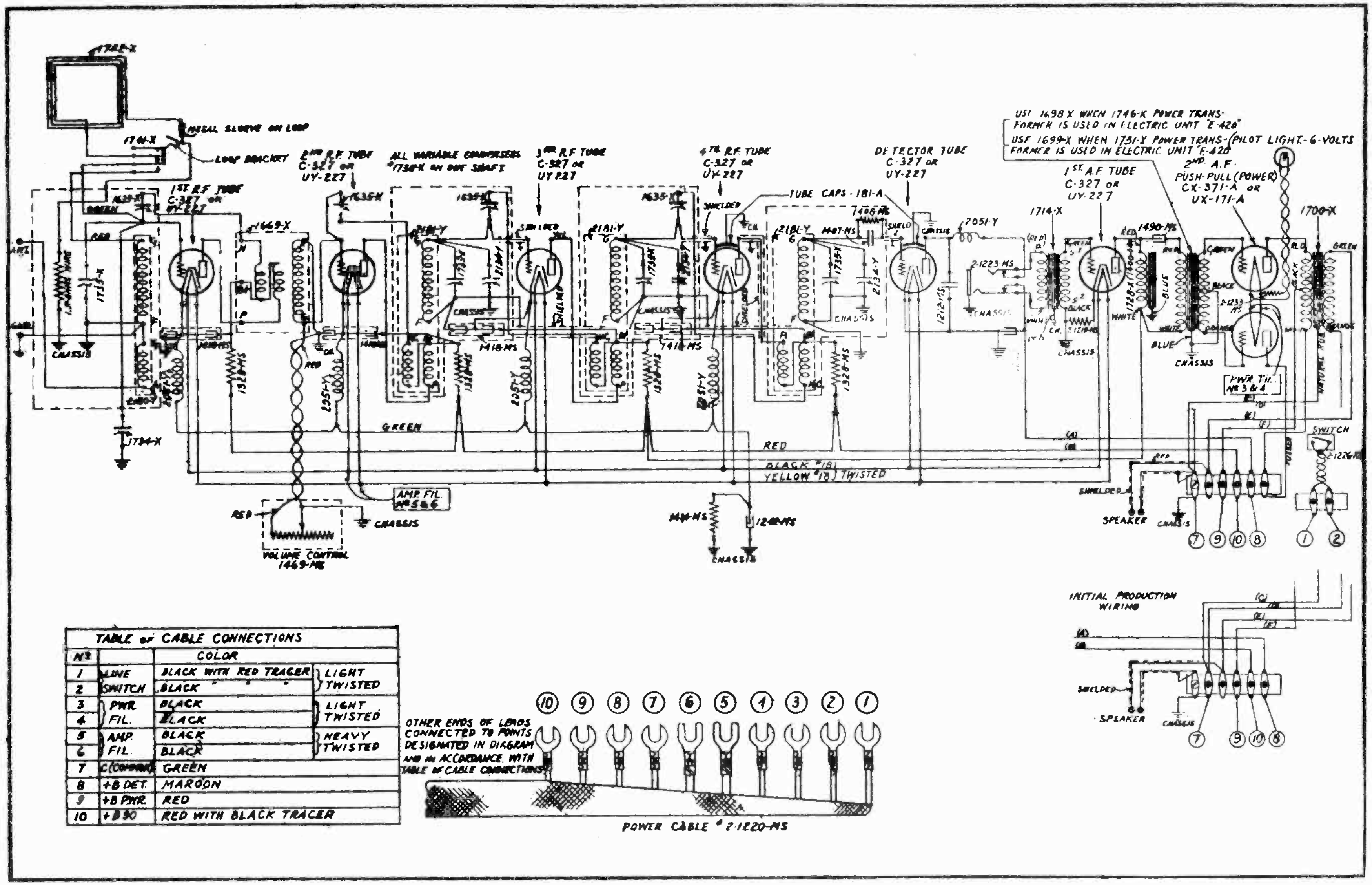
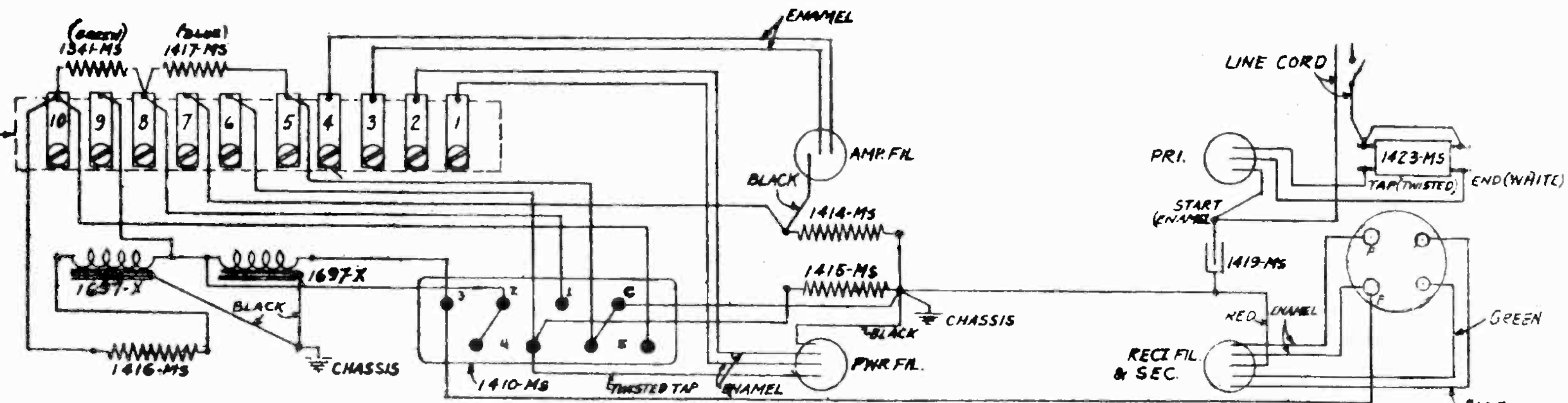


TABLE OF CABLE CONNECTIONS

Nº		COLOR	
1	LINE SWITCH	BLACK WITH RED TRACER	LIGHT TWISTED
2		BLACK " "	
3	PWR. FIL.	BLACK	LIGHT TWISTED
4		BLACK	
5	AMP. FIL.	BLACK	HEAVY TWISTED
6		BLACK	
7	C (COMMON)	GREEN	
8	+B DET.	MAROON	
9	+B PWR.	RED	
10	+B 90	RED WITH BLACK TRACER	

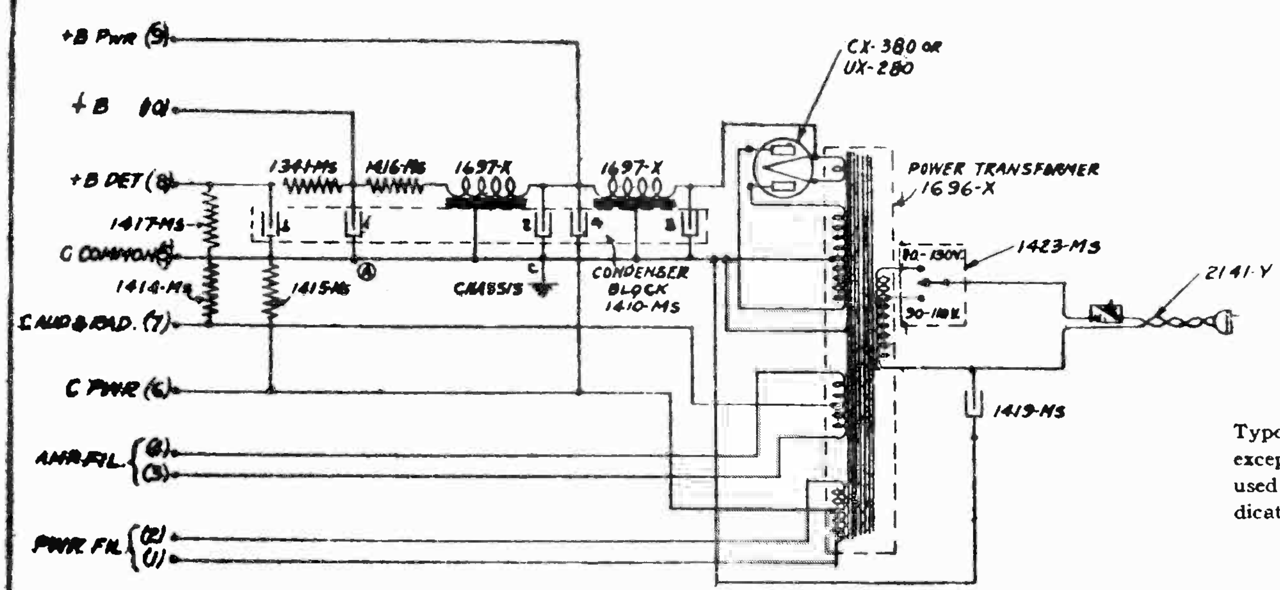
Fada 50, 70, 71 and 72 Receivers



ACTUAL WIRING DIAGRAM

TABLE OF CABLE CONNECTIONS

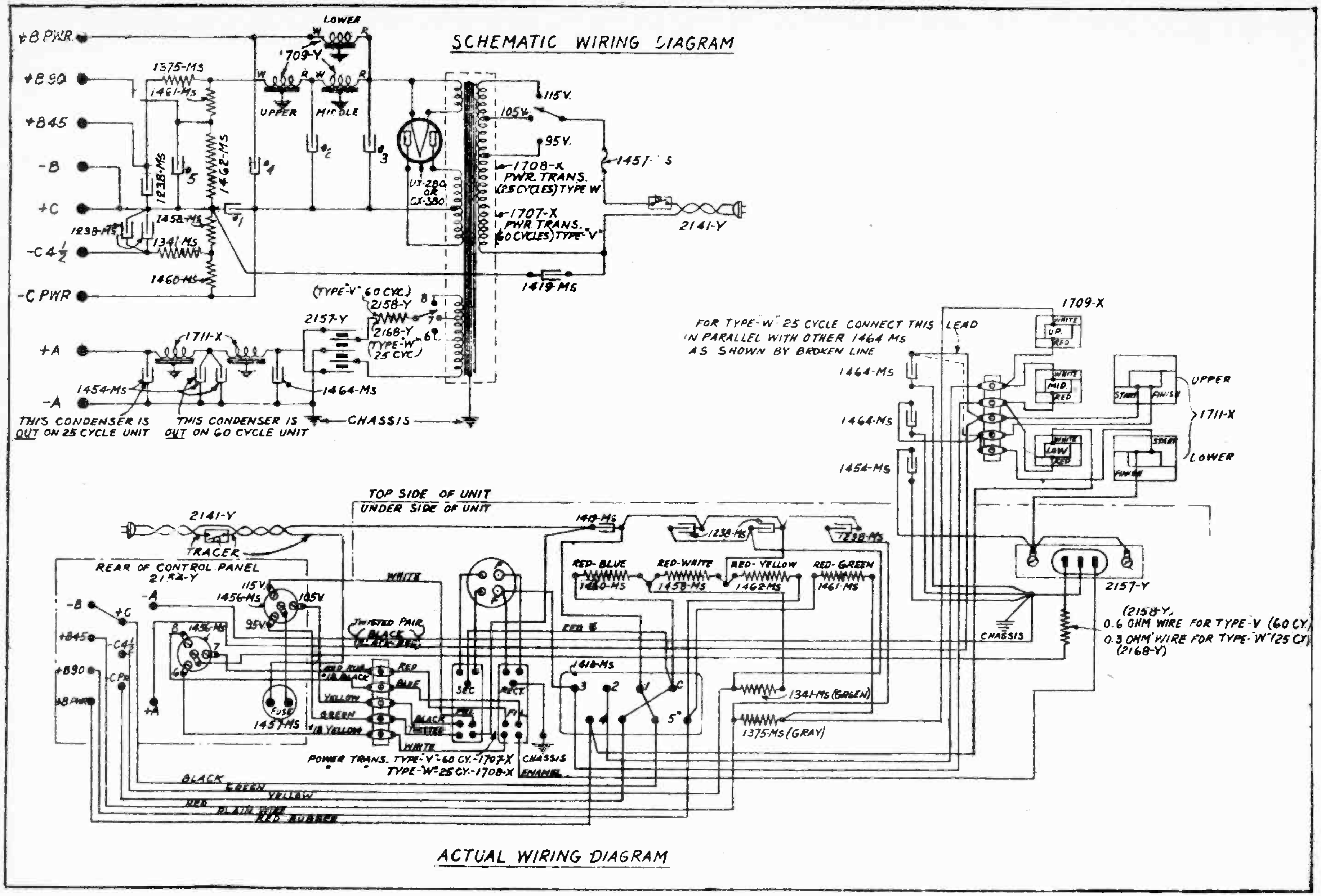
1, 2 } POWER FILAMENT
3, 4 } AMP FILAMENT
5 - C COMMON
6 - C PWR
7 - C AUD & RAD
8 - +B DET.
9 - +B PWR
10 - +B



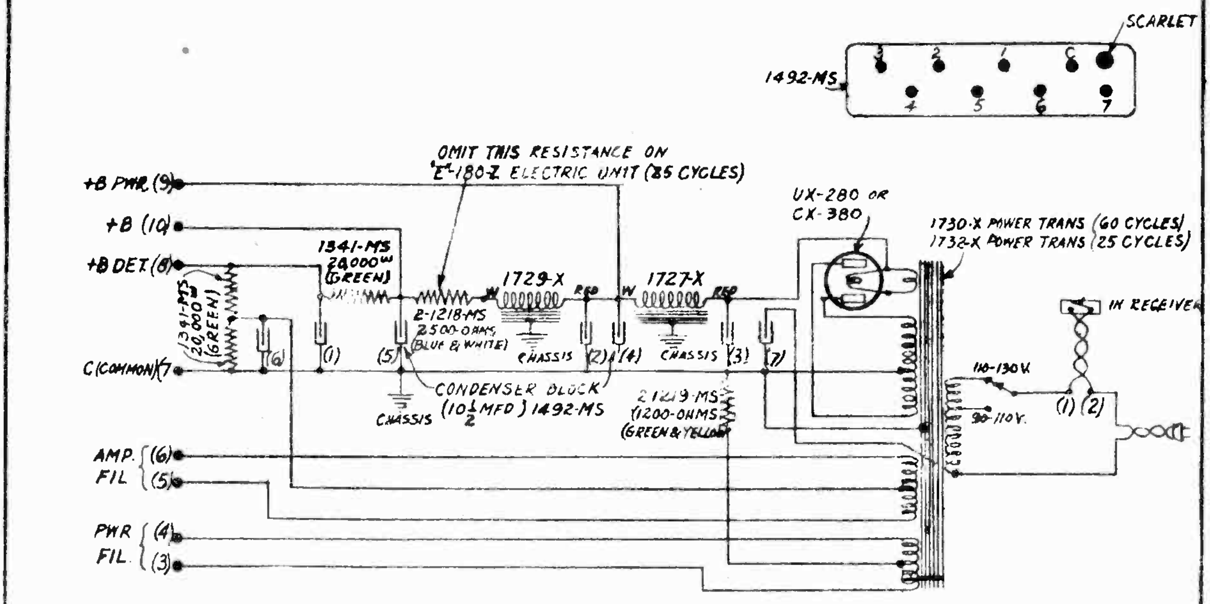
SCHEMATIC WIRING DIAGRAM

Type "J" unit for 25 cycle current is similar, except that a 1706X power transformer is used instead of the 1696X transformer as indicated on the type "C" unit for 60 cycles.

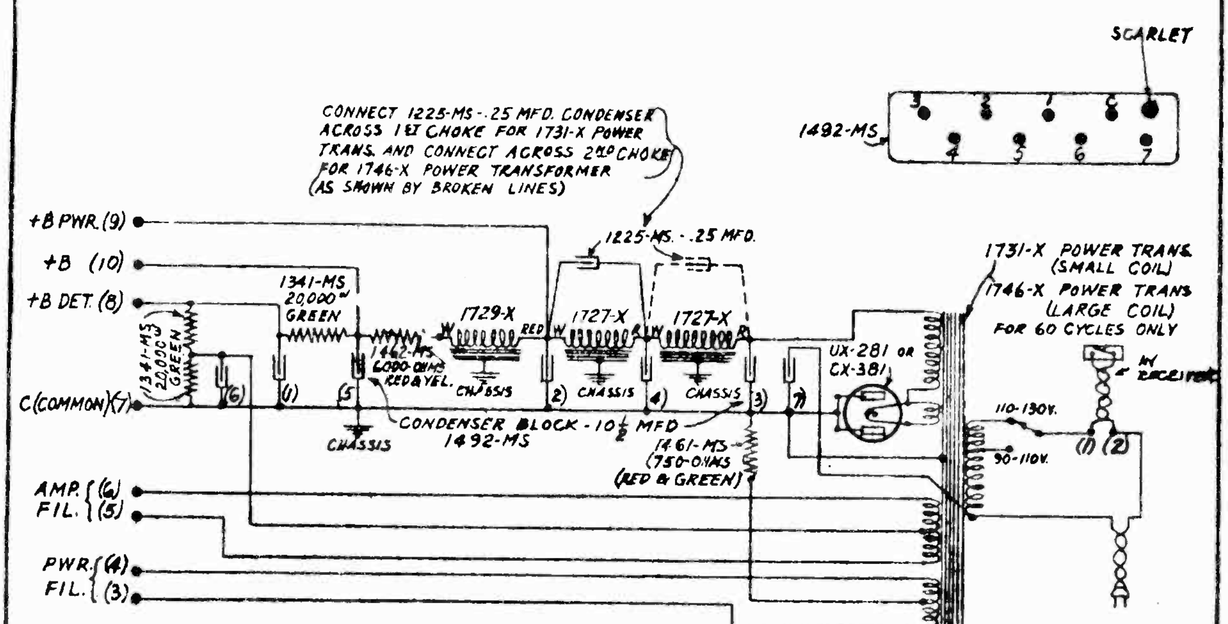
Type "C" Electric Unit, used with "Special" and "7" AC Receivers



"ABC" Six Volt Tube Supply Unit — Types 86-V and 82-W

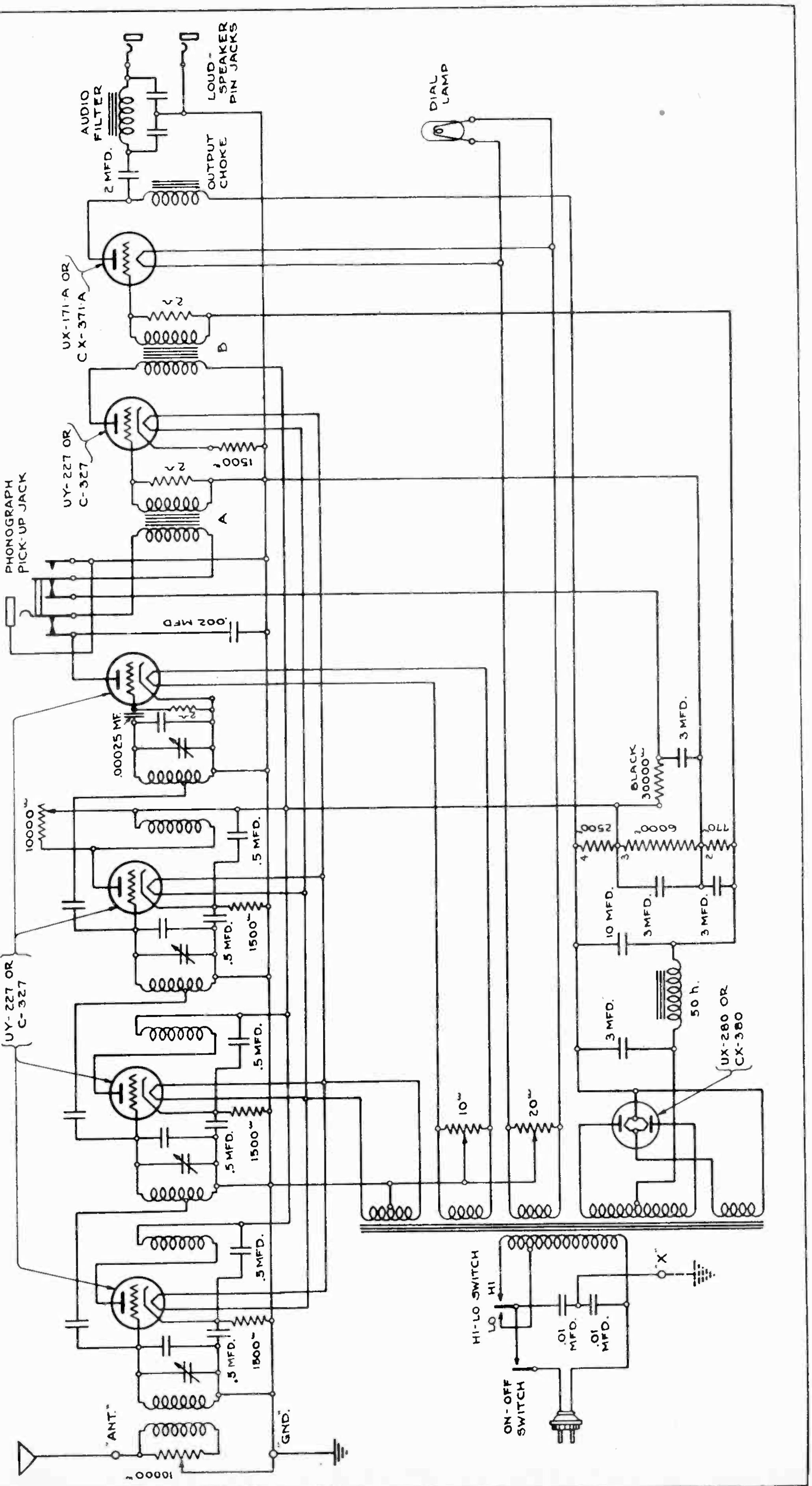


SCHEMATIC WIRING DIAGRAM OF "E"-180 & "E"-180-Z ELECTRIC UNIT

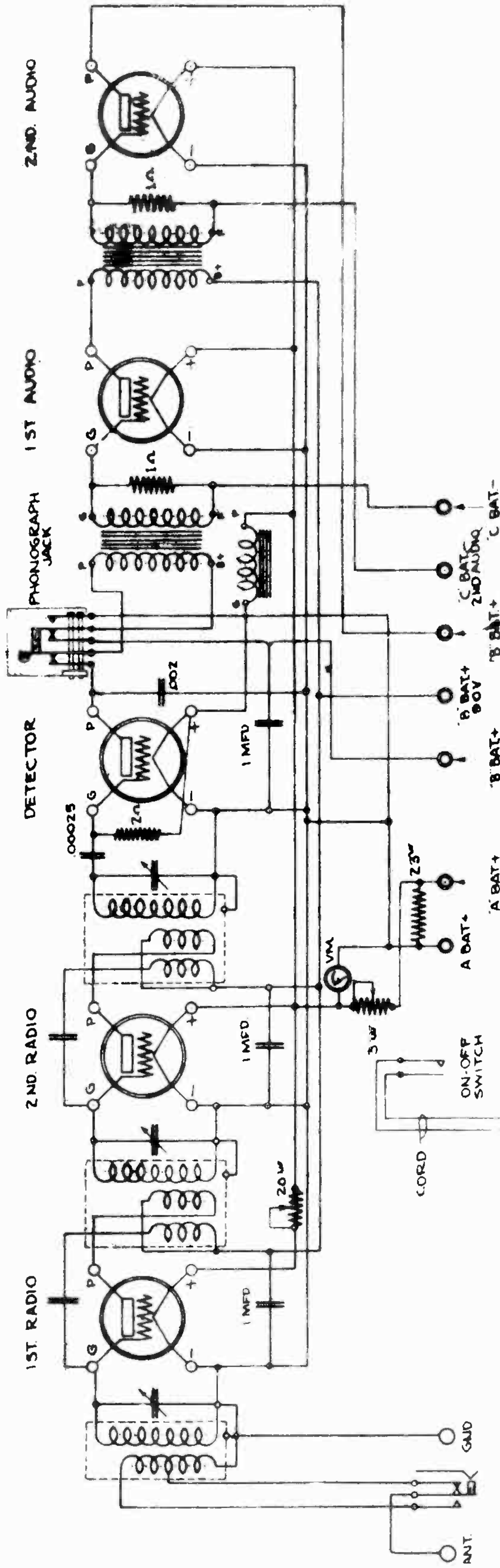


SCHEMATIC WIRING DIAGRAM OF "E-420" ELECTRIC UNIT.

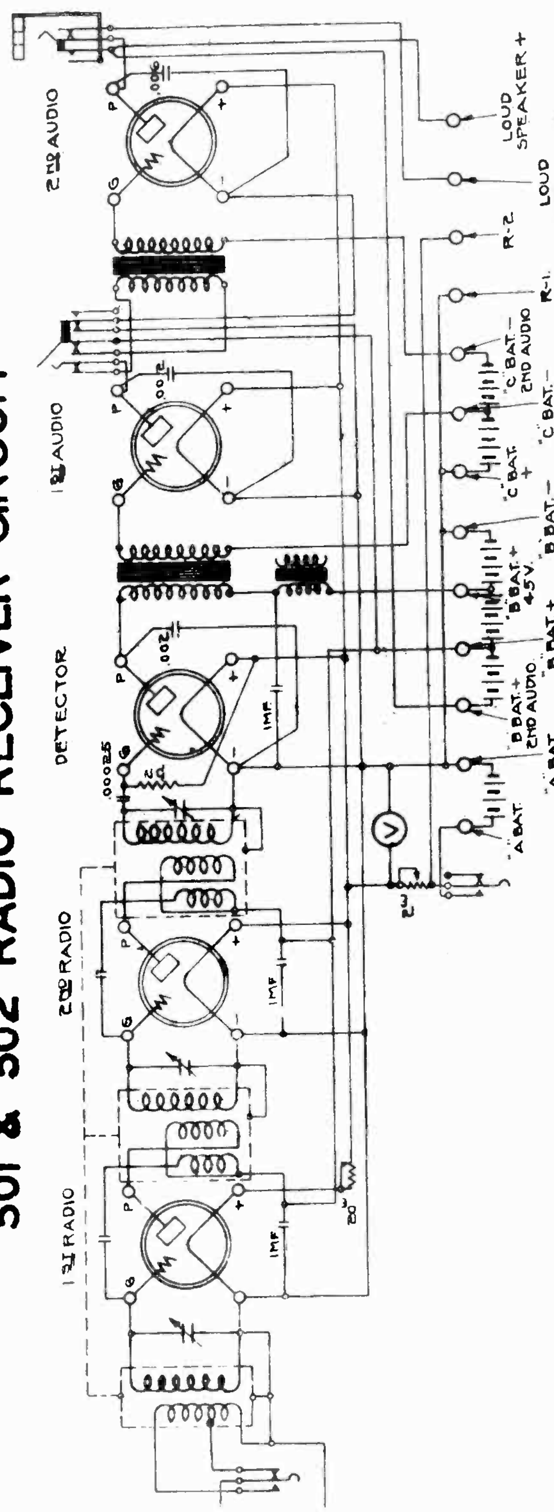
NOS. 635 AND 636 RADIO RECEIVERS
SCHEMATIC DIAGRAM
GRID LEAK DETECTION CIRCUIT



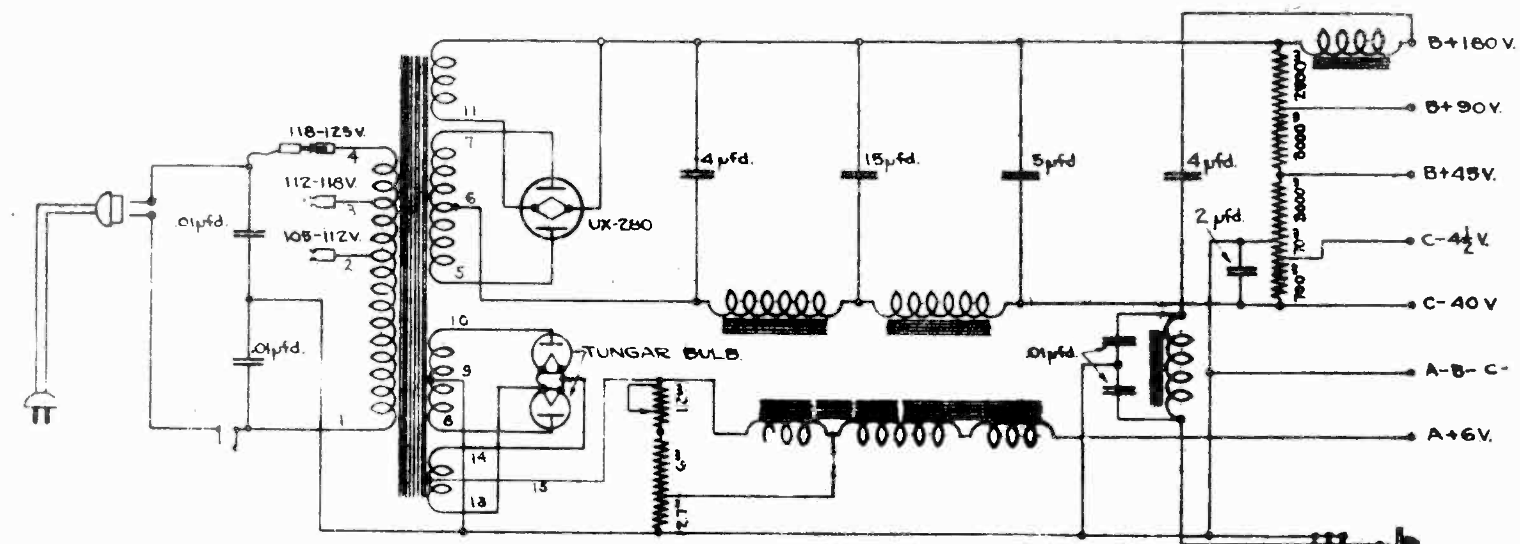
#523 & #524 RADIO RECEIVER CIRCUIT



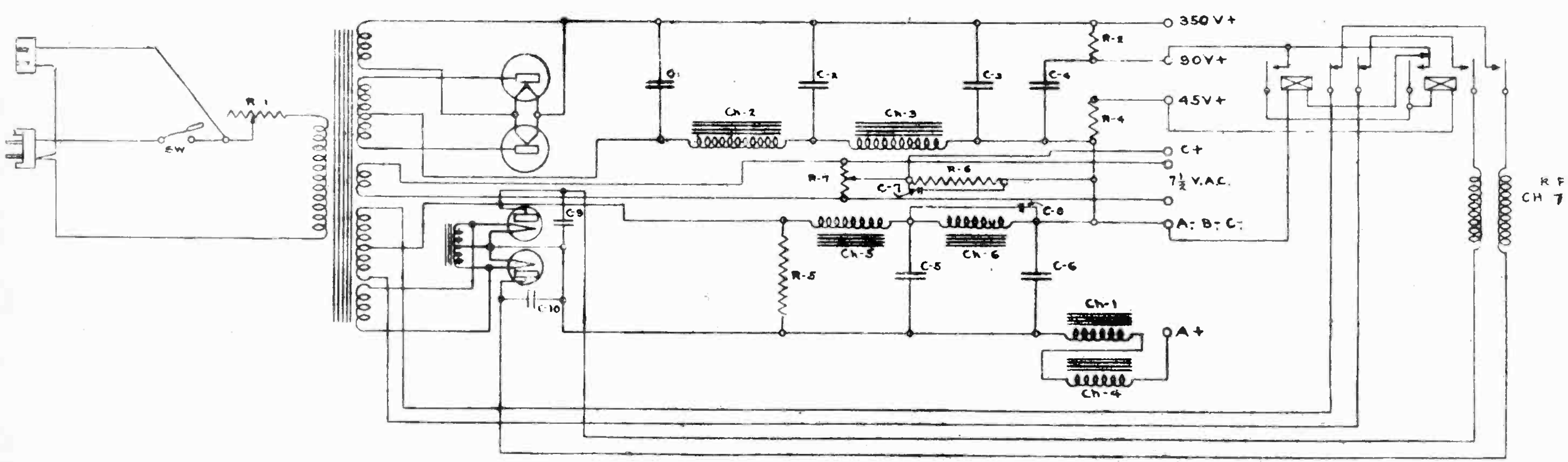
#501 & #502 RADIO RECEIVER CIRCUIT



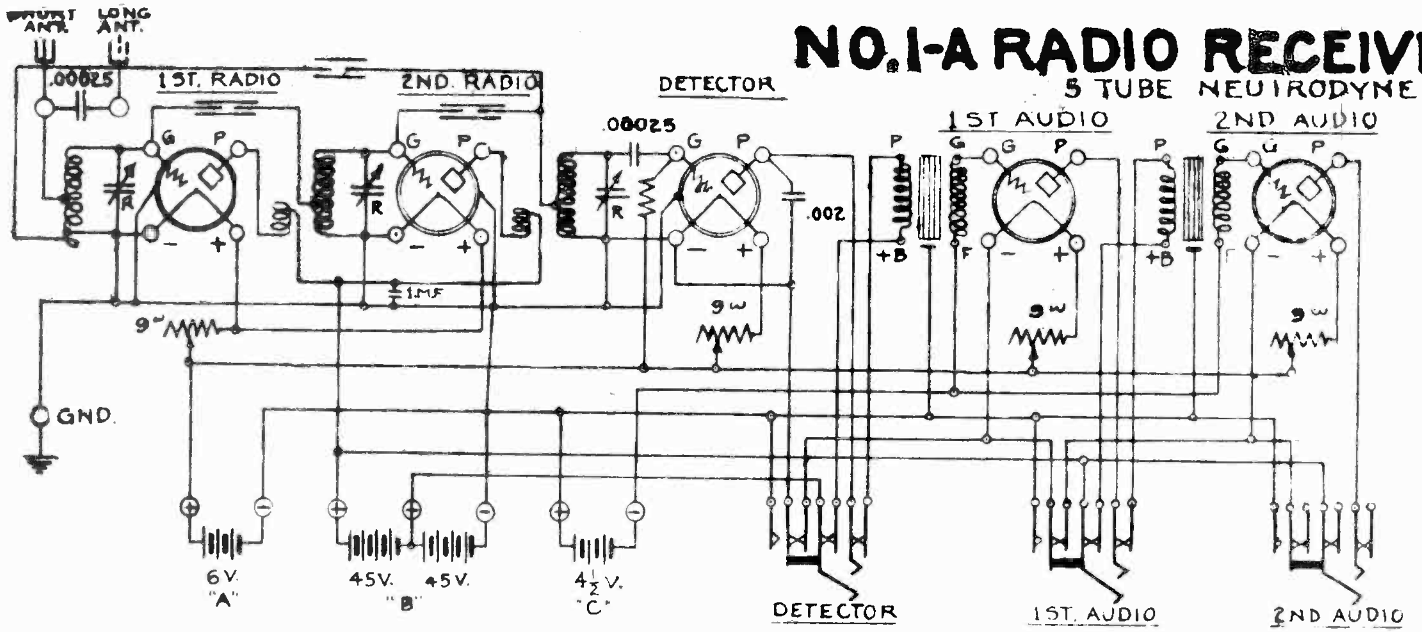
403 A A AUDIO POWER UNIT CIRCUIT.



