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Radiotorial Comment

THE Madrid treaty is so infested with "bugs" as to threaten the very life of amateur radio. But there is yet time for Congress to delouse it by making certain reservations before ratifying it. This treaty supersedes that adopted in 1927 which, bad as it was, appears as heaven compared to the hell in the Madrid treaty. To the uninformed, these strenuous terms call for a few words of explanation.

The new document provides that international amateur traffic can not be handled between any two countries if any signator is opposed to it. If France, for instance, should interpose an objection, an amateur message from New York to Toronto would be illegal, notwithstanding the fact that France is in no way concerned with amateur communication between the United States and Canada. Even if France, or whosoever it may be, does not object, another paragraph states: "Owners of amateur stations are forbidden to transmit internationally messages emanating from third parties."

Both provisions bear the ear-marks of the commercial radio companies who are trying to stop the handling of free messages between amateurs in America and the Orient. These messages are being sent without charge and emanate from people who can ill afford to pay commercial tolls. Yet which class of message, the free message or the toll message, is really most in accord with "public interest, convenience and necessity?"

The effort of the commercial companies to strangle international amateur radio is comparable to legislation that might be instigated by the railroads to forbid owners of private automobiles from carrying non-paying passengers between points served by a railroad. The comparison becomes all the stronger when it is realized that the prohibition of foreign amateur traffic is but the opening wedge to a similar prohibition of domestic amateur traffic, and possibly the eventual acquirement of amateur wave-lengths for commercial purposes.

Yet the very channels now used by the radio companies were filched from the amateurs who had demonstrated the value of these hitherto unwanted wave-lengths. Because the law does not yet forbid the amateurs to use the tithe that they still have, the commercial interests appear to be using their influence to change the law. How much more sportsmanlike would it be for the companies, instead of trying to oust the amateurs from what little they have left, to make more adequate use of the nine-tenths of the short-wave spectrum from which amateurs are barred? But big business is not sportsmanlike when dollars and cents are at stake.

Just how inadequately the present commercial frequencies are being utilized is seldom realized. In the 6000-23000-kilocycle spectrum there is a separation of 20 kilocycles between channels, this being the minimum which, the commercials claim, will allow for the maintenance of satisfactory communication. Yet an amateur thinks nothing of separating CW stations 500 cycles apart in the 14-megacycle band!

A commercial point-to-point transmitter must maintain a frequency stability of 0.02 per cent, which means, for instance, that it can deviate 3 kilocycles from an assigned 15-megacycle frequency without invoking the wrath of the R.I. On the other hand, a 100-watt broadcast station is required to maintain its frequency within 0.0033 per cent of 1500 kilocycles, a requirement which is six times more stringent than that imposed on a point-to-point transmitter. Larger broadcast rtansmitters are being operated for months at a time without varying 5 cycles from their assigned frequencies, a variation of one part in 300 thousand. Furthermore, the Bureau of Standards has achieved a transmitter stability of one part in 18 million.

These comparisons call to mind the story of the bantam rooster whose hennery adjoined the ostrich farm at Pasadena. One morning he found an ostrich egg, which he laboriously rolled into his own egg-factory. Lustily crowing and flapping his wings, he convened his feathered harem, saying: "I don't want to complain, but see what your neighbors are doing!"

To resume our argument: The actual separation of channels is five times the required stability of the transmitter and twice what it need be to carry the sidebands of a CW station sending 1000 words per minute. To reduce the separation between channels to 2½ times the required transmitter stability would double the number of available channels. To require the same stability as is required from a small broadcast station would multiply this number by six. Thus, there would be twelve channels for every one now assigned.

Reception under such conditions would be child's play. At 15 megacycles there would be a 1500-cycle separation between adjacent channels and an allowable deviation of 500 cycles from the assigned frequency. If the $80 per month operator can't master the intricacies of stable self-excited oscillators, crystal control is cheap and efficient!

The foregoing statements ignore the fact that a dozen or more point-to-point transmiters with directional antennas can use the same frequency without mutual interference if properly located around the world. This makes possible a corresponding additional multiplication in the number of radio channels.

With all these tremendous, unutilized facilities at their disposal, what justification is there for the commercials to covet the over-crowded amateur bands? Rather, should they not be obliged to surrender a few of their ill-gotten gains for the amateurs' use. The amateurs would welcome the even harmonics of the 80-meter band.

How can they get them? By using the same tactics which the commercials employed when they stole them. INFLUENCE ! ! ! Influence Congress to delouse the Madrid treaty before ratification!

Convention Profits For Prize Donors

RADIO clubs are finding it increasingly difficult to secure free prizes for their conventions because radio dealers, and others who have kindly donated prizes in the past, are inclined to discount the advertising value of these donations and to regard this practice as a racket. Yet few clubs can afford to buy worthwhile prizes for award to the winners of various convention contests.

Consequently, there is great interest in the proposal of the Santa Clara County Amateur Radio Association, which is to be host to the Pacific Division radio convention to be held in September, to divide the convention profits pro rata among the prize donors. If the total value of the prizes is $100, for example, the donor of a $10 prize will receive one-tenth of the convention profits, etc.

Figures are not available to show whether the profits are ever greater than the total value of the prizes. If so, a donation would become good business, so long as it does not carry a corresponding responsibility for a possible deficit. Hi. Anyway, the plan carries a new and different talking point for the hard working beggar who is trying to promote a successful convention.

Forecast for September

A MONTH of preparation by thousands of amateurs to get their stations in readiness to comply with the new regulations of the Federal Radio Commission, which go into effect October 1. Consequently, the pages of September "RADIO" will show how to build simple and inexpensive filter systems for use with any type of transmitter.

A new Tube Characteristics Chart 11 x 17 inches, will be in the center of the magazine. This chart gives technical data and socket connections for the newer types of tubes, also showing the characteristics of both new and older types.

There will be something in September "RADIO" of interest to every radio man. "RADIO" has been a "sell-out" on news stands almost everywhere, and many would-be buyers of the magazine have not been able to secure copies. Therefore, a subscription protects you. $1.00 for 3 months; $2.00 for 8 months; $3.00 for 1 year. There are no back-copies available.

Amateur Trans-Pacific Traffic Threatened

Provisions of the 1927 Radiotelegraph Convention relating to the transmission of messages by amateur stations read as follows:

"1. The exchange of communications between private experimental stations of different countries shall be forbidden if the Administration of one of the interested countries has given notice of its opposition to this exchange.

"2. When this exchange is permitted the communications must, unless the interested countries have entered into other agreements among themselves, be carried on in plain language and be limited to messages bearing upon the experiments and to remarks of a private nature for which, by reason of their unimportance, recourse to the public telegraph service might not be warranted."

Provisions of the Madrid convention of 1932 read:

"1. The exchange of communications between amateur stations and between private experimental stations of different countries shall be forbidden if the Administration of one of the countries convened has given notice of its opposition to the exchange.

"2. When this exchange is permitted, the communications must be carried on in plain language and be limited to messages having to do with experiments and remarks of a private nature for which, by reason of their unimportance, there could be no question of resorting to the public telegraph service. Owners of amateur stations shall be strictly prohibited from transmitting communications emanating from third parties."

NOW, let the reader keep in mind that the alterations in these provisions at Madrid were engineered by the representatives of United States Commercial communications people, that they follow many attempts of these commercials to compel the wording of the 1927 convention to read the amateurs out of their right to serve the public, and that the Madrid alterations were made with the specific purpose of stopping the transmission of messages across the Pacific Ocean by amateurs. Then study the Madrid provisions with this knowledge always in view.

First of all, it will be observed that the 1927 provisions apply solely to "private experimental stations." The Government employees in the offices of the Federal Radio Commission have always assumed that "private experimental stations" included those licensed as "amateur." It is questionable if such an assumption was justified, for, as the provision reads it applies in the United States only to stations licensed as "experimental," the most of which licenses have been granted to commercial companies. It is more likely that the provision had in view the prohibiting of such experimental stations from conducting commercial communications and collecting fees therefor.

The Madrid provision injects amateur stations into the prohibition so that it will no longer be necessary for Government employees in the United States to make a forced interpretation of "experimental" to cover "amateur." And, remember this, throughout the long line of assistants and advisers to the radio commissioners the conviction is common that amateurs should be permitted to engage in no activity that tends in any way to lessen the private profits of the privately controlled commercial corporations. That thought comes first and foremost with the majority of these assistants; the rights of 35,000 licensed amateurs and the right of the public to avail itself of the free message service of the amateurs comes last.

THESE commercial communications corporations assume that because they announce themselves as "public service" institutions they may demand that the Government prevent competition with them in the transmission of messages by radio. Their adherents in the Government employ labor under a similar delusion. The Western Union Telegraph Co. is a public service corporation. It enjoys a virtual monopoly because it renders a meritorious public service; and yet RCA has been fighting the Government for four years over the Government's refusal to grant it the privilege of setting up a domestic radiotelegraph system to compete with the adequate message service of the Western Union.

The corporation has nothing to support its delusion that the Government owes it a monopoly of the radiogram business, except a flawless effrontery born of its nesting under the wing of the big bird that Ferdinand Pecora and a group of public-spirited senators have ruffled so sadly that she will never look the same again to honest men.

In the provisions of the 1927 Convention you will note that if one of the "interested countries" has given notice that it won't permit its amateurs to exchange messages, we in the United States may not handle messages with that country. In the Madrid provisions you will see the wording "if one of the countries convened has given notice."

See the difference? In the present treaty—that of 1927—an "interested country" may prohibit its own amateurs; in the proposed arrangement any one of the countries convened at the Madrid Convention may give notice of its opposition, and thus may cause the prohibition to become general throughout all countries. The fact is that no country is of record in the Berne Bureau as prohibiting the handling of messages by its amateurs. Many countries, as we know, do so restrict them, although the countries themselves have not lived up to the treaty by filing notice to that effect. Well, the new Madrid wording makes it possible for any country to object to amateur message-handling in all countries. No country—no matter how much it is against amateur message-handling—will stand for dictation from "one of the countries convened" simply to aid privately controlled corporations that notoriously have grabbed the "lion's share" of all the short-wave channels available for the whole world without having use for one-tenth of them. Nevertheless, the phraseology gives the commercial adherents in our government still another club with which to harass and intimidate the amateur.

The Madrid Paragraph 2 tightens the screws, both on the amateurs and on foreign countries. The 1927 clause, "unless the interested countries have entered into other agreements among themselves," has been cut out. Under the altered provision no country could permit its amateurs to talk with those of another country in ham language. It must be "plain talk." If this whole asinine perversion of justice called a "treaty" is ratified by our Senate we amateurs will have to talk plainly—if, indeed, we are permitted to use our own air at all.

The 1927 provisions say: "The exchanges between amateurs must be, unless the interested countries have agreed otherwise among themselves, limited to messages of a private nature for which, by reason of their unimportance, recourse to public telegraph might not be warranted." The new Madrid wording is: ". . . for which, by reason of their unimportance, there could be no question of resorting to the public telegraph service." Feel the screws being applied to you, OM!

But listen to this one—the crowning piece of impertinence from the United States commercials who concocted and engineered the new amateur restrictions at Madrid:

"Owners of amateur stations shall be strictly prohibited from transmitting communications emanating from third parties." And note that they don't mention their own "private experimental stations." This leaves it in the power of the commercials to use their own experimental stations to handle third-party messages in the United States.

This specific and exclusive pronouncement declares against the handling by amateurs of third-party messages right here in the United States: This provision, if ratified by our Senate, would actually prevent amateur stations from fulfilling the fundamental requirement of the Radio Act—that every station must be operated for the public interest, convenience or necessity.

If this piece of consummate insolence is ratified it will become one of the restrictions automatically read into all amateur licenses! And after that if any amateur dares to transmit a message he will lose his license. Just think it over. Never mind if someone does say, "Oh, that provision won't be invoked." Never mind if publciations of amateur authorship do tell you, "There is no change from a practical standpoint in our communication regulations." YOU—every last one of the 35,000 amateurs of the United States—get busy and see that your Senator and your Representatives know what this scheme of Morgan-controlled outfits purposes to do to you. That's what you elect your Senators and Representatives for — to see that your constitutional right is preserved to use your share of the air for the benefit of yourself and the other people who own it—and there isn't a public-spirited man in Congress who won't do his utmost to support you.

The amateur traffic at which the representatives of RCA and Mackay directly aimed at at Madrid is the messages the amateurs are handling for our people in the Philippines and China. One would think, to hear the commercial men talk, that the amateurs were invading a long-occupied province of commercial radio! As a matter of truth it is RCA and Mackay that have poached in a field that was pioneered and possessed long before these commercial outfits were in it.

In that part of the world there are thousands of our own citizens — Army, Navy, Marine Corps, doctors, nurses, missionaries, educators, and other civilians. These people have not the money to pay the high tolls exacted by the commercial radio and cable corporations. Amateur stations on both sides of the Pacific have for years provided a message service of inestimable value for them and their families in the United States. The amateurs have a file of thousands of letters from grateful recipients of this service. These people will be given this article for their enlightenment and action—this and other articles describing in detail various efforts that have been made in the recent past to stop the amateur trans-Pacific traffic. The amateur appeal to Congress will have the active support of the public against this latest threat against their rights.

There is no reason why 35,000 amateurs of the United States should be forced, year after year, to fight for their lives. There is no reason why hundreds of thousands of our citizens should be forced to pay tribute to a brace of outrageously over-capitalized corporations.

—Clair Foster, W6HM.

What's the Matter With Amateur Radio?

By COL. CLAIR FOSTER, W6HM

THE EDITOR inquires, "What's the matter with amateur radio?" Nothing! We amateurs are like the man in the crowded hall who was asked if he couldn't find a seat. "Oh, I have a perfectly good seat," he replied. "All I need is a place to put it.'

Just why are the 35,000 amateur stations of the United States restricted to a few narrow bands in which 100 commercials would proclaim that they were being murdered in cold blood? And just how came this restriction? That is the place to start looking for the answer to the Editor's question.

At the bottom of the Amateur's predicament lies the fundamentally unsound premise in their own thinking; namely, that they had no rights—that they had only a few privileges. Why, it is only within the last two years that we have been able to bludgeon that word "privileges" out of amateur literature. In the speech of amateurs it is still commonly used, and is still a part of the amateur consciousness. That only "business" had rights was the conception of business men and government servants. They filled the air with that miasma and the amateurs breathed deeply of it.

In the United States we have a Constitution that—believe it or not—has stood up remarkably. One feature of it is so eminently American that it has stood the test of time—the declaration that there shall be no legislation having the effect of favoring one class of our citizens to the injury of another class. Laws enacted with the intention of discriminating have, time after time, been adjudged by the Supreme Court to be unconstitutional.

The non-commercial users of the air—from the very beginning of radio—embrace a vastly larger class of citizens than those who are in radio purely for the money. The air is public domain. It belongs to all of our citizens, just as do the public lands, the rivers, lakes and the adjacent seas. No one class of citizens has an inherent right to a monopoly of the air, any more than would one class be allowed to use the lakes, rivers and oceans to the exclusion of any other class from their reasonable use. The public domain can be lawfully used by individuals only for the greatest good to the greatest number. The commercial people claim that in their money-making activities they serve the greatest number of people. The force of that claim comes only from reiteration. If a vote were taken on the question which is more highly regarded by the public, the Amateurs or the Commercials, the Amateurs would win hands down, because most amateurs have a thousand friends and well-wishers to the Commercial Corporation's one. Besides having brought into the public domain of the air by their discoveries the most valuable part of it—the area below 200 meters—the Amateurs are performing today countless public services, free of charge, that the Commercials would not perform if they could, and could not if they would. The services that the amateur stations render to the public are limitless; they are circumscribed only by the fact that the stations are crowded together beyond belief. That much abused word, "public service," when applied to the activities of the Amateurs, carries no taint of hypocrisy.

The Government has, of course, first call on the public domain. That is sound because the citizens at large are the Government. In nearly all countries the nation comes first in its use of the air. In the United States this—so far—has not been the case. Two foreign commercial radio men have expressed to me their perplexity over their observance that in America the radio interests of business groups come first. They said, "In our country our government comes first and private business comes afterwards; in your country private business comes first and your government gets what little is left." There was nothing I could say in response, for it is all too true. Our Army and Navy and other government services had to fight the commercial lobbyists to get the comparatively small parts of the radio spectrum now assigned for government use. So far as our Government's interests are concerned, however, we do not feel so badly over this phase of the situation, for in the event of emergency our Government can take without pay any channels that may have been allocated to other interests, business or private. That is why the courts defeated the attempt of the General Electric Company to establish a "property right" in the channel used by Station WGY.

The American amateurs made their primary blunder by envisioning themselves as suppliants instead of seeing that they were a class of citizens whose interests were bound to be respected and protected. They assumed the role of the mendicant and therefore got all that a mendicant can hope for, or, indeed, deserve—a handout at the kitchen door. Having voluntarily assumed that character, it was quite consistent that they should be given little consideration. When one pleads for a handout, one is in no position to question the nature of the food. Having attired themselves in the costume of the stage tramp the amateurs got just what the make-up called for—the laugh.

The commercials gave us just what they believed would be our doom—200 meters. At that time every commercial radio man and every highbrow physicist in the world was convinced that 200 and below was useless for communication. The amateurs soon proved that the highbrows were all wrong—that the short waves were the most valuable of all. Then, having made this epochal demonstration, one would have thought the amateurs would have come to their senses and taken their place as a large class of citizens prepared to defend their earned place on the air.

Just here is where the exigencies of the situation dictated that they shed the robes of the supplicant and don the armour of the militant crusader prepared to take the offensive in a holy and just cause. Did they do it? Not they! They stood back and hoped, hoped that another plea at the back door would provide sustenance. Radio amateurs are strange animals. One part of their mental make-up is full of intense loyalties, full of a fellowship, infinitely stronger than that found in any secret society or college fraternity. They will fight for hours and weeks and years among themselves over inconsequential trifles, but they will not get together and fight for five minutes against an open threat against the whole cause of Amateur Radio.

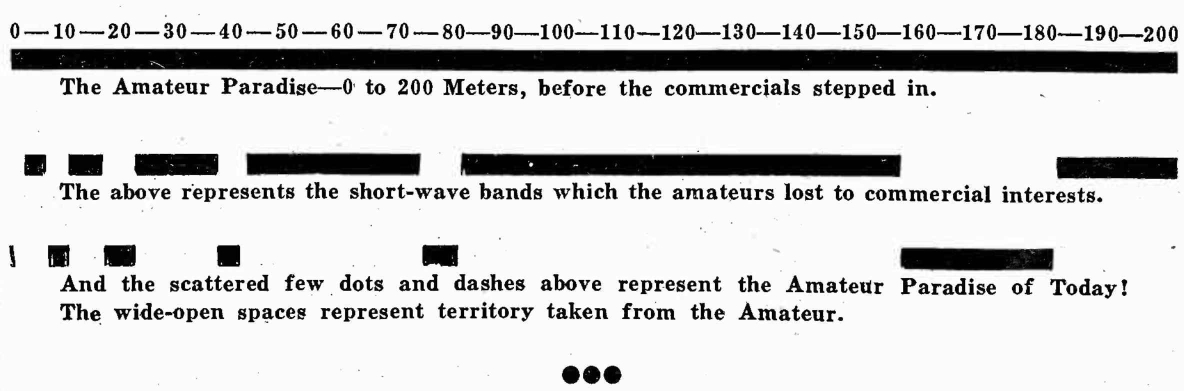
At this crucial time in their history, when they had proved to the world the value of the short waves, did they stand upright and advance with the courage that comes from full knowledge of the justice of a cause? Listen to this, and I quote from the official "Statement of Facts" presented by the Federal Radio Commission to the Court of Appeals of the District of Columbia in the matter of the injunction secured by the RCA to prevent the Commission from allocating "continental frequencies"—below 6000 K.C.—to anybody but RCA.

"Prior to February 23, 1927, the amateurs were entitled to use the entire range of frequencies from 1500 kilocycles upwards. They were the first to make practical use of short waves and demonstrated their efficacy to the world by feats of the most dramatic character. Their contributions to the science of radio communication have only too often been the demonstration of the utility ranges only to arouse the desires of the commercial interests to deprive them of the use thereof. At the various National Radio Conferences, speaking through their authorized representatives, they offered to relinquish most of their territory for commercial development."

There you have it! The amateurs **offered to relinquish most of their territory.** It must be true that the relinquishment was "offered," because before February 23, 1927, when the present Radio Act went into force, there was no law in the land that confined the amateurs even to our old 160, 80, 40 and 20 meter bands. We had been told countless times by amateurs and in public prints of amateur authorship that this was "the law" and that was "the law." That our old 40-meter band, for example, was prescribed "by law" to extend from 37.5 to 42.8 meters. Now get this straight! It was not "by law" at all, but merely by acquiescence of the amateurs themselves in the cajoleries or threats of commercials and their adherents in the government service.

The amateurs held control (their right debatable, to be sure, but concededly earned), of everything below 200 meters; and with the naivete of inexperience in the old game of grab-the-public-domain we **offered** to relinquish most of our territory to the commer-

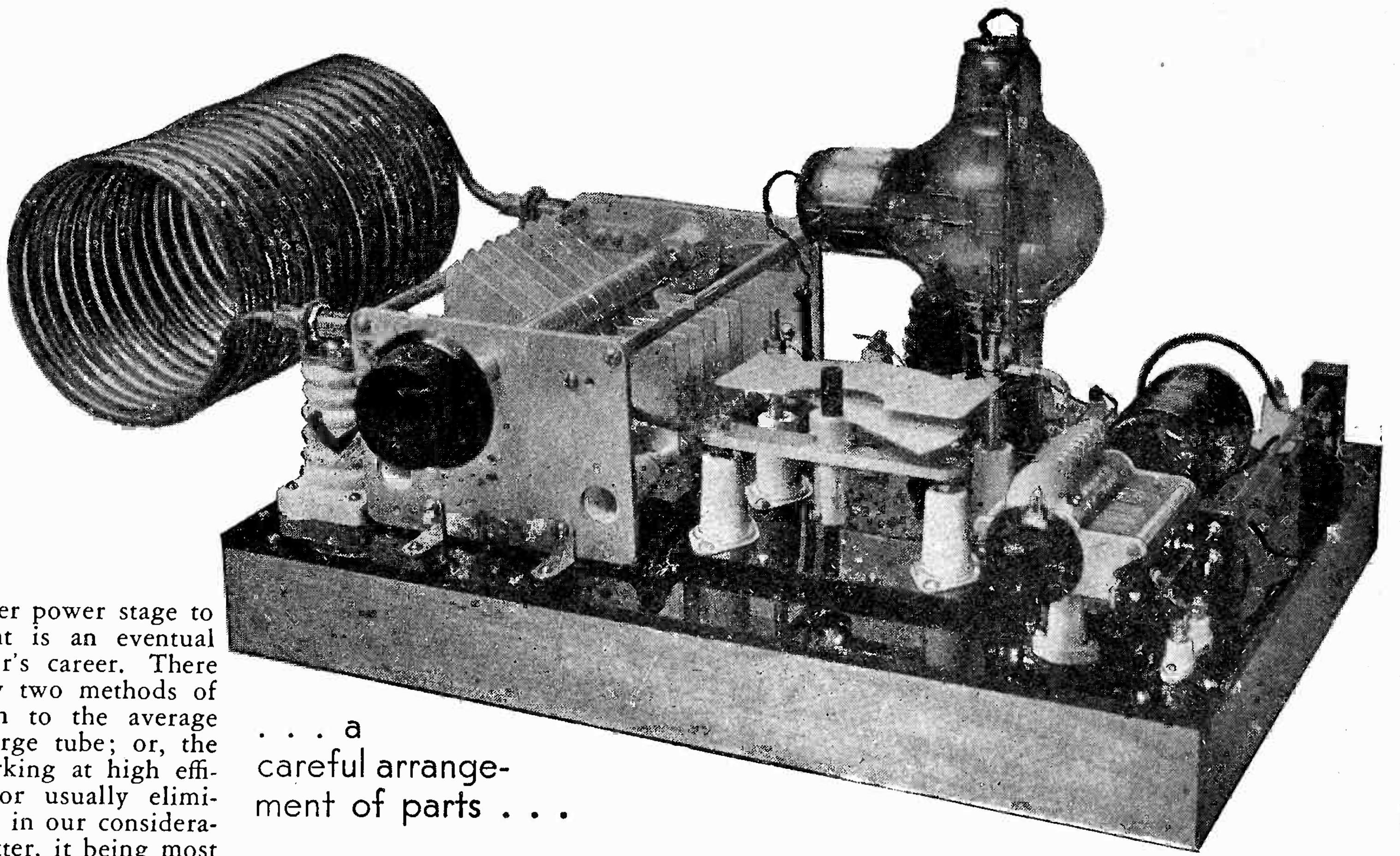
(Continued on Page 46)



? ? ? What will this chart look like in 4 years if the Amateurs don't wake up ? ? ?

Some Considerations in the Design of Hi-Power Stages

By
CLAYTON F.
BANE*



. . . a careful arrangement of parts . . .

THE adding of a higher power stage to his present equipment is an eventual step in every amateur's career. There are, strictly speaking, only two methods of achieving this result open to the average amateur: The use of a large tube; or, the use of a smaller tube working at high efficiency. The expense factor usually eliminates the former, so let us, in our considerations, consider only the latter, it being most suited to our purpose and pocket book.

A tube such as the '52, working at high efficiency and large power output, demands the following conditions for successful operation: First, high plate voltage. Second, high values of bias and excitation voltage, and last but of great importance, an efficient tank circuit. When you stop to consider that inputs of several hundred watts are successfully applied to tubes rated at a mere hundred watts plate dissipation, it is readily apparent that the tank must be taking the greater part of the load. In order for this condition to exist, the tank impedance must be considerably greater than the tube plate impedance. This condition is readily realized in practice, by the use of an efficient, high L to C tank, and by proper attention to the resistance which the antenna circuit couples into the tank circuit. Generally speaking, the closer the antenna coupling, the more resistance is coupled into the tank, and accordingly, the lower the tank impedance. This results in a greater percentage of the total wattage, being dissipated at the plate of the tubes in the form of heat.*

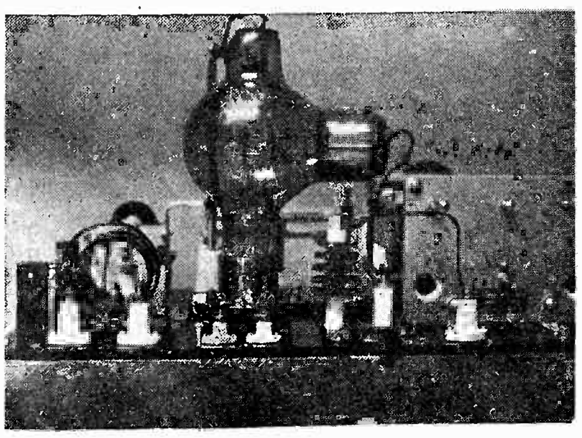
In addition to providing a higher impedance, we want a real low C tank to avoid this silly practice of wasting precious watts in heat losses. The large circulating currents and their attendant heating of the inductance, make high C extremely poor practice, except possibly in self-excited oscillators, its use there being rather a necessary evil. However, these two considerations are merely matters of careful design, and do not necessarily represent an expenditure of money. This can hardly be said of the other requirements—namely, high plate voltage and large excitation. The man desiring to install higher power usually has access to voltages to the amount of a couple of thousand volts, but to obtain twice this value is a somewhat difficult problem. The proper rectification of these higher voltages lies outside the scope of the medium power rectifier tubes—to say nothing of the filter condensers. In addition, not many of us have the price for an additional '52 or '03A to provide the excitation necessary to run the brute at maximum efficiency. But is this so called "maximum efficiency" absolutely necessary? It is, unquestionably, if we desire to get the last ounce of power from the tube, but it isn't at all if we are content to operate the tube somewhat under this value. Let's compromise.

A compromise design can be worked out that will meet the requirements of the average amateur, by rejecting some of the more costly elements and retaining others, less expensive, but none-the-less advantageous. First of all, we must take advantage of our existing stages to supply the excitation. This is entirely feasible, providing the exciting stage is at least a ten, itself properly excited. The link coupling system described in last month's issue will provide the necessary excitation to the "ten," so further discussion of that problem is harly necessary. Assuming a certain fixed amount of excitation voltage from the "ten," our next consideration is matching this value of voltage to the C bias. To clarify this statement, let us take an example: If a bias of several hundred volts is applied to the final grid in order to fix the operating point three or four times cut-off, our exciting voltage must not only equal this cut-off voltage but must be considerably **greater**, in order to drive the grid somewhat positive. (A desirable condition in obtaining respectable power output.) With a '10 as a driver, we will probably find that not only will the final grid fail to go positive (no grid current), but that the power output will be sadly lacking. Obviously, our excitation voltage is not great enough to overcome the C bias. Therefore, **decreasing** the C bias is the logical solution, provided we do not carry this action to extremes. The bias should **not** be decreased to a point **above** cutoff, if any semblance of efficiency is to be maintained. This statement is merely made as a caution, because a "ten" should be capable of driving the final well below Class B, with plenty of power output.

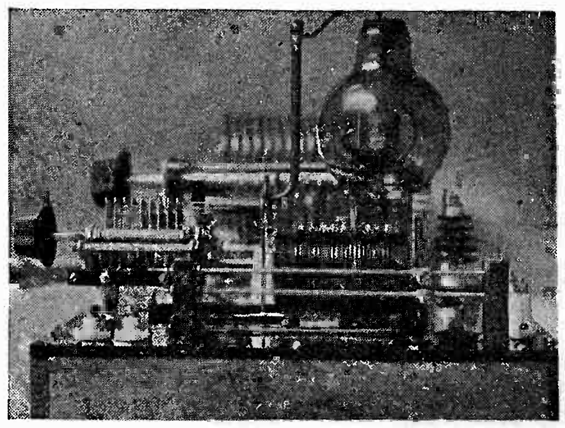
The writer does not wish to convey the impression that he is not in favor of high efficiency, large power output stages. The merits of this form of operation are not to be disputed, but it is with the thought in mind that the average amateur will find the requirements for this form of operation beyond his means that the preceding remarks on compromise adjustment have been written. If you have the necessary excitation and power supply by all means take full advantage of them. The unit about to be described has been carefully designed so as to be capable of efficiently handling higher power, if and when an increase becomes desirable.

If the saying, "A set is no better than the equipment in it," can be taken literally, the unit shown in Figure 1 is destined to perform in a remarkable manner. The equipment was selected from the dozens of similar pieces because of its quality, appearance and reasonable cost, and because of its

* "Radio Engineering"—Terman.



Back View—Showing end of grid coil and power terminals.



End View—Showing details of adjustable feed line.

adaptability to a unit of this sort. The tuning and neutralizing condensers were selected not alone for their lower cost and beautiful mechanical construction, but also for their ability to withstand higher voltages if used.

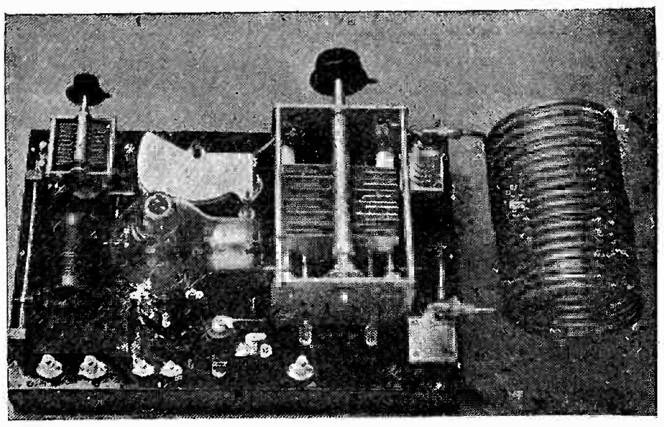
The r.f. choke used in the plate circuit deserves special mention because of the fact that it incorporates several features not usually found in other chokes. Its ability to carry rather heavy plate current, combined with a new design that insures efficient choking action, makes this choke a sure-fire bet.

The plugs and jacks for the inductance were selected without hesitancy, combining, as they do, an excellent electrical connection, with a real "he-man" mechanical strength. All the other equipment was selected because of similar advantages.

The parts are mounted on a ¼-in. bakelite panel, 12 by 18 inches, which is in turn supported by a frame of the same size, two inches deep. This frame is made of ¾-in. by 2-in. hardwood and suitably finished with either a stain or clear lacquer.

Reference to the photographs should give the reader a good idea of the mechanical construction, but since there are various little items that may not be clear in the photos, a few random remarks about some details will be in order.

It was decided to mount the inductance off to the side of the tank condenser instead of following the customary upright method of mounting. (To mount it in the upright manner would require a larger subpanel, if the metal of the condenser is to be kept out of the field of the inductance.) Metal brackets were made of heavy angle brass and drilled to fit the plugs and the standoff insulators. This mounting is extremely strong and will hold the ordinary inductance without the slightest springing. The leads from the plugs to the condenser are made very short and direct as the photos will show. It was found in preliminary experiments, that the coupling from the exciter to the grid circuit of the final was rather critical and that the method of varying the coupling loops used in the lower power stages was undesirable, so another arrangement was evolved. This latter allows an extremely fine adjustment of coupling and eliminates the danger of break-down of the insulation on the loop, and of sparking over to the grid coil. The two brass rods on which the loop slides serve as a continuation of the feed line and are of further advantage in that they provide a means of anchoring the flexible line from the preceding stage. A point that should be remembered in wiring is to put the rotor of the grid tuning condenser on the cold side



of the grid coil. Since this side is at ground potential, the very bothersome trouble of hand capacity will be eliminated. The plugs on the large tank inductance are the newest types made by General Radio and differ from their previous plugs in that they have a hole in the end that will take up to 5/16-in. tubing. They come filled with solder and all that is necessary is to sweat the tubing to the plug.

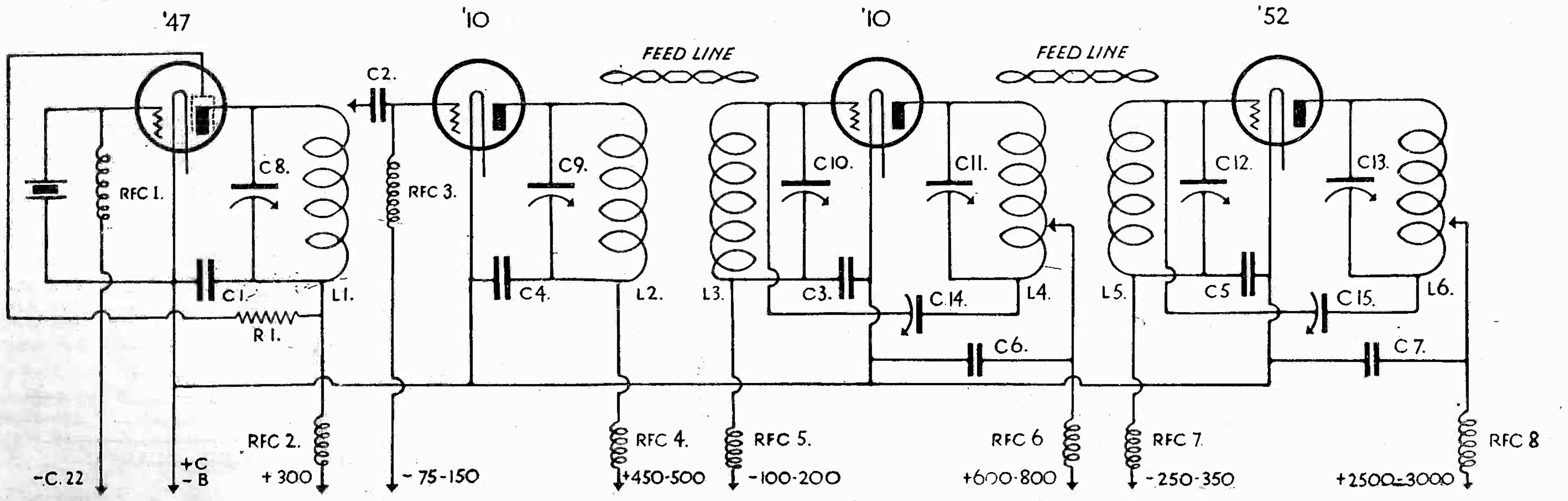
Since this unit will eventually be part of a rack-panel transmitter, it was deemed advisable to bring the power leads out to terminals, so that the unit could be removed for repairs (heaven forbid) or for making other adjustments. The small standoff insulators now on the market serve admirably as terminal supports and were used in this unit. Long machine screws running down through the standoffs and the subpanel make a neat connection to those power leads that come from the bottom of the set. The grid coil is made plug-in to facilitate rapid changing of bands, and plugs into GR plugs mounted in the subpanel. The bi-pass to ground and the C bias leads are connected to one of these plugs from underneath the panel, the connection to the tuning condenser and to the grid being made above. The r.f. choke is mounted above the panel because it would not fit otherwise, but care must be taken to keep it away from any metal by at least the diameter of the largest coil. The clip for the high voltage is made from a piece of spring brass, bent in the middle until both sides meet, and a depression to fit the tubing is made by inserting a piece of rod the size of the tubing between the two ends, and squeezing them in a vise. Do not even consider using the clips that are used on storage batteries, because these are made of iron and not only have an appreciable resistance but are actually a small closed loop. The fact that they get hot can be attested to by anyone who has ever grabbed one. Some folks like to put a little bakelite handle on the clips, but I say, "Leave it off." You're not apt to grab it if it's naked metal, while insulation may give you a false sense of security.

The tuning procedure followed in this unit is largely a repetition of that followed in tuning the ten stage, with a few exceptions.* The main consideration in tuning is to obtain the maximum amount of grid swing from the "ten" stage, without exceeding its plate dissipation. You will find the adjustable loop around the final grid tank to be a distinct help in this respect. A point can be reached where the mills in the "ten" plate circuit are at a safe value, without a material decrease in the grid current in the final. This is the correct operating point since there is little advantage in running the "ten" red hot to gain only a fractional amount of additional swing. If the coupling loop around the "ten" plate tank is fixed far back toward the plate voltage tap it will not be necessary to change the position of this loop at any time. Do all the changing with the grid loop, which is made adjustible for that very purpose. Too much stress can not be laid upon the fact that it is this careful adjustment of excitation, where a "ten" is used as an exciter, that makes the difference between success and failure—a failure that would be clearly indicated if the final plate ran hot at values of input that make a '52 stage worth-while. The neutralizing of the final is done in much the same way as in the "ten," only one caution being necessary. You will find that the stage will neutralize with several different combinations of turn adjustment and neutralizing capacity, but it also will be found that one of these combinations will give better results than any of the others. This must of necessity be determined by experiment.