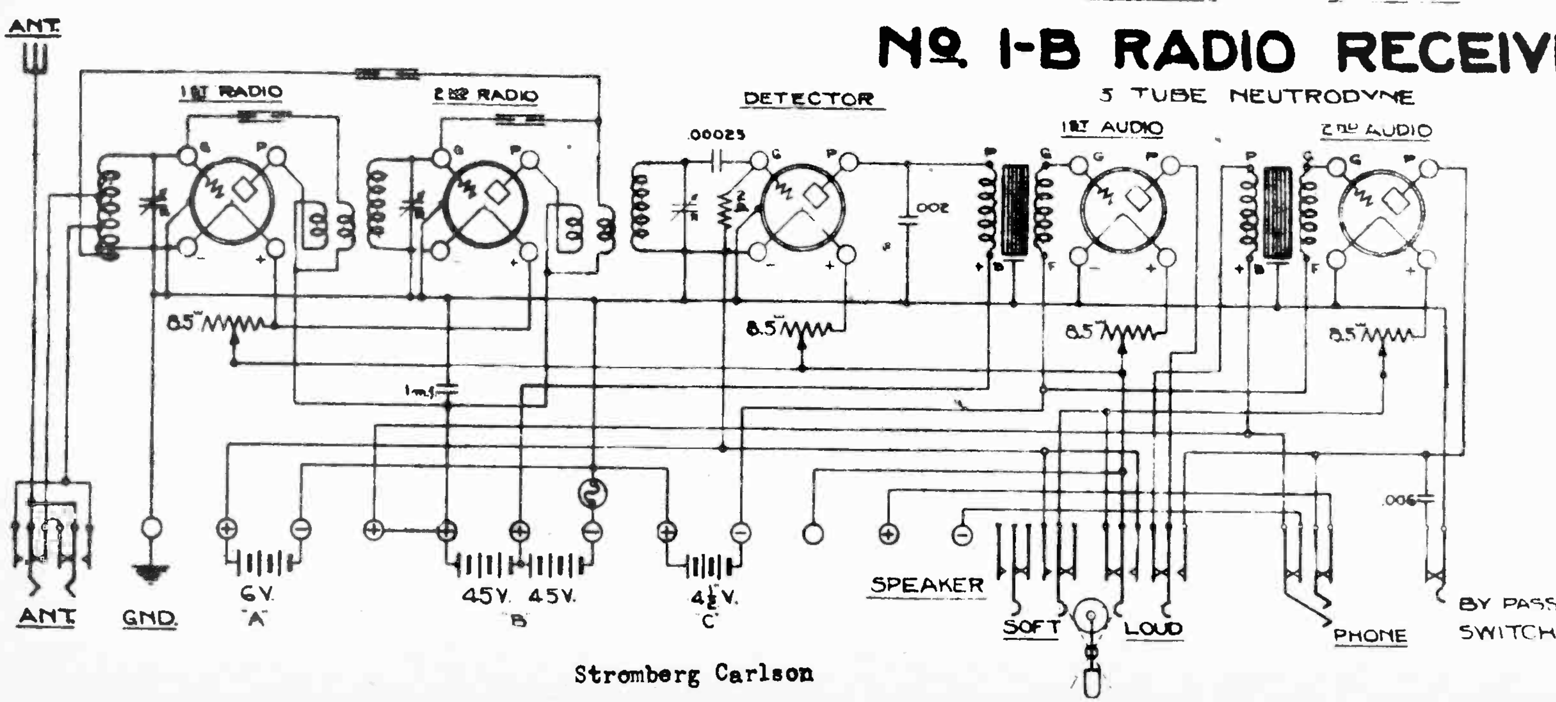
404 RA SOCKET POWER UNIT CIRCUIT



NO. I-A RADIO RECEIVER CIRCUIT
5 TUBE NEUTRODYNE

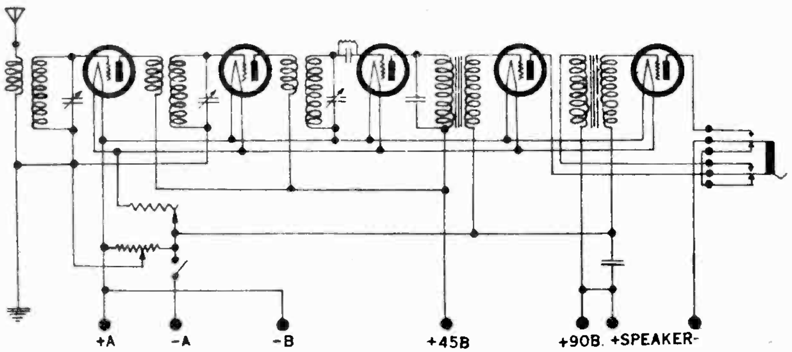


No. I-B RADIO RECEIVER CIRCUIT
5 TUBE NEUTRODYNE

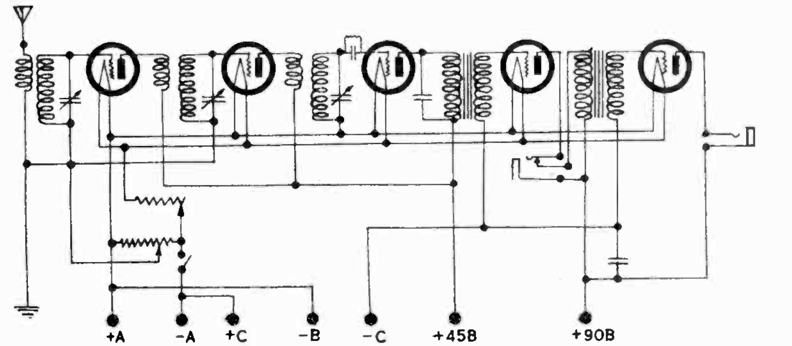


Stromberg Carlson

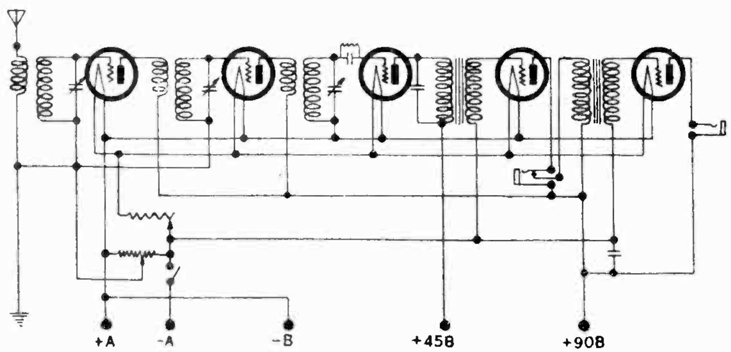
Schematic Diagram of Connections for Stewart-Warner One-Dial Receivers



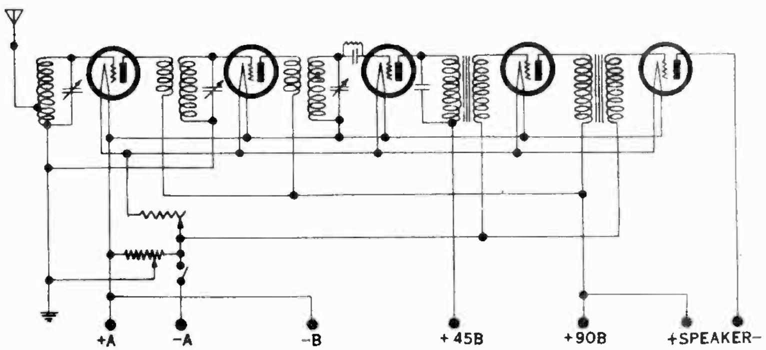
MODEL 305-315-320 WITH "45 VOLT B" ON R.F.



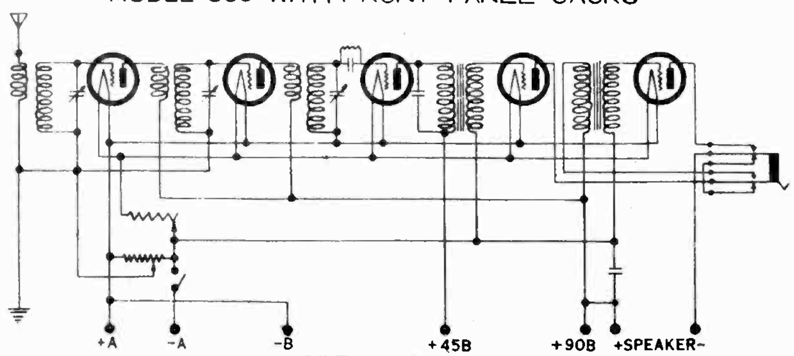
A TYPICAL TUNED R.F. CIRCUIT WITH "C" BATT. CONNECTIONS



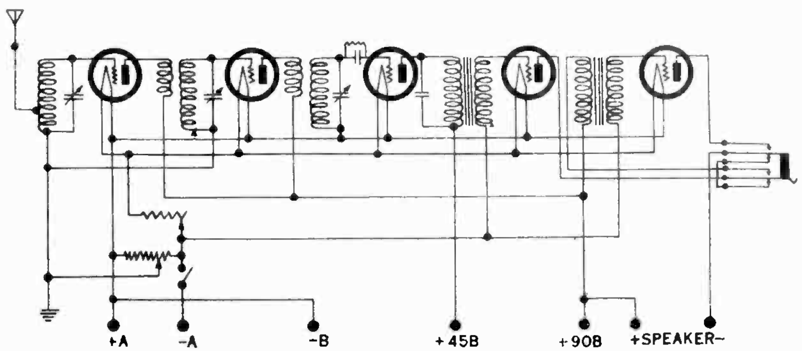
MODEL 305 WITH FRONT PANEL JACKS



MODEL 300

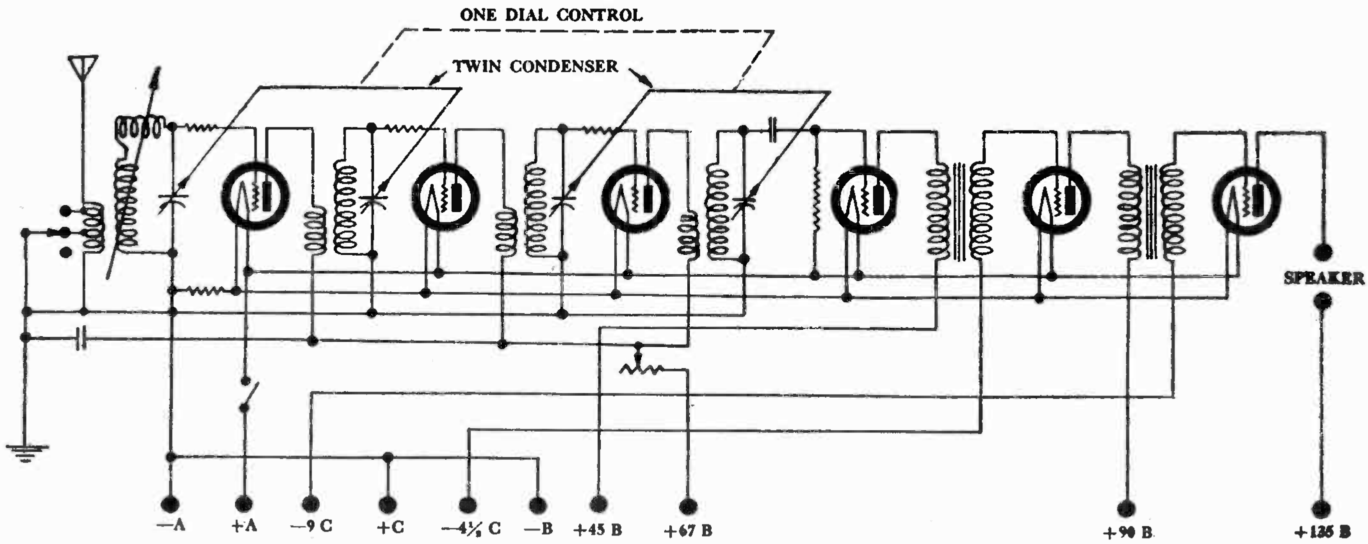


MODEL 305-315-320

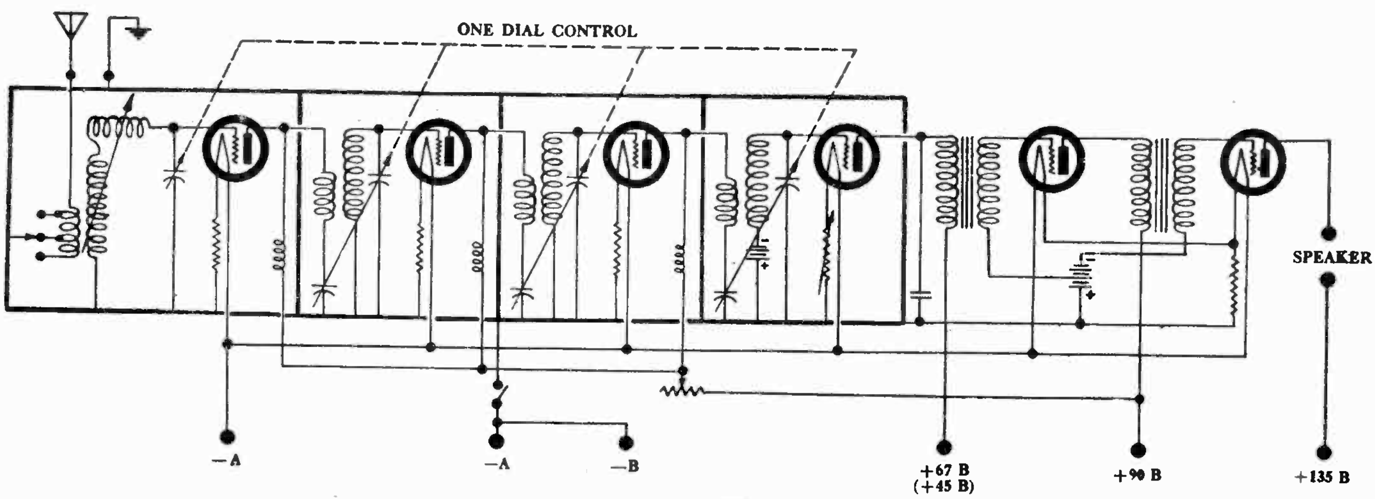


MODEL 310-325

Schematic Diagram of Connections for Stewart-Warner Radio Receivers

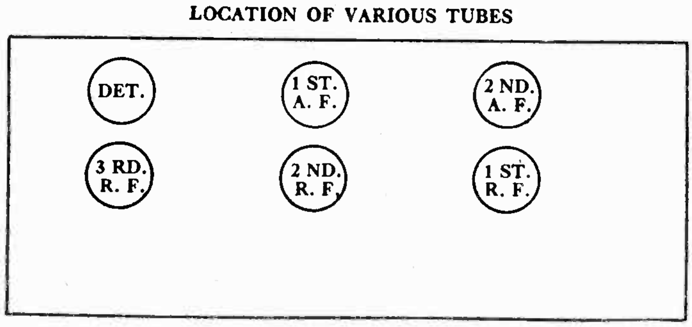


Model 500, 520, 525



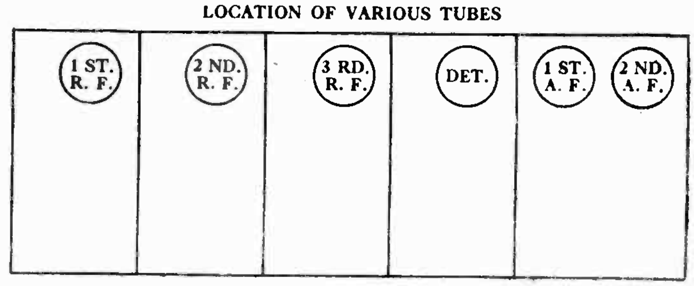
Model 700, 705, 710

LOCATION OF VARIOUS TUBES



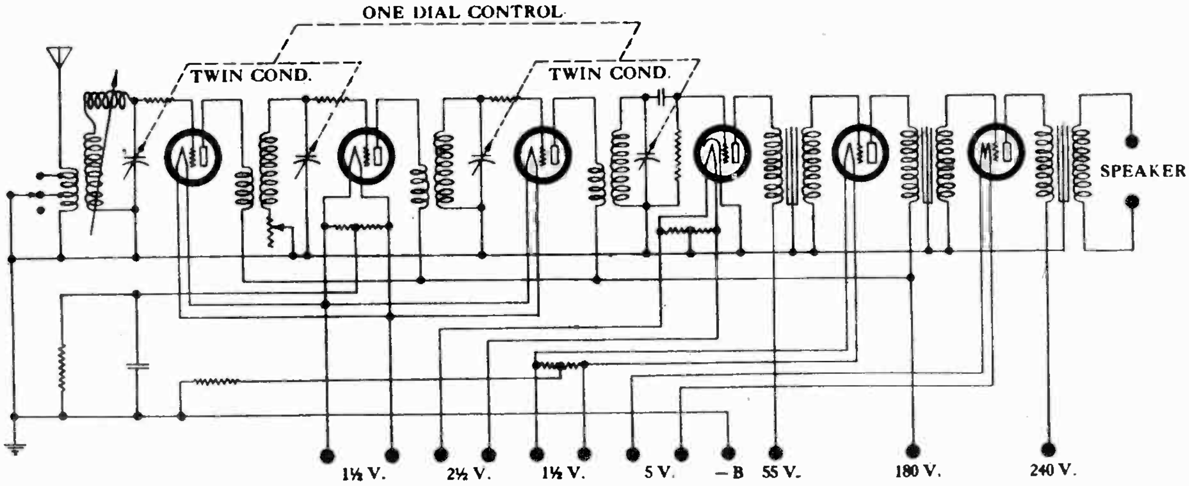
Model 500, 520, 525

LOCATION OF VARIOUS TUBES

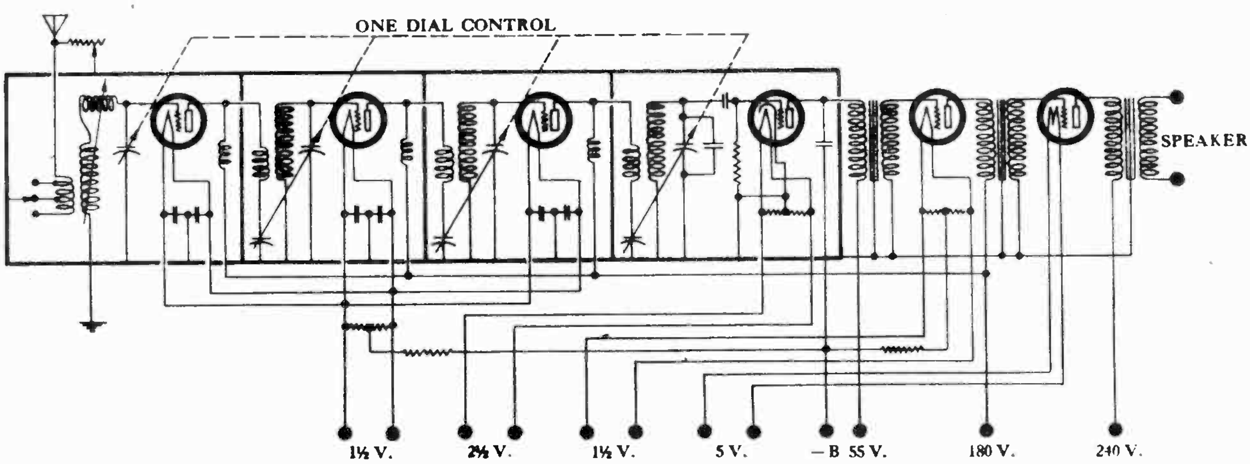


Model 700, 705, 710

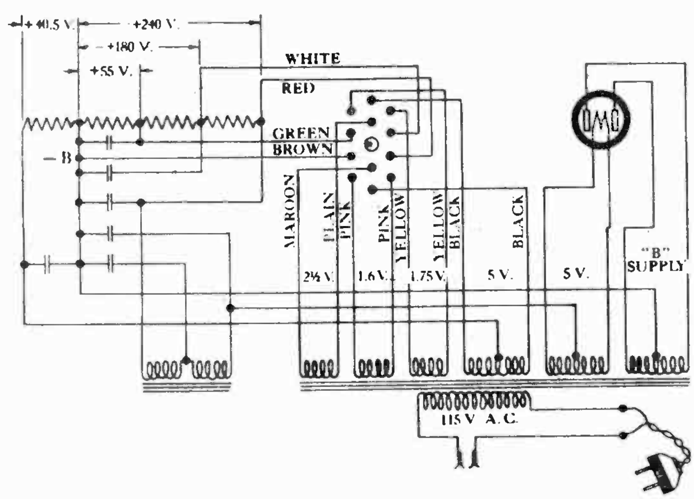
Schematic Diagram of Circuit for Stewart-Warner A.C. Radio Receivers and Power Unit



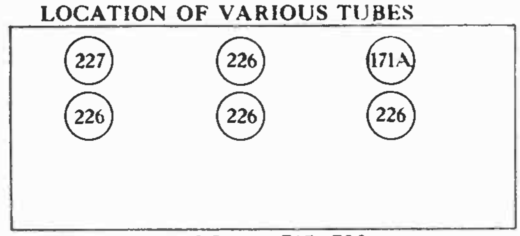
Model 530, 535



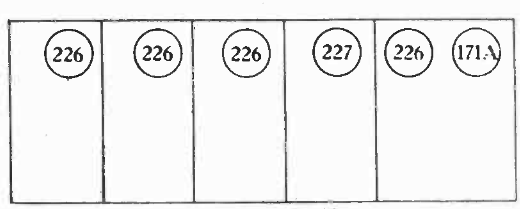
Model 715, 720



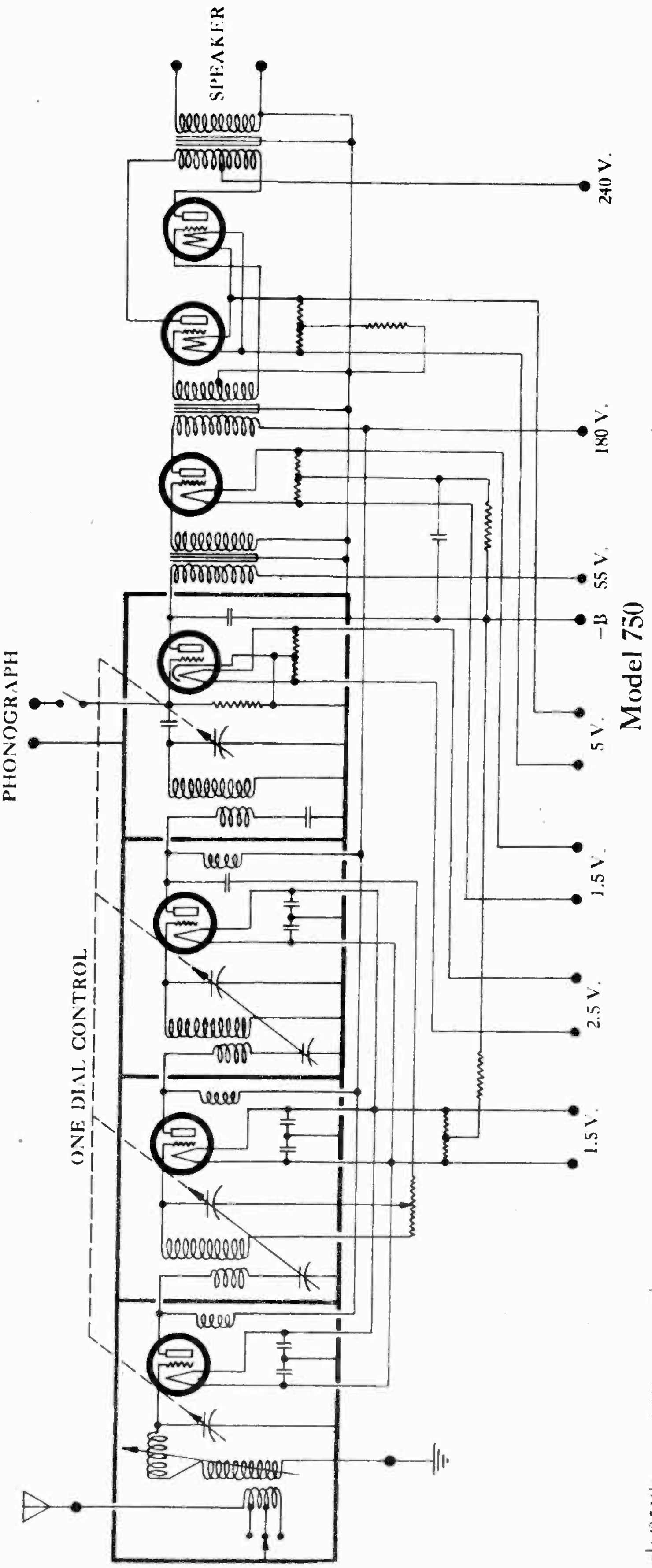
LOCATION OF VARIOUS TUBES



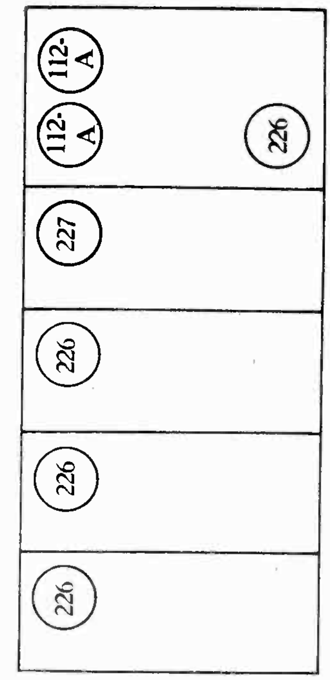
Model 715, 720



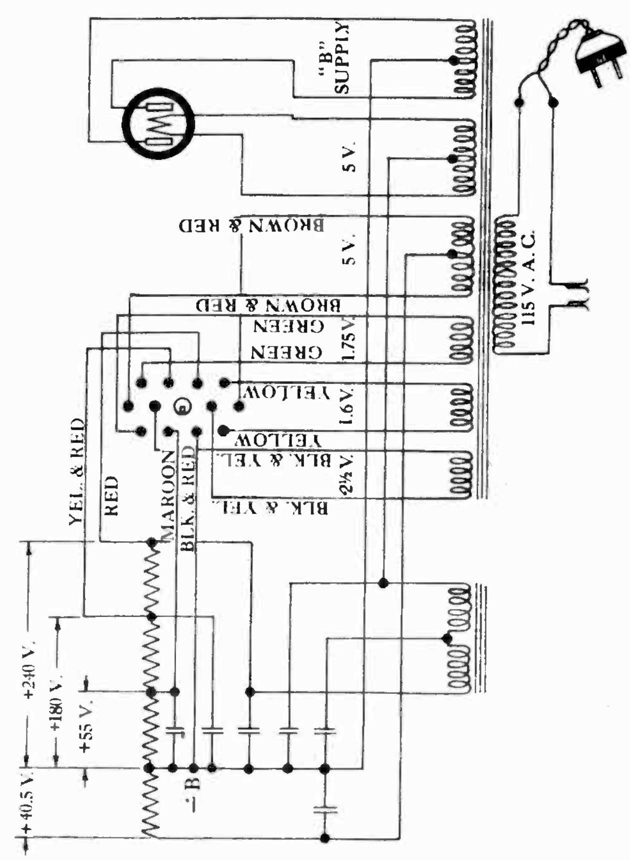
Model 530, 535



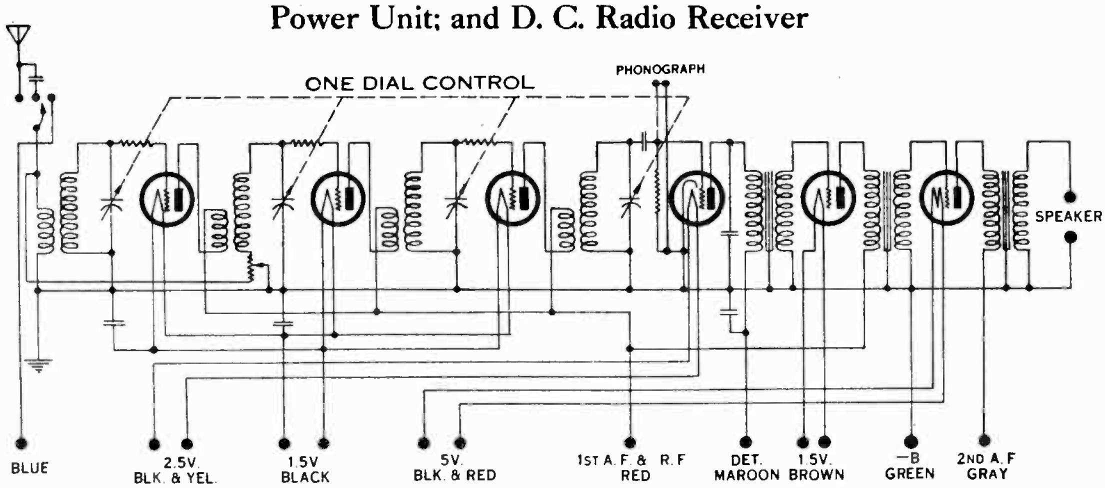
Model 750



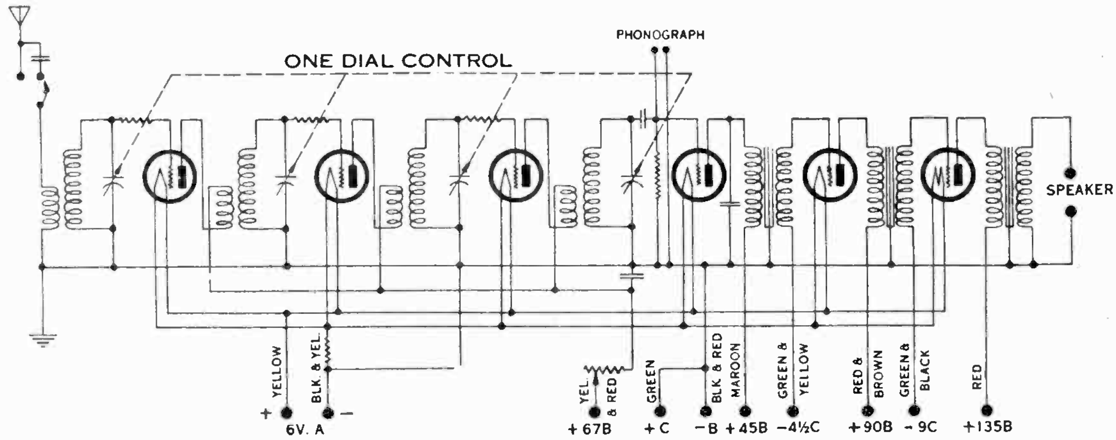
LOCATION OF VARIOUS TUBES
MODEL 750



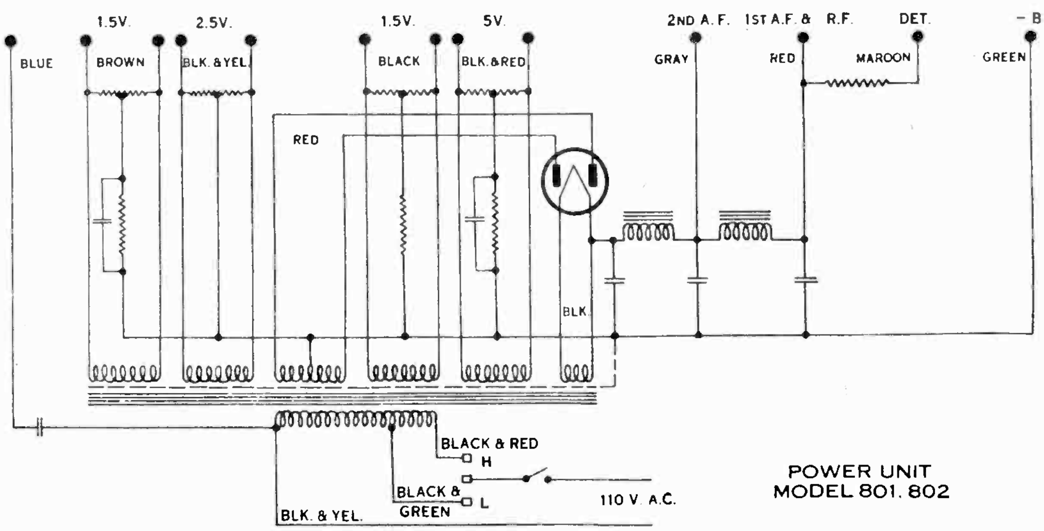
Schematic Diagram of Circuit for Stewart-Warner A. C. Radio Receiver with Power Unit; and D. C. Radio Receiver