Now a few words about keying: Center-tap keying is probably the easiest and most generally used, but it has a certain disadvantage when applied to this unit. It is evident that when the key is up, there is no return for the grid, which leaves the grid tank with no load to work into. However, this would not do any harm (since the tuning is done with the key down, and the tube is not working with the key up), but for the fact that the change in load on the grid tank reflects itself in a change in load on the exciting stage, reflected by a radical increase in plate current every time the key is up.

(Continued on Page 31, Col. 3)

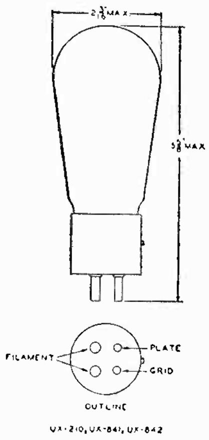
* See last month, "Writing 'Finis' to the grid choke problem").

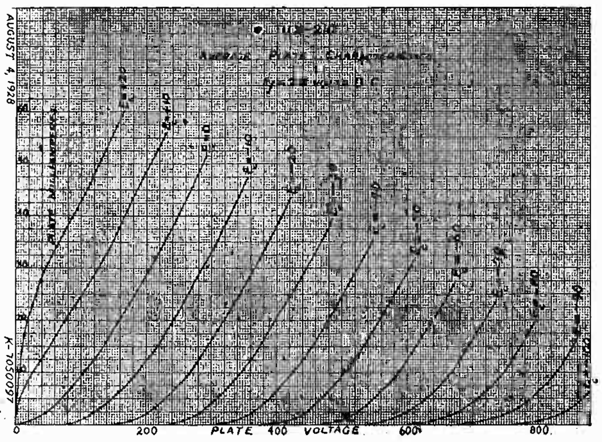


C1-C3-C4-C6—.006 Sangamo 2000 v. Fixed Mica Condensers.
C2—.00025 Sangamo.
C7—.004 (Two .002's) Sangamo 5000 v.
C8-C9-C10—.001 Cardwell Midget Variables.
C11—.0001 Cardwell 407-B.
C12—Cardwell 407-B, with alternate plates removed.
C13—Wireless Shop Heavy Duty Variable. SW7510.
C14—Cardwell 305-B Variable.
C15—Wireless Shop WSN852 Neutralizing Condenser.

L1-L2-L3-L4—See June issue "Writing Finis to Grid Choke Problem".
L5—Grid coil. 18 turns No. 14 enameled, on 2¼-in. bakelite form, space wound.
L6—Plate coil. ⅜-in. copper tubing, 16 turns, 5-in. dia.
RFC1 & RFC3—National No. 100 chokes.
RFC2-4-5-6—Home-made peramble wound in sections.
RFC8—National No. 152 R.F. Transmitting choke.
R1—20,000-25,000 ohms.
Center-tap resistors are General Radio throughout.
E. F. Johnson Stand-Off Insulators & Sockets were used in the Lab. Model.

Technical Information on Transmitting Tubes





RADIOTRON RCA-210 TECHNICAL INFORMATION

Use .... General Purpose

CLASS "A" SERVICE

Maximum Operating Plate Voltage .... 425 Volts
Maximum Plate Dissipation .... 12 Watts
Typical Operation
  Ep=425 Volts, Eg=—39 Volts, Ef=7.5 Volts.
DC Plate Current .... 18 Ma.
Peak Grid Swing .... 35 Volts
Load Resistance .... 10200 Ohms
Power Output (5% 2nd harmonic) .... 1.6 Watts

MODULATOR

Maximum Operating Plate Voltage .... 425 Volts
Maximum Plate Dissipation .... 12 Watts
Typical Operation
  Ep=350 Volts, Eg=—35 Volts, Ef=7.5 Volts.
Modulation Factor 0.6
DC Plate Current .... 5 Ma.
Peak Grid Swing .... 31 Volts
Oscillator Input per Modulator Tube .... 4.0 Watts

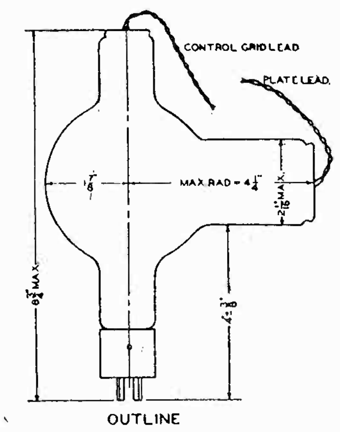
* Selected for non-microphonic qualities.

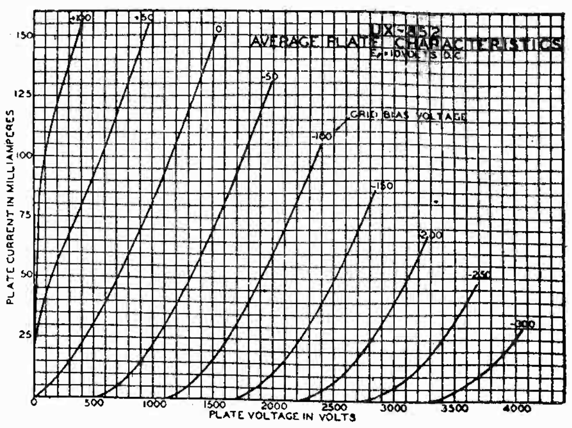
CLASS "B" SERVICE

Maximum Operating Plate Voltage .... 450 Volts
Maximum DC Plate Current (Unmodulated) .... 30 Ma.
Maximum Plate Dissipation .... 15 Watts
Maximum RF Grid Current .... 5 Amp.
Maximum DC Grid Current .... 15 Ma.
Typical Operation
  Ep=350 Volts, Eg=—39 Volts, Ef=7.5 Volts.
DC Plate Current (Unmodulated) .... 43 Ma.
Peak Power Output .... 12 Watts
Carrier Output, Modulation Factor 1.0 .... 3.0 Watts

CLASS "C" SERVICE

Maximum Operating Plate Voltage:
  Modulated (DC) .... 350 Volts
  Unmodulated (DC) .... 450 Volts
  AC (RMS) .... 450 Volts
Maximum DC Plate Current .... 60 Ma.
For other maximum values, see Class B Service.
Typical Operation
  Ep=350 Volts, Eg=—100 Volts (approx.) Ef=7.5 Volts.
Power Output .... 10 Watts
Socket Type UR-542





RADIOTRON UX-852 TECHNICAL INFORMATION

GENERAL

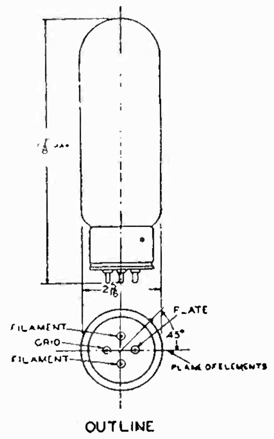
Main Use .... Oscillator and R-F Power Amplifier
Number of Electrodes 3
Filament Voltage .... 10 Volts
  Current .... 3.25 Amperes
  Type .... Thoriated Tungsten
Average Characteristic Values Calculated at
  Eb=2000, Ec=—108, Ef=10 volts D-C
  Plate Current .... 0.050 Amperes
  Amplification Factor 12
  Plate Resistance .... 10,000 Ohms
  Mutual Conductance .... 1200 Micromhos
Approximate Direct Interelectrode Capacities
  Plate to Grid .... 3 mmf.
  Grid to Filament .... 2 mmf.
  Plate to Filament .... 1 mmf.
Maximum Overall Dimensions
  Length .... 8¾ Inches
  Radius .... 4¼ Inches
Type of Cooling .... Air

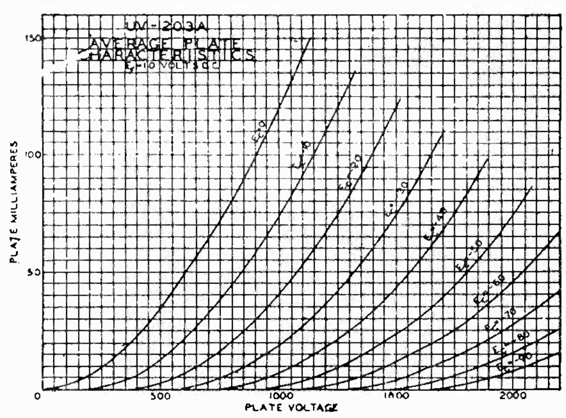
R-F POWER AMPLIFIER—CLASS B

Maximum Operating Plate Voltage .... 3000 Volts
Maximum Unmodulated D-C Plate Current .... 0.085 Amperes
Maximum Plate Dissipation .... 100 Watts
Maximum R-F Grid Current .... 10 Amperes
Typical Operation
  Ep=2000, Ec=—150, Ef=10 volts D-C
  Unmodulated D-C Plate Current .... 0.060 Amperes
  Peak Output .... 120 Watts
  Carrier Output—Modulation Factor 1.0 .... 30 Watts

OSCILLATOR & R-F POWER AMPLIFIER—CLASS C

Maximum Operating Plate Voltage
  Modulated D-C .... 2000 Volts
  Unmodulated D-C .... 3000 Volts
  A-C (R.M.S.) .... 3000 Volts
Maximum D-C Plate Current .... 0.100 Amperes
Maximum D-C Grid Current .... 0.040 Amperes
Maximum Plate Dissipation .... 100 Watts
Maximum R-F Grid Current .... 10 Amperes
Typical Operation
  Ep=2000, Ec=—250 approx. Ef=10
  Output .... 100 Watts
Socket Type .... UR-542 plus clips





RADIOTRON UV-203A TECHNICAL INFORMATION

GENERAL

Main Use .... Oscillator and R-F Power Amplifier
Number of Electrodes 3
Filament Voltage .... 10 Volts
  Current .... 3.25 Amperes
  Type .... Thoriated Tungsten
Average Characteristic Values Calculated at
  Eb=1000, Ec=—10 and Ef=10 volts
  Plate Current .... 0.072 Amperes
  Amplification Factor 25
  Plate Resistance .... 6000 Ohms
  Mutual Conductance .... 4200 Micromhos
Approximate Direct Interelectrode Capacities
  Plate to Grid .... 15 mmf.
  Grid to Filament .... 8 mmf.
  Plate to Filament .... 7 mmf.
Maximum Overall Dimensions
  Length .... 7⅞ Inches
  Diameter .... 2$\frac{5}{16}$ Inches
Type of Cooling .... Air

R-F POWER AMPLIFIER—CLASS B

Maximum Operating Plate Voltage .... 1250 Volts
Maximum D-C Plate Current—Unmodulated .... 0.150 Amp.
Maximum Plate Dissipation .... 100 Watts
Maximum R-F Grid Current .... 7.5 Amperes
Typical Operation
  Eb=1000, Ec=—35 and Ef=10
  D-C Plate Current—Unmodulated .... 0.130 Amperes
  Peak Output .... 160 Watts
  Carrier Output—Modulation Factor 1.0 .... 40 Watts

OSCILLATOR & R-F POWER AMPLIFIER—CLASS C

Maximum Operating Plate Voltage
  Modulated D-C .... 1000 Volts
  Unmodulated D-C .... 1250 Volts
Maximum D-C Plate Current .... 0.175 Amperes
Maximum D-C Grid Current .... 0.060 Amperes
Maximum Plate Dissipation .... 100 Watts
Maximum R-F Grid Current .... 7.5 Amperes
Typical Operation
  Eb=1000, Ec=—100 (approx.) and Ef=10
  Output .... 100 Watts
Socket Type UT-541

A 2-Volt Dry-Cell Super Using the New 1A6 Tube

THE new 1A6 is an ideal tube for use as a mixer or first detector and oscillator, combined, in a dry-cell battery-operated superheterodyne. Its low filament current consumption permits design of economical and quiet-operating receivers. The new tube enables one to develop a super that consumes only 0.37 amperes filament current, for a 5-tube receiver. Obviously, common dry-cells can be used for its operation. The new tube apparently solves many of the problems of light-weight portable receiver design and opens a new market for the manufacture of inexpensive dry-cell operated supers for short waves.

The short-wave fan will welcome the news of the arrival of this tube. The radio amateur will busy himself with the construction of an inexpensive super that assures quiet operation.

The 1A6 has a 2-volt filament, which consumes 0.06 amperes. It can be operated from dry-cells, from an air-cell or from a single 2-volt storage cell. The plate-current consumption of a superheterodyne, using this and other 2-volt tubes, is very low. A set of good B-batteries should give service for almost a year, under ordinary operating conditions, and four dry-cells, connected in two banks (series-parallel), should likewise give long and faithful service.

Heretofore, short-wave fans and radio amateurs had to content themselves with regenerative or t.r.f. receivers, if dry-cell operation was desired. The new 1A6 permits general use of a superheterodyne for those who will accept nothing short of dry-cell operation.

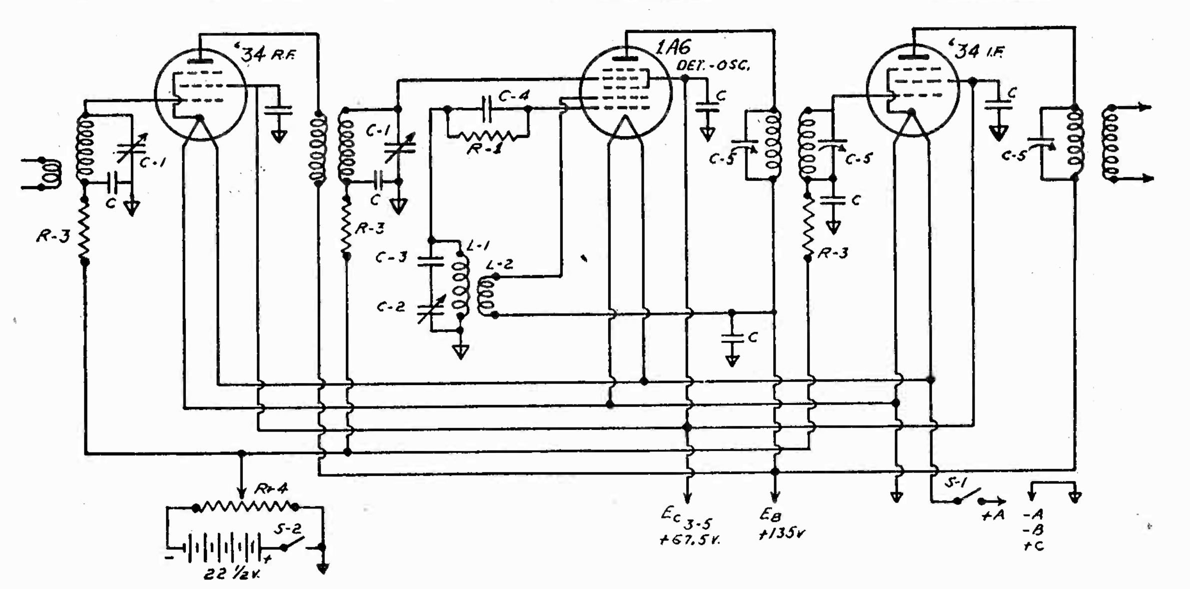
There is no "hum" to be eliminated in a dry-cell receiver; no power unit is required. Weak signals are more easily readable.

The circuit diagram shows a super using the new tube. A '34 tube is used in the radio-frequency stage ahead of the 1A6. '34's are also used in the Intermediate stages. A 5-tube dry-cell-operated super would use the '32 tube as a second detector and a '31 in a Class A output stage. For greater volume, but with greater current consumption, the '19 tube in the output stage, with a '30 as a driver, would give more than 2,000 milliwatts of audio output. Here is the legend for the circuit diagram:

C	**1 mfd.**
C1, C2	**Ganged tuning condenser**
C3	**Padding condenser**
C4	**Oscillator grid condenser, 200 mmf.**
L1	**Oscillator grid inductance } coupled**
L2	**Oscillator plate inductance } coupled**
M	**Mutual L1 to L2**
M L	**.25 to .4**
R1	**Adjust to limit total cathode current to 9 MA. (Usually 50,000-100,000 ohms with 100 v. Ec3-5).**
S1&S2	**On-off switch (ganged together)**
R3	**500,000 ohm filter resistors**
R4	**Volume control. (Value should be such that it causes life of C battery to be equal to plate battery. The usual value is from 150,000-250,000 ohms.)**

The use of variable bias battery, essential in this circuit for volume control, differs from the method in which bias is obtained from the power source, or from a dropping resistor. The potentiometer shunted across the 22.5-volt battery should have a resistance of from 150,000-250,000 ohms. Improved battery life will result if the bias battery circuit is opened by a double-pole switch which opens the 22.5-volt battery circuit at the same time the set is turned off.

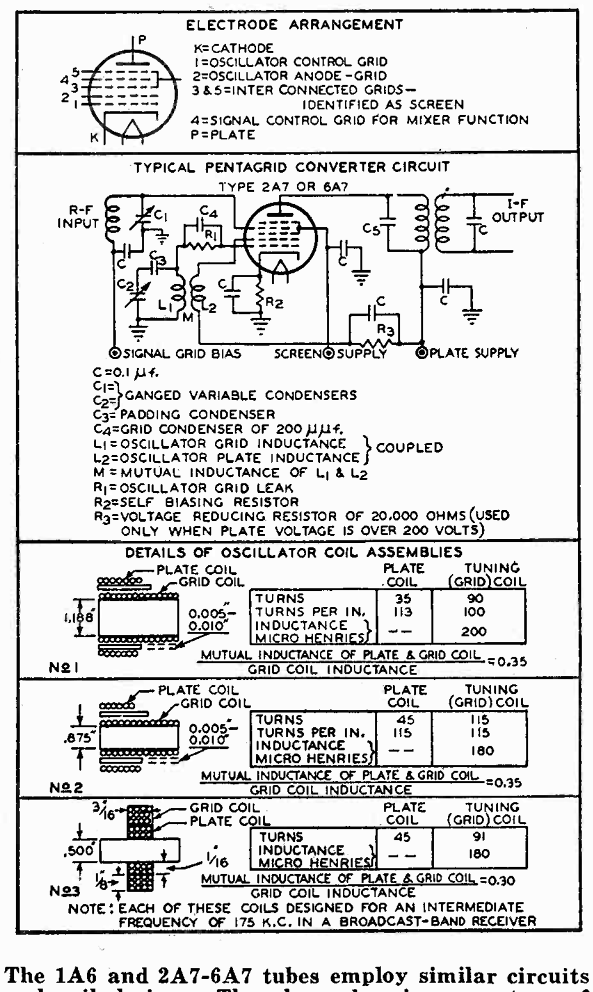
The design of a super using the 1A6 tube is not difficult. The r.f. input coil, the i.f. transformers and the gang-tuning arrangements are all conventional. In designing the oscillator coils for the 1A6 the coupling should be a little greater than that usually used for triode oscillators. The ratio of M/L, the mutual inductance M between oscillator anode coil and grid (tuning) coil should be from 0.25 to 0.40. Higher values of coupling may give rise to difficulty in the tracking of the oscillator, whereas lower values will result in reduced translation gain, even though the tube will oscillate with ratios as low as 0.1.



Superheterodyne circuit showing proper use of new 1A6 Pentagrid Converter Tube. The following tubes are required for this receiver: '34 as r.f. amplifier ahead of 1A6; '34's for the intermediate stages; '32 for second detector; '31 if Class A output stage is desired, or '19 if Class B output is used. A '30 will drive the '19 satisfactorily. Using a '31 in the output stage the tube filaments for this 2-volt dry-cell super will consume only 0.37 amperes, assuring long battery life.