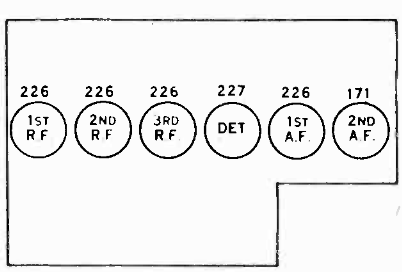
MODEL 801. 802



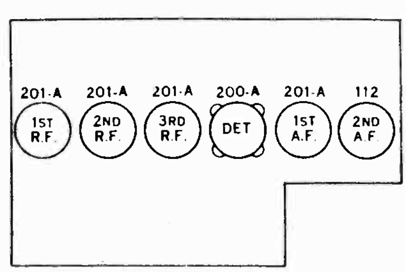
MODEL 806



POWER UNIT
MODEL 801. 802

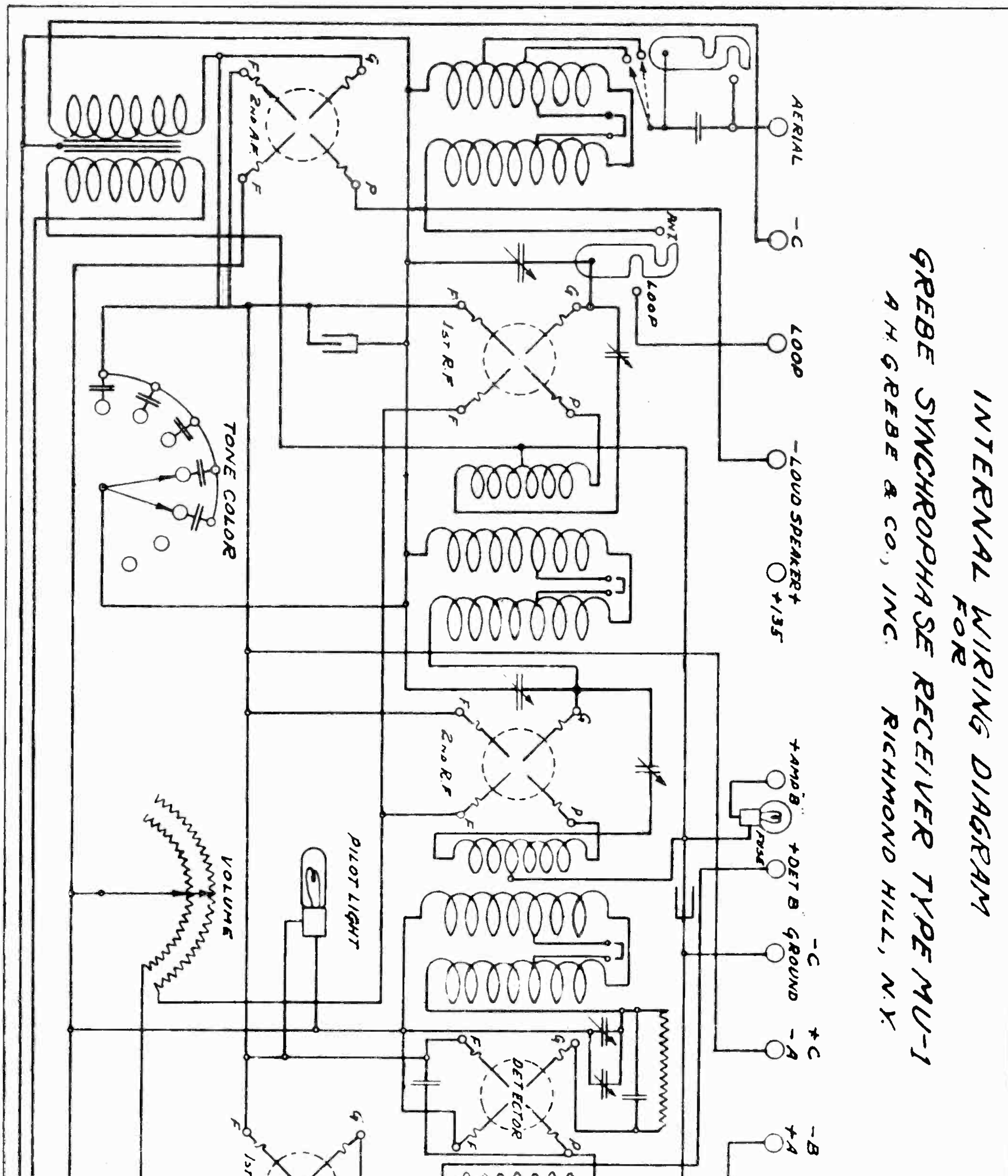


MODEL 801. 802



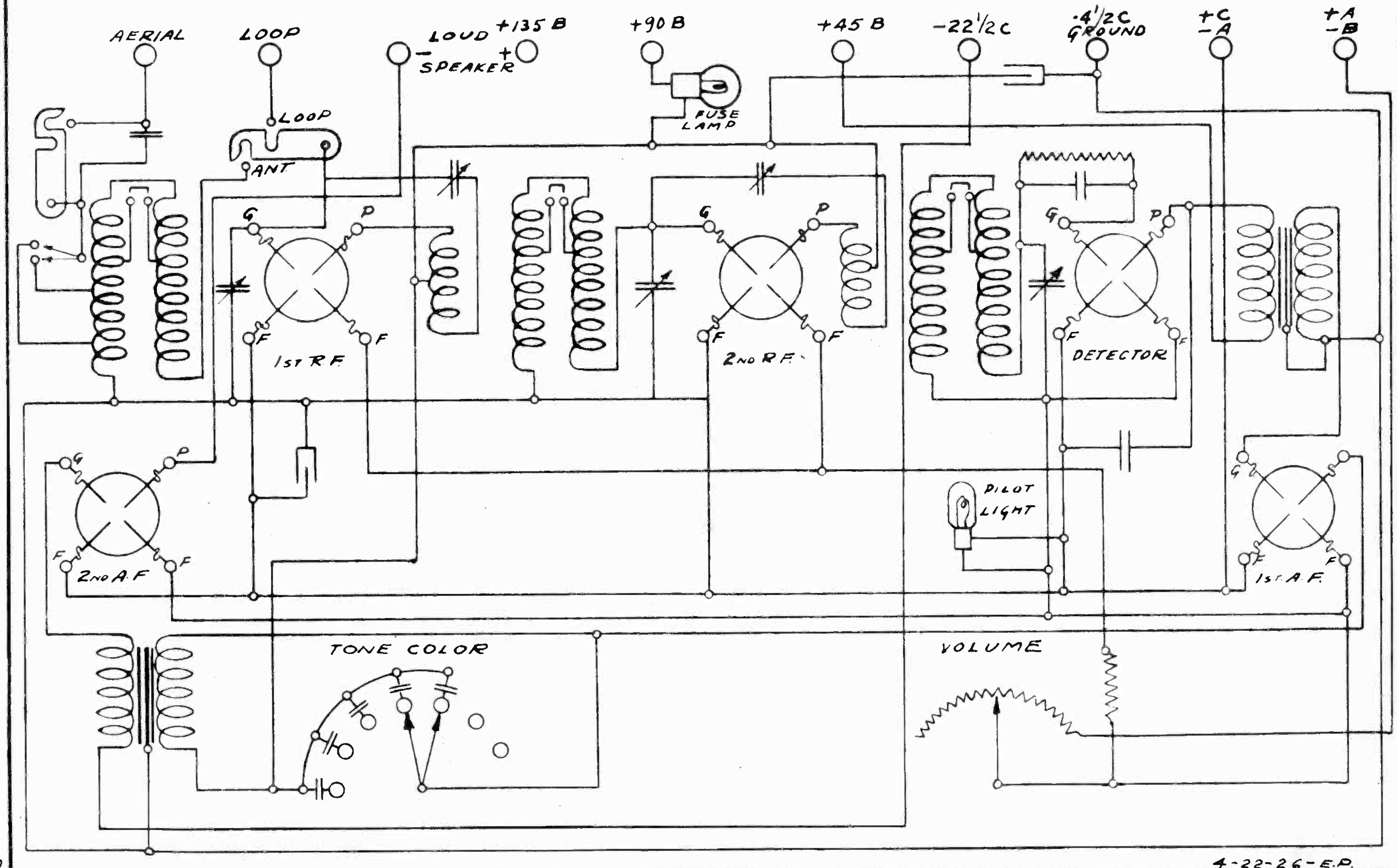
MODEL 806

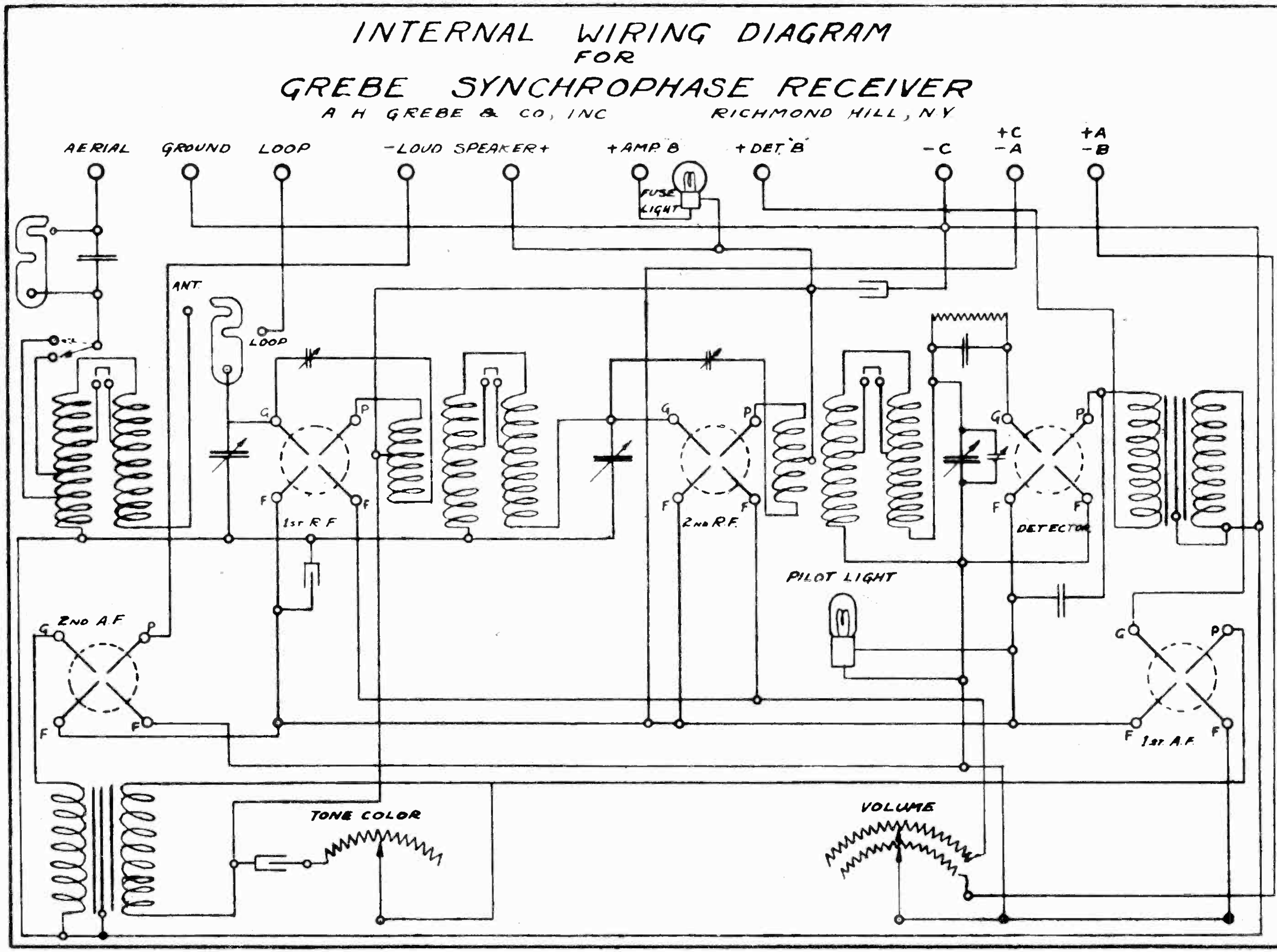
LOCATION OF VARIOUS TUBES


INTERNAL WIRING DIAGRAM
FOR
GREBE SYNCHROPHASE RECEIVER TYPE MU-1
A.H. GREBE & CO., INC. RICHMOND HILL, N.Y.
AERIAL
-C
LOOP
-LOUD SPEAKER+
+135
+AMP B
+DET B
-C GROUND
+C -A
-B +A
ANT
LOOP
2ND A.F.
1ST R.F.
2ND R.F.
DETECTOR
1ST A.F.
TONE COLOR
VOLUME
PILOT LIGHT
FUSE
8-16-26-E.P.

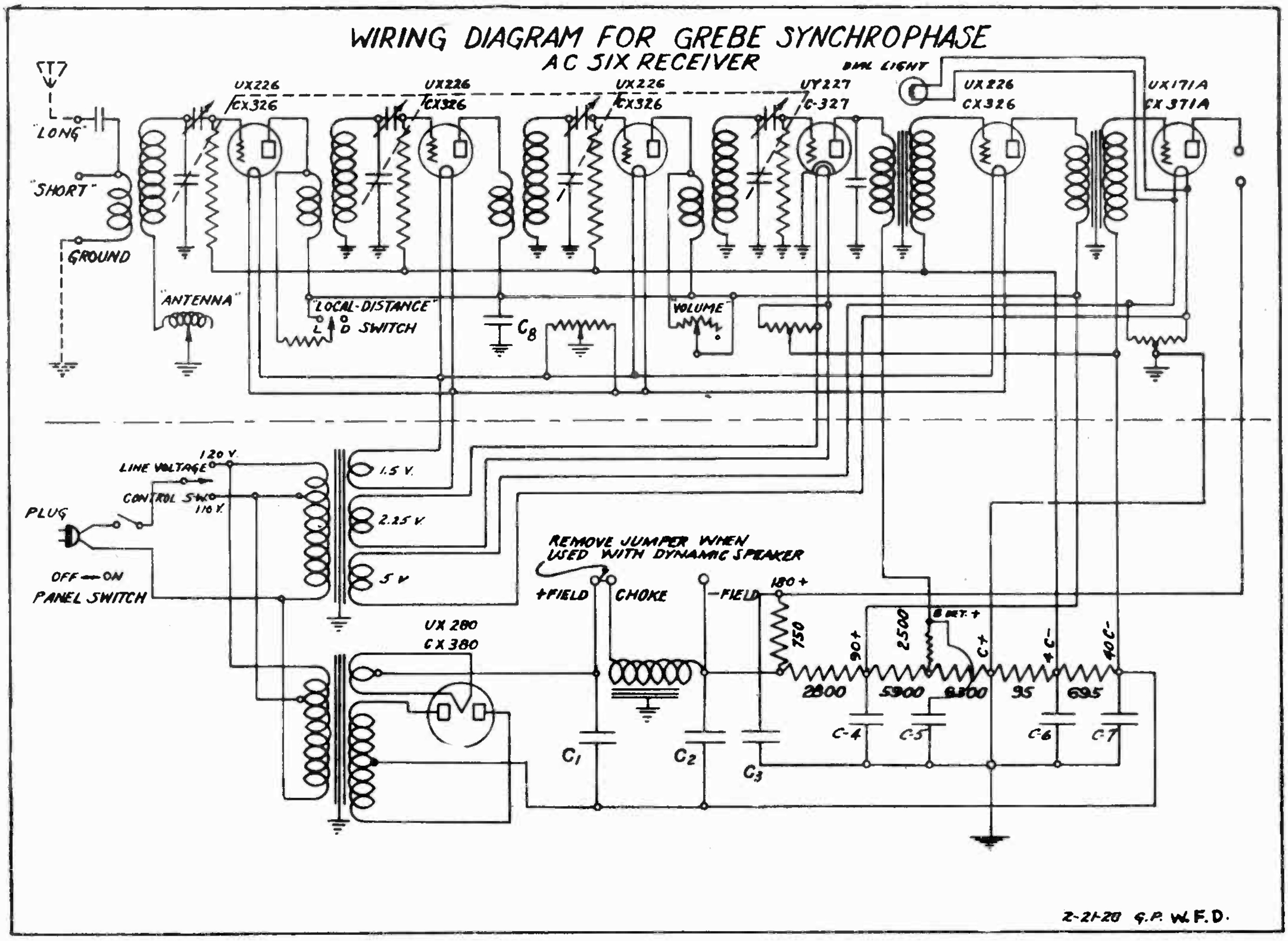
INTERNAL WIRING DIAGRAM FOR GREBE SYNCHROPHASE RECEIVER TYPE MU-2

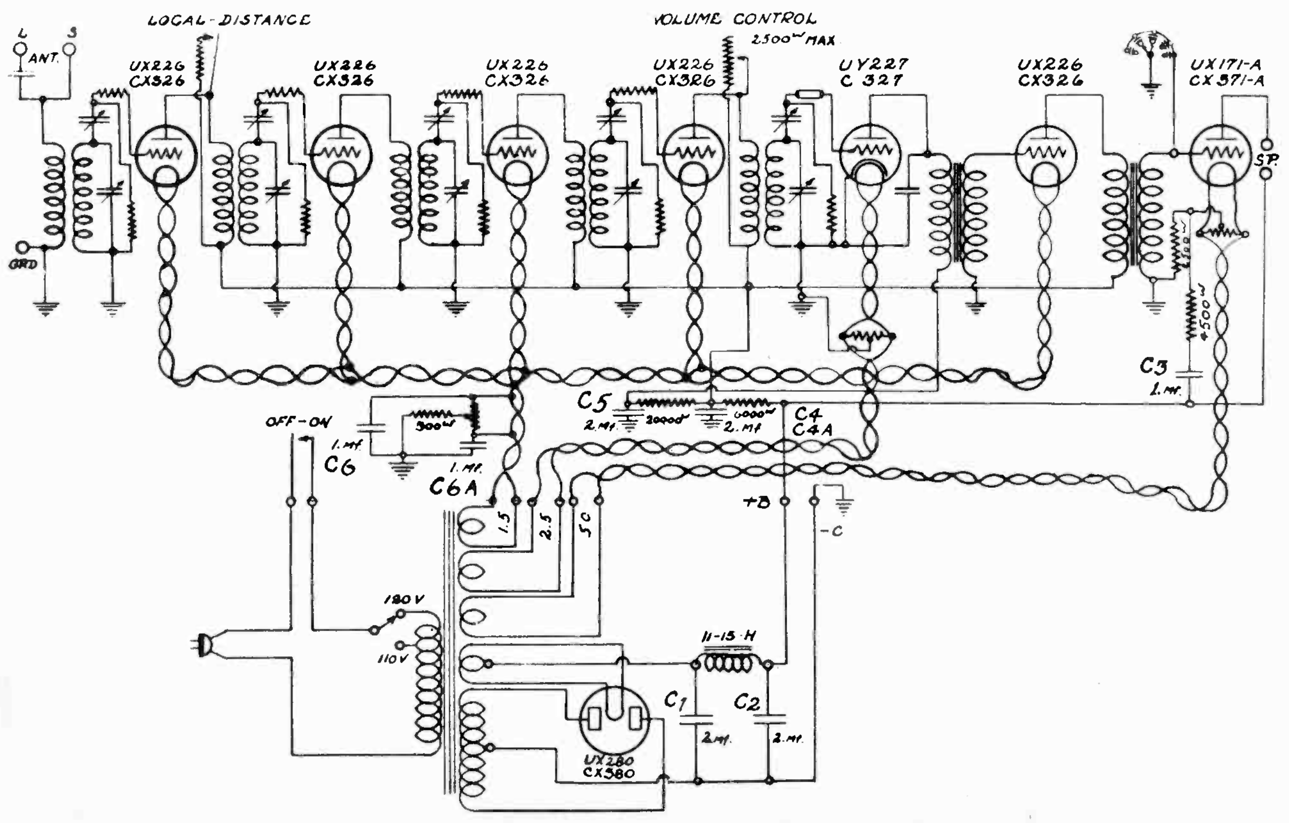
A.H. GREBE & CO. INC. RICHMOND HILL, N.Y.




INTERNAL WIRING DIAGRAM
FOR
GREBE SYNCHROPHASE RECEIVER
A H GREBE & CO, INC
RICHMOND HILL, N.Y.
AERIAL
GROUND
LOOP
-LOUD SPEAKER+
+AMP B
+DET B
-C
+C
-A
+A
-B
FUSE LIGHT
ANT.
LOOP
G
P
F
1st R.F.
2nd R.F.
DETECTOR
PILOT LIGHT
2nd A.F.
1st A.F.
TONE COLOR
VOLUME

8-29-25 E.P.



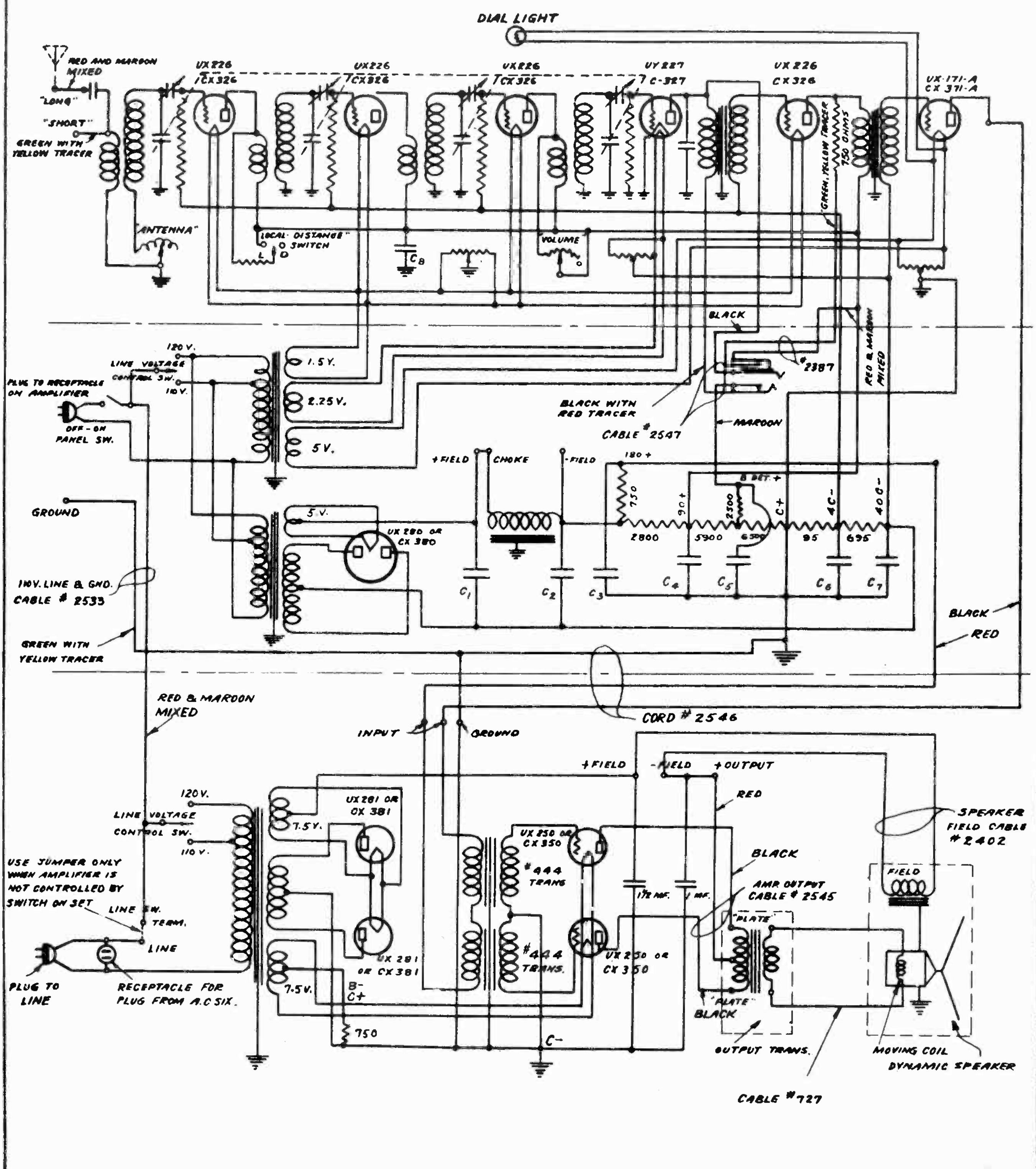


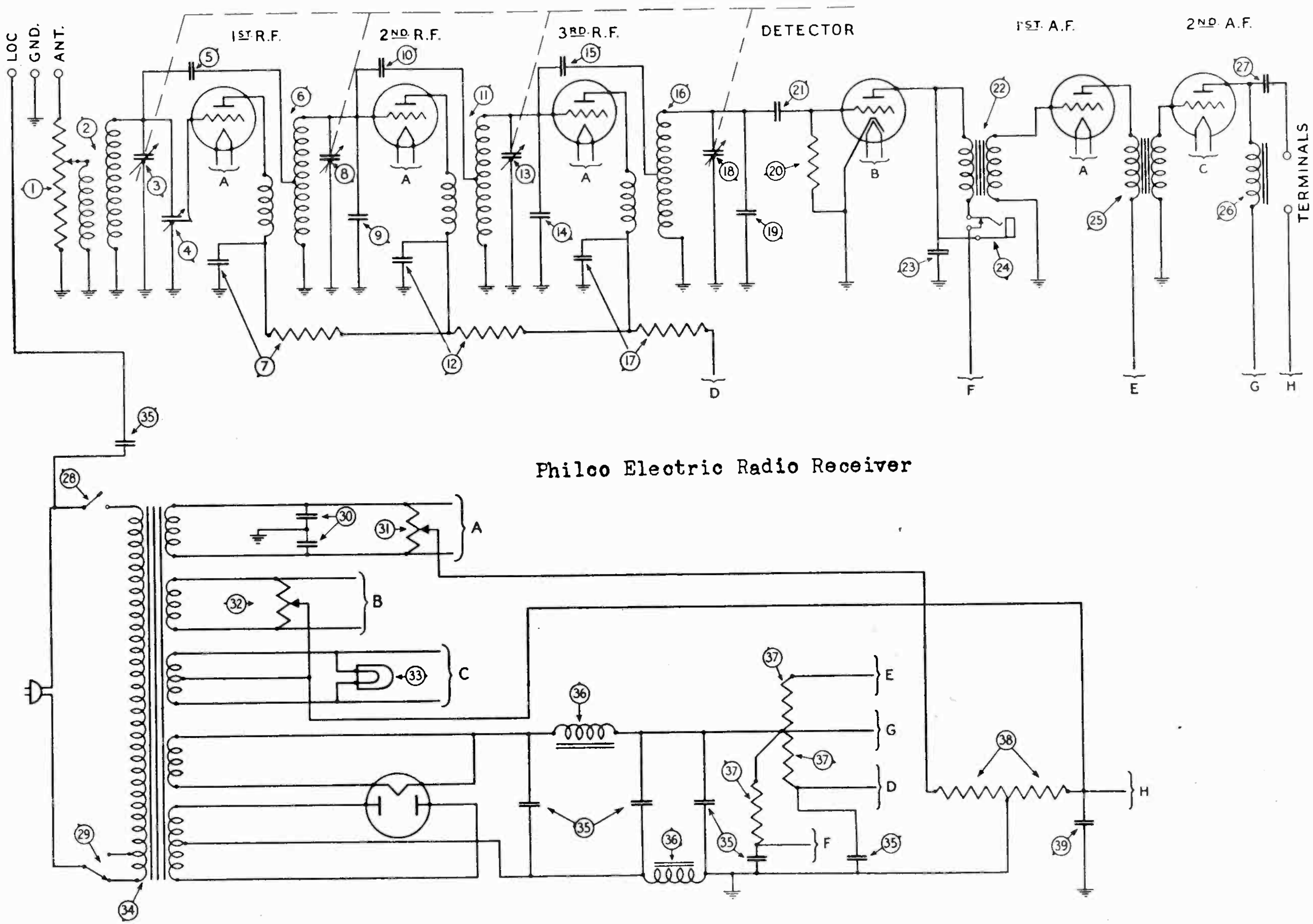
Grebe syncrophase AC 7

WIRING DIAGRAM FOR GREBE DELUXE CONSOLE TYPE 428

A.C. SIX RECEIVER, PUSH PULL AMPLIFIER TYPE 412
OUTPUT TRANS. TYPE 413 AND DYNAMIC SPEAKER TYPE 400

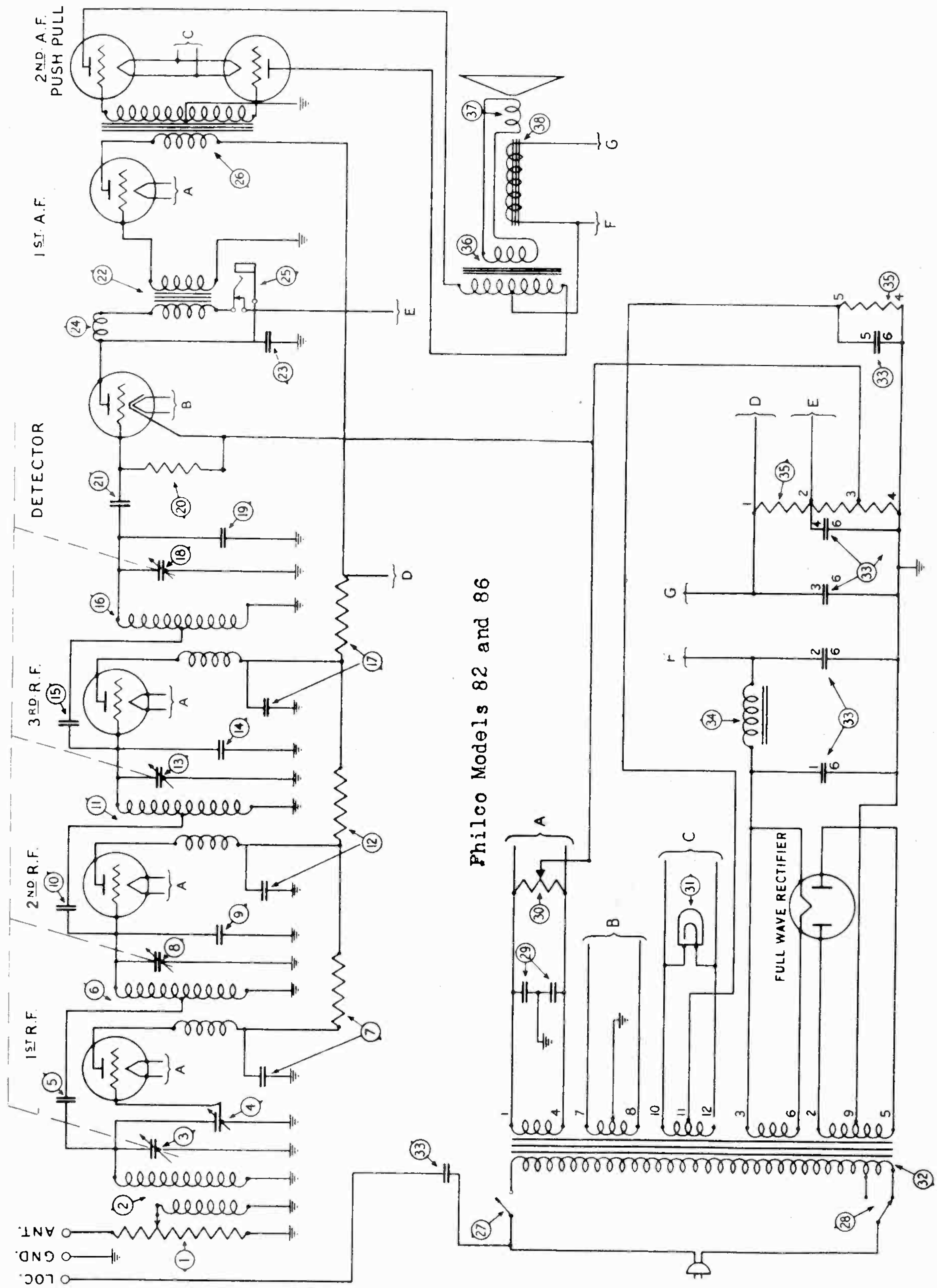
A.H. GREBE & CO., INC.
RICHMOND HILL, N.Y.



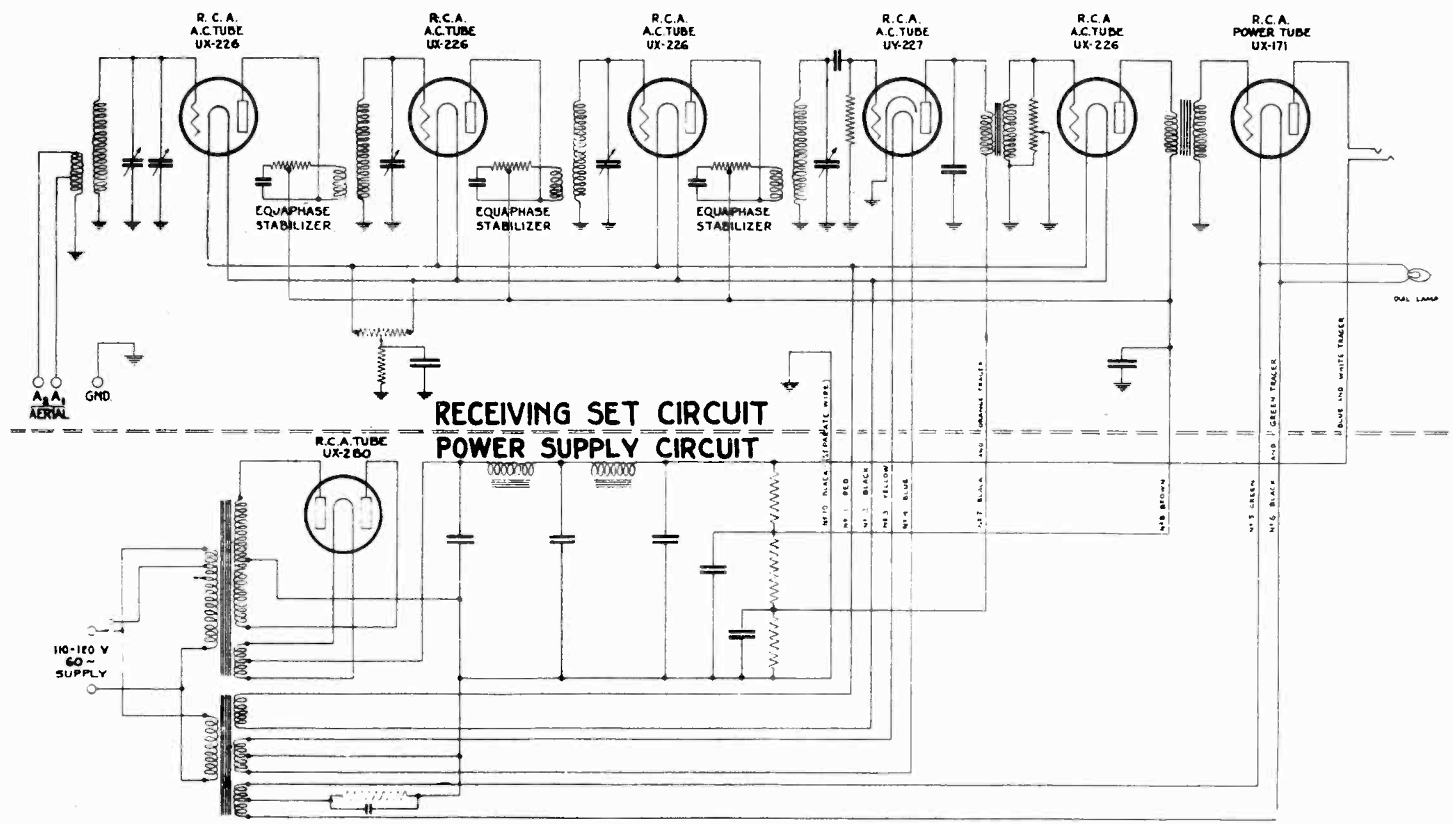


Philco Electric Radio Receiver

Freshman



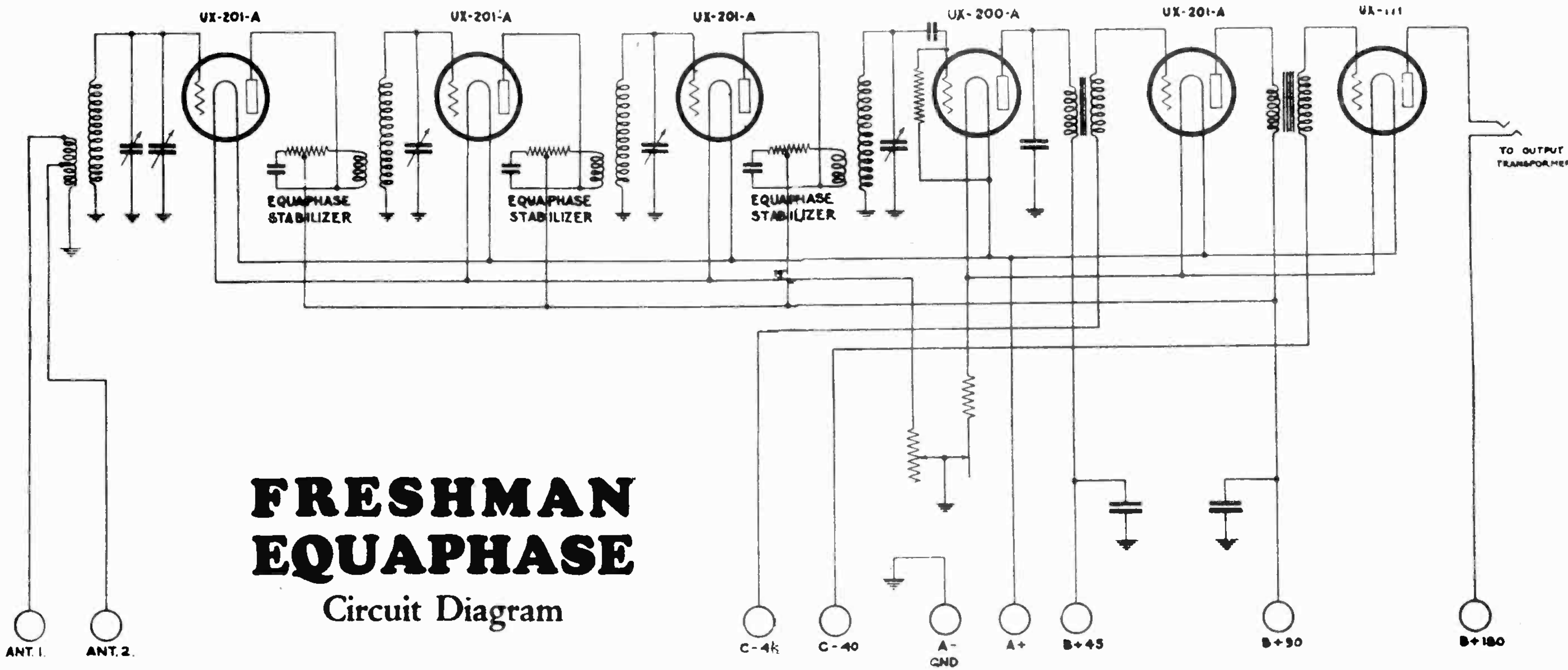
Philco Models 82 and 86

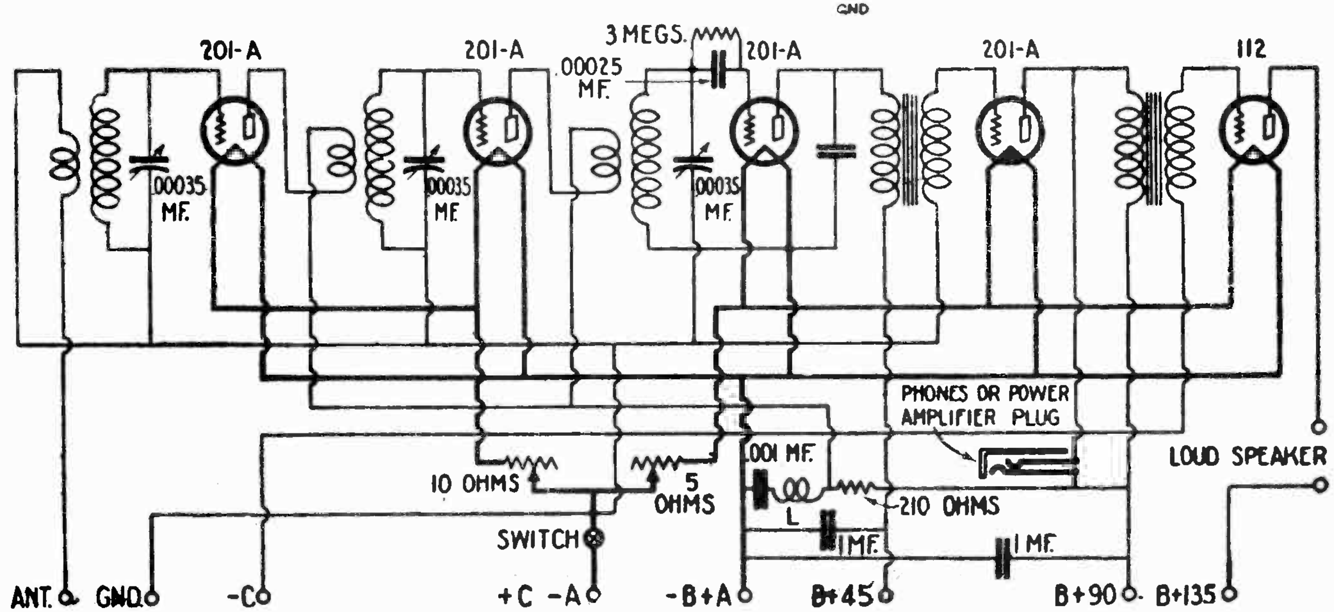


Schematic diagram of Model "G" Chassis and G-60-S Power Supply.
Note the two choke coils in Power Supply Circuit.

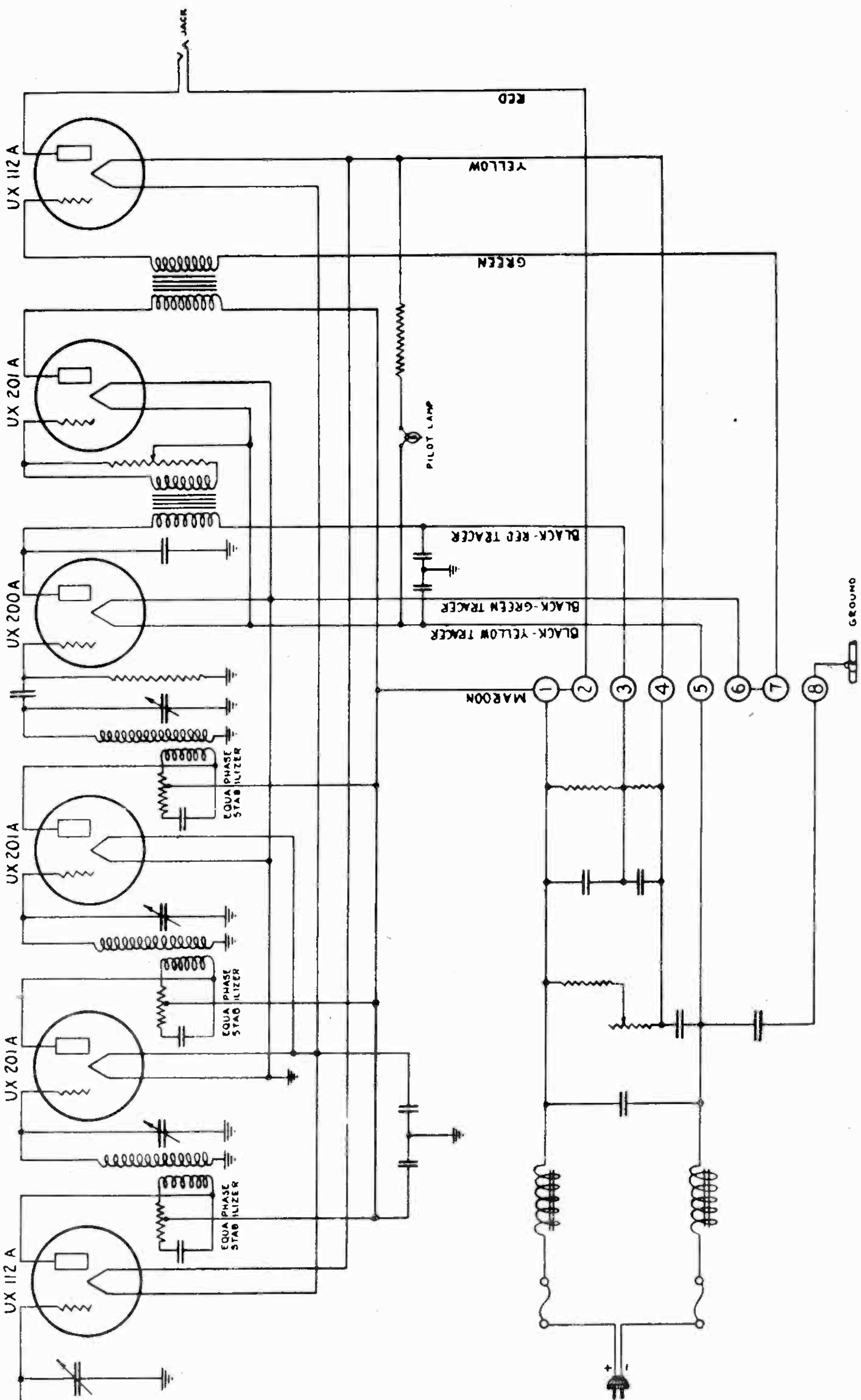
FRESHMAN EQUAPHASE

Circuit Diagram



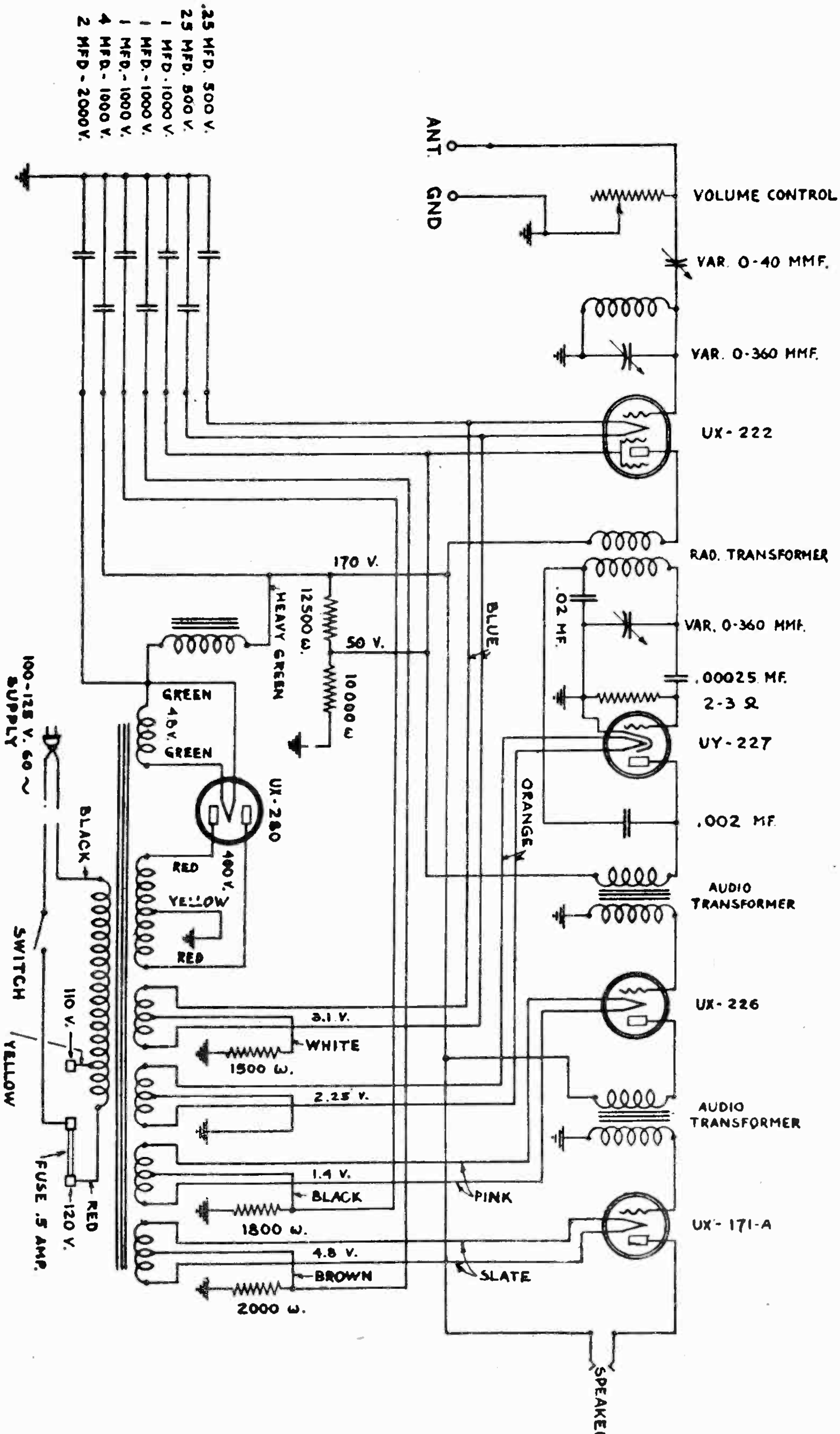


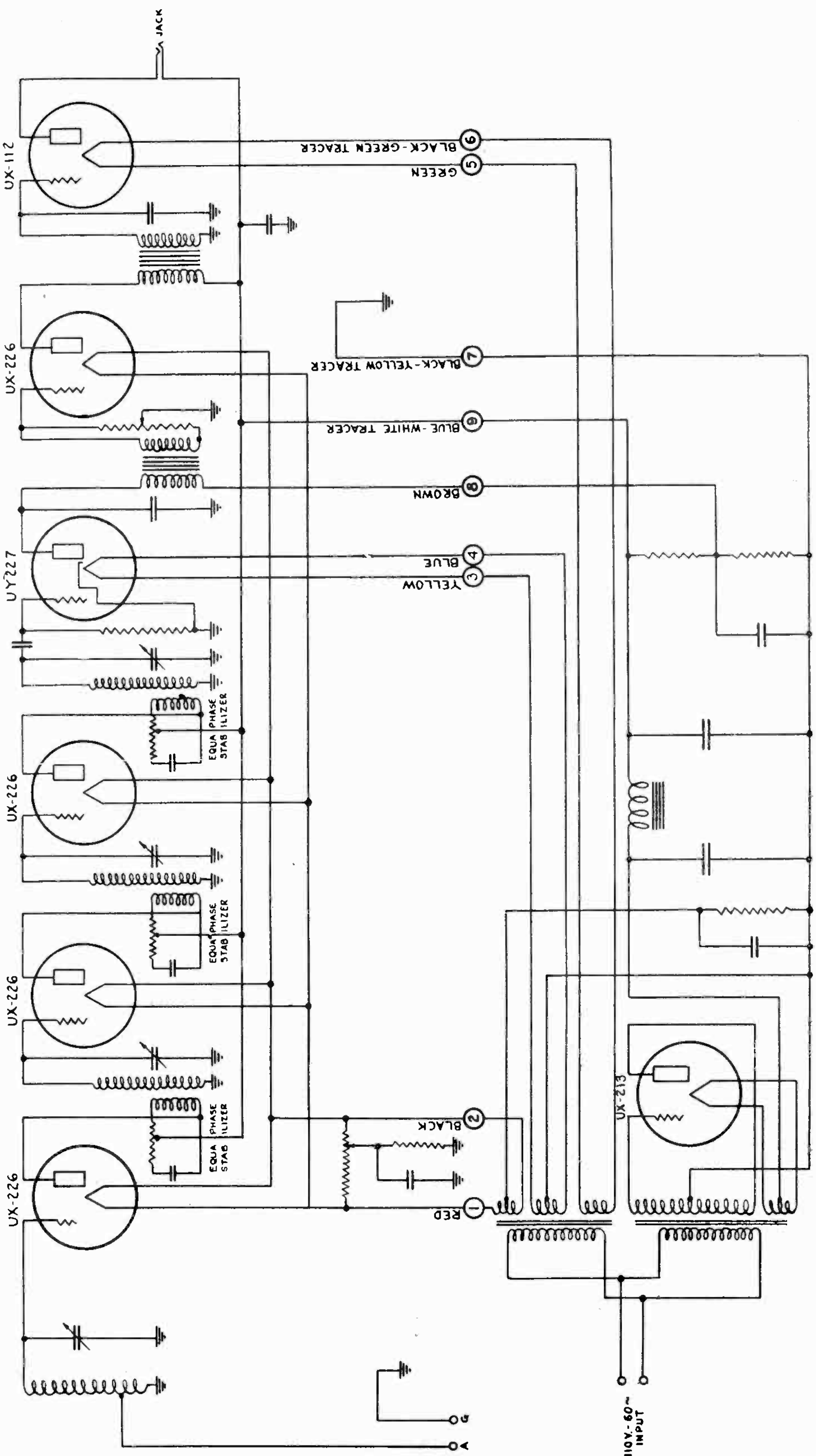
The latest available circuit diagram of the Freshman Masterpiece three-control receiver. A special R.F. choke and a fixed resistance, which do not appear in the earlier types, are employed in this receiver. The receiver is also designed for power-tube operation.



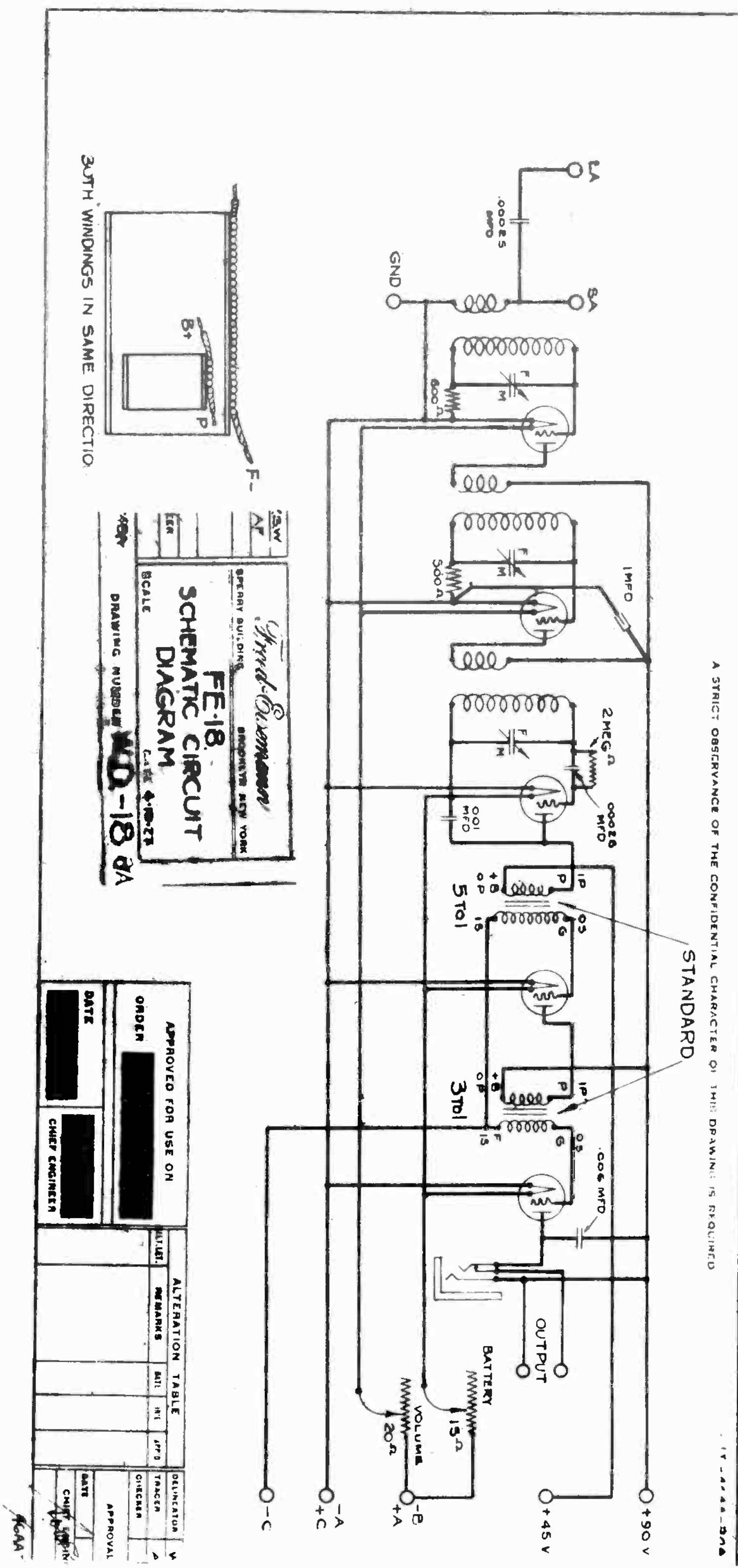
Combination Model L & LS
Schematic Circuit Diagram.
Freshman

Freshman Q15

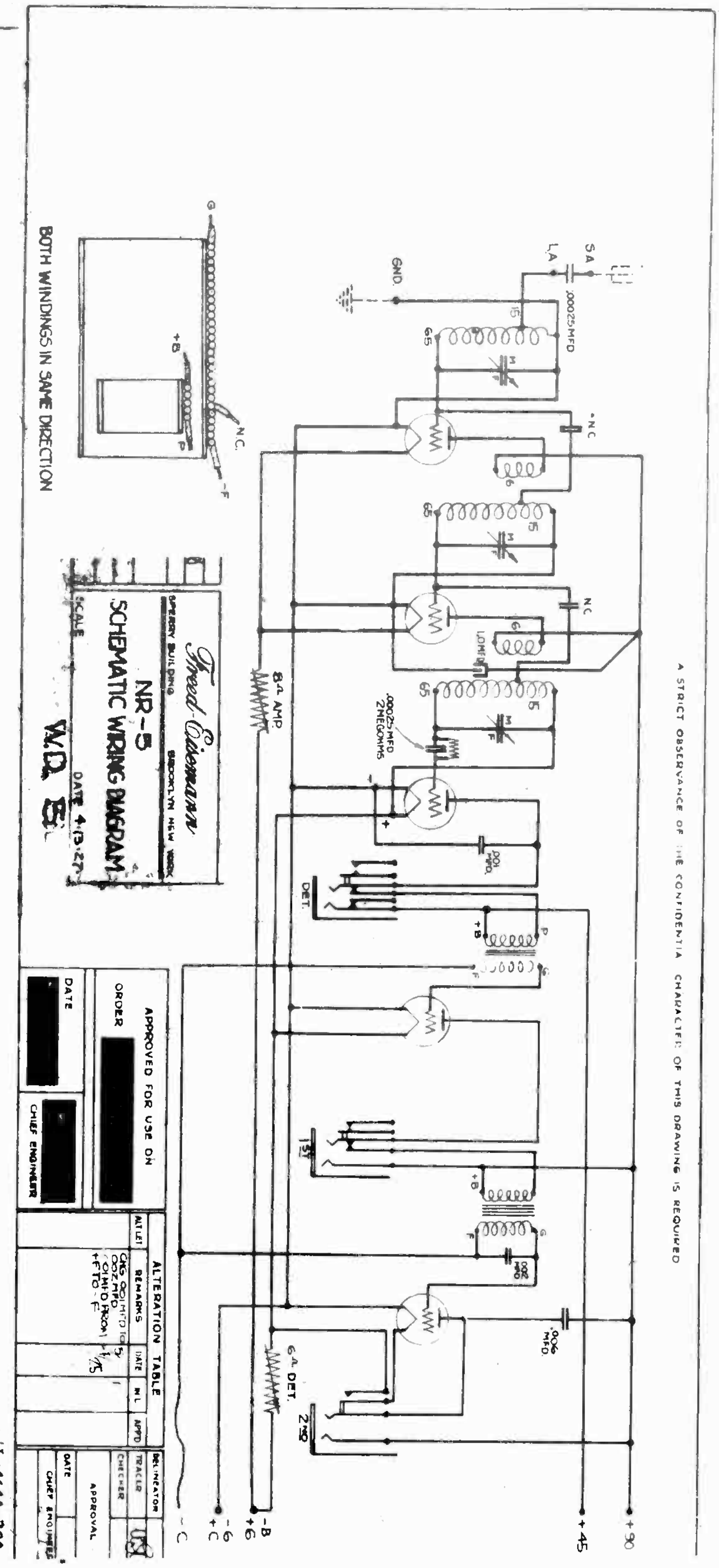




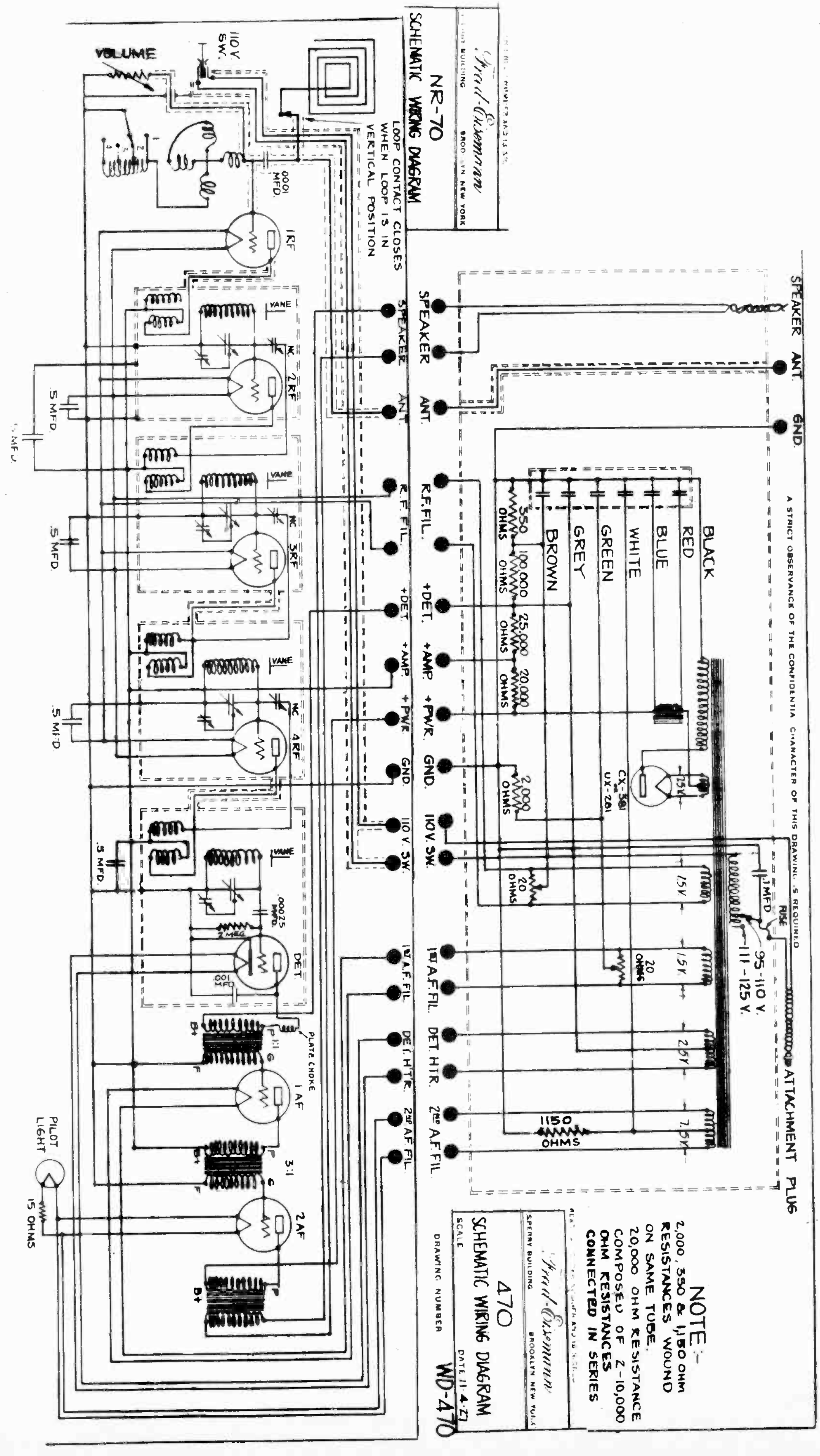
Combination Model K & K-60-S
Schematic Circuit Diagram.
Freshman



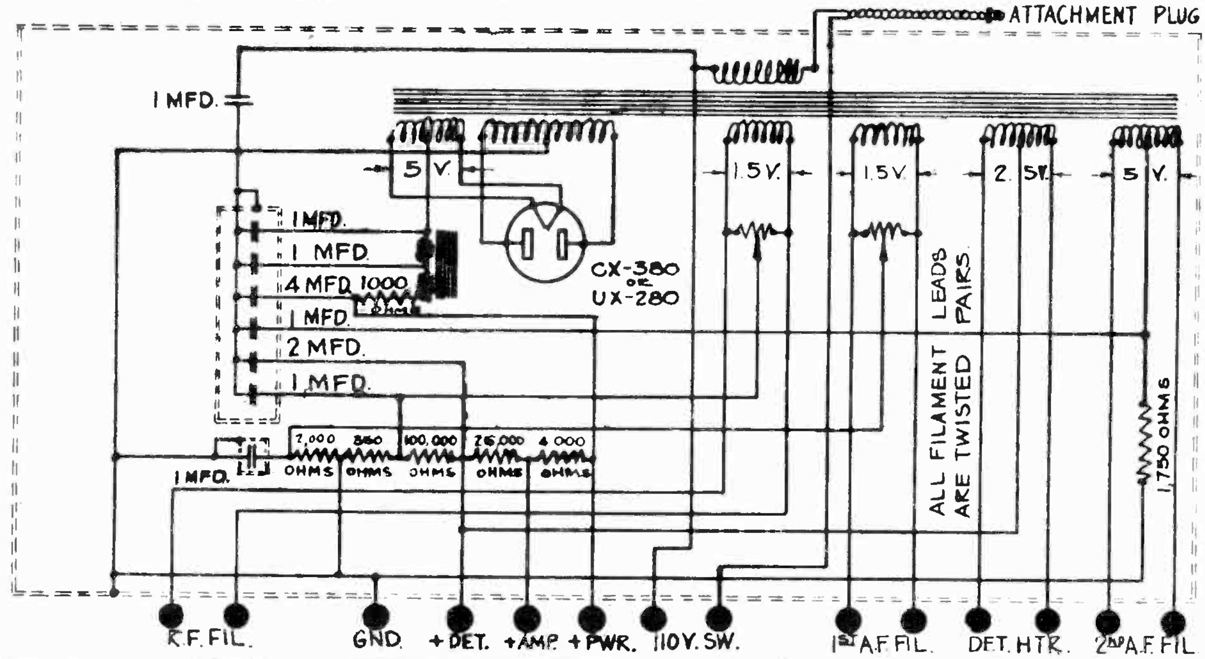
Freed-Eisemann
SPERRY BUILDING BROOKLYN NEW YORK
FE-18
SCHEMATIC CIRCUIT DIAGRAM
SCALE
DRAWING NUMBER
APPROVED FOR USE ON
ORDER
DATE
CHIEF ENGINEER
ALTERATION TABLE
APPROVAL
STANDARD
5 To 1
3 To 1
OUTPUT
BATTERY
VOLUME
LA
SA
GND
.00025 MFD
1 MFD
2 MEG Ω
.001 MFD
.006 MFD
+90 V
+45 V
-B +A
-A +C
-C
BOTH WINDINGS IN SAME DIRECTION



A STRICT OBSERVANCE OF THE CONFIDENTIAL CHARACTER OF THIS DRAWING IS REQUIRED
Freed-Eisemann
SPERRY BUILDING BROOKLYN NEW YORK
NR-5
SCHEMATIC WIRING DIAGRAM
SCALE
DATE 4-13-27
APPROVED FOR USE ON
ORDER
DATE
CHIEF ENGINEER
ALTERATION TABLE
REMARKS
APPROVAL
BOTH WINDINGS IN SAME DIRECTION
SA
LA
GND
.00025 MFD
.00025 MFD 2 MEGOHMS
.001 MFD
.006 MFD
DET.
1ST
2ND
6 A DET.
8 A AMP
+90
+45
-B +6
-6 +C
-C
A STRICT OBSERVANCE OF THE CONFIDENTIAL CHARACTER OF THIS DRAWING IS REQUIRED


NR-70
SCHEMATIC WIRING DIAGRAM
LOOP CONTACT CLOSES WHEN LOOP IS IN VERTICAL POSITION
Freed-Eisemann
BROOKLYN NEW YORK
VOLUME
110 V. SW.
.0001 MFD.
1RF
2RF
3RF
4RF
DET.
1 AF
2AF
VANE
NC
.5 MFD.
.00025 MFD.
2 MEG
.001 MFD
PLATE CHOKE
3:1
B+
PILOT LIGHT
15 OHMS
SPEAKER
ANT.
R.F. FIL.
+DET.
+AMP
+PWR.
GND.
110V. SW.
1ST A.F. FIL.
DET. HTR.
2ND A.F. FIL.
SPEAKER ANT. GND.
A STRICT OBSERVANCE OF THE CONFIDENTIAL CHARACTER OF THIS DRAWING IS REQUIRED
BLACK
RED
BLUE
WHITE
GREEN
GREY
BROWN
350 OHMS
100,000 OHMS
25,000 OHMS
20,000 OHMS
2,000 OHMS
CX-381 UX-281
20 OHMS
1 MFD
FUSE
95-110 V.
111-125 V.
1150 OHMS
ATTACHMENT PLUG
NOTE:-
2,000, 350 & 1,150 OHM RESISTANCES WOUND ON SAME TUBE.
20,000 OHM RESISTANCE COMPOSED OF 2-10,000 OHM RESISTANCES CONNECTED IN SERIES
470
SCHEMATIC WIRING DIAGRAM
SCALE
DATE 11-4-27
DRAWING NUMBER
WD-470
SPERRY BUILDING
BROOKLYN NEW YORK

A STRICT OBSERVANCE OF THE CONFIDENTIAL CHARACTER OF THIS DRAWING IS REQUIRED



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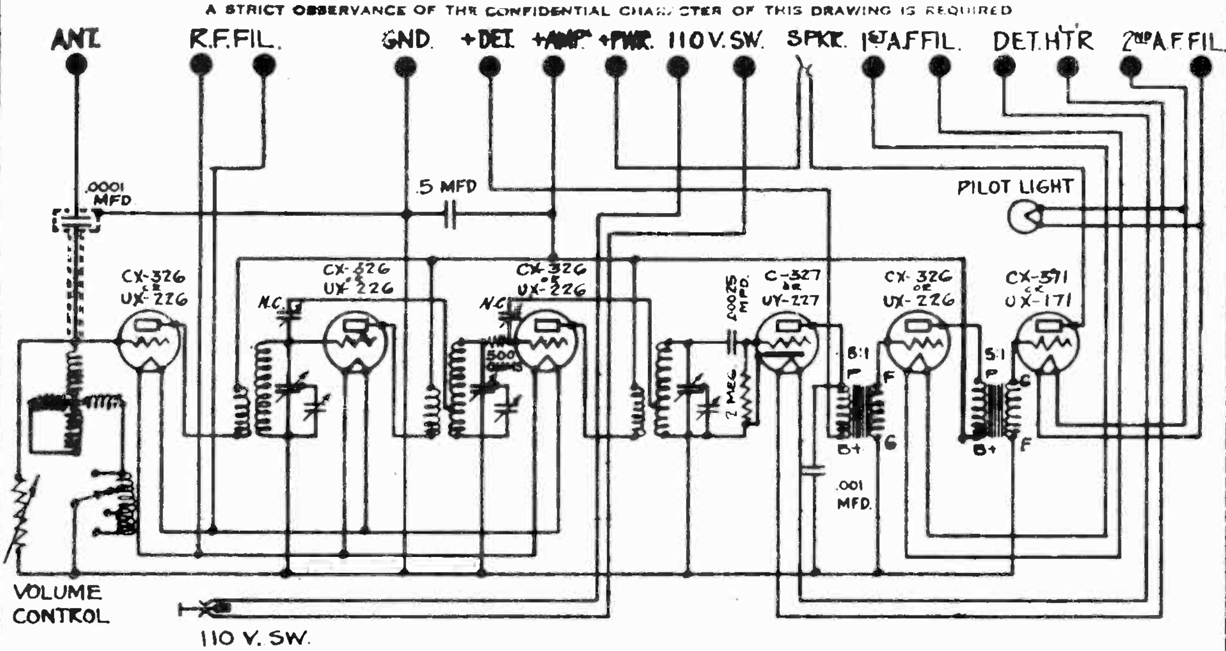
[redacted] CHIEF ENGINEER		CHIEF ENGINEER	SCHEMATIC WIRING DIAGRAM
			SCALE DATE 11-4-27

DRAWING NUMBER WD-457

A STRICT OBSERVANCE OF THE CONFIDENTIAL CHARACTER OF THIS DRAWING IS REQUIRED



THIS DRAWING IS NOT APPROVED ...