For use with a 175 k.c. intermediate frequency amplifier, the grid and plate coils L1 and L2 may be made of small layer-wound or honey-comb coils, as follows: On a ½-in. dia. form (paraffined round hardwood), wind 45 turns of insulated wire, preferably single silk enamel or double cotton covered. This constitutes the plate coil. Insulated from the plate coil with a thin layer of paper or other insulating material, wind a coil with 91 turns of wire. This constitutes the grid, or tuning coil. No. 28 wire is suitable for winding the coils. The oscillator thus produced will approximately cover the broadcast band. Exact check of the tracking must then be made in the usual manner by means of a test oscillator. For covering the amateur or police bands it will be necessary to use other values for grid and plate coils.

CIRCUIT DETAILS



The 1A6 and 2A7-6A7 tubes employ similar circuits and coil design. The above drawing, courtesy of RCA-CUNNINGHAM, will help you in selecting the proper I.F. coils for a super using the 1A6 tube.

W9USA To Be Given Away

GOOD NEWS is in store for all radio amateurs who contemplate attending the WORLD-WIDE RADIO AMATEUR CONVENTION at the Medinah Michigan Avenue Club, 505 North Michigan Avenue, Chicago. Delegates will have the opportunity to participate in the drawing for W9USA transmitter. This famous cw and phone installation complete with tubes and ready for operation together with a National FB7 complete with power pack and tubes will be given away during the banquet on the closing night of the convention.

Mr. T. L. McElroy, present holder of the Worlds Champion Radio Operator title, will be in Chicago at the World-Wide Radio Amateur Convention to participate in the code speed contest and defend his title which he captured in Boston in 1922, copying 56.3 words per minute. It is expected that Mr. McElroy will have plenty of stiff competition during the three days of the convention —August 3, 4 and 5.

The Convention Committee of the World's Fair Radio Amateur Council will award a prize of $25 in cash to the radio club having the largest percentage of attendance at the World-Wide Radio Amateur Convention.

Call Book Changes

Globe Wireless advises they have discontinued Press broadcasts, so WPN, KTK and KKB should be deleted from the list of Px, Tx and Wx in June call book.

Bahamas now use VP2 prefix, USSR uses U. Official.

Frequency Meters

By WILLIAM P. HUGHES*

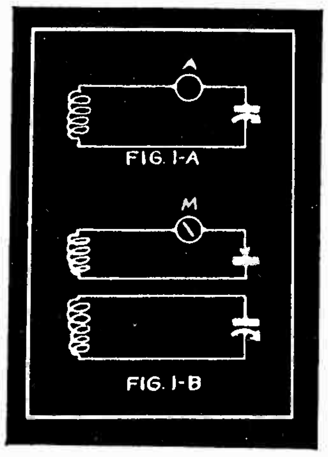


FIG. 1A-1B showing the use of a hot-wire or thermo-couple ammeter as the resonance indicating device.

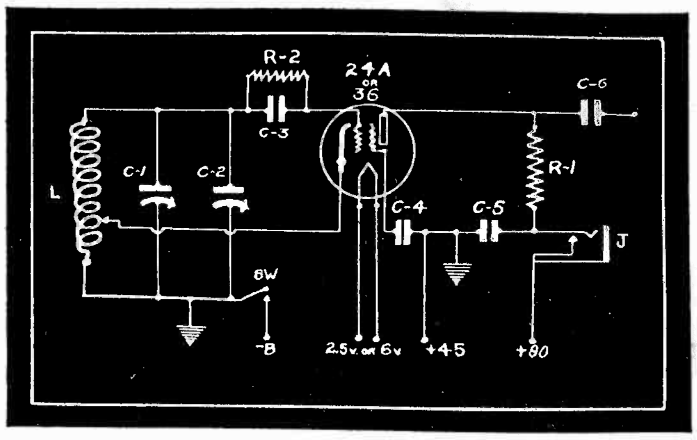


FIG. 2—Conventional Circuit Diagram of an Electron-Coupled Frequency Meter.
C1-C2—Band-spread Condenser. R.E.L. Cat. No. 187-H.
C3—Grid condenser, .0002 mfd.
C4-C5—0.1 mfd. by-pass condensers.
C6—.00005 mfd.
R1—50,000 ohm, non-inductive.
Re—0.1 meg.
SW—SPST switch.
J—Single-circuit closed jack.
L—75 turns No. 36 enameled wire on 1-in. dia. tubing, tap 25 turns from grounded end.

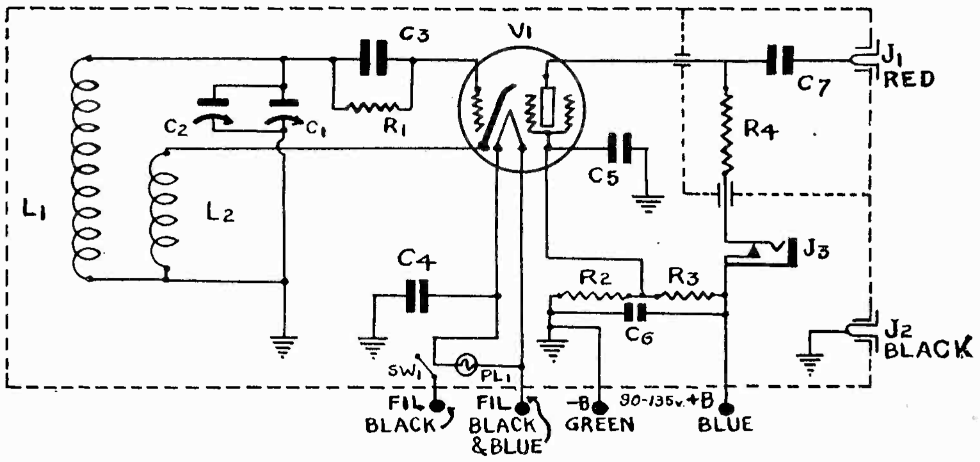


FIG. 3. J-1 (Red) and J-2 (Black) are the Output Terminals.

L1-L2—R.E.L. Cat. 291A special inductance.
C1-C2—R.E.L. Cat. 187-H tank and vernier cond.
V1—UY tube socket for 36 or 24-A tube.
SW1—Yaxley No. 210 pilot light and switch.
R1—0.1 meg grid leak.
R2—15000 ohm resistor grid leak type.
R3—15000 ohm resistor grid leak type.
R4—50000 ohm resistor grid leak type.
C3—.0002 mfd. receiving type fixed condenser.
C4, 5, 6—0.1 mfd. 300-volt by-pass condensers. (If possible, obtain the three condensers mounted in one case with a common connection.
C7—.00005 mfd. receiving type fixed condenser.
J1-J2—Output and ground jacks—Yaxley No. 422, or plain binding posts.
J3—Single circuit—closed jack.

THE determination of frequency is one of the major problems confronting the amateur. In its simplest form a frequency meter consists of a coil shunted by a variable condenser, with some method for indicating when the meter is in tune or resonance. Figure 1A shows the use of a hot wire or a thermocouple ammeter as the resonance indicating device. In figure 1B we see a crystal detector and milliammeter coupled by means of a few turns to the frequency meter, to indicate resonance. This particular method has the advantage that damage to the meter M will not affect the calibration of the instrument. While these meters are useful and absolutely indispensable in general radio laboratory work, they have no place in the amateur station as accurate frequency checks.

The elimination of absorption type frequency meters leaves, as our best bet, the use of some tube oscillator. For various reasons, of the utmost importance, an electron coupled oscillator is chosen. First, the electron coupled oscillator is one of the most stable known. Secondly, with the proper plate and screen voltages applied to the elements of the tube, slight variations in supply voltages will have a negligible effect on the frequency. Third, the high harmonic content of the output circuit makes the use of plug-in coils unnecessary, and last but by no means least, a load can be applied to the output circuit without any frequency shift.

Circuit diagrams of efficient electron coupled oscillators, which can also be used as monitors, are given in Figures 2 and 3. The first shown is the usual circuit employed by hams, while the second is used in the REL Cat. No. 291 frequency meter and monitor, pictured in Figures 4 and 5.

This instrument can be taken as an example of the high spots desired in a practical ham job.

1. Rigidity of construction; thin panels and insecure mounting of parts cannot be countenanced in an accurate meter. If it is necessary to use a panel of less than ⅛-in. thickness, it should be backed up by another bakelite panel. The same applies to the sides of the containing cabinet. The writer has seen several frequencv meters which could be tuned by applying pressure of varying intensities to the sides of the cabinet.

2. The Dial; this should be an accurately engraved vernier dial of the type which eliminates parallax. A smooth running dial, absolutely free from backlash, is essential.

3. Band Spread Condenser: a well-made condenser, preferably of the tank and vernier type, is to be desired. A condenser of this construction permits the placing of a lumped capacity across the inductance so that the vernier will give wide spread tuning over the band desired. Choose a condenser having heavy plates as they are less likely to bend, due to slight jars in handling.

4. Voltage Stabilization; the use of resistors R2 and R3, in Fig. 3, provides voltage stabilization in that the proportion of screen to plate voltage is maintained when variations in the high voltage supply occur.

5. Calibration Curve; a large calibration curve for the instrument should be drawn so that readings, commensurate with the accuracy of the meter, can be made. Many amateurs err in this matter, by making curves which can be read only to 1 per cent, while the accuracy of their meter is .1 per cent or better. A standard size of cross-section paper, 18 inches by 23 inches, with 10 by 10 lines to the inch, is available from supply houses for this purpose.

The construction of an electron coupled frequency meter should present no difficulties, if due care is given to the main points stressed above. Constants for the components are given under each circuit diagram.

After the meter has been wired and given a preliminary test, it is well to see that the vernier completely covers the band from 1715 to 2000 Kc. before calibration is attempted. This can be checked by listening to the meter, with the output coupled to the antenna of your receiver. From previous experience with your receiver, you should be able to roughly check whether the vernier covers the entire 160-meter band with about ten degrees to spare at each end of the dial. When this is determined the position of the vernier condenser should be locked or fixed in some manner to prevent any movement while handling. The next step is to look up the schedules of standard frequency stations, such as W6XK, W9XAN and W1XP. When the time for calibration approaches, have the

(Continued on Page 45)

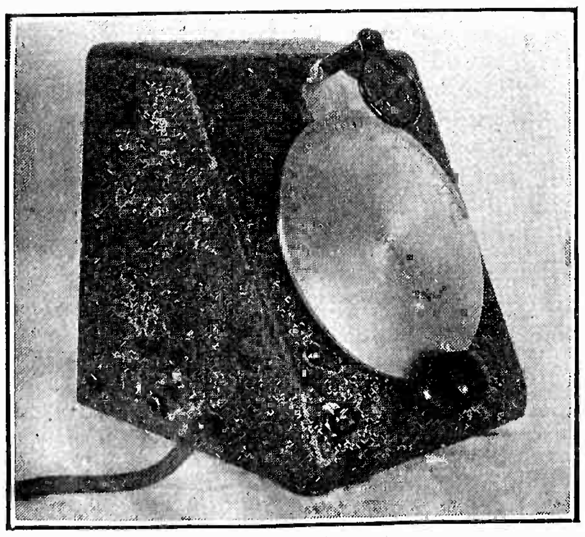


FIG. 4

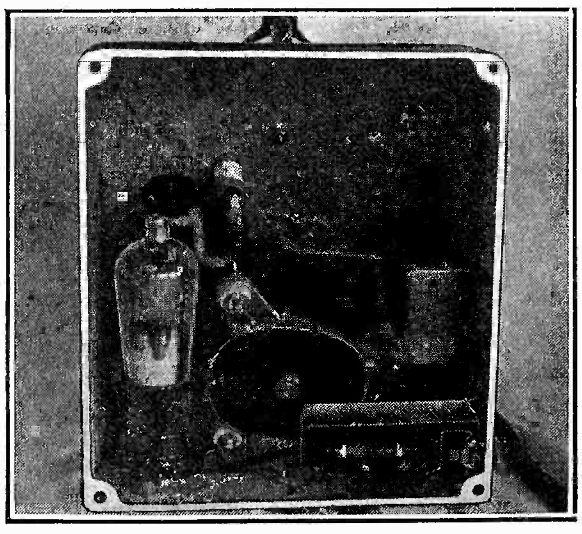


FIG. 5

The R.E.L. Cat. No. 291 frequency meter-monitor which is built along the lines mentioned in this article.

* Radio Engineering Laboratories.

NEW AMATEUR REGULATIONS

NEWS FROM THE F. R. C.

Radio Commission Continued

THE Federal Radio Commission is to be continued, not being affected by President Roosevelt's plan for reorganizing the government departments and independent bureaus. During consideration of the government office reorganization plan, the Radio Manufacturers' Association and other radio interests, notably the National Association of Broadcasters, urged that the Commission be not abolished, transferred to the Department of Commerce or otherwise disturbed.

New F. R. C. Amateur Regulations

THE new regulations of the Federal Radio Commission, effective October 1, 1933, contain many important changes. One regulation, effective immediately, allows amateur radio-telephony between 1800 and 2000 k.c. for the "160-meter band." The 28,000-28,500 k.c. band is now open for radio-telephone transmission and telephone operation is also permissible on the 56,000-60,000 k.c. and 400,000-400,001 k.c. bands. These bands are open for use by all licensed amateurs, without restriction. No special endorsement, or other authority, is needed for operation in these bands.

Perhaps the most important of the new regulations is one forbidding the use of improperly filtered direct-current plate supply on frequencies below 14,400 k.c. This marks the end of broad, interfering waves. It cannot but help relieve some of the present congestion in the amateur bands but the new regulation will give rise to much controversy in amateur circles.

The discontinuance of the Amateur Extra First Class License will be mourned by some, but usually those who are capable of passing the examination for this class of license are also capable to pass the examination for a regular commercial license.

The new regulations for amateur license are extremely fair and should work no hardship on anyone. The 125-mile airline requirement may inconvenience some amateurs but it will be soon accepted as a generally good regulation. All in all, the new regulations are a step in the right direction for amateur radio. Here is a complete summary of the high-light of the new regulations:

New Amateur Regulations of the Federal Radio Commission.

The following new amateur regulations are effective immediately:

The following bands of frequencies are open for use by amateur stations using radio telephone, type A-3 emission:

1,800 to 2,000 k.c.
28,000 to 28,500 k.c.
56,000 to 60,000 k.c.
400,000 to 401,000 k.c.

The following excerpts cover the important points of new amateur regulations which will become effective on October 1, 1933.

Licenses for amateur mobile stations will be issued for portable mobile stations located aboard aircraft, and capable of operating in the 56,000-60,000 k.c. and 400,000-400,001 k.c. bands only.

All bands of frequencies so assigned may be used for radio telegraphy, type A-1 emission. Type A-2 emission may be used in the following bands:

28,000 to 30,000 k.c.
56,000 to 60,000 k.c.
400,000 to 400,001 k.c.

The following bands of frequencies are open for use by amateur stations using radio telephony, type A-3 emission:

1,800 to 2,000 k.c.
28,000 to 28,500 k.c.
56,000 to 60,000 k.c.
400,000 to 400,001 k.c.

Amateurs who hold radio operator licenses endorsed for the Class A privilege may use radio telephony, type A-3 emission, in the following bands of frequencies:

3,900 to 4,000 k.c.
14,150 to 14,250 k.c.

Licensees of amateur stations using frequencies below 14,400 k.c. shall use adequately filtered direct current power supply for the transmitting equipment, to prevent frequency modulation and broad signals.

Those holding amateur portable station licenses shall advise the Inspector in Charge, in advance, of all locations where portable stations will be used, approximately, and further notices each 30 days thereafter are required.

The amateur operator classifications are changed, the following licenses being issued:

Class A—Unlimited Amateur Privileges.

Class B—Unlimited Radio Telegraph Privileges. Radio telephone operation restricted to 1800-2000 k.c.; 28,000-28,500 k.c.; 56,000-60,000 k.c.; and 400,000-400,001 k.c.

Class C—Same as Class B Privileges, except that the Commission may require the licensee to appear for a supervisory written examination and code test during the license term.

Applicants for Class A amateur licenses will be required to have held an amateur operator license at least one year, and must appear personally for examination at an office of the Commission (or at examinations conducted at designated locations in the field). Applicants must be able to send and receive not less than 10 words per minute, must have a technical knowledge of amateur radio apparatus, both telegraph and telephone, and must be familiar with the Radio Act of 1927, subsequent acts, treaties, and rules and regulations of the Federal Radio Commission, with particular reference to amateur licenses.

Requirements for Class B privileges are similar to those for Class A, except that no experience is required, and the questions on radio-telephone apparatus are not so extensive.

Requirements for Class C operator licenses shall be the same as Class B, except that the examinations are to be given by mail. To be eligible for this class of privilege the applicant must reside more than 125 miles (airline) from Washington, D. C., a radio district office of the Commission, or in a city where examinations are held.

Applicants who have held a radio-telephone second-class license, or higher, or an equivalent commercial grade license, or who have been given unlimited amateur radio-telephone privileges within the five years before date of application, may only be required to submit proof as to code ability, and knowledge of the laws, regulations, treaties, etc., affecting amateurs.

Applicants for the Class B or Class C amateur operator's privileges who have held a radio-telegraph third-class license, or higher, or an equivalent commercial license, or who have held an amateur extra-first class license within five years from the date of application, will be granted licenses by passing an examination in laws, treaties and regulations affecting amateurs.

All amateur operator and station licenses are to be issued for a three-year period.

The former radio districts are "amateur call areas" and the same numerical system of assigning call letters will be continued.

Temporary Amateur Class Licenses Renewable Again

AMATEURS holding Temporary Licenses and residing more than 100 miles airline distance from a city where examinations are held may now renew their licenses upon expiration, without examination. The Federal Radio Commission has changed the Regulations Governing the Issuance of Radio Operators Licenses as follows: "Temporary amateur class licenses may be renewed without examination provided the following proof is submitted in affidavit form: (1) That the applicant after having received notice of examination was unable to appear on the date specified because of residing more than 100 miles (airline) from the examining point, or that he was unable to appear for examination because of illness or other emergency circumstances; and, (2) That the applicant has communicated by radio, using the Continental Morse Code, with at least three amateurs during the last three months of the license term. The call letters of the amateur stations with which communication was carried on, as well as the time and date of each communication, must be stated. In the absence of sufficient reason for the applicant's failure to appear for examination, or failing to pass the examination for the amateur first class license, the temporary amateur license held will be cancelled and the holder will be required to wait for a period of ninety days from the date of cancellation of the temporary license held, or from the date he failed to pass the examination for the amateur first class license, before making application for a new license."

Add-a-Stage Beginner's Crystal-Control Transmitter

Part II—Showing How to Add a 210 Amplifier to the 2A5 Oscillator Which Was Described In the Last Issue

EDITOR'S NOTE—Readers have asked why the Beginner's Transmitter was designed for use in the 80-meter band. Beginner's luck depends on the ability of others to answer his calls. There are more beginners on the 80-meter band and more recognition is given the newcomer's QSO's. Furthermore, the 80-meter band has suddenly become a humdinger for DX. Coast amateurs are working VK's and ZL's, Eastern amateurs are working the Coast. In midsummer the band seems almost as good as it was in winter months. Amateurs everywhere are remarking about the unusually fine DX that is being done on 80. Two months ago the 80-meter band was quite dead. But something has happened of late, and the band has come to life with a bang. The addition of an amplifier stage to the original transmitter, as herein described, will enable many an amateur to hang-up some fine new records on 80. This transmitter is not a theoretical brainstorm, neither is there anything new about it. Yet, it has worked New Zealand on 80; it costs but little to build. Nothing could be more simple, more inexpensive than the oscillator-amplifier outfit here described. A doubler can be added at any time, so that 40-meter transmission can be enjoyed. Next month's RADIO will tell you how to do it. But if you want a real thrill on the 80-meter band, give this simple two-tuber a whirl. It has proved its worth.

●●●

THE large and unexpected amount of correspondence received in regard to the construction of the simple one-tube crystal control transmitter described in last month's issue brings up a question, almost general in character, "Why was a 2A5 tube used instead of a 47?"

The 2A5 is a newer tube, is low in price, has given better results in actual test, when used with a low-voltage power supply, such as a B-eliminator of the receiving set type. Many beginners like to begin at the beginning, with the most inexpensive equipment that money can buy. The 47 tube is easily substituted for the 2A5 in this transmitter and the builder can make the change by merely referring to the Radio Notebook diagrams shown in the June issue. The 2A5 is a slow heater, the 47 heats rapidly. But the 2A5 gives greater output than the 47 when low power is used. Therefore, it is a most economical transmitter to build.

Under actual operation conditions this 2A5 transmitter has been doing fine work over distances of more than 1000 miles, with 250 volts on the plate. It has given far better results than the much-used '45 transmitters and the signals from this little 2A5 outfit have been pronounced "perfect" by many who have reported. With the present congestion in all amateur bands, it is a sign of good sportsmanship to use crystal control, not to mention the greater distances that are spanned with this little 2A5 outfit. If more power output is wanted, one need but increase the plate voltage to 500, or even to 750 and substitute the 47 tube for the 2A5. The 47 will stand up under 750 volts in a C.W. transmitter because only an intermittent load is applied. However, the key should not be held down for long intervals.

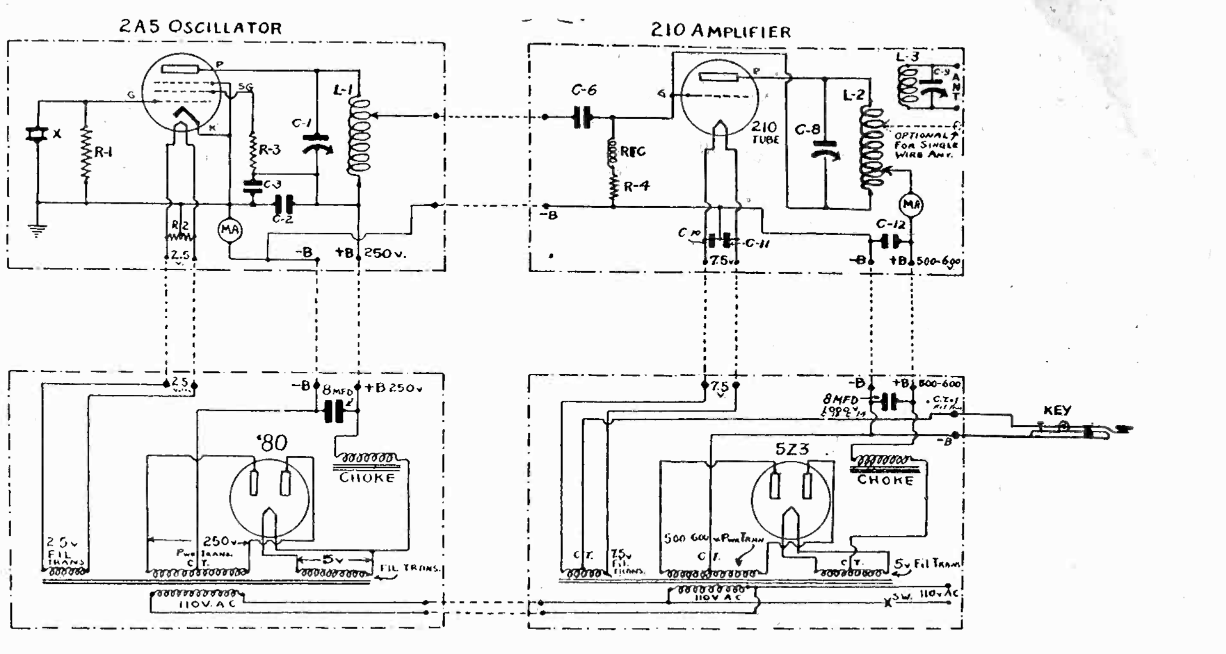
So it remains for the builder to decide which tube to use. If the pocketbook permits, the 47 can be used, with higher plate voltage, greater output.

Fundamentally the circuits are the same. The purpose of this series of low-priced transmitter constructional articles is to give the amateur the most for the least money.

This month's article deals with amplifiers for use in conjunction with the original oscillator. Here, again, two choices confront the builder. The price bugaboo once more enters into consideration. You have your choice of a 46 tube as an amplifier, or you can use the larger and more powerful 210. No buffer is required, so why go to the expense of adding such a stage? Because most beginners get their start on the 80-meter band, the amplifier here described is for use in that band. The oscillator stage feeds directly into the amplifier. Two circuit diagrams are shown—one for the 46 tube as an amplifier, the other for the 210 tube.

With a 2A5 tube as oscillator, and a 210 as amplifier (no buffer stage being used), a similar transmitter in use in the laboratory has been reaching to Georgia, New Jersey and Ohio from San Francisco. That's not so bad, in these months when conditions are none too good. The laboratory transmitter is connected to an 80-meter Zepp antenna, the exact dimensions being shown in Fig. 1.

The amplifier baseboard, whether for use with a 46 or 210 tube, is the same size. Likewise, it is the same size as the oscillator baseboard, so that both stages can be arranged side-by-side on the table. Uniformity is maintained, and a business-like appearance is given the entire outfit. The amplifier stage uses a separate power supply. It is advisable



Complete circuit diagram of oscillator-amplifier Beginner's Transmitter using 2A5 tube as oscillator and 210 as amplifier. Separate power units are used. For simplicity, each of the four fundamental units are shown in broken-line enclosures. Connector leads from oscillator to power unit, from oscilator to amplifier, and from amplifier to its separate power unit, are all shown in dotted lines, although these connections, when made, are run direct to the connector terminals on the respective units. In place of the 2A5 tube in the oscillator a '47 can be used by making a simple change in socket connections. Refer to the RADIO NOTEBOOK page in the June issue for circuit diagram.

Here is the Legend and List of Parts for this beginner's transmitter:

OSCILLATOR

X—Crystal, 80 meters.
R1—Resistor across crystal, 5,000 to 50,000 ohm (not critical). This resistor can be an ordinary 2-watt type.
R2—20-ohm, center-tapped resistor across filament terminals. This resistor is not required if a center-tapped filament transformer is used. (The center-tap of such a transformer is connected to the negative B terminal and the 20-ohm center-tap resistor is eliminated).
R3—40,000 ohm, 2 watt resistor. This resistor reduces the voltage supplied to the screen of the 2A5 tube.
C1—Variable condenser, receiving type, 9 to 13 plates.
C2—.002 mfd. mica fixed condenser.
C3—.002 mfd. mica fixed condenser.
L1—Plate inductance, 30 turns, No. 20 double silk covered wire, wound on 1½-in. dia. coil form (4-prong type).
MA—0-100 (or 0-200) Readrite Milliammeter.
Note:—A ground connection can be made to the negative B terminal but this is not absolutely essential.

POWER SUPPLY FOR OSCILLATOR

The 2A5 tube should not be supplied with more than 250 volts, in which case an ordinary receiving set power supply can be used for the oscillator. If a '47 tube is used, in place of the 2A5, the tube will oscillate on 250 volts but it will give greater output if the voltage is increased to over 400 volts.

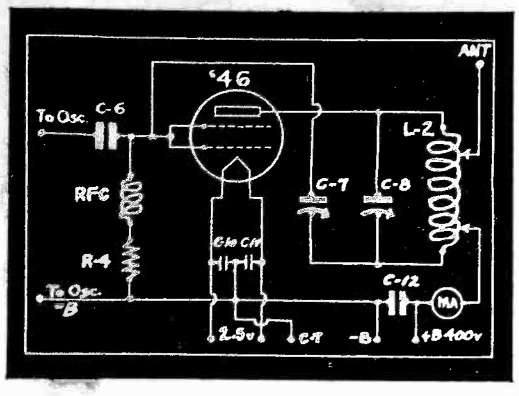
Parts for Oscillator Power Unit:
1—2.5 volt filament transformer, receiving set type, for lighting 2A5 (or '47) tube filament.
1—5 volt filament transformer for lighting '80 tube filament.
1—250-CT-250 (or higher voltage) power transformer, receiving set type.
1—Type '80 rectifier tube.
1—4-prong socket for tube.
1—Receiving set type power unit choke coil, 30 henrys, 60 milliamps.
1—8 mfd. filter condenser, electrolytic. Two of these can be connected in series, in which case the working voltage will be doubled, but the capacity will be only 4 mfds. However, 4 mfds. is ample for this power unit.

210 AMPLIFIER STAGE LEGEND

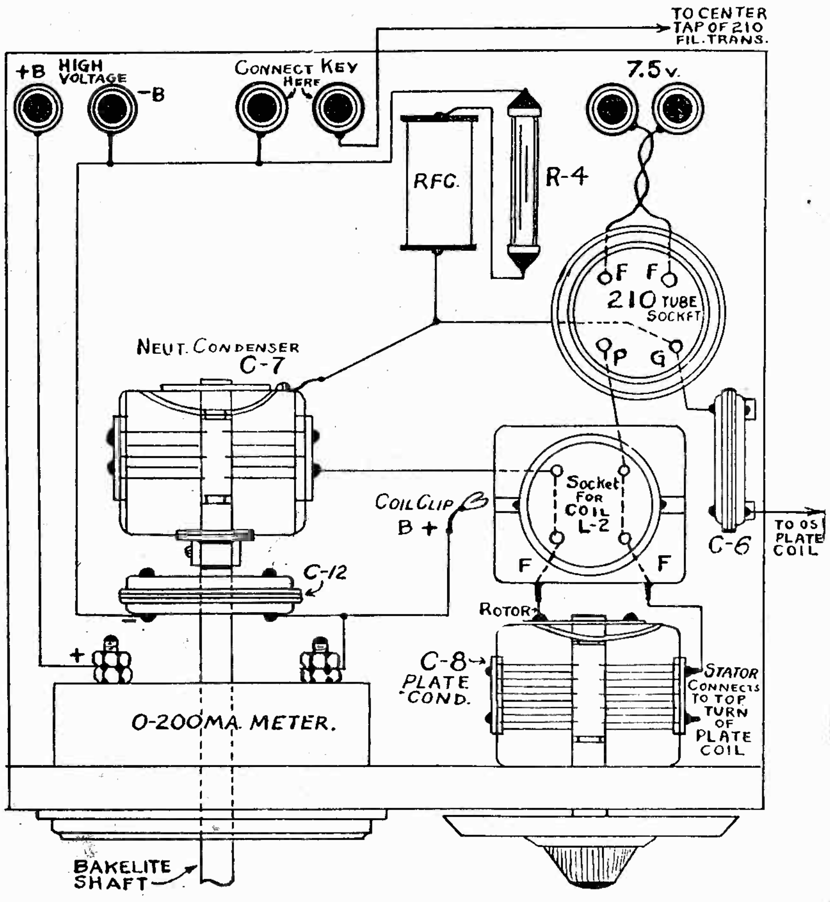
C6—.00025 mfd. mica fixed condenser.
C7—Neutralizing condenser, about 7 plates, midget receiving type.
C8—Plate tuning condenser. Receiving type. .00035 mfd.
C9—Antenna feeder tuning condenser, Receiving type, .00035 mfd.
C10—.002 mfd. fixed mica condenser.
C11—Ditto.
C12—Ditto.
L2—Plate Inductance Coil, 30 turns, No. 20 double silk covered wire, space wound on 1½-in. dia. coil form, and tapped 4 turns from lower end of coil.
L3—Antenna Inductance, 10 to 20 turns No. 20 double silk covered wire, wound on 1½-in. dia. form. Correct number of turns must be found by experiment.
MA—0-200 MA milliammeter, Readrite.
RFA—0-2A R.F. Antenna Meter.

210 AMPLIFIER POWER SUPPLY

Parts Required:
1—7.5v. center-tapped filament transformer for 210 tube.
1—5v. center-tapped filament transformer for 5Z3 tube.
1—5Z3 Rectifier tube. (Choke input can be used with this tube).
1—Power Transformer, 620-CT-620, or 750-CT-750 volts.
1—30 henry choke (minimum 125 ma. current capacity).
1—SPST 110-volt line switch.
1—4 MFD. 1000-volt filter condenser, or a bank of two or four 8 MFD dry electrolytic condensers connected in series. A good D.C. note can be secured from as little as 1 mfd. for the filter condenser.



A '46 can be used instead of a 210. Here is the circuit. The filament voltage of the '46 is 2.5 volts.



Baseboard Lay-Out and Pictorial Wiring for Beginner's 210 Amplifier

The baseboard and front panel for this stage is the same in size and appearance as the one used for the oscillator stage which was shown in the June issue. However, the respective positions of the milliammeter and condenser dial are reversed so that all connecting leads can be made as short as possible. Note the placing of the plate condenser, socket for the plate coil and socket for the 210 tube. The plate coil plugs into a 4-prong socket, of which only two contacts are used (F-F). The remaining two unusued contacts are bridged with connectors, shown in dotted lines; consequently the plate lead from condenser to coil can be run direct to the plate of the tube. The neutralizing condenser (C-7) is secured to the baseboard. A bakelite extension shaft, protruding through a hole in the front panel, is used to vary the capacity of the neutralizing condenser. This shaft is placed beneath the milliammeter. Another method for mounting the neutralizing condenser would be in an upright position and the extension shaft to the front panel would not then be required. Fixed condensers C10-C11 can be mounted on the baseboard, if desired, directly behind the neutralizing condenser. Most constructors prefer to install these condensers in the power supply unit.

to feed the amplifier stage separately, thus permitting the use of two low-priced transformers. The market is offering transformers of relatively high voltage for a 210 amplifier stage for as little as $2.25. The circuit diagram of the power supply for the amplifier stage is so simple that explanation is not needed.

If a 210 tube is used in the amplifier stage, it can be made to carry 750 volts in the plate circuit without injury to the tube. Again, this is because the load is applied only when the key is depressed. Ordinary 8-mfd. dry electrolytic condensers are used in the rectifier circuit and a number of these are connected in series-parallel. The laboratory transmitter, using 750 volts, is giving fine results with a bank of six 8-mfd. condensers, four in each bank, connected in series-parallel.

The transmitter emits a pure d.c. note, one that you can be proud of. If you cannot afford to buy a 750-volt transformer for the amplifier stage, a smaller transformer will give satisfaction, although the output of the transmitter will be decreased. At any rate, the addition of this amplifier stage to the original transmitter, with only 450 or 500 volts on the amplifier tube, will give the signal a real boost and will greatly increase its range.

The parts should be placed and spaced as shown in the lay-out pictorial. Short, direct leads in the plate and grid circuit are of paramount importance.

TUNING

TUNING is made extremely simple, even for the novice, if instructions are followed to the letter. A small neon glow tube is all that is required. The milliammeters on the front panels of the oscillator and amplifier stages must be watched closely. Step by step, the procedure is as follows:

(1) Connect the amplifier stage to the oscillator. Turn on the plate and filament current for both stages, but **remove** the rectifier tube from the power supply that feeds the **amplifier** stage. Hold the glow lamp near the plate-lead end of the coil in the oscillator stage. Adjust the oscillator plate condenser until maximum brilliance is indicated by the neon glow lamp. Look at the oscillator milliammeter. It will read somewhere between 20 and 45 milliamps. Slowly rotate the plate condenser of the oscillator circuit and a sudden rise in plate current will be indicated by the milliammeter. This rise indicates that the circuit it NOT tuned properly. Rotate the condenser until maximum brilliance is indicated by the glow lamp, yet MINIMUM indication shown by the milliameter. This is an indication that the oscillator stage is tuned to resonance.

(2) With the amplifier stage connected to the oscillator, with the rectifier tube in the amplifier power supply unit removed from its socket, but with the filament of the tube in the amplifier stage lighted (no plate voltage being supplied to the amplifier tube), we are ready to NEUTRALIZE the amplifier stage. The plate voltage is not supplied to the amplifier until **AFTER** this stage has been neutralized. Connecting the amplifier to the oscillator usually results in throwing the oscillator stage out of resonance, because the oscillator is now feeding into the amplifier. It is merely necessary to **slowly** adjust the oscillator condenser until maximum brilliance is shown in the glow lamp.

(3) Hold the glow lamp near the top of the plate coil of the **amplifier** stage. Slowly rotate the **neutralizing** variable condenser until the glow in the lamp is extinguished. Now look at the milliammeter in the **oscillator** stage. Does it still read the same as it did when the oscillator was first tuned to resonance? If not, slowly readjust the oscillator plate condenser until the oscillator is again in resonance. Hold the glow lamp near the top of the plate coil in the amplifier stage once more. If it glows, the amplifier is **NOT** neutralized. Slowly rotate the neutralizing condenser once more until the glow is extinguished. Again see, if the oscillator stage is still in resonance, for if the oscillator is not in resonance, a false indication will be secured. Every time a change in the neutralizing condenser is made, it is advisable to immediately check back on the oscillator to see if it is still oscillating, as indicated by the glow in the lamp when held near the oscillator plate coil.

When you find the position of the neutralizing condenser where the lamp will NOT glow, and with the oscillator circuit in resonance, slowly rotate the plate tuning condenser of the amplifier stage. Perhaps the lamp will glow again, when held near the plate coil of the amplifier stage. If so, this is an indication that the amplifier is NOT completely neutralized. And this necessitates another adjustment of the NEUTRALIZING condenser, until a point is found where the lamp refuses to glow. But, again, look and see if the oscillator stage is still in resonance, because changes in the tuning of the amplifier stage often throw the oscillator out of oscillation.

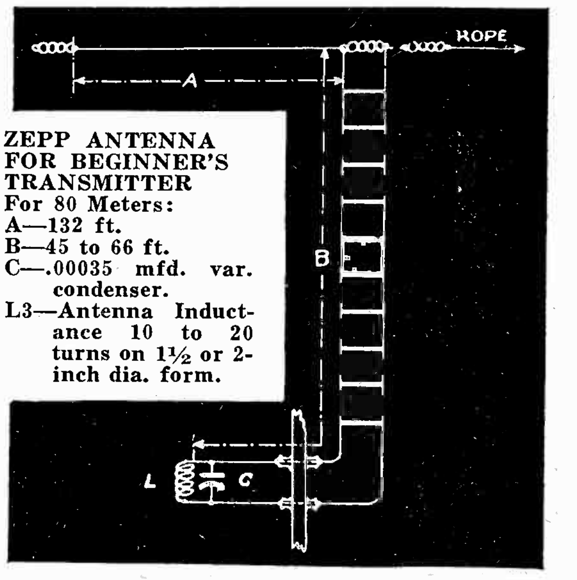
(4) The final check-up. The amplifier stage is tuned when and if:

(a) The oscillator stage is in resonance, as indicated by a glow in the lamp, when held near the oscillator plate coil.