APPROVED FOR USE ON	ALTERATION TABLE	DELINEATOR	Fred. Eisemann
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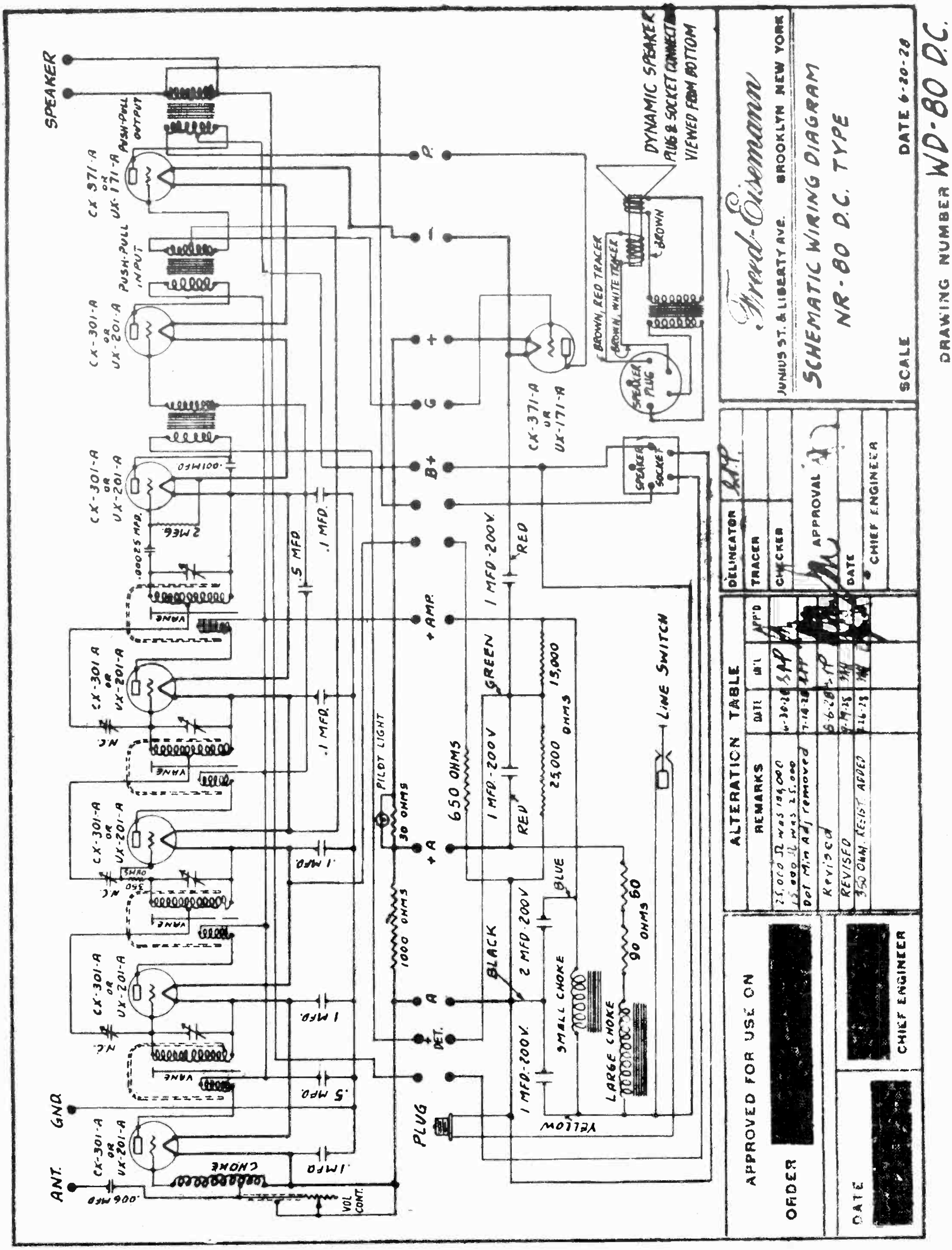
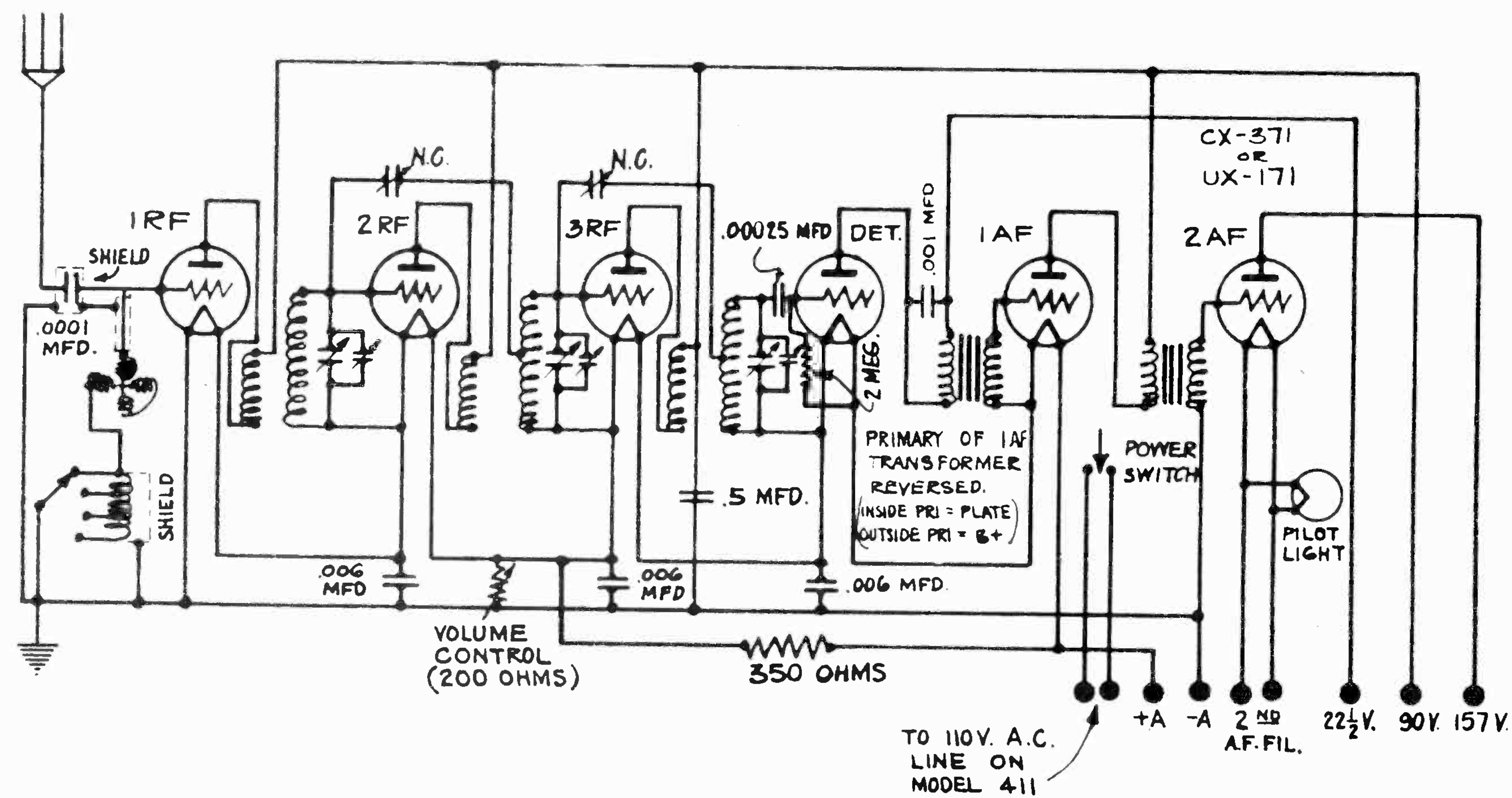
			SCALE DATE 11-4-27

DRAWING NUMBER WD-57


Freed-Eisemann
JUNIUS ST. & LIBERTY AVE. BROOKLYN NEW YORK
SCHEMATIC WIRING DIAGRAM
NR-80 D.C. TYPE
SCALE
DATE 6-20-28
DRAWING NUMBER WD-80 D.C.
DYNAMIC SPEAKER PLUG & SOCKET CONNECT VIEWED FROM BOTTOM
DELINEATOR
TRACER
CHECKER
APPROVAL
DATE
CHIEF ENGINEER
ALTERATION TABLE
REMARKS
DATE
APPROVED FOR USE ON
ORDER
DATE
CHIEF ENGINEER
SPEAKER
PUSH-PULL OUTPUT
PUSH-PULL INPUT
CX 371-A OR UX-171-A
CX-301-A OR UX-201-A
CX-371-A OR UX-171-A
.001 MFD
2 MEG.
.00025 MFD.
.5 MFD
.1 MFD.
.1 MFD.
1 MFD.
1 MFD.
.5 MFD.
1 MFD
VANE
N.C.
350 OHMS
ANT.
GND.
.006 MFD
CHOKE
VOL CONT.
PLUG
PILOT LIGHT
30 OHMS
1000 OHMS
650 OHMS
P
G
B+
+AMP.
+A
A
DET.
1 MFD-200V.
RED
GREEN
15,000
25,000 OHMS
BLUE
60
90 OHMS
BLACK
2 MFD-200V
1 MFD-200V.
SMALL CHOKE
LARGE CHOKE
YELLOW
LINE SWITCH
SPEAKER PLUG
SPEAKER SOCKET
BROWN, RED TRACER
BROWN, WHITE TRACER
BROWN
Revised
REVISED
350 Ohm. RESIST. ADDED
Det. Min Adj removed

A STRICT OBSERVANCE OF THE CONFIDENTIAL CHARACTER OF THIS DRAWING IS REQUIRED



THIS DRAWING IS NOT APPROVED AND IS NOT TO BE USED FOR MANUFACTURING PURPOSES UNLESS IT BEARS AN [illegible] NUMBER AND IS SIGNED

APPROVED FOR USE ON

ORDER [redacted]

DATE [redacted]

[redacted]
CHIEF ENGINEER

ALTERATION TABLE

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DELINEATOR	TJP
TRACER	
CHECKER	
APPROVAL	
DATE	
CHIEF ENGINEER	

Fred-Eisemann

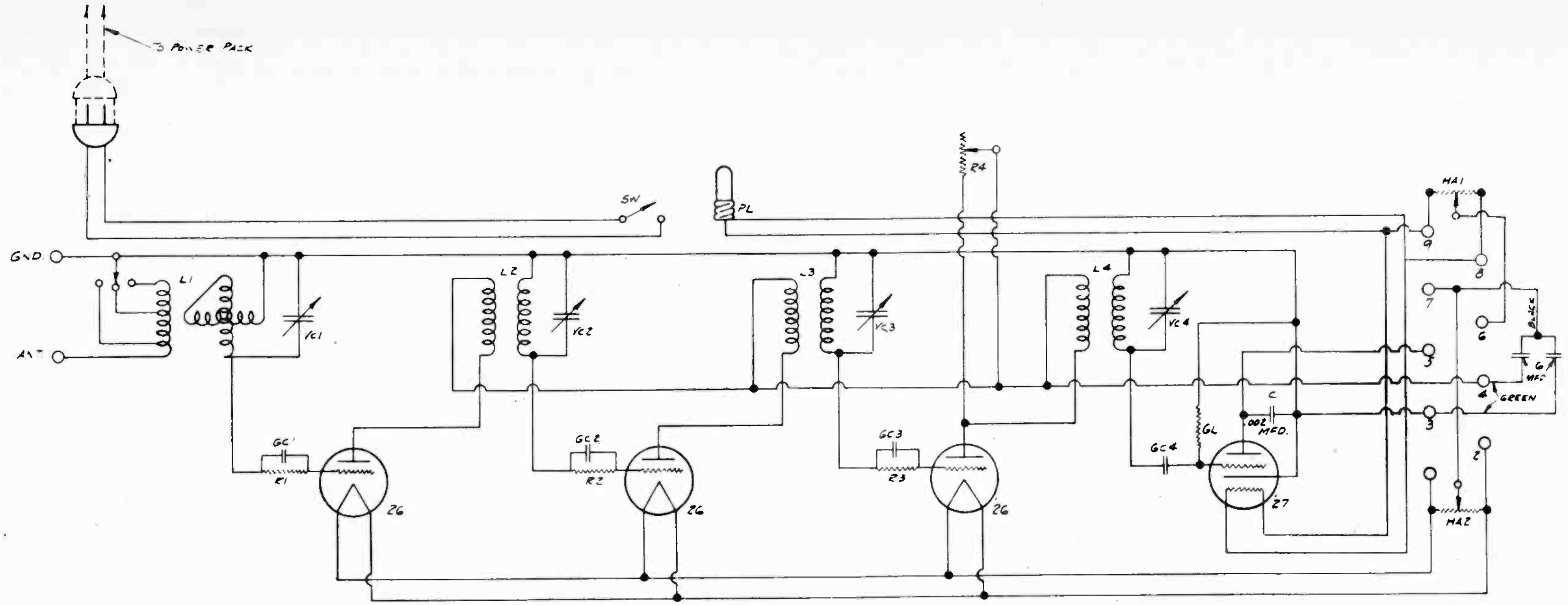
SPERRY BUILDING BROOKLYN NEW YORK

NR-11

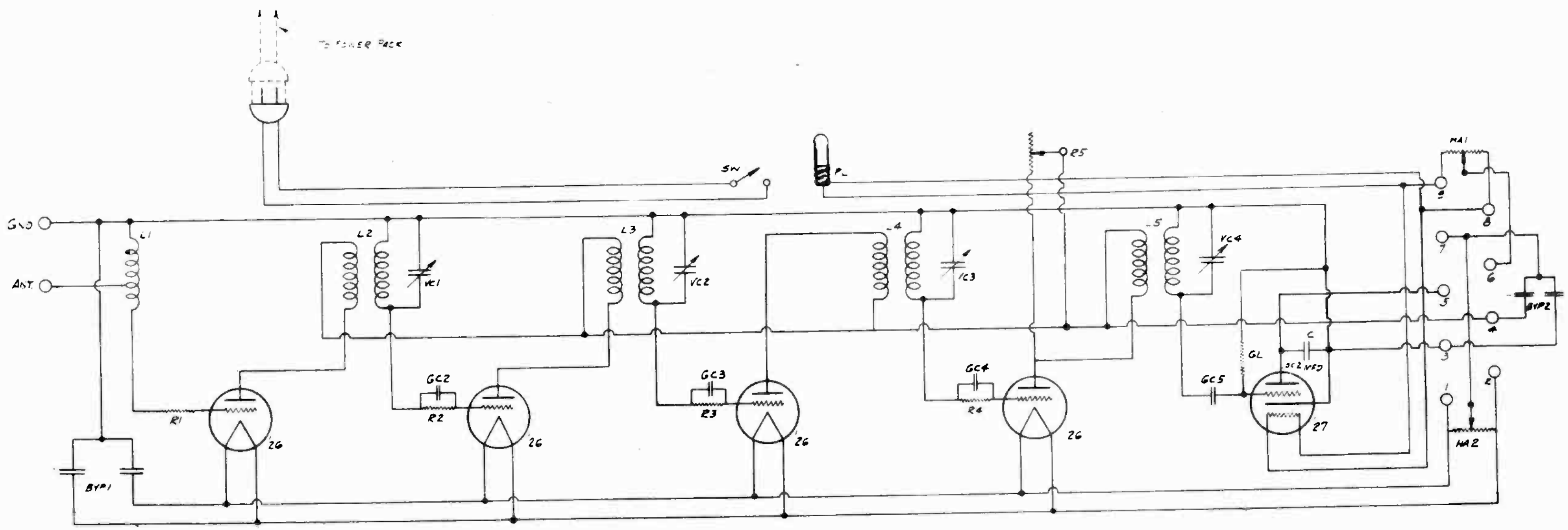
SCHEMATIC CIRCUIT DIAGRAM

SCALE DATE 2-3-28

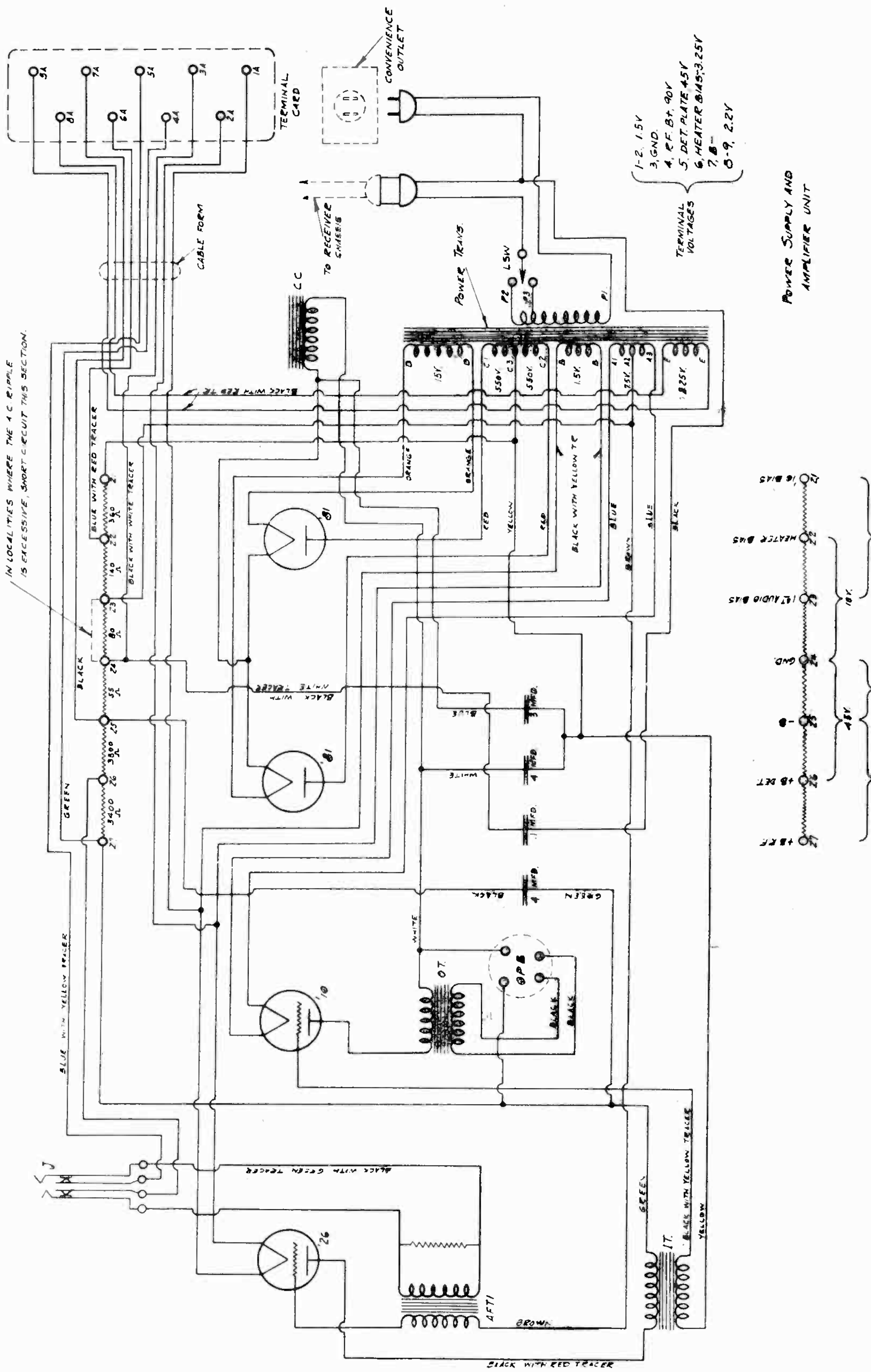
DRAWING NUMBER [redacted] WD-11



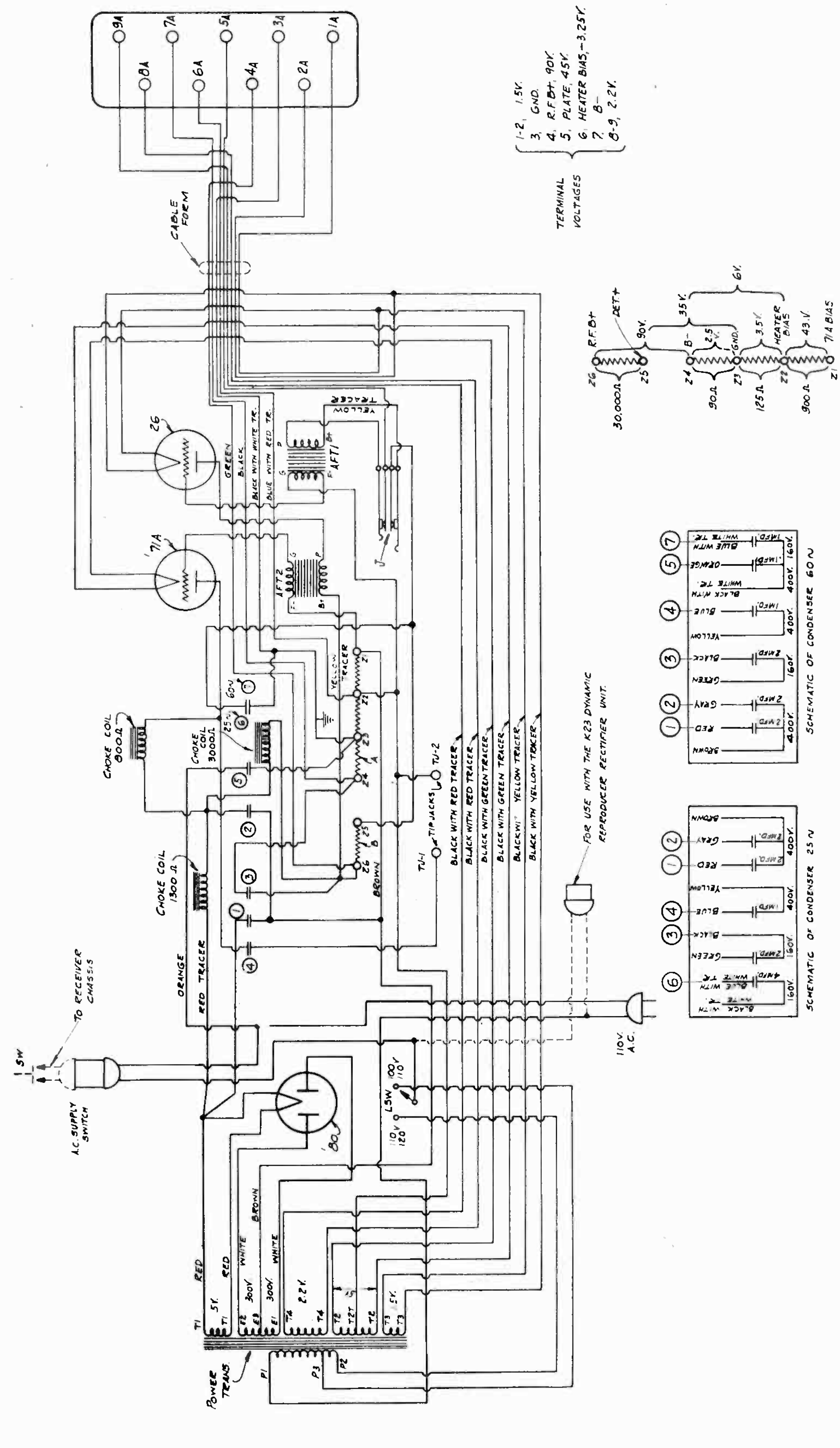
Schematic diagram of the four tube chassis as used with six tube sets.



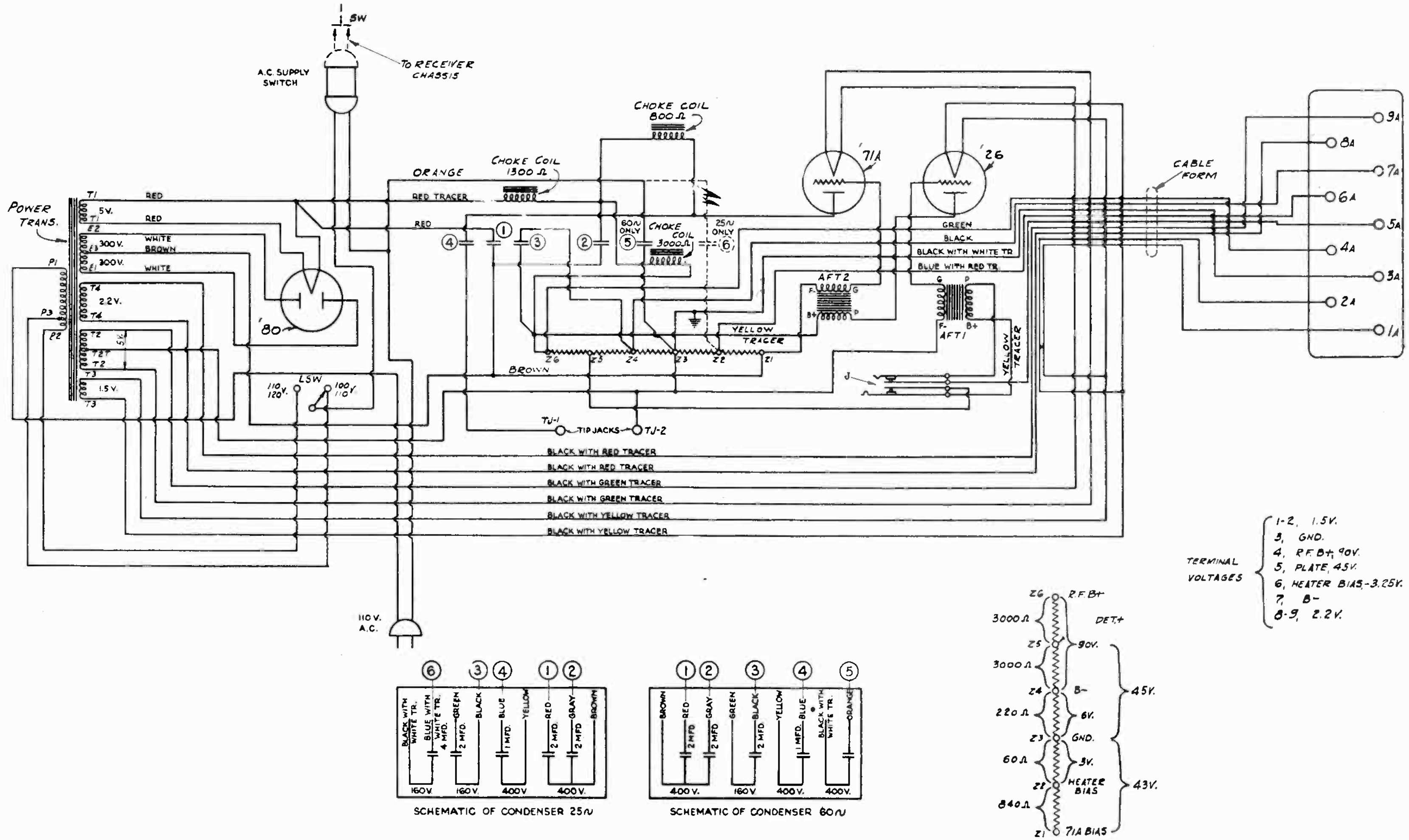
Tuning chassis for seven tube sets.



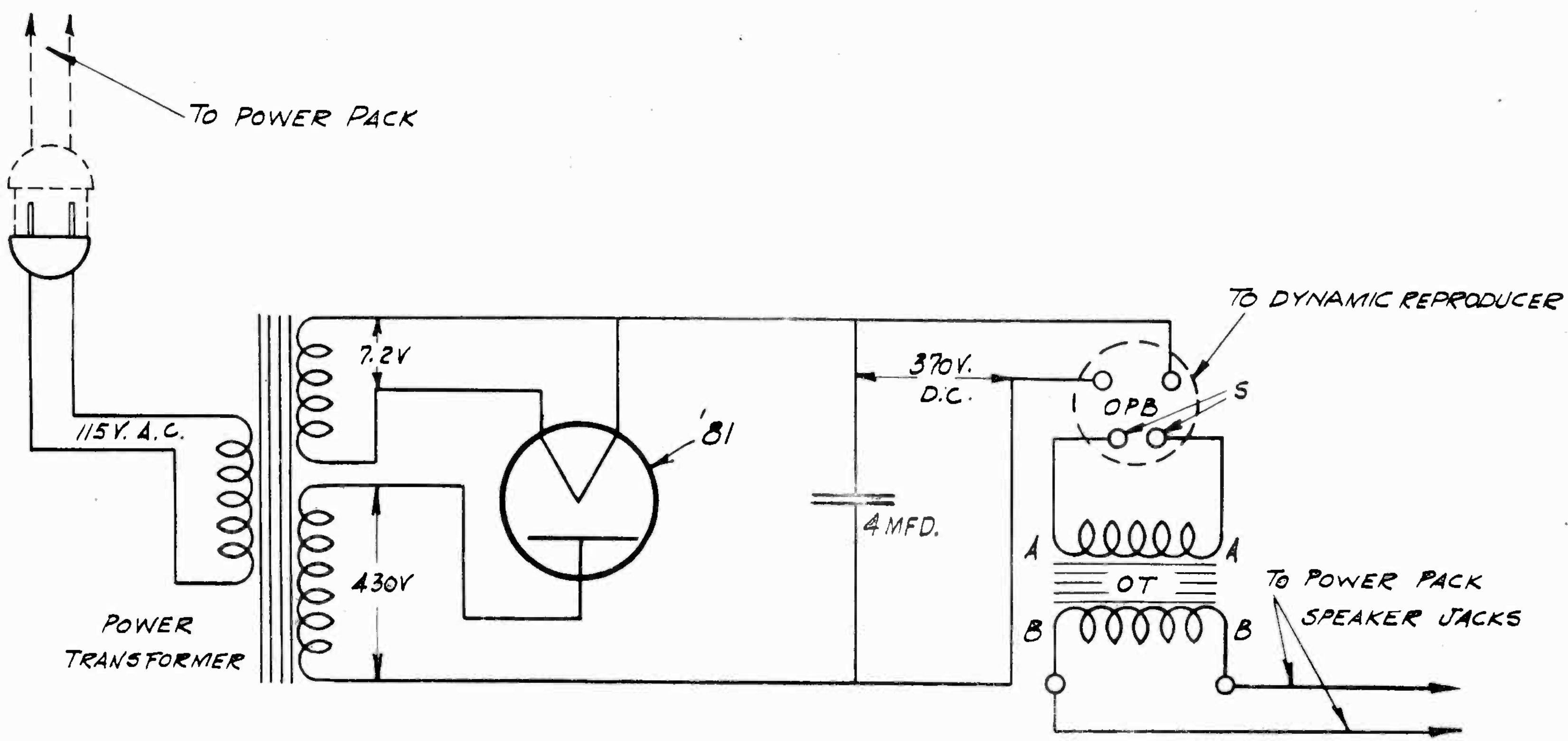
Schematic diagram of the Power Supply and Power Amplifier Unit.



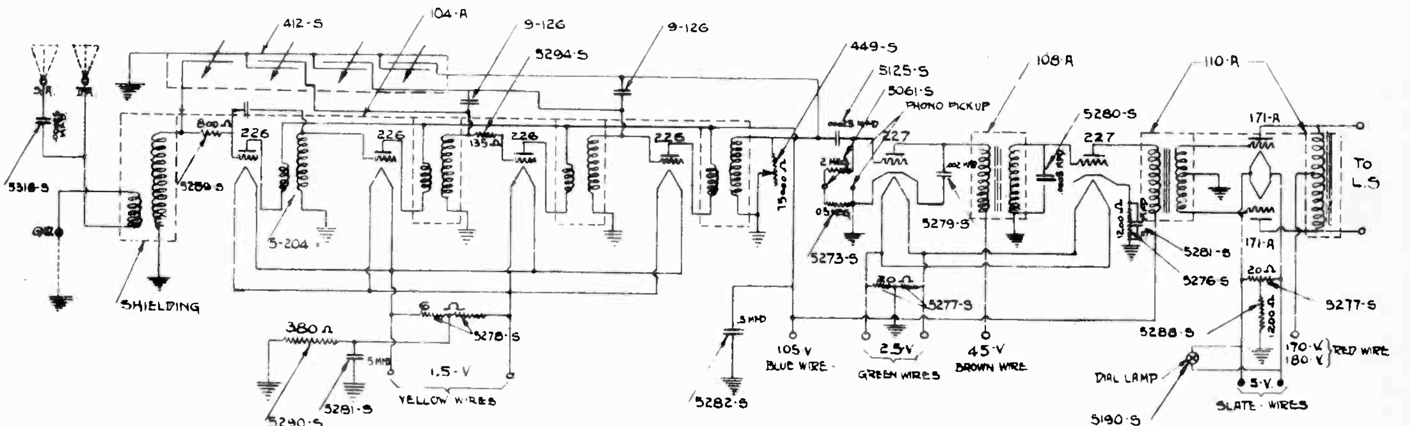
Schematic diagram of seven tube receiver Power Pack and Audio Amplifier.



Schematic diagram of the Power Pack and Audio Amplifier in the six tube sets. Bottom view.

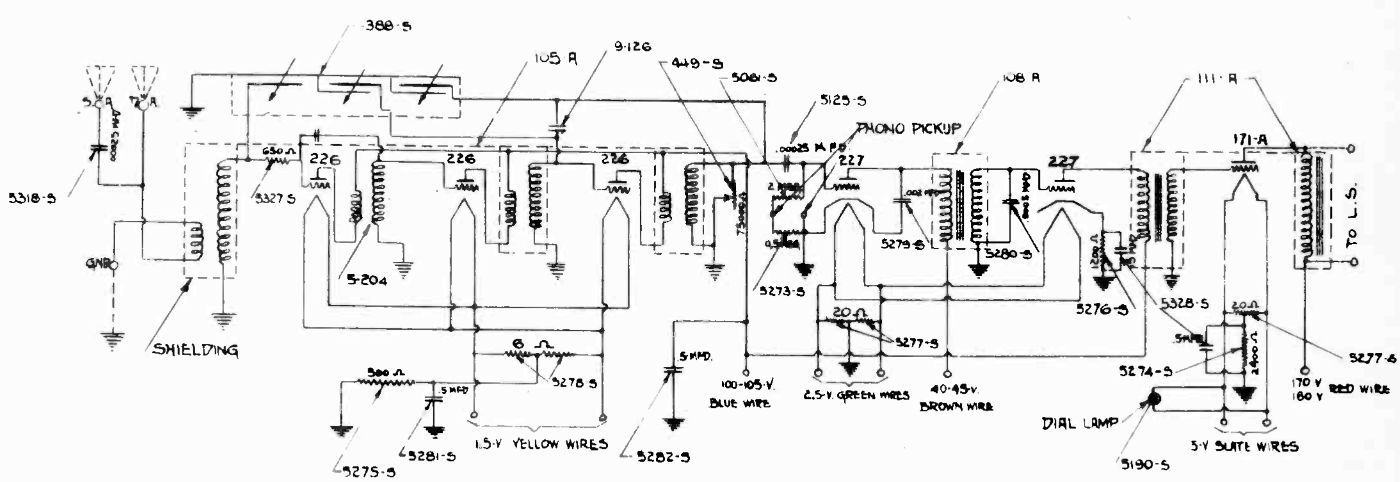


Schematic diagram of Rectifier Unit, K-23.