(b) The neutralizing condenser has one "spot" where the glow lamp ceases to glow, when this "spot" is found.

(c) The plate condenser of the amplifier stage, when rotated over its entire scale, shows **NO** illumination of the glow lamp.

Consequently, any glow in the lamp, when held near the plate coil of the amplifier stage, and indicated when the plate condenser of the amplifier is rotated over its entire scale, is an indication that the stage is NOT neutralized properly. A little practice and a bit of patience will make neutralizing



ZEPP ANTENNA FOR BEGINNER'S TRANSMITTER
For 80 Meters:
A—132 ft.
B—45 to 66 ft.
C—.00035 mfd. var. condenser.
L3—Antenna Inductance 10 to 20 turns on 1½ or 2-inch dia. form.

easy for anyone. But always remember . . . the oscillator stage must be in resonance, else you will get a false indication in the amplifier stage.

To make this explanation more simple, the amplifier is neutralized when NO GLOW is indicated by the lamp, when it is held near the amplifier stage plate coil, no matter in

(Continued on Page 45)

RCA-Cunningham Announce the 1A6—a 2-Volt Pentagrid Conver Tube for Battery-Operated Super-Heterodynes

THE 1A6 is a multi-electrode type of vacuum tube designed primarily to perform simultaneously the function of a mixer tube and of an oscillator tube in superheterodyne circuits. Through its use, the independent control of each function is made possible within a single tube. The 1A6 is designed especially for use in battery-operated receivers. In such service, this tube replaces the two tubes required in conventional circuits and gives improved performance.

The action of this tube in converting a radio frequency to an intermediate frequency depends on independent control of the electron stream (1) by three electrodes (including the filament) connected in an oscillator circuit and (2) by a fourth electrode (a grid) to which the radio input is applied. As a result of this arrangement, it is apparent that the simultaneous control by these two groups of electrodes will produce variations in the electron stream between cathode and plate. Since the electron stream is the only connecting link between these two control-factors, this converter system may be said to be "electron coupled."

Electron-Coupled Frequency-Converter Considerations

IN a superheterodyne receiver, the tubes and circuits used to generate the local frequency and to mix it with the incoming radio signal to produce an intermediate frequency, may be called a frequency-conversion device.

The usual methods employ a mixer (first detector) tube in which the radio signal and local frequency are applied to the same grid. The local frequency may be generated by a separate tube or within the mixer tube. These methods generally depend on coupling the oscillator and mixer circuits by either capacitive or inductive means.

Another method of interest to circuit designers depends on electron coupling instead of reactive coupling. This arrangement offers advantages in eliminating undesired intercoupling effects between signal, oscillator, and mixer circuit and in reduction of local-frequency radiation. Furthermore, not only simpler circuits can be utilized, but also greater oscillator stability can be obtained because the oscillator operates under conditions of essentially no load. A simple electron-coupled device may be imagined in which the space current of the mixer tube is modulated by variation in cathode emission. Conceivably, the cathode current might be modulated by variation in cathode temperature produced by filament-current variation. Practically, however, this same effect can be accomplished by placing a grid and a supplementary anode-grid between the cathode and the control-grid and by using these electrodes in conjunction with the cathode to accomplish the modulation of the cathode current.

With this latter arrangement, the cathode and the first two grids may be regarded theoretically as a composite cathode which supplies a modulated electron-stream. This modulated cathode-stream may be further controlled and utilized by means of the addition of other grids and a plate. For example, a control-grid placed between the composite cathode and the plate will provide for the introduction of the radio signal. Additional grids placed either side of the

RCA RADIOTRON RCA-1A6 — **CUNNINGHAM C-1A6**

PENTAGRID CONVERTER TENTATIVE RATING AND CHARACTERISTICS

Filament Voltage (D.C.)	2.0	Volts
Filament Current	0.060	Amperes
Direct Interelectrode Capacitances (approx.):		
Grid #4 to Plate	0.25*	uuf.
Grid #4 to Grid #2	0.2*	uuf.
Grid #4 to Grid #1	0.1*	uuf.
Grid #1 to Grid #2	0.8	uuf.
Grid #4 to all other electrodes (R-F Input)	10.5	uuf.
Grid #2 to all other electrodes (Osc. Output)	6	uuf.
Grid #1 to all other electrodes (Osc. Input)	5	uuf.
Plate to all other electrodes (Mixer Output)	9	uuf.
Overall Length	4-9/32" to 4-17"32"	
Maximum Diameter	1-9/16"	
Bulb	ST-12	
Cap	Small Metal	
Base (Refer to Drawing No. 92S-4275)	Small 6-Pin	

CONVERTER SERVICE

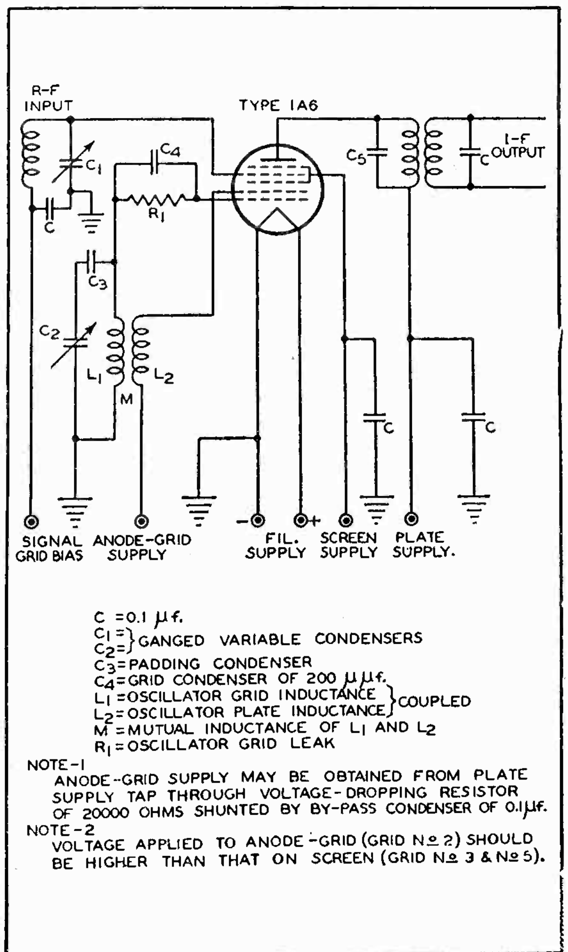
Plate Voltage	180 max.	Volts
Screen Voltage (Grids #3 & #5)	67.5 max.	Volts
Anode-Grid (Grid #2)	135 max.	Volts
Control-Grid (Grid #4)	-3 min.	Volts
Total Cathode Current	9 max.	Milliamperes

Typical Operation:			
Filament Voltage	2.0	2.0	Volts
Plate Voltage	135	180	Volts
Screen Voltage (Grids #3 & #5)	67.5	67.5	Volts
Anode-Grid (Grid #2)	135	135	Volts
Control-Grid (Grid #4)	-3	-3	Volts
Oscillator-Grid (Grid #1) Resistor	50000	50000	Ohms
Plate Current	1.2	1.3	Milliamperes
Screen Current	2.5	2.4	Milliamperes
Anode-Grid Current	2.3	2.3	Milliamperes
Oscillator-Grid Current	0.2	0.2	Milliamperes
Total Cathode Current	6.2	6.2	Milliamperes
Plate Resistance	0.4	0.5	Megohm
Conversion Conductance**	275	300	Micromhos
Conversion Conductance at -22.5 volts on grid #4	4	4	Micromhos

* With shield-can
** Conversion Conductance is defined as the ratio of the intermediate-frequency component of the mixer output current to the radio-frequency signal voltage applied to grid #4.

RCA Radiotron RCA-1A6 — Cunningham Radio Tubes C-1A6

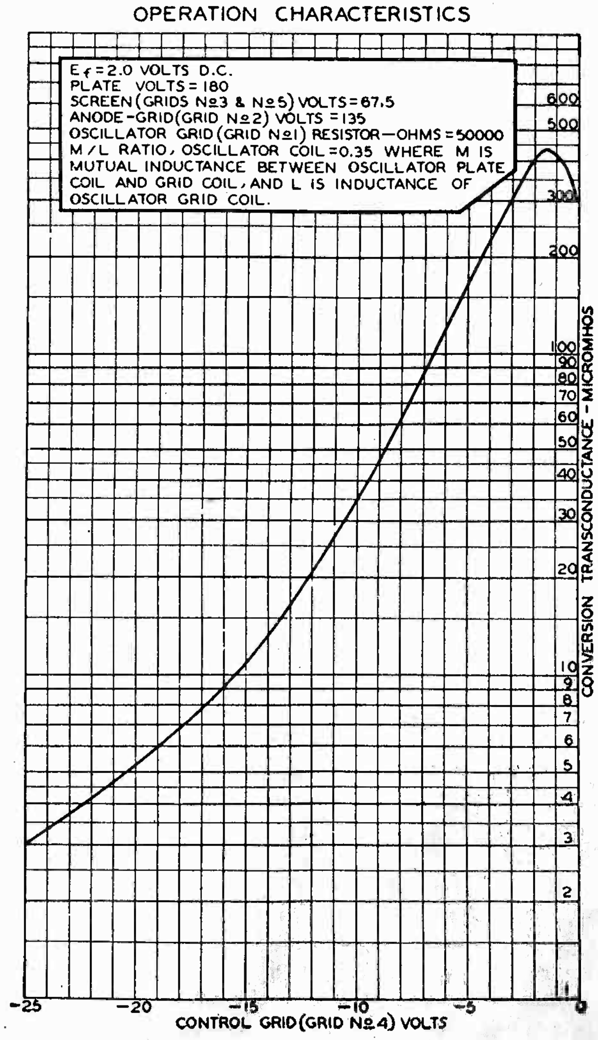
TYPICAL PENTAGRID CONVERTER CIRCUIT



The license extended to the purchaser of tubes appears in the License Notice accompanying them. Information contained herein is furnished without assuming any obligations.

RCA Radiotron RCA-1A6 — Cunningham Radio Tubes C-1A6

OPERATION CHARACTERISTICS



control-grid will shield the control-grid electrostatically from the other electrodes, and increase the output impedance of the tube, a desirable characteristic from a gain standpoint. Of these two grids, the one (No. 3) nearest the cathode serves also to reduce local-frequency radiation.

This design just considered is incorporated in the 1A6 to make aavilable for battery-operated receivers a tube which combines efficiently in one bulb all the functions of a frequency converter.

Installation

THE BASE pins of the 1A6 require the use of a standard six-contact socket which should be installed to operate the tube in a vertical position. Base connections and external dimensions of the 1A6 are given in Characteristics Table. The No. 4 grid connection is made to the cap on top of the tube.

The coated FILAMENT of the 1A6 may be operated conveniently from dry-cells, from a single lead storage-cell, or from an air-cell battery. For dry-cell operation, a filament rheostat may be used together with a permanently installed voltmeter to insure the proper filament voltage. For operation from a 2-volt lead storage-cell, the 1A6 requires no filament resistor. Operation with an air-cell battery requires a fixed resistor in the filament circuit. This resistor should have a value such that with a new air-cell battery, the voltage applied across the filament terminals will not initially exceed 2.15 volts. Series operation of the filament of the 1A6 with those of other two-volt battery types is not recommended.

Complete SHIELDING of the 1A6 is generally necessary to prevent intercoupling between its circuit and those of other stages.

Application

FOR converting the radio-frequency input to an intermediate frequency, the 1A6 is recommended for use in battery-operated superheterodyne receivers.

The feature that independent control of mixer and oscillator functions is made possible in a single tube with high gain is of practical advantage to the set designer.

As a FREQUENCY CONVERTER in superheterodyne circuits, the 1A6 can supply the local oscillator frequency and at the same time mix it with the radio-input frequency to provide the desired intermediate frequency. For this service, design information is given under RATING and CHARACTERISTICS. It is important to note that the anode-grid voltage and the plate voltage must each be higher than the screen voltage.

For the oscillator circuit, the coils may be constructed according to conventional design, since the tube is not particularly critical. The voltage applied to the anode-grid (No. 2) should not exceed the maximum value of 135 volts, but should always be higher than the screen (grids No. 3 and 5) voltage. The anode-grid voltage may be obtained from a suitable tap on the B-battery or from the plate-supply tap through a voltage-dropping resistor of 20000 ohms shunted by a by-pass condenser of 0.1 uf. The size of the resistor in the grid circuit of the oscillator is not critical but requires design adjustment depending upon the values of the anode-grid voltage and of the screen voltage. Adjustment of the circuit should be such that the cathode current is approximately 6 milliamperes. UNDER NO CONDITION OF ADJUSTMENT SHOULD THE CATHODE CURRENT EXCEED A RECOMMENDED MAXIMUM VALUE OF 9 MILLIAMPERES.

The bias voltage applied to grid No. 4 can be varied over relatively wide limits to control the translation gain of the tube. For example, with 67.5 volts on the screen (No. 3 and 5), the bias voltage may be varied from —3 to plate current cut-off (approximately —25 volts). With lower screen voltages, the cut-off point is proportionally less. The extended cut-off feature of the 1A6 in combination with the similar characteristics of super-control tubes can be utilized advantageously to adjust receiver sensitivity.

Since the capacity between grid No. 4 and plate is in a parallel path with the capacity and inductance of the plate load, it is important to use a load capacity of sufficient size to limit the magnitude of the r-f voltage built up across the load. If this is not done, r-f voltage feed-back will occur between plate and grid No. 4 to produce degenerative effects. For this reason, the size of the load condenser in the plate circuit should be not less than 50 uuf.

Converter circuits employing the 1A6 may easily be designed to have a translation gain of approximately 40. A typical circuit is shown on the drawing. This circuit provides exceptionally uniform oscillator output over entire grid-bias range.

Socket Contacts

(Bottom Side of Base)

Pin No. 1—Grid No. 2
Pin No. 2—Plate
Pin No. 3—Filament (positive)
Pin No. 4—Filament (negative)
Pin No. 5—Grids No. 3 and No. 5
Pin No. 6—Grid No. 1
Cap—Grid No. 4

The A-B-C of Modulation

By MAURICE J. FLYNN*

HOW OFTEN we have listened-in on the phone bands and have heard some well-meaning amateur advising his fellow amateur: "I think your outfit sounds a bit mushy tonight; perhaps you're not modulating enough—maybe your bias is off the r.f. amplifiers, etc. (with a couple of Hi, Hi's)." However, very seldom does this advice actually hit at the root of modulation troubles, and the amateur labors on indefinitely, "groping in the dark," for the actual solution of his difficulties. It is the purpose of this series of articles to explain the theory of modulation and to describe working combinations which can be adapted economically for use by amateurs. Modulation principles, and how these principles are used in practice, will be first discussed.

Modulation, by definition, is the process by which electrical waves, impressed on the microphone by sound waves, vary the amplitude of the transmitted radio-frequency in accordance with the sound waves. If the modulating sound is of a single frequency, or pitch, the variations in the antenna current amplitude will be as shown in Fig. I. At A is shown how the amplitude of the radio-frequency current varies between twice the normal unmodulated carrier and zero. This is what takes place when the radio-frequency carrier wave is modulated 100 per cent. At B is shown how the carrier varies when the modulation is less than 100 per cent. At C the modulation is over 100 per cent (very bad practice). It is well to define what is meant by "percentage of modulation." This is the ratio of half the difference between the maximum and minimum amplitudes of a modulated wave to the average amplitude expressed in percentage. Or:

$$100 \times \frac{i_{max.} - i_{min.}}{2 \times i_{car.}} = \text{Pct. of Modulation}$$

where $i_{max.}$ is the maximum amplitude of a modulated wave

$i_{min.}$ is the minimum amplitude of a modulated wave

and $i_{car.}$ is the average unmodulated carrier amplitude.

It is desirable to have the percentage of modulation as high as possible without exceeding 100 per cent modulation and consequently running into distortion caused by unsymmetrical modulation, such as shown in Fig. 1-c. The average amplitude in this case is different than the unmodulated carrier, and causes "frequency wobbulation," or "shifting," and even if the modulating sound is of a single pitch, both distortion and a broad signal will result. Of course, there are many other causes of "frequency wobbulation" with its broad signal, such as an unstable carrier or radio-frequency oscillator. Modulation of the oscillator, for this reason, is to be regarded as very poor practice, even if modulation percentage is low, frequency modulation usually results. To be on the safe side, the oscillator and the modulated radio-frequency amplifier should be separated by at least two well-regulated, well-filtered, and correctly neutralized buffer amplifiers to completely stabilize and isolate the oscillator from any tendency to shift its frequency when the modulated amplifier is heavily modulated. An extremely stable unmodulated carrier is a prerequisite for a high quality phone transmitter.

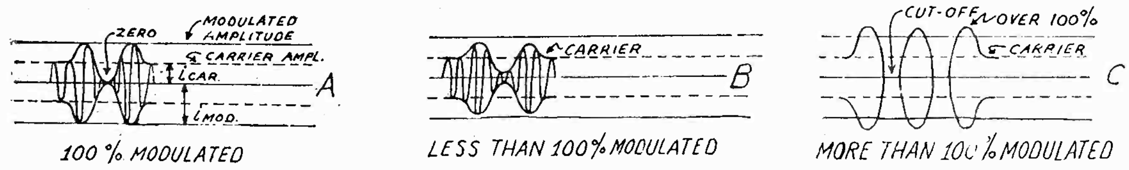


FIG. 1

Methods of Modulation

MANY systems have been devised to modulate the radio-frequency carrier. Some vary the radio-frequency current directly, and others vary the direct current input to the radio frequency amplifier tubes. The former is very ineffective and causes all kinds of trouble, such as frequency shift, "wobbulation," broad signal, very poor quality and excessive interference. The

(Continued on Page 24)

* Chief Engineer, Electronic Laboratories.

A Good, Easily-Constructed Air-Gap Crystal Holder

Complete Constructional Details of An Adjustable High-Quality Crystal-Holder Which Can Be Constructed at Minimum Cost

By PAUL R. FENNER

TO UTILIZE the piezo-electric properties of quartz plates, it is necessary to use some kind of a holder. Connections must be provided for conducting the charges at the surfaces of the quartz into the associated circuits. The holders which are used for this purpose consist of two metal plates, and suitable leads for contacting them.

Practical crystal holders are of three general types. These are the so-called "pressure" type, the air-gap holder type, and the clamp type, which holds the crystal firmly.

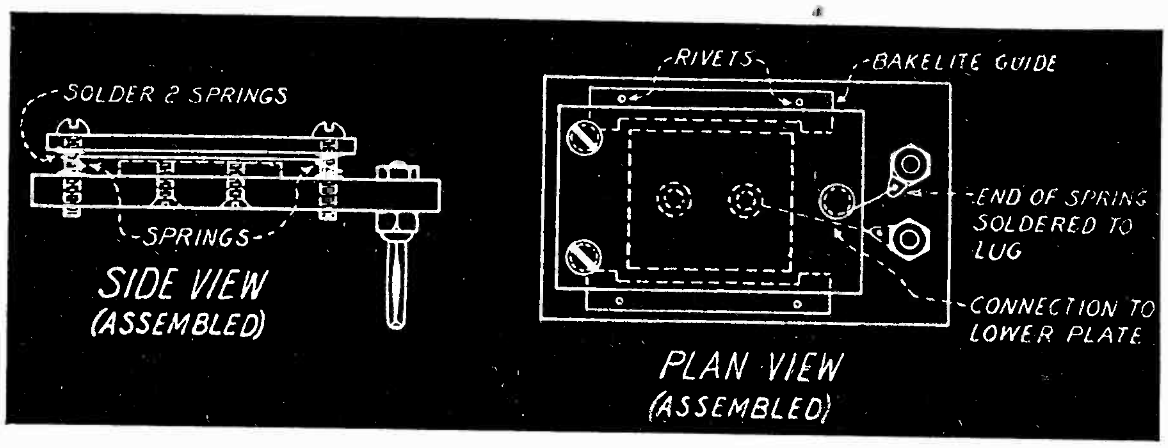
The pressure type is perhaps the first of these to have come into general use. It consists of two metal plates mounted on an insulated base. The crystal rests on the lower plate and the top-plate rests on the crystal; top-plate is held against the crystal by a suitable spring and connections are made to the two plates. During operation, the crystal does not contact either plate, but raises itself above the lower plate, and maintains the upper plate a small distance above it. The pressure type holder is really an air-gap holder.