NOTE: ABOVE INDICATED PART NUMBERS ARE THE ELECTRICAL PART AND ASSEMBLY NUMBERS OF ITEMS USED IN CIRCUIT WHEN ORDERING PARTS OR ASSEMBLIES SPECIFY THIS NUMBER AS WELL AS NAME OF ITEM.

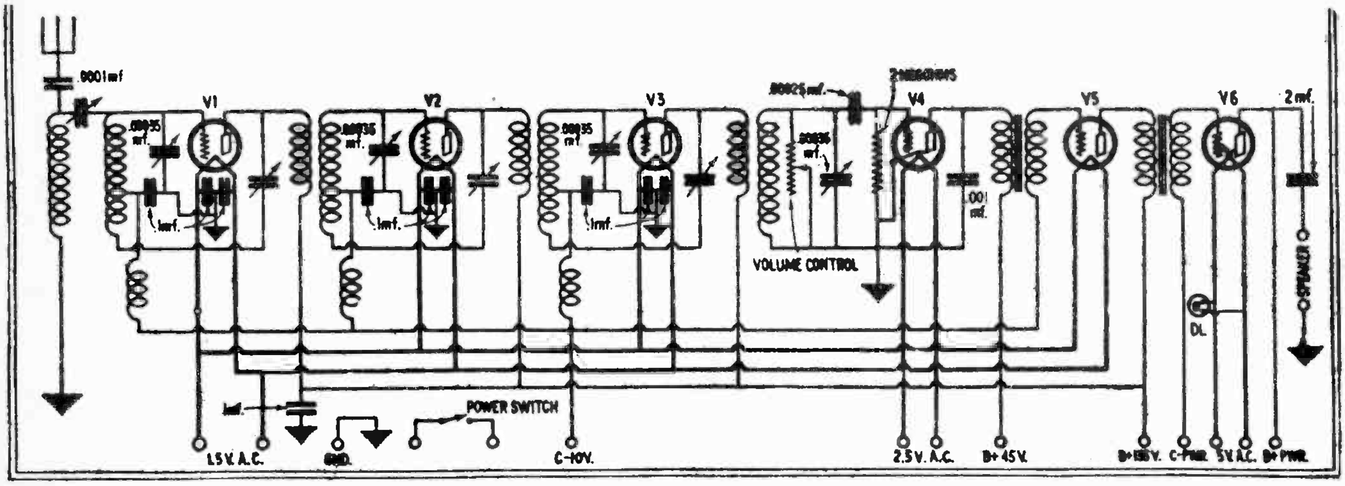
8 TUBE A.C. (MODELS 8C, 83, 84, 85, 86, AND 88)



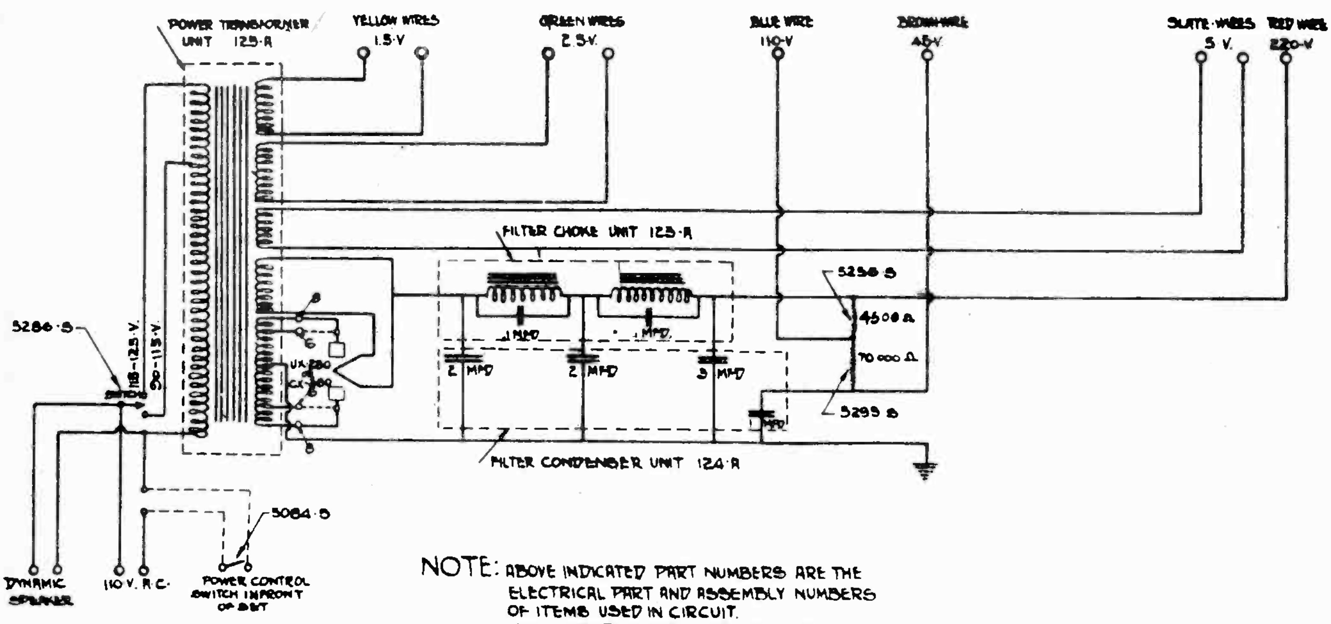
NOTE: ABOVE INDICATED PART NUMBERS ARE THE ELECTRICAL PART AND ASSEMBLY NUMBERS OF ITEMS USED IN CIRCUIT. WHEN ORDERING PARTS OR ASSEMBLIES SPECIFY THIS NUMBER AS WELL AS NAME OF ITEM.

FIG. 1
CIRCUIT DIAGRAM OF
6 TUBE A.C SET

6 TUBE A.C. (MODELS 60, 61, 62, 65, AND 66)

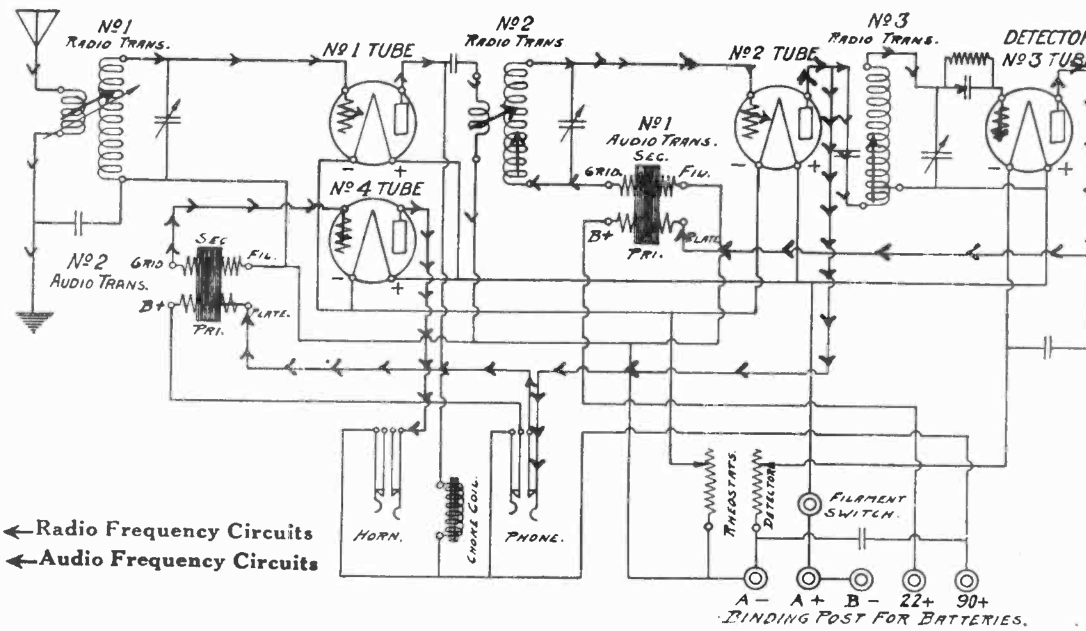


-The schematic diagram of the All-American 6-tube electric receiver.

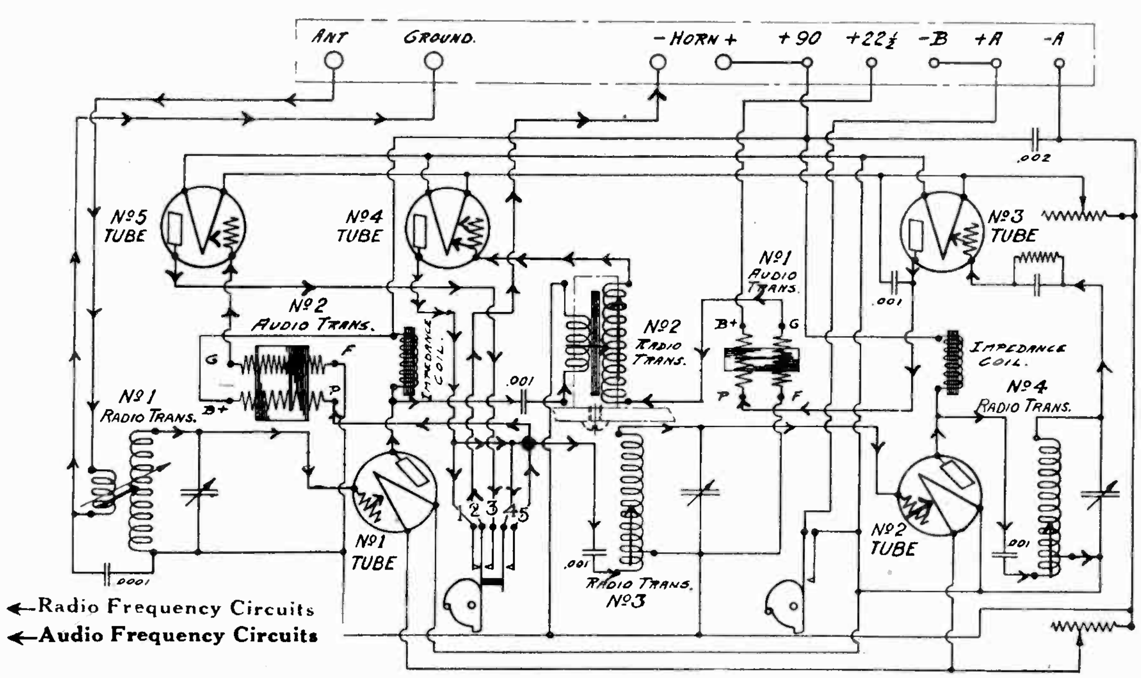


NOTE: ABOVE INDICATED PART NUMBERS ARE THE ELECTRICAL PART AND ASSEMBLY NUMBERS OF ITEMS USED IN CIRCUIT. WHEN ORDERING PARTS OR ASSEMBLIES SPECIFY THIS NUMBER AS WELL AS NAME OF ITEM

FIG # 5
CIRCUIT DIAGRAM OF —
6 & 8 TUBE A.C SET-POWER PACK

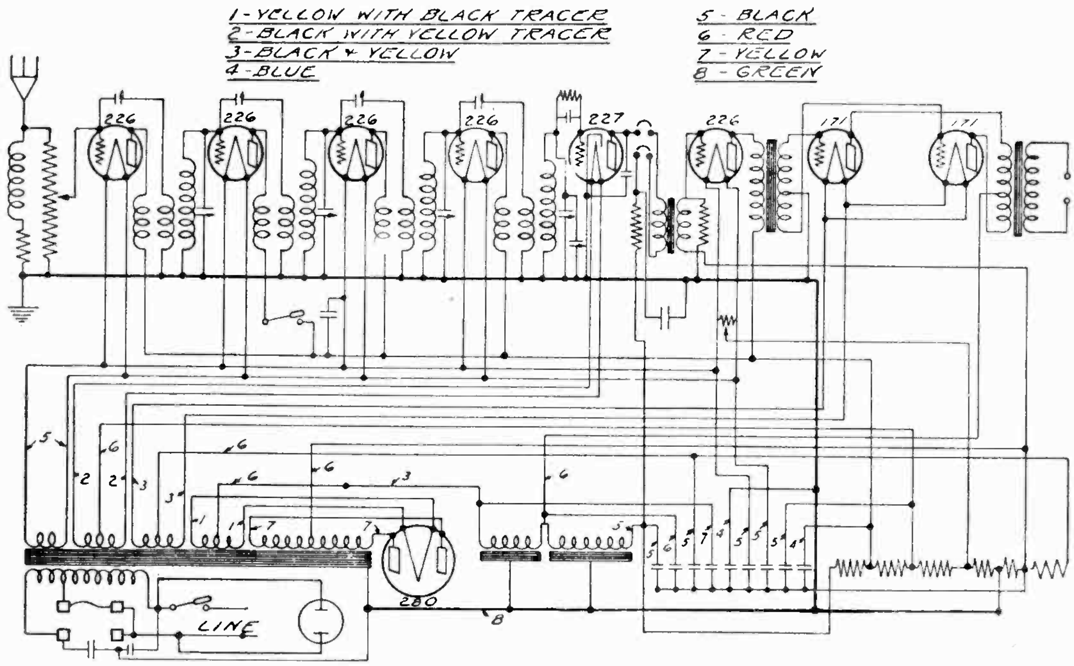


OEM-7 — 4-Tube



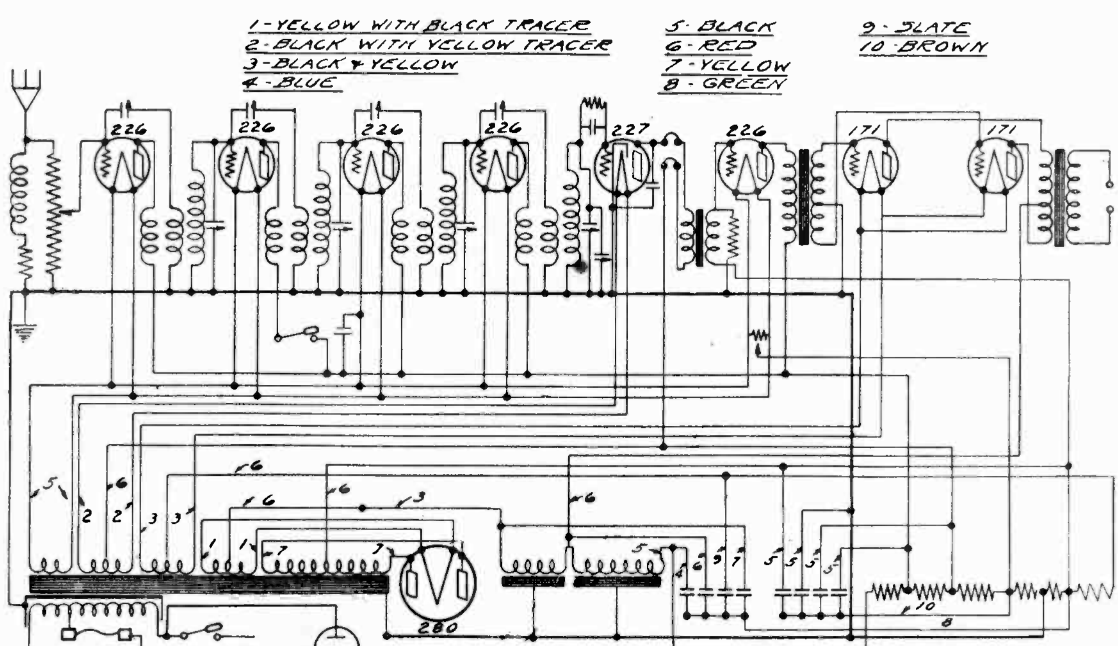
Model #5044

DAY-FAN FIVE — 5-Tube — 1925 Model

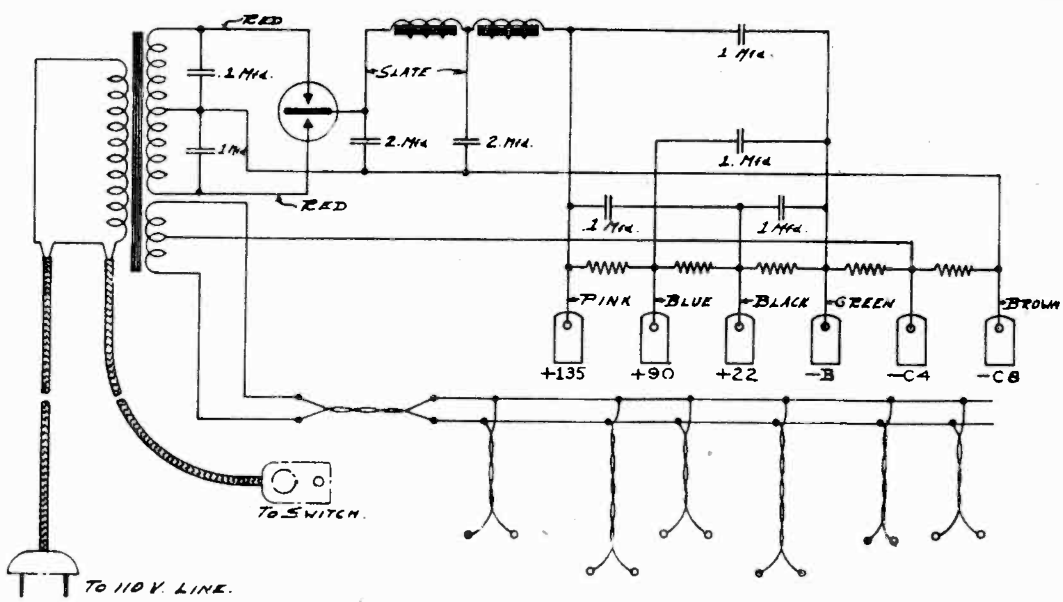


DAY-FAN 8—A. C. POWER SET

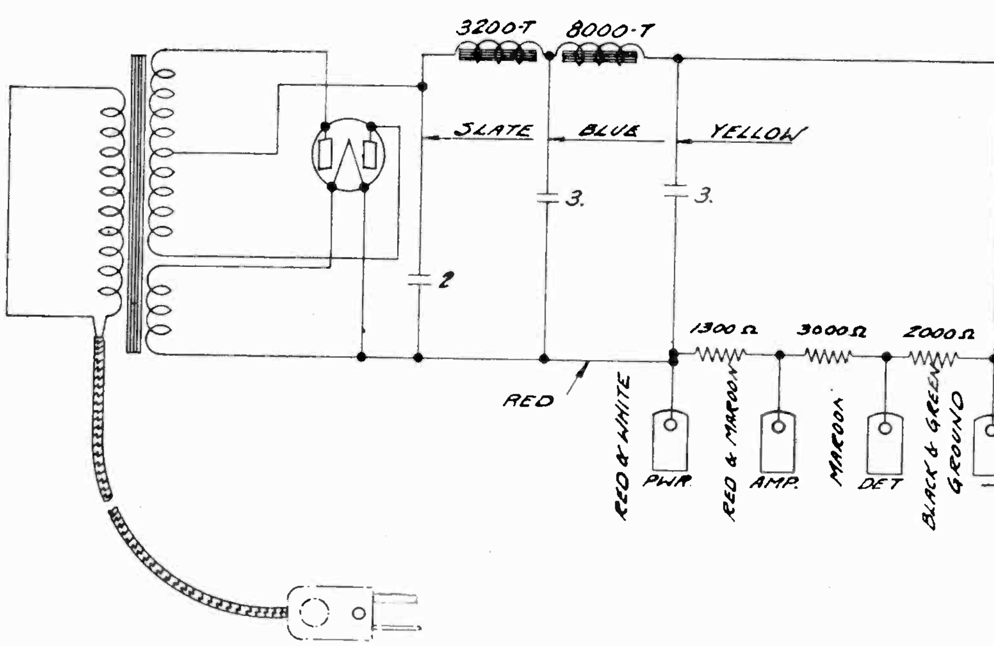
Note—Use this circuit diagram for receivers equipped with sealed power blocks, or condenser blocks not having brown nor slate colored leads.



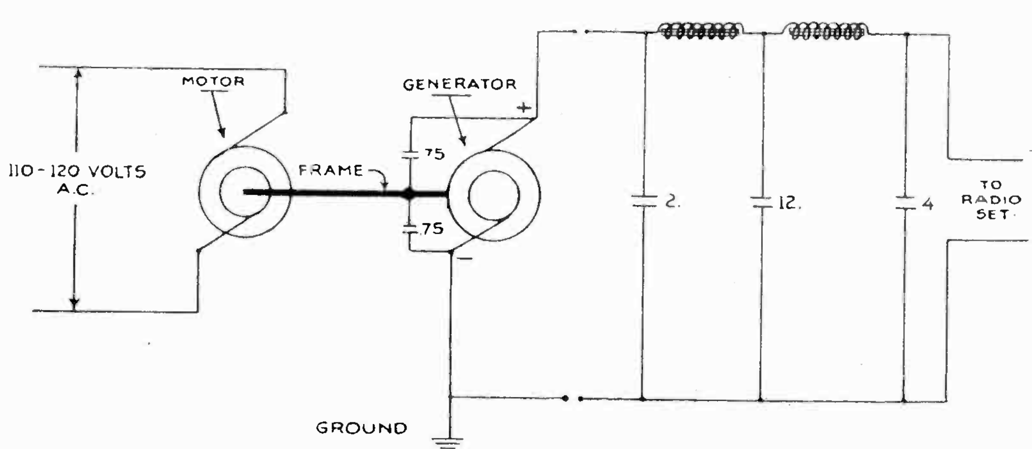
DAY-FAN 8—A. C. POWER SET



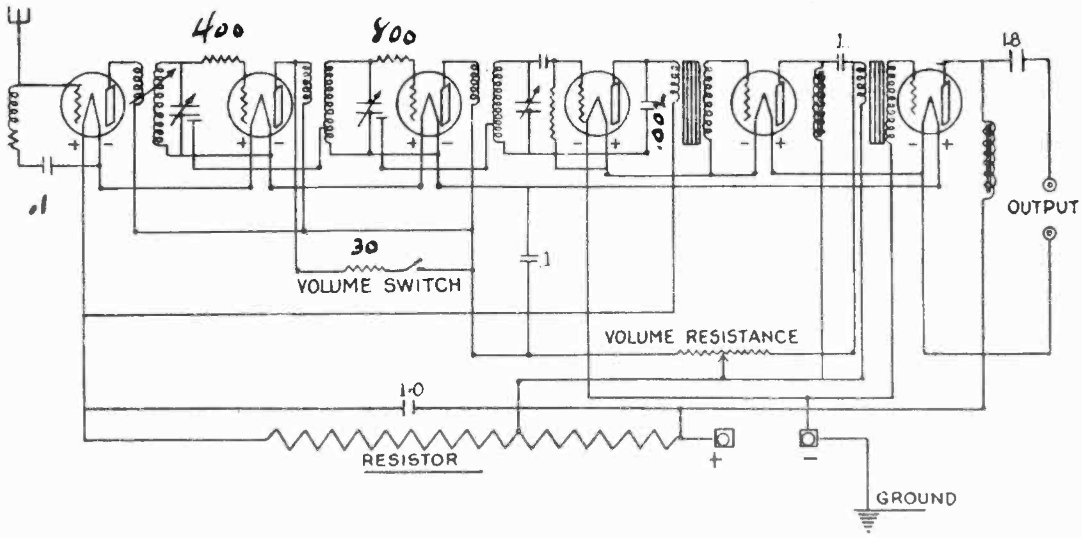
POWER SUPPLY FOR 6 TUBE A. C. SET



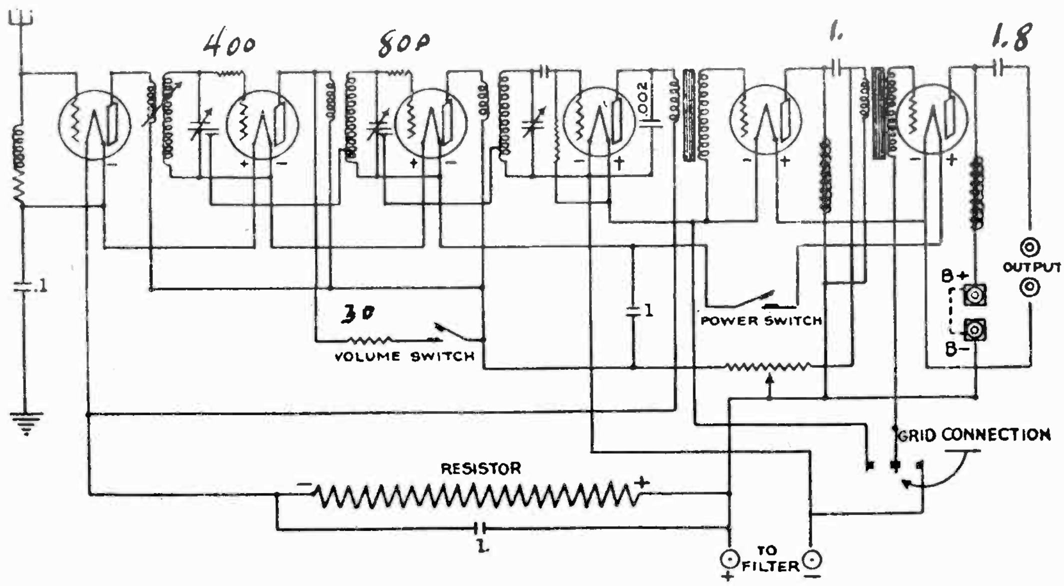
RADIO "B" POWER SUPPLY—MODEL NOS. 5524 AND 5525



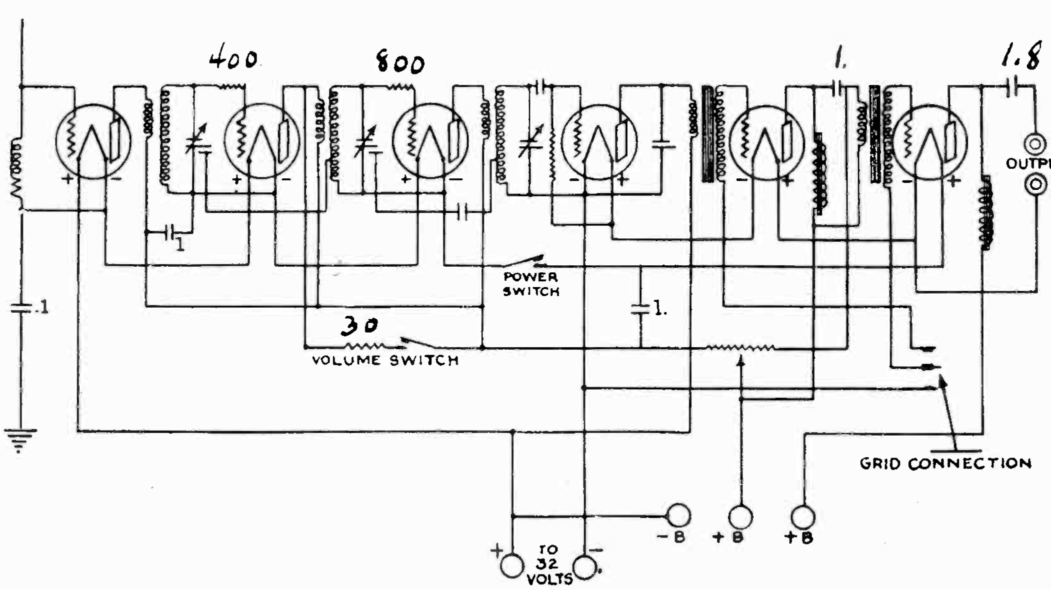
MOTOR GENERATOR AND FILTER



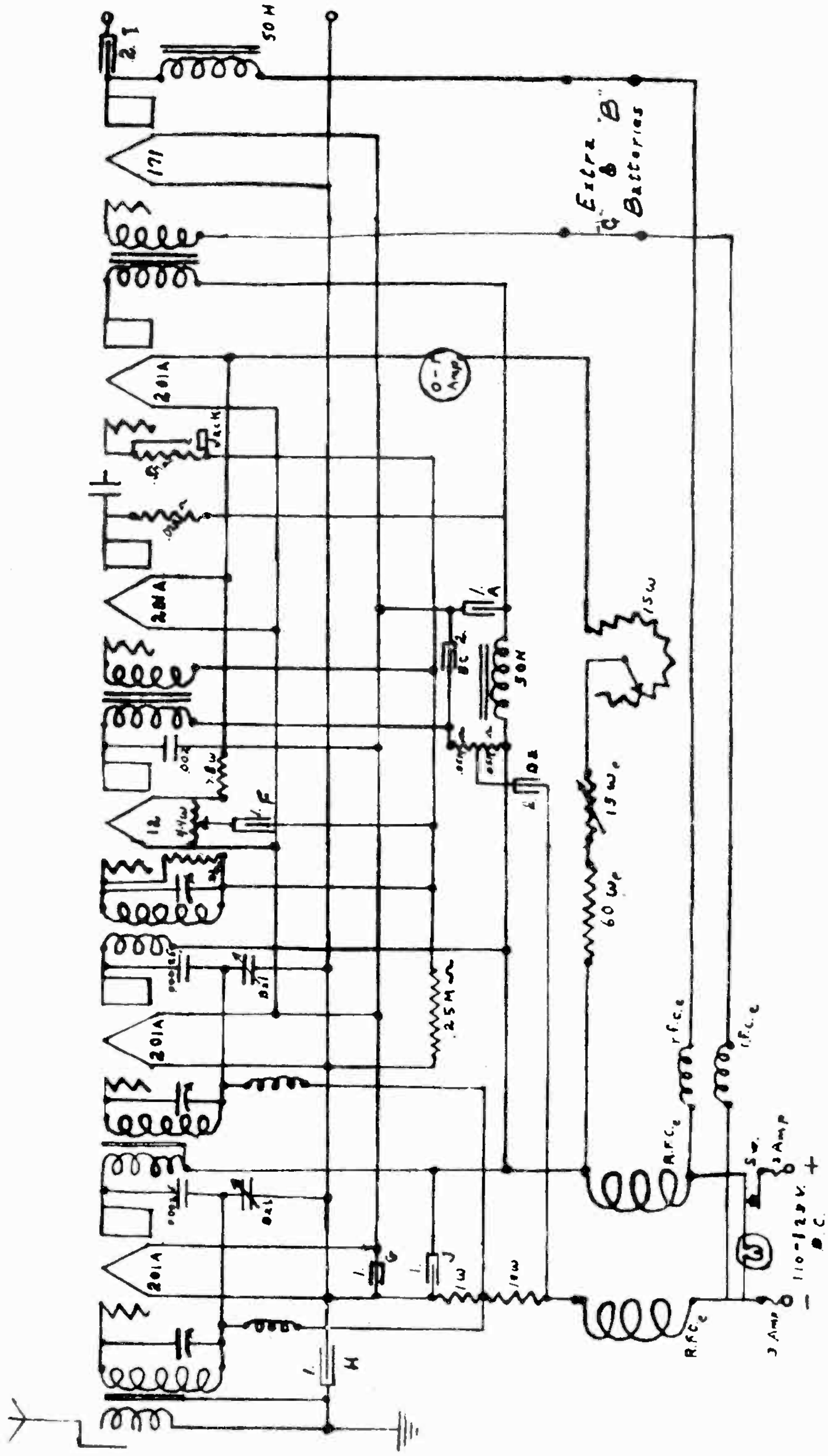
MOTOR GENERATOR SET—6 TUBE

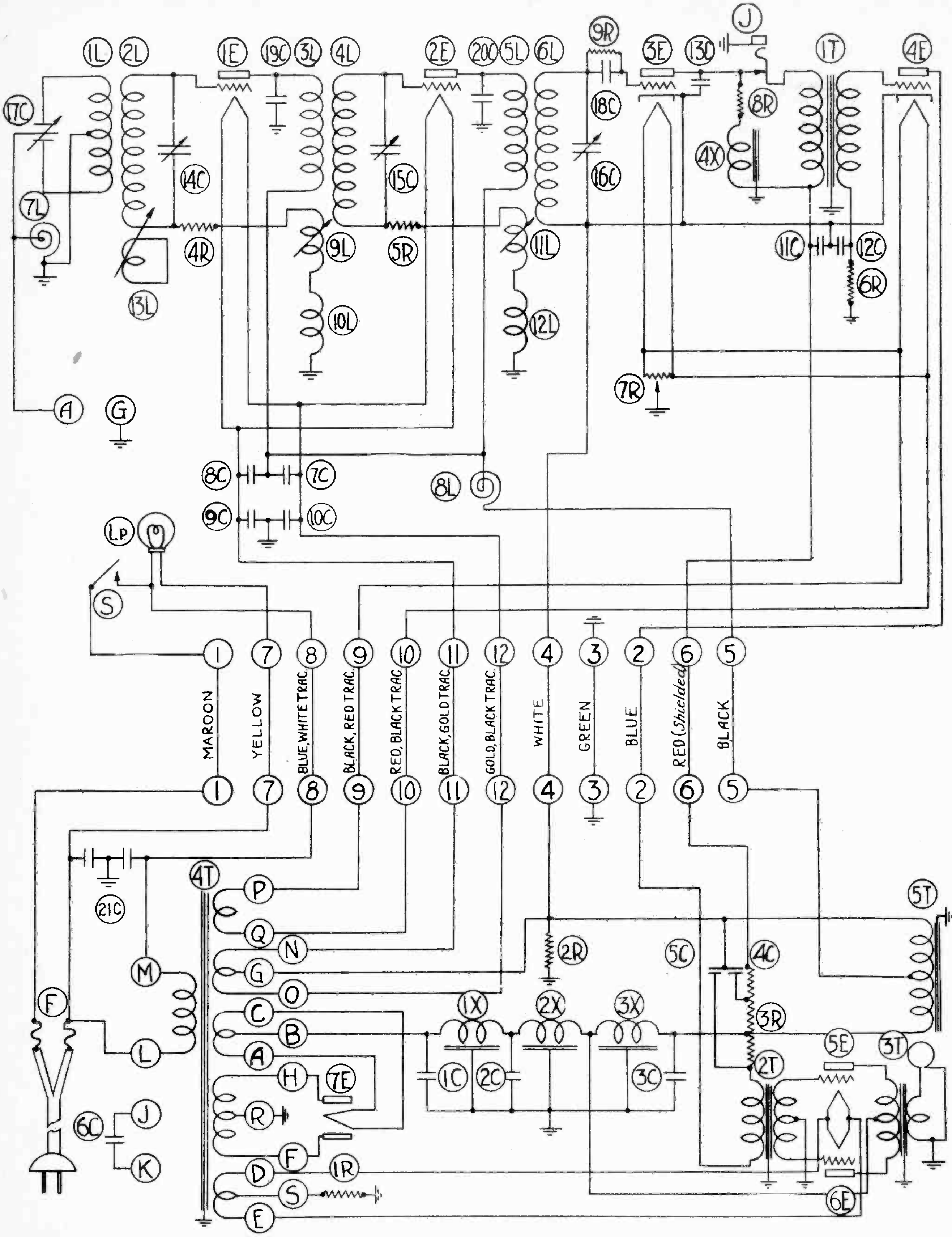


110 VOLT DIRECT CURRENT SET—6 TUBE



32 VOLT DIRECT CURRENT SET—6 TUBE

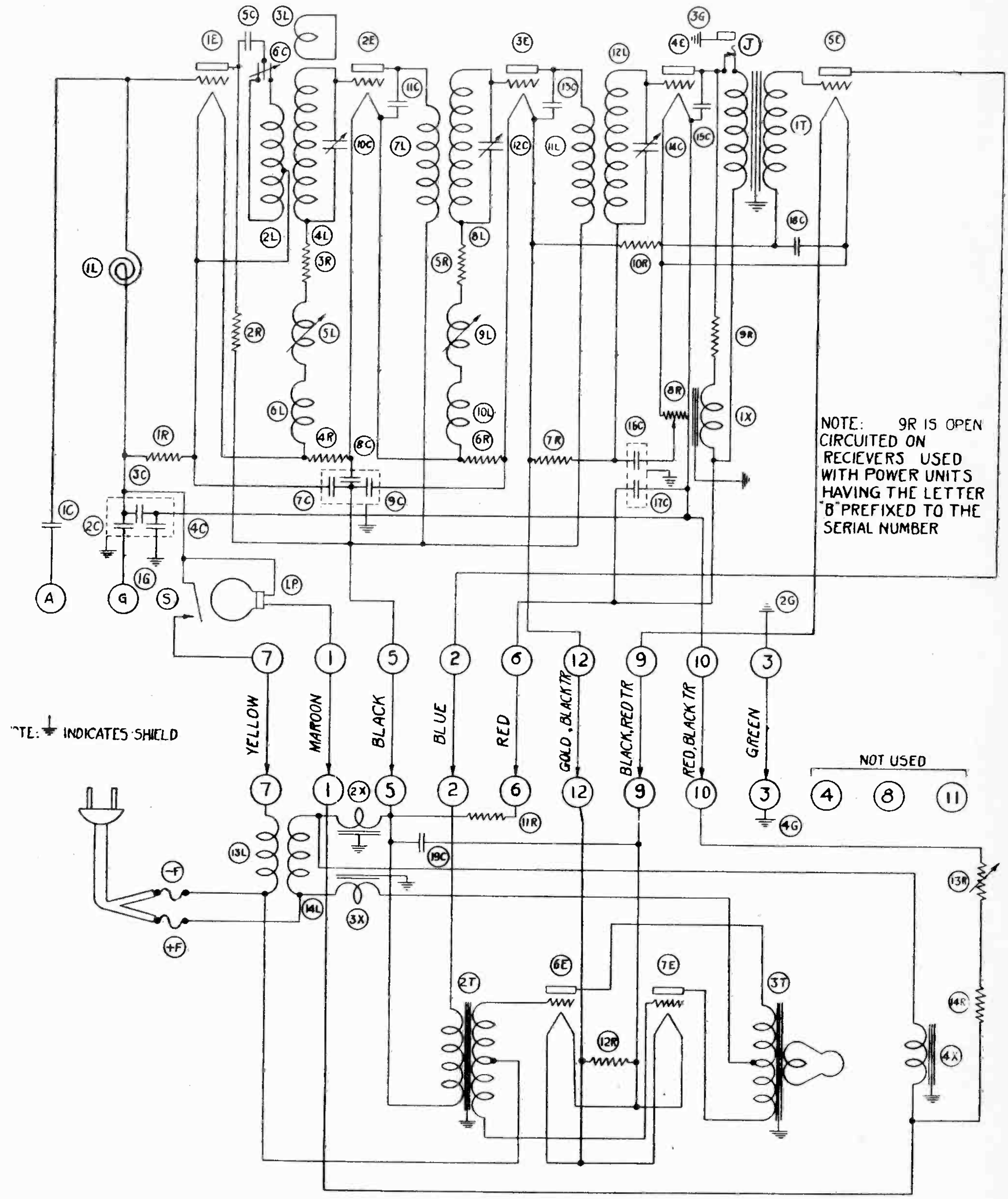

50 H
171
Extra "C" & "B" Batteries
201A
0-1 Amp
Jack
201A
15 W
50 H
112
60 W
.25 M
201A
201A
R.F.C.
Sw.
3 Amp
110-125 V. D.C.
3 Amp