The air-gap type holder consists of a flat metal plate which serves as a lower electrode and is similar to that in the pressure holder described above. The upper metal plate, however, is self-supporting and adjustable, in that any desired space can be maintained between the upper surface of the crystal and the inner surface of the top plate. Adjustment consists in varying the width of the air-gap. Adjusting the air-gap varies the frequency generated. The variation in frequency by this method is comparatively great. The variation in frequency by adjustment of the air-gap is such that crystal holders can be designed to produce a compensating effect. For example, increasing temperature in such a holder can be made to increase or decrease the air-gap, and for good designs, the frequency can be maintained to within ten parts or so in one million.

The clamp type holder grips the crystal firmly between the usual electrodes, or separate electrodes, if used. If these "clamps" are also the electrodes, they must be machined over a greater part of their surfaces so that a few thousandths of an inch air-gap remains between the electrodes and the crystal. The clamp type holder is perhaps the best, for it assists in maintaining frequency. Crystal holders used in precision frequency-standard work are of the clamp type. In these, the crystal is held firmly in a fixed position between the electrodes.

The holder to be described is of the air-gap type, but a method for using it as a clamp type holder will also be shown. This design is not elaborate, requires no complicated machine work, is not particular as to dimensions, but yet allows precision adjustment.

The following material is required:



1 Base (Bakelite or other insulation $\frac{3}{16}$" x $1\frac{1}{2}$" x $2\frac{1}{2}$"
1 Brass bottom plate $\frac{3}{32}$" x 1" x $\frac{7}{8}$"
1 Brass top plate $\frac{3}{32}$" x $1\frac{7}{8}$" x $1\frac{1}{8}$"
3 Round-head brass screws, $\frac{1}{2}$" long (6-32)
2 Flat-head brass screws, $\frac{1}{4}$" long (6-32)
3 Brass springs, small.
2 Plugs (Banks Inter-Air)
2 Pcs. Bakelite $\frac{1}{8}$" thick, $\frac{1}{4}$" x $1\frac{1}{2}$"
4 Wire brads or nails, small

A few drills, a 6-32 tap, hack saw, breast-drill (or hand drill and file) are the tools needed. Start with the base and drill the holes as shown in the drawing. Then drill and tap the brass bottom-plate; mount it on the base. Use quarter-inch flat-head screws for this purpose. These will protrude from the bottom-plate so must be filed off. This is done as carefully as possible so that the surface of the brass will not be scratched. Make the upper plate next. Drill the three holes in it and remove the burrs made while drilling with either a larger drill or a countersink tool.

The two brass plates should be rubbed on a piece of plate glass on which there is a small quantity of FFF Carborundum and water. This is called "lapping." Continue rubbing the plates with a circular motion, and turning them at the same time, until there is a frosted appearance over the entire surface of the plate. If the brass is smooth, flat, and devoid of scratches, one soon has two flat plates, accurate to a half thousandth of an inch or better. If a plate cleans well over its entire surface it will be satisfactory. Small scratches too deep to grind out, however, need not be bothered with. Care in drilling and filing will prevent such scratches.

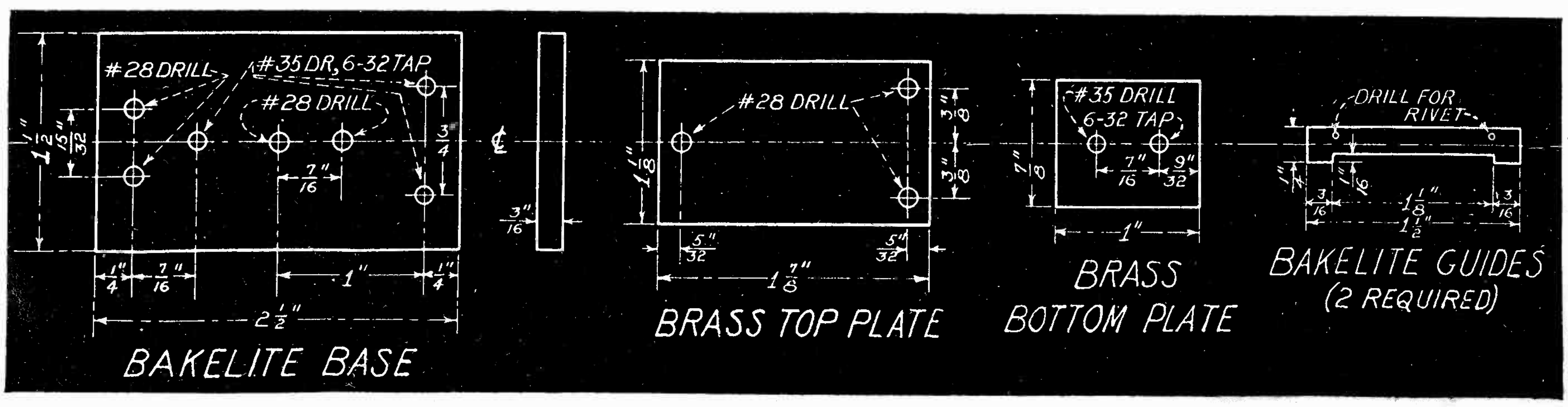
The two plugs are now mounted. These are spaced so as to plug into a tube-socket. They may be dispensed with and two connecting wires used instead. Solder two of the small brass springs to the upper plate and solder the third one to the lug at the plug, as shown on the drawing. A short connector is also soldered from the flat-head screw (under the base) to the other plug terminal.

The last operation is to cut out two small bakelite pieces for holding the crystal in place. If the clamp type holder is desired, these pieces are not needed. The bakelite pieces are riveted to the base. If a very thin crystal is to be used, they must be filed down lower than the upper surface of the crystal when it is laid on the lower plate. This will permit freedom of movement so that the upper plate can be adjusted against the crystal without first resting on the bakelite guides.

When mounting a crystal, lay it on the bottom plate between the guides, place the upper plate over it, and gently press the upper plate down until it just touches the crystal. Then insert the three screws and tighten them. Plug the holder into the oscillator circuit and unscrew each of the three screws an equal amount, perhaps a fraction of a turn. When the crystal oscillates, adjust each screw separately and carefully, for maximum output. It is wise to add a word of caution. Be sure that the plates of the holder and the crystal are clean before assembling. After cleaning, blow gently on both holder plates and both sides of a crystal to remove any particles of dust or lint.

If you desire to use this holder as a clamp, no alterations are needed. The crystal itself

(Continued on Page 45)



Design of Practical Crystal-Controlled Transmitters

Part II—Effect of Circuit Constants On the Frequency of Crystal Oscillators

Crystal-Controlled Transmitters Have Advantages Not Found In Other Arrangements. Certain Factors Must Be Carefully Considered To Obtain Maximum Efficiency From Oscillators Employing Quartz Plates. A Practical Quartz-Crystal Transmitter, and All Circuit Constants Are Herein Presented. Written By a Well-Known Expert Who Understands Thoroughly the Crystal As Well As the Oscillator In Which It Must Operate. Another Article By the Same Author Will Appear In the Next Issue.

By A. F. HOEFLICH

THE fact that the apparent frequency of a crystal sometimes changes when it is moved from one oscillator to another is of extreme importance in the adjustment of high precision frequency control apparatus.

The most fundamental factor affecting the frequency of the crystal oscillator is the so-called pulling effect of the plate circuit. This is the change in the frequency of the oscillator which occurs with the tuning of the plate tank condenser. The circuit in Fig. 1 shows the quartz plate connected from grid to filament and is the usual type of circuit used for high-frequency work. The equivalent network for the circuit is shown below. It is evident that the quartz plate becomes a part of the circuit into which it is coupled and might therefore be influenced in regard to its fundamental frequency. This actually happens as the circuit is found to oscillate at a frequency slightly off the frequency of the quartz plate fundamental. The exact frequency resulting is influenced by the degree of coupling of the plate to the circuit and by the values of the constants of the entire circuit.

A tuning curve for an 80-meter crystal oscillator is shown in Fig. 2. It can be seen that a possible variation in the frequency of the oscillator of about .01 per cent can be obtained by turning the plate tank condenser. (This is a smooth variation of frequency with tuning and should not be confused with frequency jumping caused by an improperly ground crystal plate.) Notice also from the curve that the variation in the frequency for a given change of the plate capacitance is greater as the frequency of the plate tank circuit is made to approach the point at which the oscillator circuit jumps out of the oscillating condition.

It is evident from the above that the point of operation on the tuning curve should be specified if accurate calibration of the crystal is to be duplicated.

Related to the pulling effect of the plate circuit are variations caused by tube capacity changes. From the equivalent network diagram it is evident that the grid-filament, grid-plate, and filament-plate capacities are wholly or partly across the plate tank. Thus changes in their values might be expected to cause a change in the pulling effect of the tank circuit. Also a change in the G-P capacitance varies the amount of feed-back or excitation with a further effect on the frequency. Actually an increase in the grid-plate capacity such as might be caused by substitution of a new tube is found to cause a lowering of the circuit frequency. Similarly, an increase in the grid-filament capacity causes a very slight change in the circuit frequency.

The correct filament and plate voltages should be used if high accuracy is to be maintained when setting-up the crystal oscillator. Likewise, the value of the grid-leak resistance used in the original calibration oscillator should be adhered to. It is evident that a change in the plate resist-

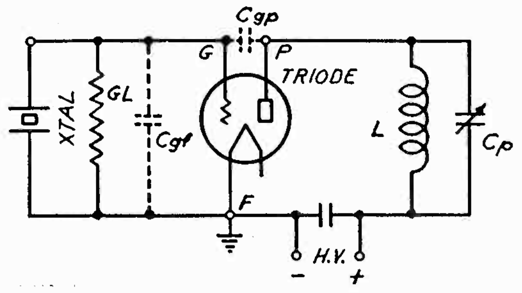
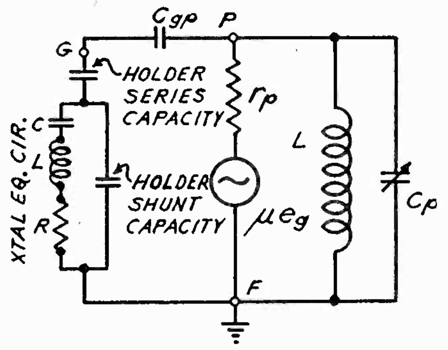


FIG.1



ance can be caused by either a change in the plate voltage, a change in the filament current, or a change in the grid bias.

This can be proven by referring to the characteristic curves for the tube used as the oscillator. A reduction in the tube resistance lowers the frequency of the circuit while an increase in the tube resistance naturally has the reverse effect. Thus an increase in filament emission caused by raising the filament voltage will reduce the plate resistance and lower the frequency of the circuit.

The general conclusion to the above discussion of the voltage effects is that an increase in voltage of the supply lowers the circuit frequency and vice-versa.

Changing the value of the grid-leak resistance is found to cause a slight but measurable effect on the frequency of the oscillator. When the grid-leak resistance is lowered the mean value of the plate current is lowered and this is equivalent to a slight decrease in the resistance of the tube. A decrease in the circuit frequency is the result.

Changing the pressure of the mounting electrodes has been found to cause a noticeable frequency change. An increase in pressure generally raises the frequency. Similarly, changes in the position of the crystal in the holder is found to cause small variations in frequency. A variable air-gap holder is found useful when the frequency of the crystal oscillator is to be varied over comparatively large ranges. Increase in the air-gap separation between crystal and top mounting electrode causes an increase in the frequency of the circuit.

Crystal Plate Specifications

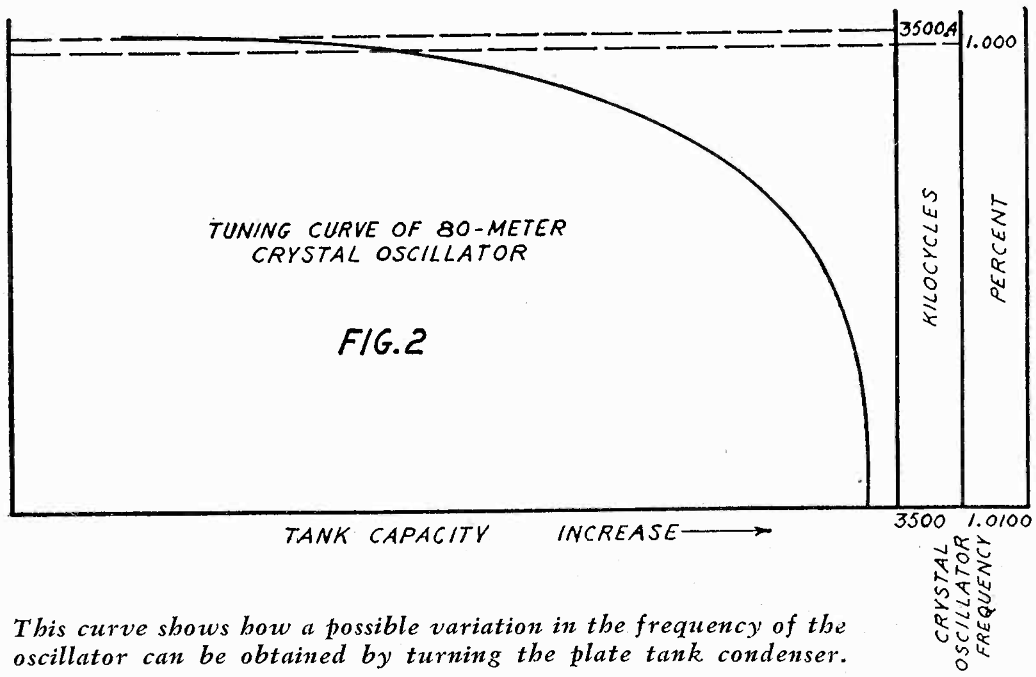
Cut..
Frequency..
Tube..
Plate Voltage...
Filament Voltage..
Holder..
Grid-Leak R...
Operating Point..
On Tuning Curve..
Percentage Frequency Tolerance.................
Operating Temp..

Fig. 3

The effect of temperature is considerable and will be the subject of a future article.

From the foregoing it can be seen that the calibration curve given with a crystal plate should include a specification of the tube used, the values of the voltages used during calibration and complete data on the holder used. The grid-leak resistance should be specified and the point of operation on the tuning curve should also be included. A form such as that in Fig. 3 would suffice.

In Fig. 4 is given a table that shows the percentage effect, on the frequency of a good



This curve shows how a possible variation in the frequency of the oscillator can be obtained by turning the plate tank condenser.

crystal oscillator circuit, of variation in the circuit constants. This is due to L. B. Hallam, Jr., of Station WSFA.

Conclusion

IF a summation from the table of all the possible circuit constant variations is made it is seen that a possible frequency change of about one-tenth of 1 per cent, or 3.5 K.C. at 3500 K.C. is possible when changing the crystal plate from one oscillator to another. Actually this is extreme and many of the effects cancel so that the actual change is only a fraction of that value. However, if the same tube is used in both oscillators (the calibration oscillator and the oscillator used in the transmitter) and the specified plate voltage, filament voltage and type of mounting are adhered to, together with operation at the specified portion of the tuning curve, an accuracy of better than one-half of one-

Variable	Variation	Resulting Frequency Change	Cycles Change at 3500 K.C.
Plate Tuning Cond.	50%	.01%	350
Plate Voltage	50%	.01%	350
Grid Leak Res.	700%	.004	140
Grid-Plate Cap.	20 mmf.	.013	450
Grid-Fil. Cap.	To Stop Oscil.	.006	210
Air Gap	.5 mm.	.075	3 K.C.

Fig. 4

tenth of 1 per cent may be attained, with reference to the calibration frequency without actually adjusting the frequency of the set-up.

With regard to frequency stability, it appears that plate and filament voltages should be reasonably constant to suppress possible frequency modulation. The grid and screen resistors, if used, should be of sufficient power rating to dissipate the power without heating as the resistance should not change during operation.

The oscillator tube should not overheat as possible expansion of the elements may occur with the resultant change in inter-element capacities.

As mentioned in a previous article, operation at the bend or above on the tuning curve will reduce the effects of changes in circuit constants but observance of the above precautions will still further improve the stability of any crystal circuit so operated.

Pacific Division Convention Opens September 3rd

The 14th Annual Pacific Division amateur convention will be held in San Jose, California, September 2nd, 3rd and 4th. On the opening day the program includes registration, examinations for amateur license, official welcome of delegates, sending and receiving contests and a talk by Earl R. Meissner on The Ribbon Microphone. At 7:30 p.m. there will be a smoker. And what a smoker!

On Sunday, September 3rd, registration will continue from 9:00 a.m. until noon. At 8:30 a.m. there will be breakfast for the R.M.S. and O.R.S. At 10:00 a.m. a talk by Dr. Terman, followed by an ultra-short-wave demonstration by Frank C. Jones. The afternoon will be reserved for open forum, and bridge contests will entertain the ladies. In the evening there will be a talk by Ralph Heintz, followed by technical motion pictures. Transmitting tubes will be analyzed by D. B. McGown. A lecture on Cathode Ray Television may also be given. There will also be a special meeting of the phone men and a number of last-minute surprise features will greet the visitors.

On Monday, September 4th, there will be a Naval Reserve Meeting at 9:00 a.m. From 10 till noon there will be talks on Electron-Coupled Oscillators, 5-Meter Developments, and other subjects to be announced at a later date. At 1:00 p.m. the visitors will be taken to the naval air base, to the Ryan high-voltage laboratory and to the new KPO super-power station. A large banquet and the awarding of prizes will begin at 7:00 p.m. Mr. Ralph Heintz has announced a $25 prize award for the construction of the best ¾-meter transmiter and receiver. 'Phone equipment will be given preference.

The general chairman of the convention is E. R. Booker, W6YAF, Dean of the Wilmerding School of Industrial Arts. The vice-chairman is Harry Engwicht. Traffic meetings will be in charge of F. J. Quement, who will also supervise the trips to the naval air base and to the Ryan laboratories. Sylvia Apra will be in charge of YL, OW, YF reception and Mrs. E. J. Amarantes will be general ladies' chairman.

Technical talks and ticket sales will be supervised by Harry Engwicht; registration and bus trips by Jack Anderson; program and reception by Willis Clayton and Doc Breen; code contest by E. J. Amarantes; forum and banquet by S. G. Culver; technical matters by Terry Hansen. George Call has been assigned the task of housing, feeding and entertaining the visitors.

Reservations have been made for 500 amateurs. Tickets are now available at $3 each. Included with the ticket is the banquet, trips to the various places of interest and other affairs. Reasonable hotel rates at the St. Claire will prevail. Rooms for six people, with three double beds, can be had for as little as $1 per person.