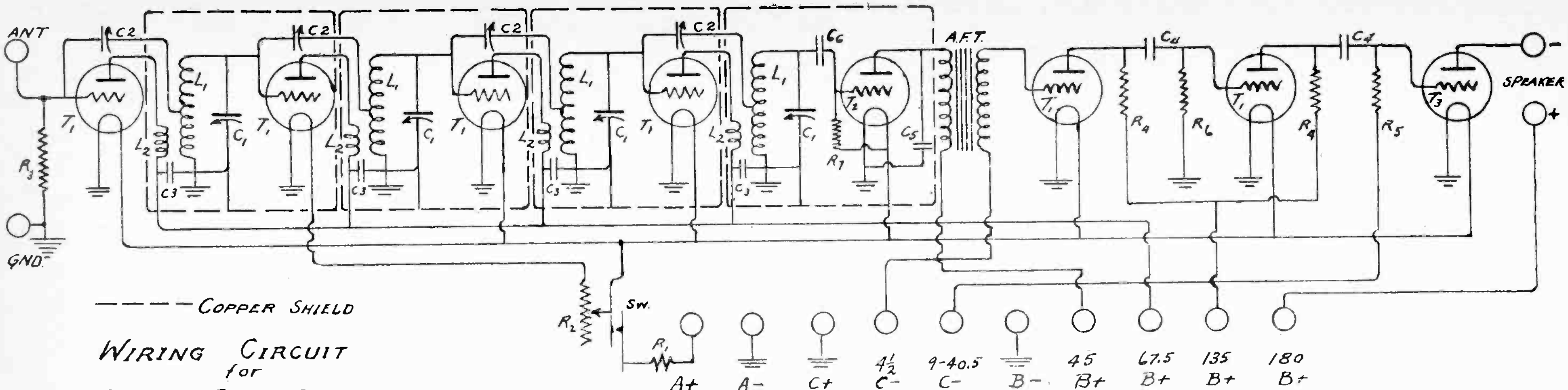
CIRCUIT DIAGRAM

Model 31 AC 60001-5001

COLONIAL RADIO CORPORATION



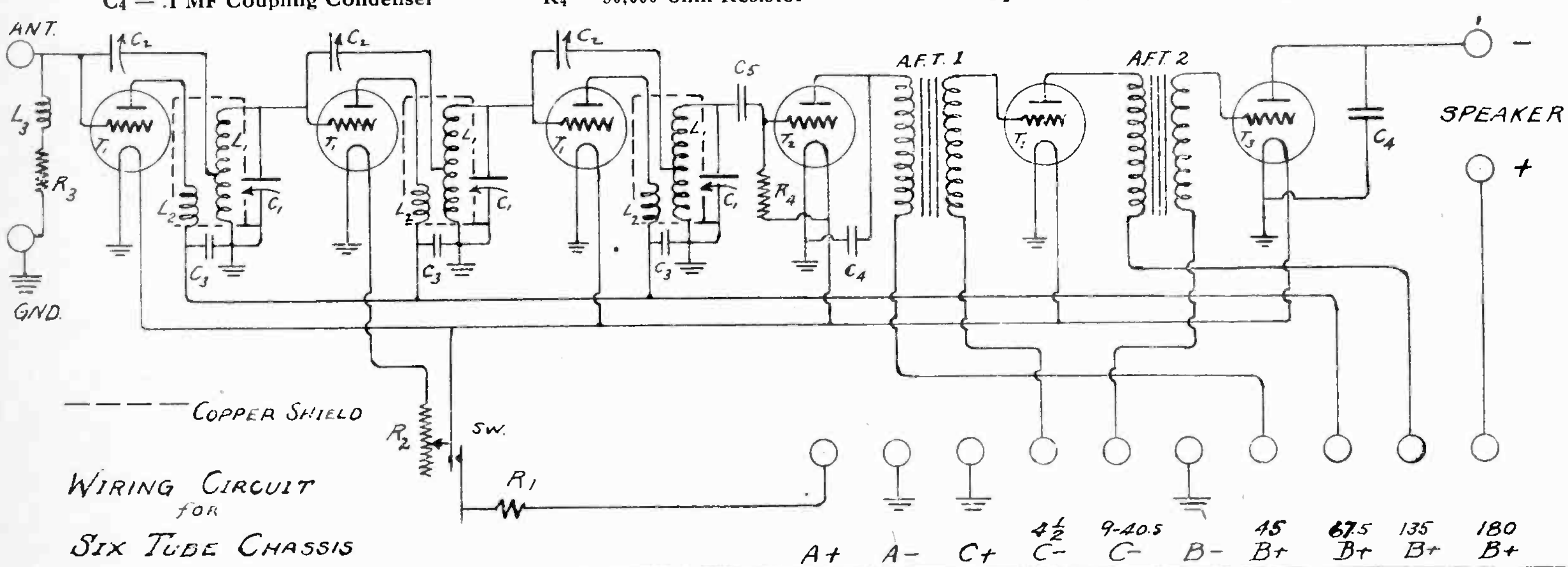
CIRCUIT DIAGRAM
MODEL 31 D.C. 50,001 - 40,001
COLONIAL RADIO CORPORATION



WIRING CIRCUIT for EIGHT TUBE CHASSIS

EIGHT TUBE CHASSIS

L_1 — Secondary of R. F. Transformer
L_2 — Primary of R. F. Transformer
C_1 — 500 MMF Variable Condenser
C_2 — Neutrodon Condenser
C_3 — 1. MF By Pass Condenser
C_4 — .1 MF Coupling Condenser
C_5 — .002 MF By Pass Condenser
C_6 — .00025 MF Grid Condenser
R_1 — Fil: Resistance Unit, 2.35 AMP
R_2 — 25 ohm Rheostat-Switch
R_3 — 5000 ohm Resister
R_4 — 50,000 ohm Resistor
R_5 — 100,000 ohm Resistor
R_6 — 500,000 ohm Resistor
R_7 — 2 Meg ohm Grid Leak
A.F.T. — Audio Transformer
T_1 — Cx 301 A Vacuum Tube
T_2 — Cx 300-A Detector Tube
T_3 — CX 112 or CX 371 Power Tube
Ant — Antenna Post
Gnd — Ground Post
Sw — Switch

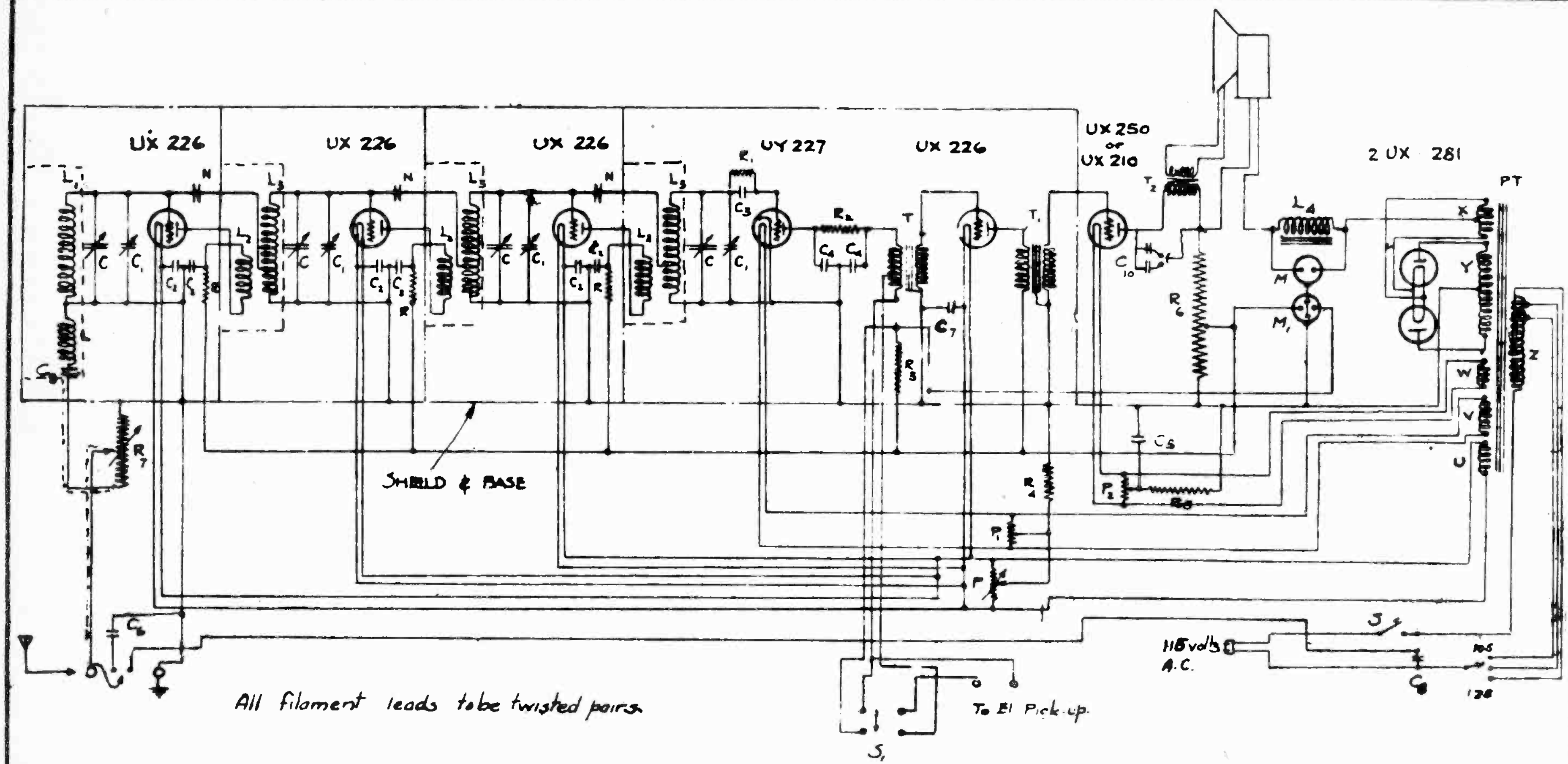


WIRING CIRCUIT FOR SIX TUBE CHASSIS

SIX TUBE CHASSIS

L_1 — Secondary of R. F. Transformer
L_2 — Primary of R. F. Transformer
L_3 — Antenna Choke Coil
C_1 — 350MMF Variable Air Condenser
C_2 — Neutrodon Condenser
C_3 — 1. MF. By Pass Condenser
C_4 — .002 MF By Pass Condenser
C_5 — .00025 MF Grid Condenser
R_1 — Fil. Resistance Unit, 1.85 Amp.
R_2 — 25 ohm Rheostat Switch
R_3 — 350 ohm Resistor
R_4 — 2 Meg ohm Grid Leak
A.F.T.1 — 1st Audio Transformer
A.F.T.2 — 2nd Audio Transformer
T_1 — Cx 301-A Vacuum Tube
T_2 — Cx 300-A Detector Tube
T_3 — CX 112 or CX 371 Power Tube
Sw — Switch
Ant — Antenna Post.
Gnd — Ground Post

UNITED STATES ELECTRIC CORP. WORKRITE DIVISION

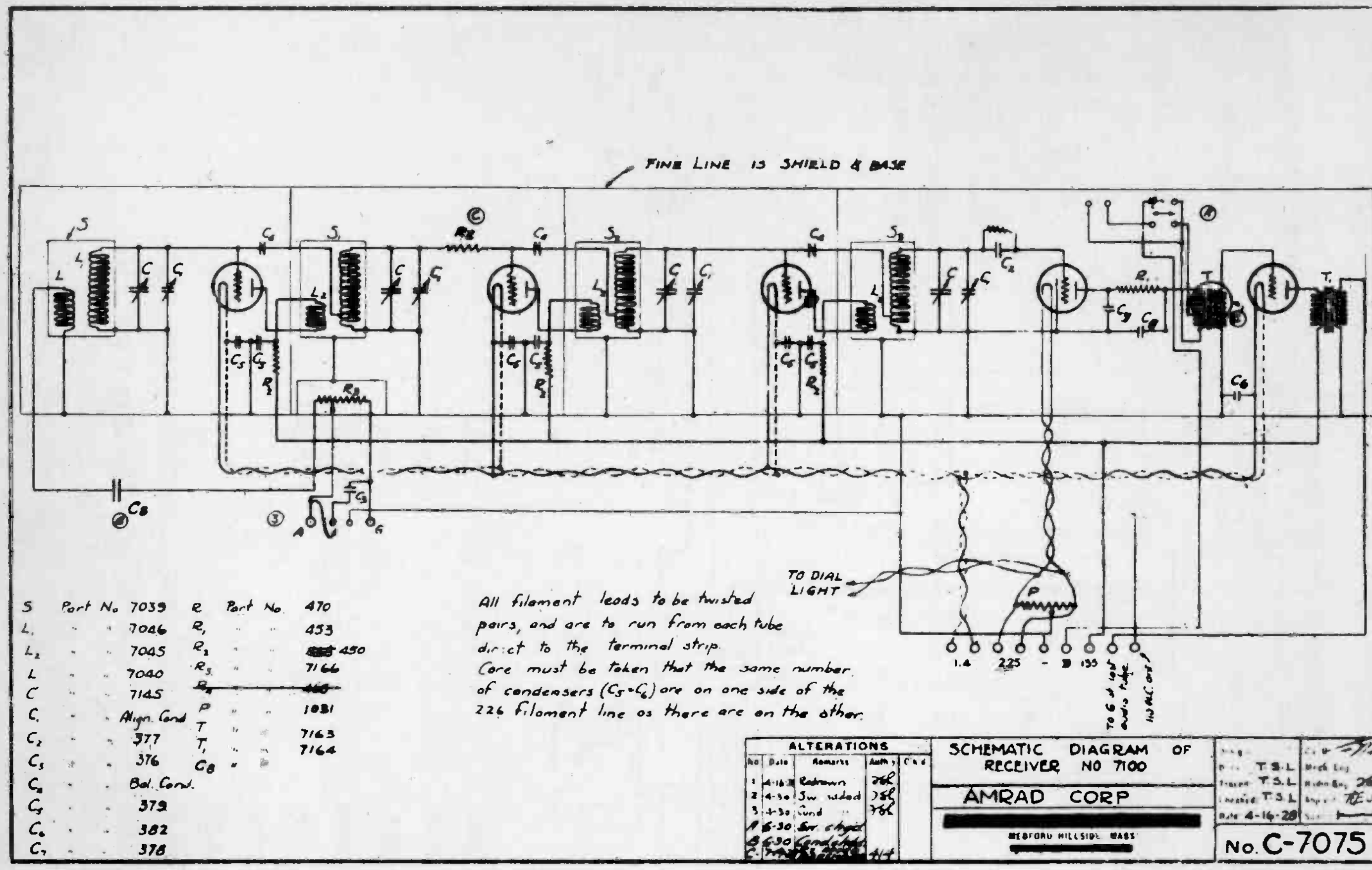


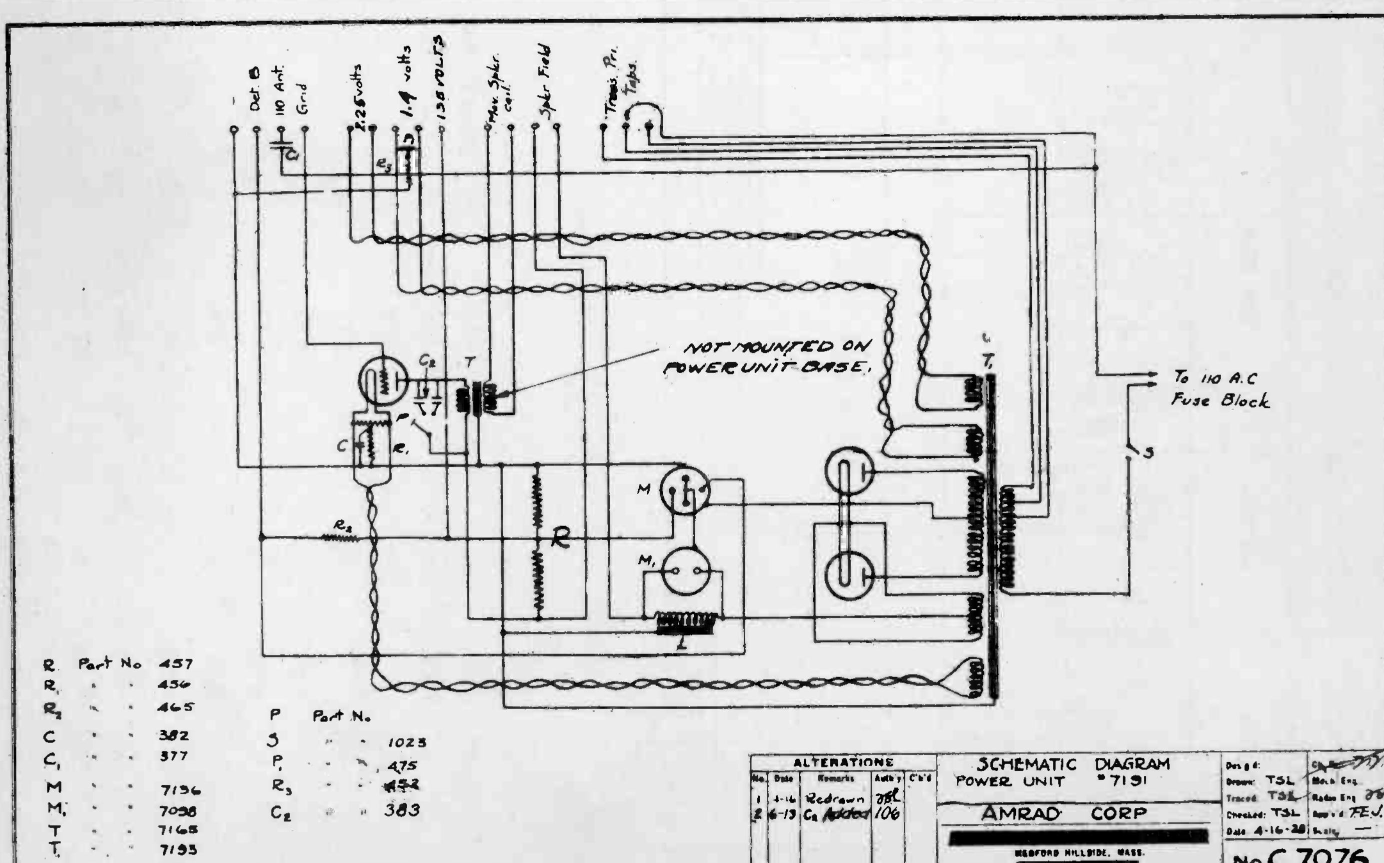
L	PART NO		C	PART NO		R	PART NO		T	PART NO
L	PART NO	7040	C	PART NO	7222	R	PART NO	450	T	7163
L_1	" "	7046	C_1	" "	Align. Cond	R	" "	470	T_1	7164
L_2	" "	7045	C_2	" "	379	R_2	" "	453	T_2	7165
L_3	" "	7045	C_3	" "	377	R_3	" "	7203	M	7098
L_4	" "	7197	C_4	" "	378	R_4	" "	452	M_1	7136
P	" "	475	C_5	" "	382	R_5	" "	456		
P_1	" "	1031	C_6	" "	1016	R_6	" "	457		
P_2	" "	1032	C_7	" "	382	R_7	" "	7166		
S	" "	1023	C_8	" "	377	R_8	"	7203		
S_1	" "	1024	N	" "	Bal. Cond	PT		7193		
			C_9	" "						
			C_{10}	"						

SCHEMATIC DIAGRAM OF
AMRAD RECEIVER
70

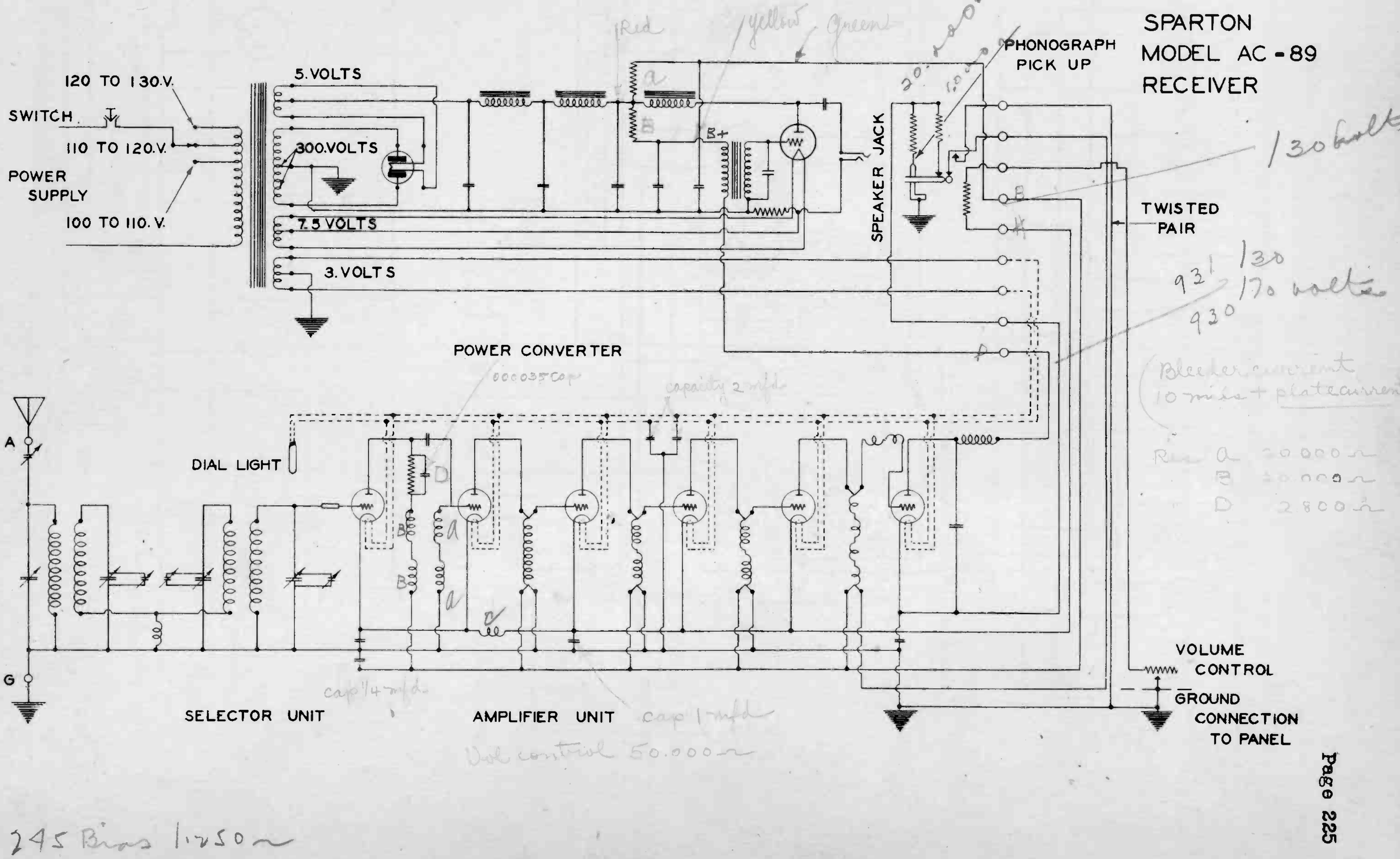
APRIL 6-1928 T.S.L.

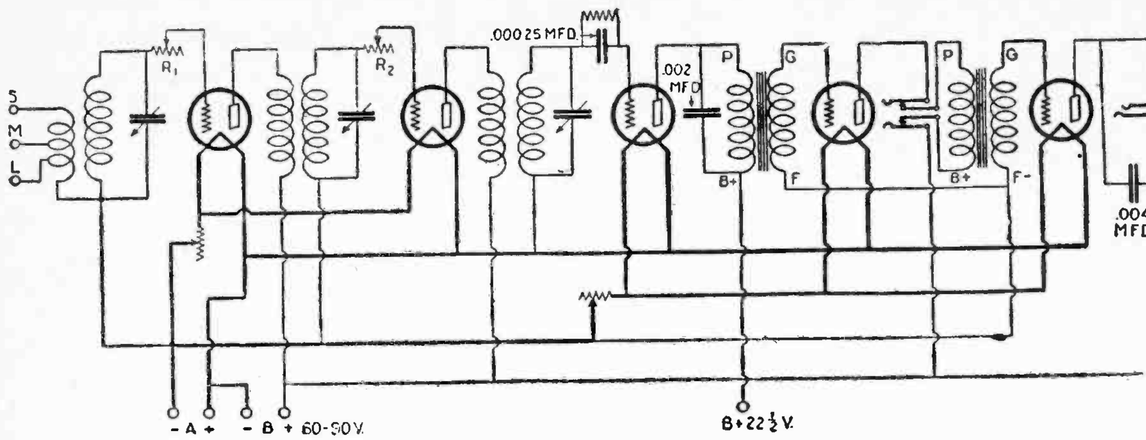
B-7286


FINE LINE IS SHIELD & BASE
TO DIAL LIGHT
1.4
225
135
S Part No. 7039
L, 7046
L2 7045
L 7040
C 7145
C, Align. Cond.
C2 377
C3 376
C4 Bal. Cond.
C5 379
C6 382
C7 378
R Part No. 470
R, 453
R2 450
R3 7166
P 1031
T 7163
T, 7164
C8
All filament leads to be twisted pairs, and are to run from each tube direct to the terminal strip.
Care must be taken that the same number of condensers (C5 - C6) are on one side of the 226 filament line as there are on the other.
ALTERATIONS
SCHEMATIC DIAGRAM OF RECEIVER NO 7100
AMRAD CORP
MEDFORD HILLSIDE, MASS.
No. C-7075

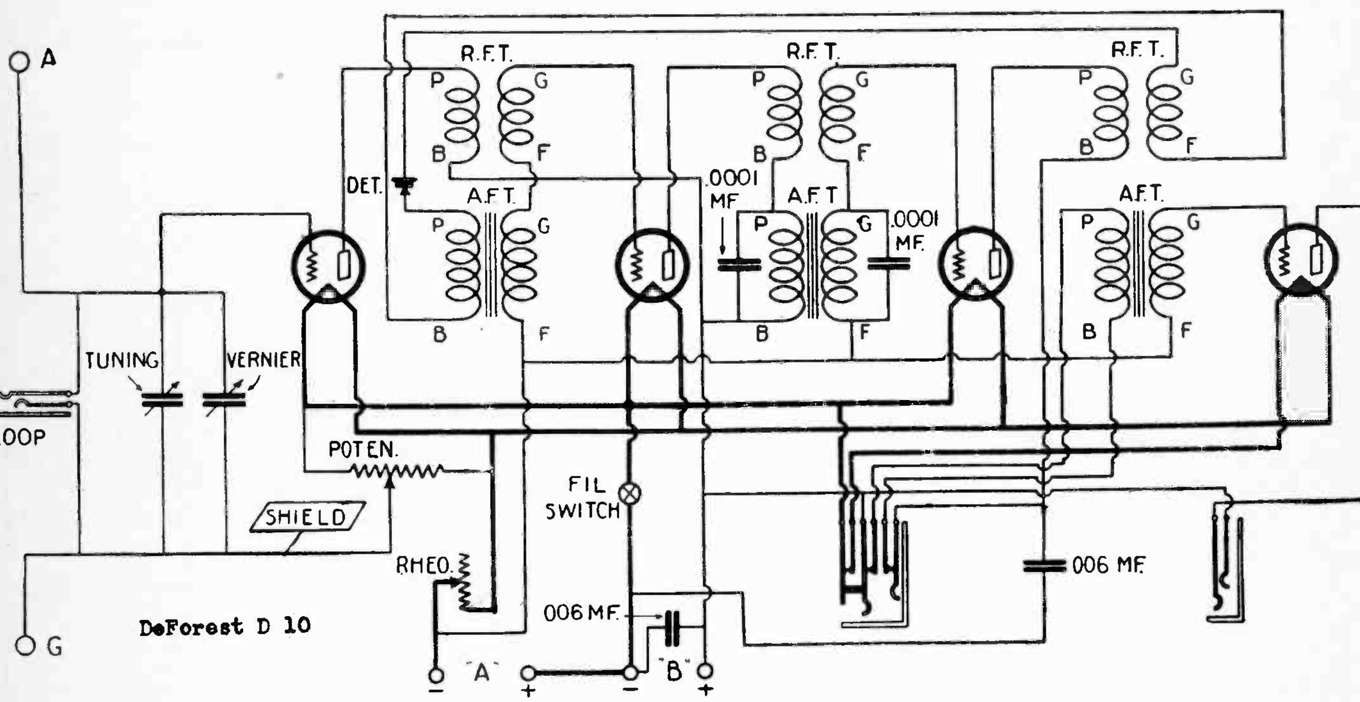

Det.
110 Ant.
Grid
2.25 volts
1.4 volts
135 VOLTS
Mov. Spkr. coil
Spkr. Field
Trans. Pri. Taps
NOT MOUNTED ON POWER UNIT BASE.
To 110 A.C Fuse Block
R Part No 457
R, 456
R2 465
C 382
C, 377
M 7136
M, 7098
T 7165
T, 7193
L 7197
P Part No.
S 1023
P, 475
R3 452
C2 383
ALTERATIONS
1 4-16 Redrawn
2 6-13 C2 Added
SCHEMATIC DIAGRAM POWER UNIT #7191
AMRAD CORP
MEDFORD HILLSIDE, MASS.
No. C 7076

Schematic Drawing of the Sparton Equasonne Circuit

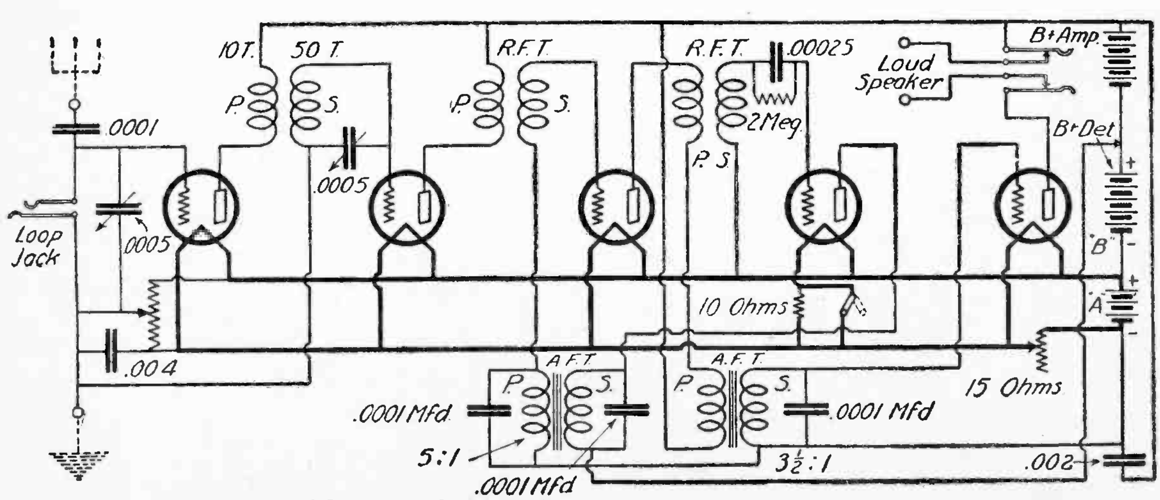




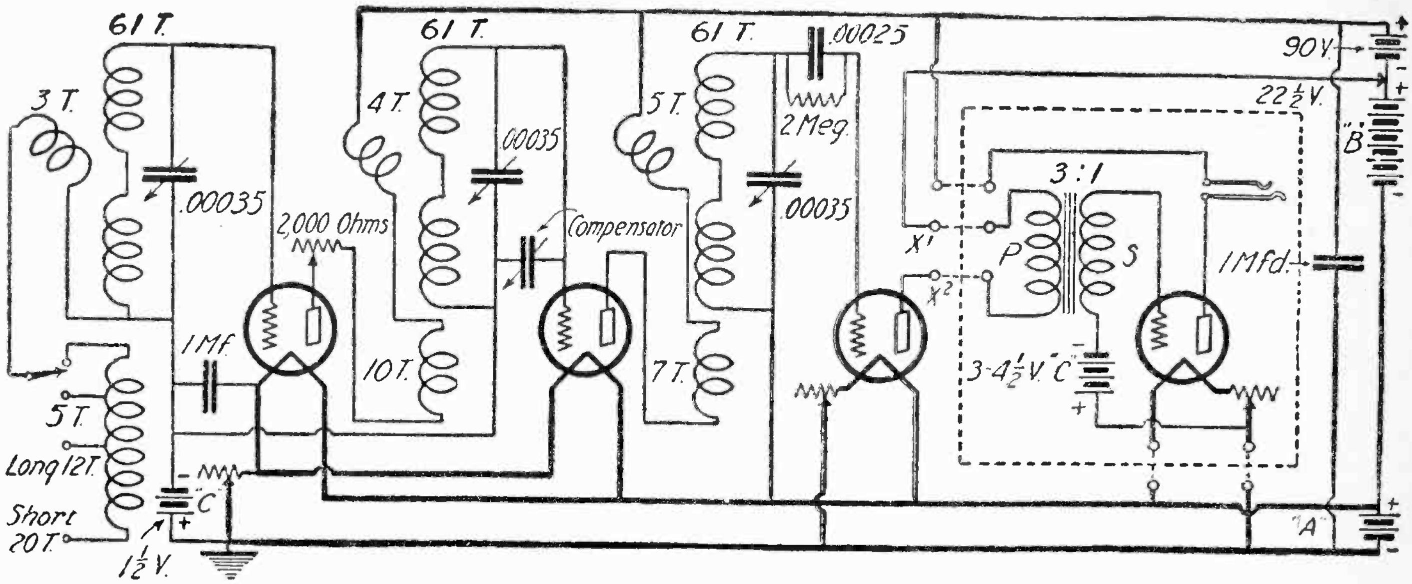
Schematic circuit of "Type F-5" DeForest radio set.



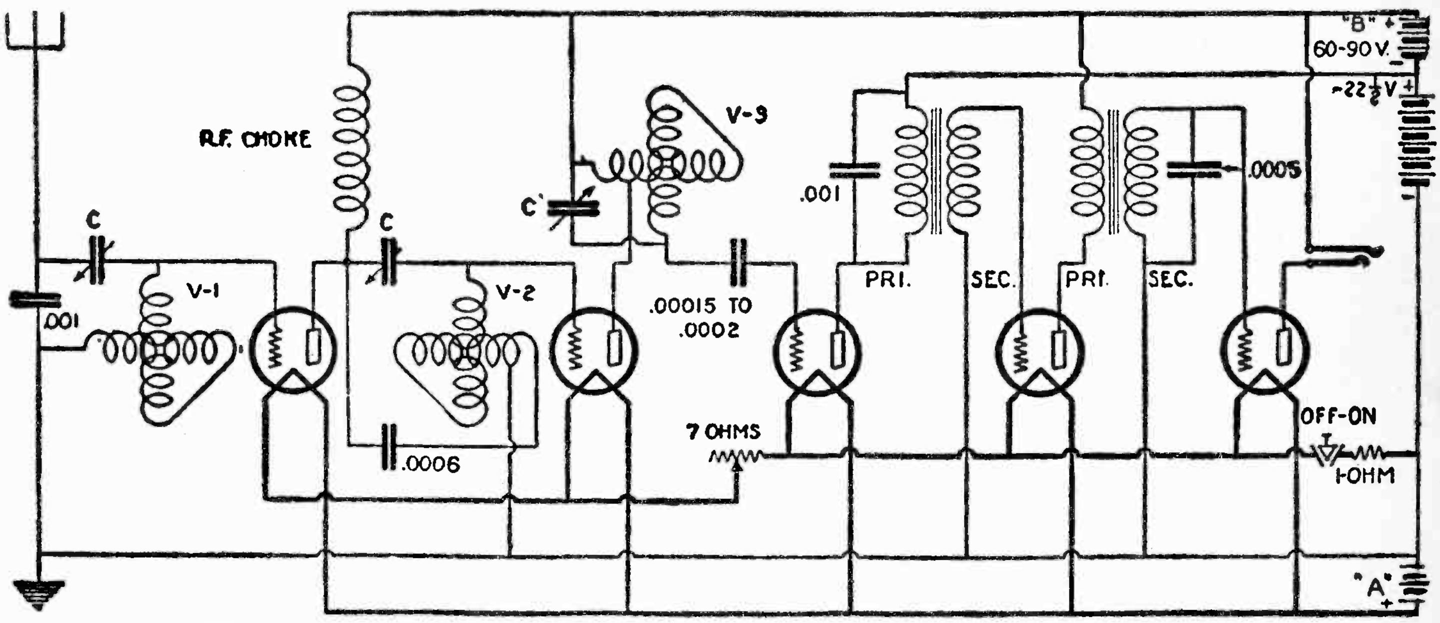
DeForest D 10



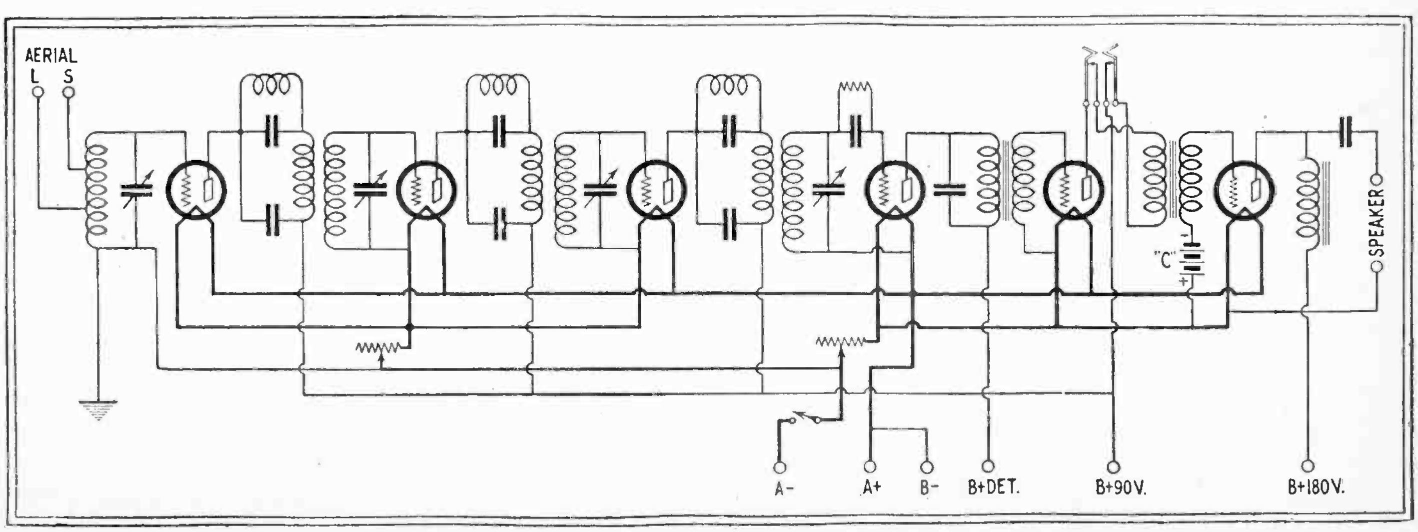
The DeForest D-17 Reflex Loop Receiver.



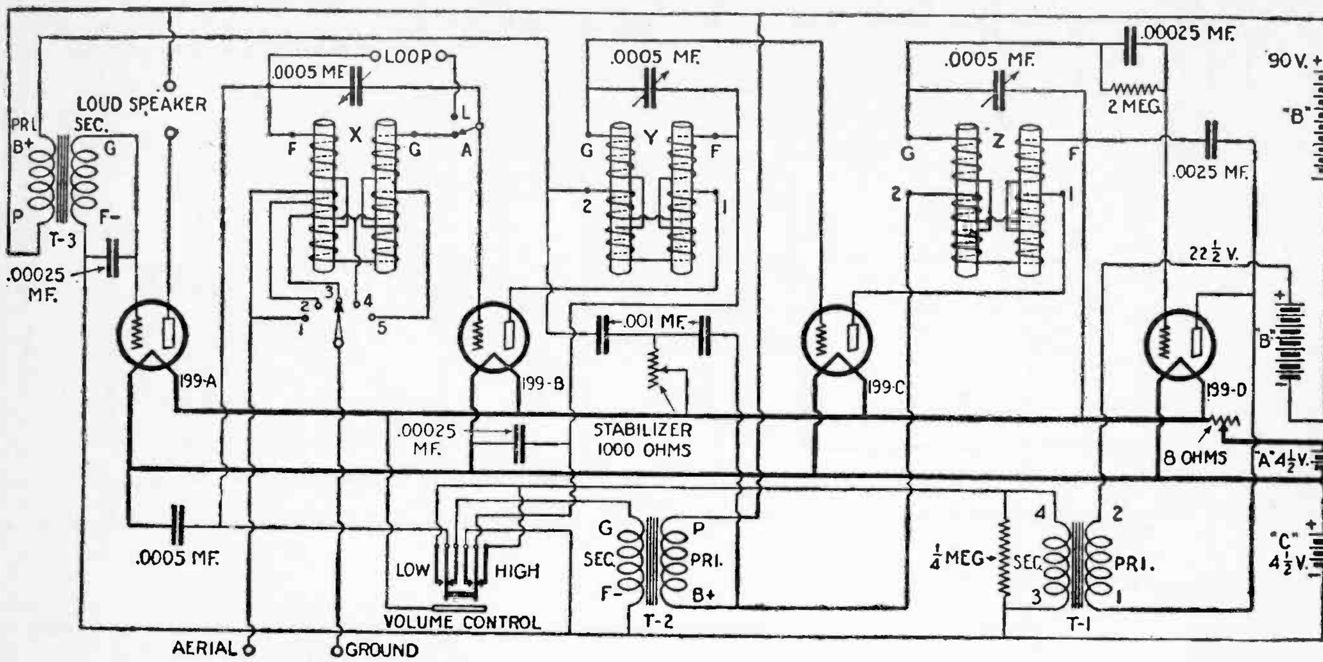
The Super-Zenith circuit.



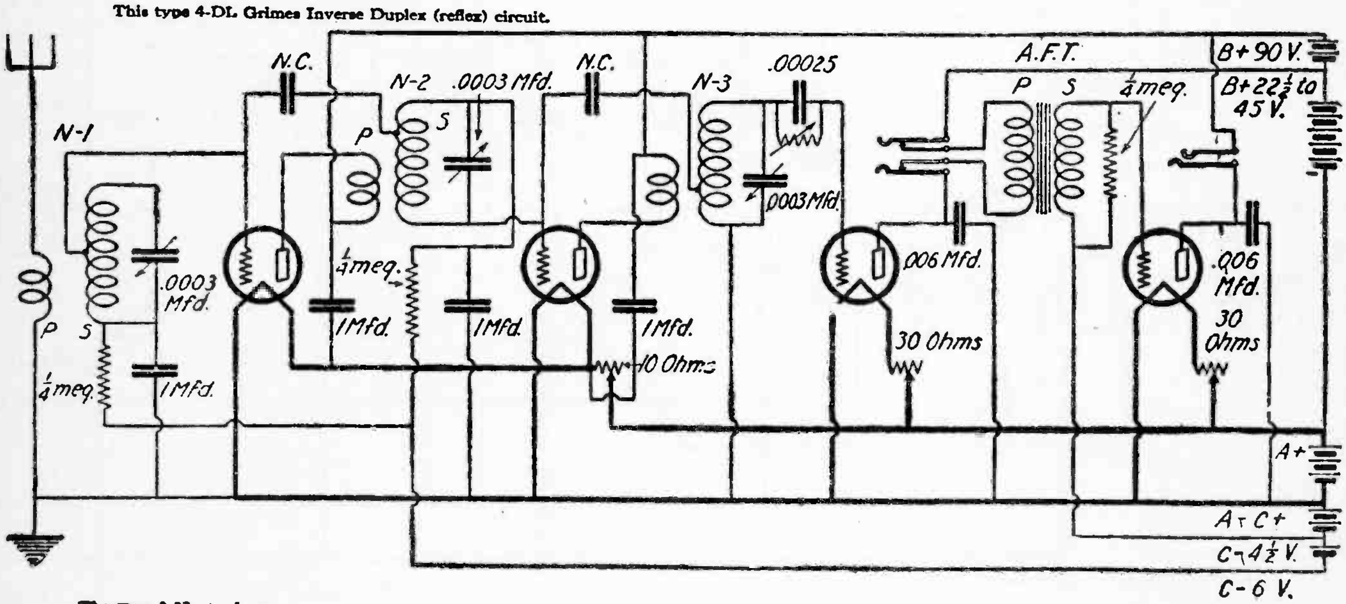
The Magnavox One-dial Receiver



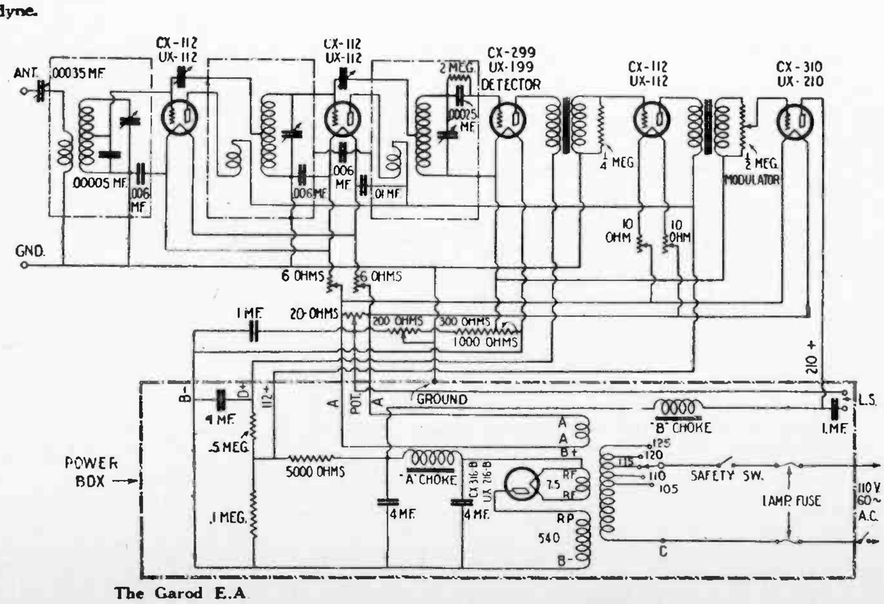
-The schematic diagram of the "Thermiodyne" receiver



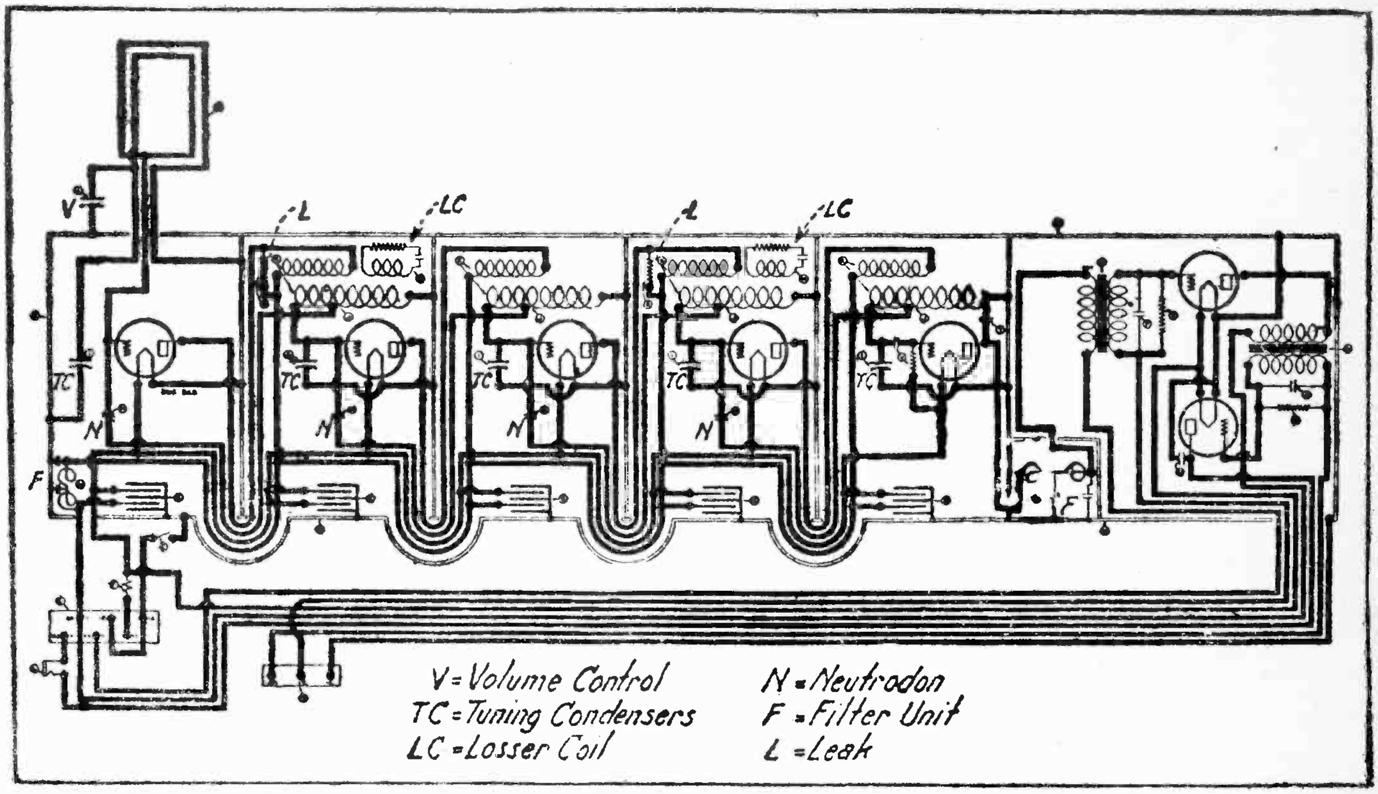
This type 4-DL Grimes Inverse Duplex (reflex) circuit.



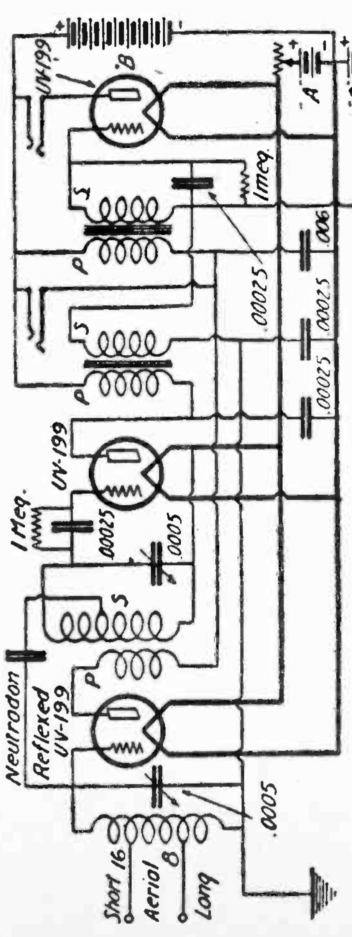
The Garod Neutrodyne.



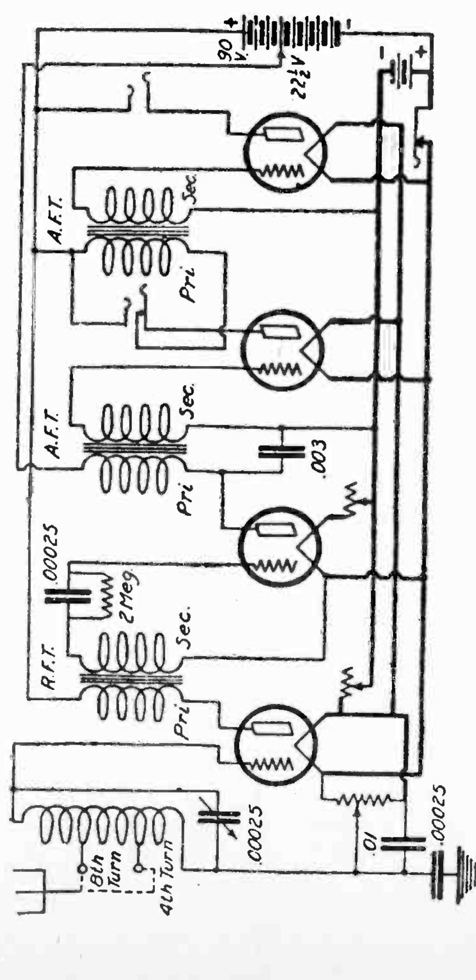
The Garod E.A.



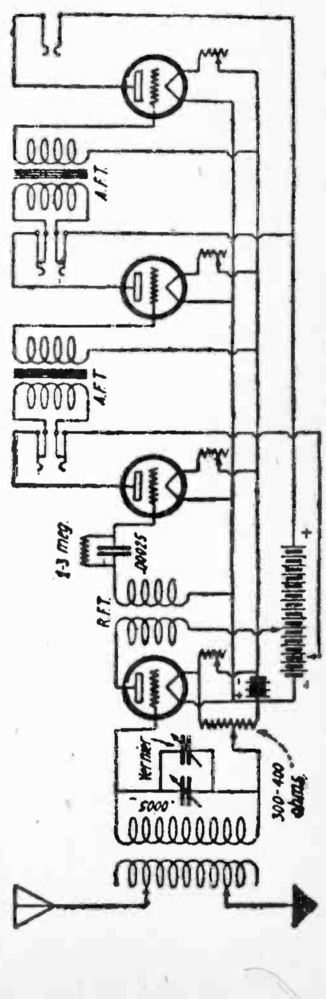
Complete wiring diagram of the seven-tube loop operated Ware.



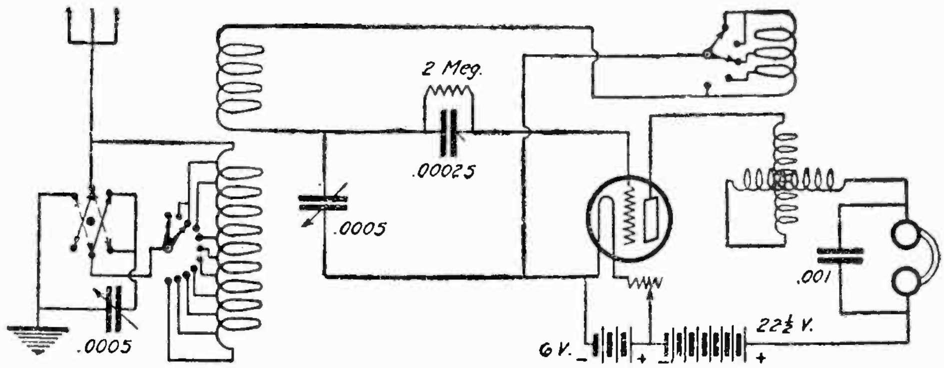
(190) The Ware Type T, reflexed, two-control Neutrodyne. Only one stage of radio frequency amplification, neutralized, instead of the usual two stages. An unusual way of employing a single circuit jack, to tap the reflexed stage output, is shown.



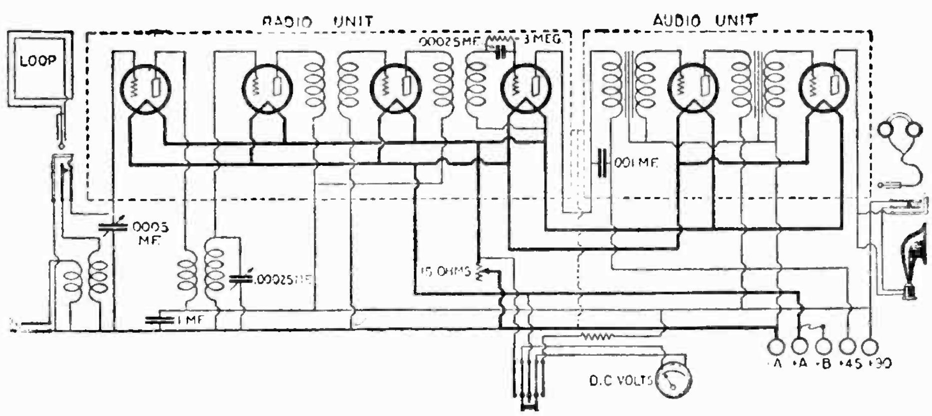
Schematic diagram of the Federal Type 102 Special Receiver.



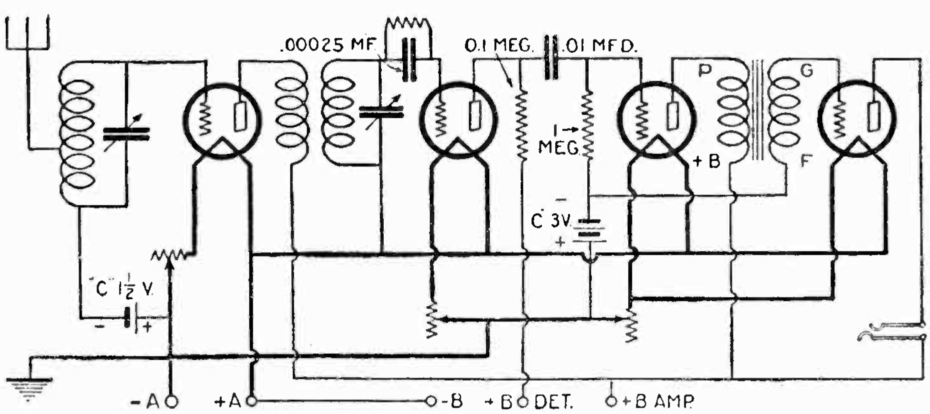
Circuit diagram of the Federal Type 59 Receiver.



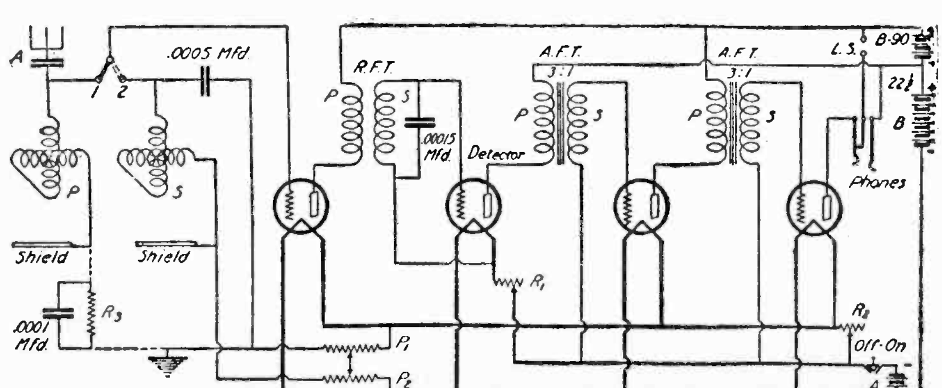
Kennedy Type-220 regenerative receiver



The circuit of the Operadio portable receiving set



The Sleeper RX-1 Receiving Circuit.



The Amrad "Inductrole."

Here is a list of troubles associated with battery type radio receivers. In this classification should be included radio receivers employing D.C. tubes with battery source of filament potential and a B eliminator. The remedy is obvious

A--Tube or Tubes Do Not Light

1. Burned out tube or tubes.
2. Corroded battery terminal or inperfect contact at battery terminal.
3. Open filament circuit between battery and filament switch
4. Filament switch does not operate.
5. A battery discharged.
6. Imperfect contact between tube prongs and socket contacts.
7. Burned our filament rheostat or voltage control unit.
8. Open filament circuit between switch and socket.

B--Tubes Light but No Reception

1. Incorrect polarity of A battery.
2. Incorrect polarity of B potential.
3. Aerial disconnected.
4. Speaker disconnected.
5. Defective B potential source.
6. Defective speaker.
7. Open circuit in plate potential cable.
8. Lack of detector tube plate potential.
9. Shorted or disconnected detector grid condenser.
10. Open in plate circuit of R.F. tube.
11. Open in plate circuit of A.F. tube.
12. Defective tube or tubes.
13. Incorrect polarity of C bias.
14. Shorted bypass condenser in plate circuits

C--Weak Reception or Low Volume

1. Defective tube.
2. Low operating potentials.
3. Defective power supply.
4. Defective detector grid condenser or leak or both.
5. Open in secondary of grid circuit of radio frequency or audio frequency transformers.
6. Deactivated filaments.
7. Grounded aerial.

7a. No aerial.

8. No ground.
9. Shorted radio frequency transformer.
10. Poor location of aerial.
11. Incorrect B bias.
12. Lack of resonance in tuned stages.
13. Poor contact between tube and sockets.

14. Incorrect adjustment of stabilizing system.
15. Incorrect wiring (if newly constructed).
16. Shorted or defective bypass condensers in grid circuit system.
17. Oscillating R.F. stage.

D--Distortion

1. Defective tube in detector or audio stages.
2. Incorrect operating potentials.
3. Lack of C bias.
4. Incorrect C bias (value).
5. Defective speaker.
6. R.F. system oscillating.
7. Defective bypass condensers in audio plate circuits.
8. Incorrect units employed in audio grid circuits. (shunt resistances or condensers).
9. Overloading of audio tubes.
10. Lack of detector grid leak.
11. Defective audio units.
12. Heterodyne (one station interferes with another).

E--Hum, Howl and Whistle

(Certain causes for"hum" are present in battery operated receivers of the type mentioned.)

1. Open detector plate circuit.
2. Insufficient plate potential. (detector tube).
3. Induction from power line to receiver.(detector or audio system).
4. Open grid circuit. (audio system).
5. Defective B eliminator (rectifier,filter system or bypass condensers).
6. Open grid circuit.(detector).

Howl may be due to insufficient separation between speaker and set. Speaker points toward audio tubes. Microphonic detector tube. Continuous whistle may be due to excessive regeneration in audio system. Station heterodyning. Excessive regeneration in radio frequency amplifier.

F--Fluctuating Reception

1. Natural fading of distant signals.
2. Swinging aerial wires.
3. Intermittent grounding of aerial and lead in wires.
4. Run down batteries.
5. Fluctuating A or B potentials.
6. Imperfect contacts.
7. Corroded connections.
8. Line voltage fluctuation.
9. Defective grid leak.
10. Defective C batteries.

Troubles in A.C. Sets

(By A.C. sets we mean electric A.C. receivers employing A.C. tubes)

A--All Tubes Do Not Light

1. House supply "off".
2. Power plug not connected to socket.
3. Open power plug cable.
4. Open primary of power transformer.
5. Poor contact between power plug and house socket.

B--One or More Tubes Do Not Light

1. Burned out filament or filaments.
2. Open filament winding of transformer.
3. Open filament control resistance, if used.
4. Open filament circuit.
5. Poor contact between tube and socket.

C--Tubes Light but No Reception

1. Aerial grounded.
2. No aerial
3. Defective rectifier in B eliminator.
4. Shorted filter condenser in B power unit.
5. Open filter system in B power unit.
6. Open output plate choke or primary of output transformer.
7. Shorted output plate choke or primary of output transformer.
8. Open plate circuit in R.F. or A.F. system.
9. No plate voltage on detector.
10. Minus B lead open.
11. Open voltage divider system in B power unit.
12. Shorted plate circuits bypass condenser.
13. Defective tube.
14. Open plate voltage winding in B power unit transformer.

D--Poor or Weak Reception.

1. Poor aerial.
2. Poor ground.
3. Shielded aerial.
4. Defective rectifier.
5. Low plate voltage.
6. Low filament voltage.
7. Incorrect grid bias
8. Open grid circuit in R.F. system.
9. Defective grid leak.
10. Incorrect plate voltages.
11. Alignment of tuning condensers.
12. Defective R.F. or A.F. transformers.

13. Defective neutralizing condenser.
14. Shorted R.F. grid circuit.
15. Poor contact between tube and socket.

E--Continuous Hum or Whistle

1. Defective rectifier tube.
2. Low line voltage.
3. Open detector plate circuit.
4. Open A.F. grid circuit.
5. Open filament shunt resistance or center tap.
6. Open B eliminator bypass condenser.
7. Shorted filter choke in A or B unit.
8. Open ground system.
9. Coupling between power system and detector.
10. Low plate voltage.
11. Open detector grid circuit.
12. Coupling between speaker cable and power line.
13. Incorrect adjustment of filament shunt resistance.
14. Coupling between power line and audio system.
15. Heterodyne between stations.
16. Microphonic tube.
17. Speaker too close to receiver.
18. Excessive regeneration in audio system.
19. Lack of bypass condensers.

F--Distortion

1. Open bypass condenser.
2. Oscillating R.F. system.
3. Shorted grid suppressor.
4. Incorrect grid bias.
5. Low plate potentials in A.F. system.
6. Excessive signal voltage.
7. Defective tube.
8. Defect in speaker.

G--Fluctuating Signal Intensity

1. Same as in D.C. receivers.
2. Defective B power unit.
3. Excessive line voltage fluctuation.
4. Loose element in rectifier.

H--Overheating of Rectifier Unit

1. Shorted filter condenser.
2. Shorted filament circuit will overheat transformer.
3. Shorted rectifier will overheat transformer.
4. Shorted secondary winding will overheat transformer.