PACIFIC DIVISION CONVENTION EXECUTIVES

Top Center: E. R. Booker, General Chairman. Center, Left: Harry Engwicht, Vice-Chairman. Center, Right: F. J. Quement, Traffic.

500 Western Amateurs are expected to attend the Coast's big affair.

Here we have E. J. Amarantes and the Missus Amarantes. Both are actively engaged in making the convention a success.

Mrs. Amarantes is general chairman, ladies' committee. Sylvia Apra is in charge of YL activities.

Vacuum-Tube Voltmeter Design

Theory and Construction of Some Practical Voltmeters

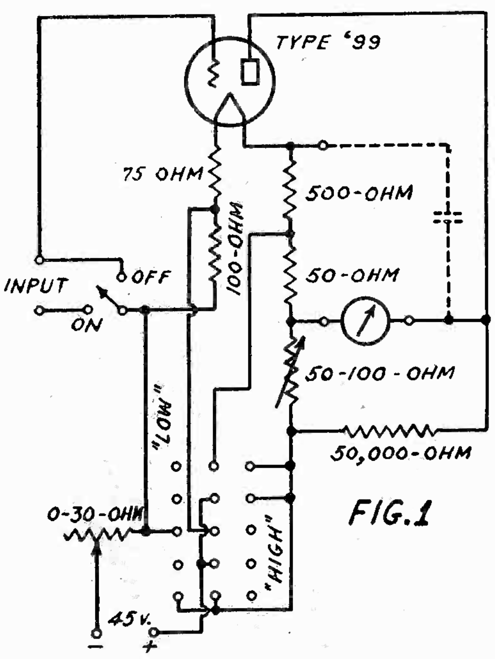
By A. R. HAIDELL

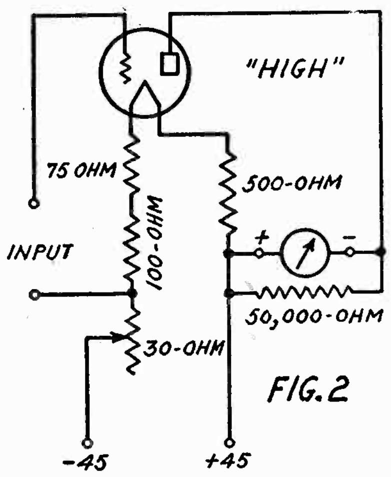
IN radio work, there is a need for measuring small alternating voltages of high frequency. The usual type of electromagnetic voltmeter is not suitable because it requires comparatively large current for operation, and its calibration is greatly affected by frequency. The electrostatic voltmeter has neither defect, but has others; its sensitivity is low and adjustment difficult. The versatile vacuum-tube is applicable to A.C. measurements. Although the range of a tube voltmeter is low, covering from perhaps a tenth to 10 volts, the sensitivity is favorable. Changes of about .01 to .05 volt, at the high values, are detectable in the usual type.

Various vacuum-tube voltmeters are possible. One type uses an adjustable grid-bias voltage which is made to balance out the plate current caused by an A.C. potential on the grid; it measures peak voltages. Other types employ detector action. The vacuum-tube voltmeter of Fig. 1 uses grid-bias (or "plate circuit") detection.

For communication measurements, the usefulness of a tube voltmeter is determined by:

1. *Variation of calibration with frequency.*
2. *Input impedance.*
3. *Variation of calibration with wave form.*
4. *Sensitivity.*
5. *Range.*
6. *Stability of calibration.*





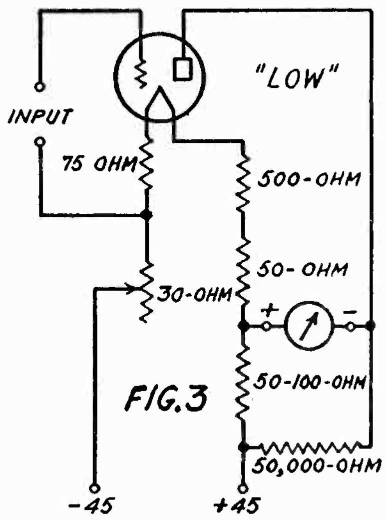


FIG. 1: Complete diagram of connections for two-range Vacuum Tube Voltmeter.
FIG. 2: When the change-over switch in Fig. 1 is on the "high" side, the connections are as given above.
FIG. 3:—When the change-over switch in Fig. 1 is on the "low" side, the connections are as given above.

The voltmeter circuit of Fig. 1 will be discussed first. To obtain a wide voltage range, without flow of grid current, two sets of plate and grid-bias voltages are provided for. These voltages are supplied by resistance drops in the filament circuit. The use of a '99 type tube (60 milliamperes filament current) allows all power to be taken from 45-volt B batteries, if desired. Two large-sized units in parallel are best. One set of resistances gives the low voltage range, the other the high range. For the high range, the grid is biased beyond the point at which plate current disappears. For fixed battery voltage, there exists an optimum proportion of voltages to give best sensitivity and maximum range.

There is a considerable difference between the normal plate currents for different tubes. In some tubes, as much as 2 microamperes flows at high grid bias, whereas other tubes show no current.

One tube voltmeter arrangement is shown in Fig. 1. When the switch is on the "high" side, the circuit is that of Fig. 2; when on "low," the circuit is that of Fig. 3. A telephone key can be used for a switch. A key is also used to disconnect the voltmeter from the A.C.; this key short-circuits the terminals, when the A.C. is disconnected, to prevent the rise in plate current accompanying the free grid. The entire assembly of tube resistances and keys can be mounted in a case, terminals being provided for battery and microammeter. A Rawson type 501 microammeter having 3 ranges (0-20, 0-200, 0-2000 microamperes) can be used although any galvanometer with scale giving readable deflections on a few microamperes is satisfactory. There is difficulty in maintaining the false zero in sensitive instruments; slight fluctuations in battery voltage or shocks applied to the tube can be observed on a 0-20 microampere range. The resistances need not be non-inductive. The tube socket should be of the shock-absorbing type. For the less complicated instrument described in a later paragraph, an ordinary 0/1 milliammeter can be used.

When A.C. is applied to the grid, a mean increase in plate current results, which divides between the two filament terminals.

The calibration is not independent of meter resistance. The lowest range of a Rawson meter has about 1000 ohms which is not negligible compared with 50,000 ohms. The variation between meters of various manufacture but of similar range causes not over 1% error. Changes in filament rheostat settings (to compensate for falling battery voltage) also theoretically change the actual mean increase, due to plate circuit resistance changes. Varying the 30-ohm rheostat causes only a slight change in the voltage applied to the circuit.

A tube voltmeter can be calibrated at high frequencies as shown by Fig. 4. Calibration at low frequencies is described later. Typical calibration curves for 1000 cycles are shown in Fig. 5 and Fig. 6. A flow of grid current reduces the input impedance and biases the grid differently when flowing through different resistances. This can be shown by using no grid bias. The flow of grid current limits the range. The calibration curves show where grid current starts (horizontal arrows from vertical dotted lines).

To calibrate (see Fig. 4), the current should be kept constant at about 2 milliamperes and the load at 5000 ohms, non-inductive. The thermocouple is calibrated before use. The waveform should be approximately sine-wave.

Under load, the wave-form of the output current from the usual oscillators departs considerably from sinewave. Errors in measurement due to wave-form may result if tube voltmeters are used, unless precautions are taken to eliminate them. Differences in wave-length are exaggerated but not, for commercial wave-forms, objectionally so.

Calibration does not vary appreciably with frequency at audio frequencies; for wide ranges, variation of calibration can be corrected by means of a condenser. The use of a condenser connected between plate and filament prevents the curves from falling off at higher frequencies due to the inductance in the plate circuit. The condenser is connected as may be seen in the diagrams. The calibration curves for no condenser ("C-O") are used below 1000 cycles.

The stability of calibration over the entire life of a tube is questionable. In general, for accurate work, the calibration will remain constant for periods of operation of about 40 hr.

The input capacity of a '99 tube voltmeter as in Fig. 1, is about 30 mmfd.; input conductance .004 micromhos.; the latter increases rapidly as the grid approaches positive potential. The impedance is 5 megohms at 1000 cycles, is usually high, and the power factor is low.

To measure voltage across a condenser, a conductive path must exist (such as between the condenser plates) since the meter has no gridleak.

There is a wide field of use in which a ratio of voltages must be measured, such as comparing two impedances. If the waveform is unsymmetrical with respect to the axis, the same side of the wave should be impressed toward the grid. The harmonics in a current wave contribute to the voltage in different degrees in a reactance and in a resistance. This is exemplified by the fact that the measured impedance is different for reversed oscillator terminals.

Measurements are frequently desired of inductance or alternating voltage in iron-core coils, transformers, etc., while carrying a polarizing or magnetizing current. A grid-stopping-condenser type of voltmeter can be used; this type of voltmeter, however, gives large waveform error, restricted range and some frequency error. It is more sensitive, though, due to the accumulative effect of the condenser charge.

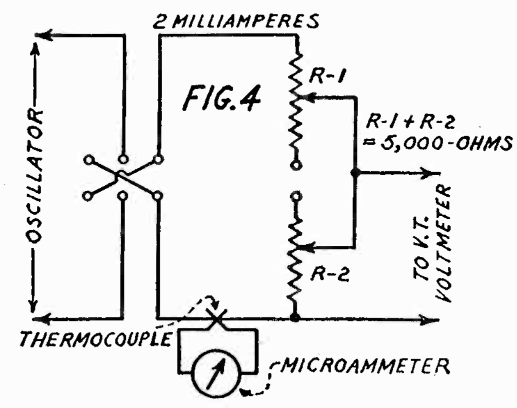


FIG. 4: Calibration circuit for Vacuum Tube Voltmeter.

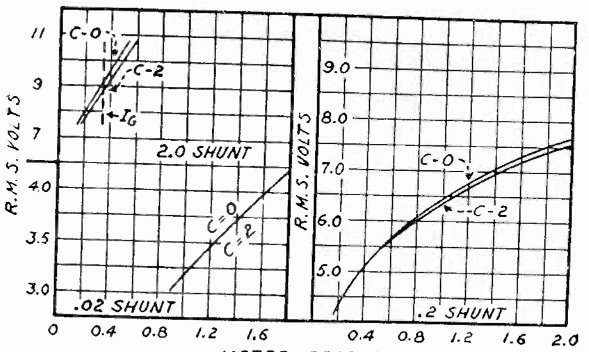


FIG. 5: Sample 1000-cycle calibration for high range, with and without 2-mfd. shunt condenser.

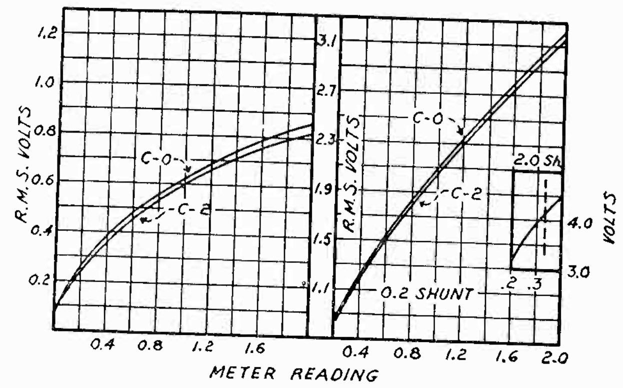


FIG. 6: Sample 1000-cycle calibration for low range, with and without 2-mfd. shunt condenser.

Wave-Form Error

Certain types of tubes have characteristics well suited for eliminating wave-form error; the low-mu power tubes, in general, are good. The '71 tube has a range of about 27 volts, over which the wave form error is negligible. A 16-volt r.m.s. curve applied to a '71 tube gives no error when the tube is operated at minus 20 volts bias, although the peak of the wave (23 volts) exceeds the theoretical limit by 8 volts. For accurate work, a sine-wave waveform is best.

For the voltmeter of Fig. 1, the wave-form error is, in general, small, although on the higher range, differences in waveform are exaggerated. The mere fact that a voltmeter reads r.m.s. volts correctly for ordinary waveforms, does not permit the use of any waveform, without error.

A Practical VacuumTube Voltmeter for Ordinary Work

If by-pass condensers are used, and the nature of the work is such that extreme accuracy is not necessary, a voltmeter calibrated at 60 cycles can also be used at radio frequencies. All necessary values for a simple tube voltmeter are shown in Fig. 7. The calibration curve for several widely differing frequencies (with by-pass condensers, as in Fig. 7) is shown in Fig. 8.

A 0/1 milliammeter (1000 microamperes) can be used for the indicator.

A zero reading of 10 microamperes is used for all work, a slight change in plate or grid voltages being made to secure this value when necessary. Without by-pass condensers, different curves are obtained for widely separated frequencies.

By reproducing the instrument of Fig. 7, the same calibration will hold at 1,000,000 cycles. For ordinary work the instrument can be calibrated at 60 cycles. A potentiometer, step-down transformer and low reading A.C. meter are used for the 60-cycle calibration. More complicated apparatus is necessary for high-frequency calibration where exceptional accuracy is required; circuit and principles have been described.

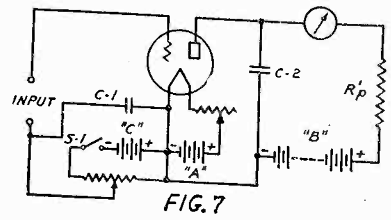


FIG. 7: '99 Type Vacuum Tube and Socket.
25-Ohm Rheostat.
200-Ohm Potentiometer.
0-100 Microammeter.
0-100 Milliammeter.
C1—1 mfd. by-pass condenser.
C2—2-4 mfd. by-pass condensers.
R'p—10,000-Ohm Resistor.
"C"—4.5 Volts.
"B"—22.5 Volts.
"A"—4 or 4.5 Volts.

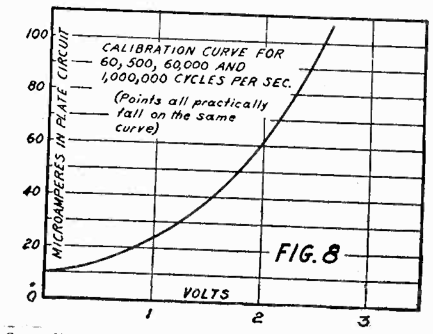


FIG. 8: Low range calibration of meter with by-pass condensers.

RCA RADIOTRON
RCA-6F7

CUNNINGHAM
C-6F7

TRIODE-PENTODE
TENTATIVE RATING and CHARACTERISTICS

THE RCA Radiotron Company, Inc., and E. T. Cunningham, Inc., have recently announced to equipment manufacturers a Triode-Pentode tube designated as Radiotron RCA-6F7 and Cunningham C-6F7.

Combining in one bulb a triode and an r-f pentode of the remote cut-off type, the 6F7 may be used in circuits in several ways, since the two units are independent of each other except for the common cathode sleeve. For instance, in superheterodyne receivers, the triode unit may serve as oscillator while the pentode unit functions as mixer tube (first detector).

GENERAL

Heater Voltage	6.3	Volts
Heater Current	0.3	Ampere
Direct Interelectrode Capacitances:		
Triode Unit—Grid to Plate	2.0	uuf.
Grid to Cathode	2.5	uuf.
Plate to Cathode	3.0	uuf.
Pentode Unit—Grid to Plate (with shield can)	0.008 max.	uuf.
Input	3.2	uuf.
Output	12.5	uuf.
Overall Length	4-9/32-in. to 4-17/32-in.	
Maximum Diameter	1-9/16-in.	
Bulb	ST-12	
Cap	Small Metal	
Base (For connections, see Note 1)	Small 7-Pin	

CHARACTERISTICS

	Triode Unit	Pentode Unit	
Plate Voltage	100 max.	250 max.	Volts
Screen Voltage	—	100 max.	Volts
Grid Voltage	—3	—3 min.	Volts
Amplification Factor	8	900	
Plate Resistance	17800	850000	Ohms
Mutual Conductance	450	1100	Micromhos
Mutual Conductance at —35 volts bias	—	10	Micromhos
Plate Current	3.5	6.5	Milliamperes
Screen Current	—	1.5	Milliamperes

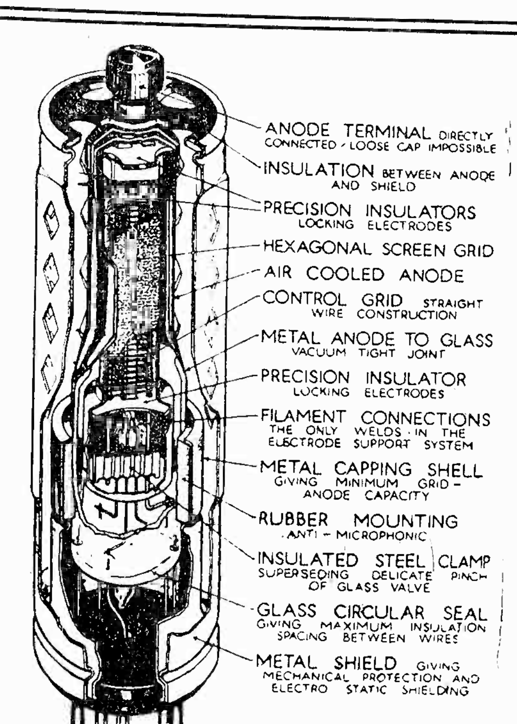
CONVERTER SERVICE

	Triode Unit	Pentode Unit	
Plate Voltage	100 max.	250 max.	Volts
Screen Voltage	—	100 max.	Volts
Grid Voltage	##	—3 min.**	Volts
Oscillator Plate Current (average)	4 max.	—	Milliamperes
Typical Operation:			
Plate Voltage	100°	250	Volts
Screen Voltage	—	100	Volts
Grid Bias Voltage	#	—10*	Volts
Oscillator Peak Voltage Input	—	7	Volts
D-C Grid Current	0.15	0	Milliamperes
D-C Plate Current	2.4	2.8	Milliamperes
Screen Current	—	0.6	Milliamperes
Plate Resistance	—	2.0	Megohms
Conversion Transconductance	—	300	Micromhos

Usually obtained by means of a grid-leak resistor.
** Grid bias should be at least 3 volts greater than the peak oscillator voltage applied to the pentode grid.
° May be obtained from 250-volt source through 60000-ohm dropping resistor.
* Obtained by means of 1700-ohm self-biasing (cathode) resistor.
# Obtained by 100000-ohm grid-leak resistor returned directly to cathode.

NOTE 1: Pin 1—Pentode Screen
Pin 2—Pentode Plate
Pin 3—Heater
Pin 4—Heater
Pin 5—Cathode
Pin 6—Triode Grid
Pin 7—Triode Plate
Cap —Pentode Grid

Pin numbers are according to RMA Standards Sheet 801-A (M8-116).



NEW IDEA IN TUBES

THE Catkin tube, a new Osram and Marconi product, is primarily distinguished from other tubes by reason of the fact that metal has largely replaced glass in construction. The anode of copper forms the external envelope and the general construction of the tube is such that it is practically unbreakable. In addition, the dimensions are so small that the Catkin tube boxed occupies one-sixth of the space ordinarily taken by an orthodox tube in its box. The tubes are made as equivalents of existing types, so that Catkins can be used as replacements for present tubes. Uniformity of characteristics is claimed to be one of the outstanding advantages of the new form of construction.

The illustrations show the tube in section and as it appears in its finished state. Details of the points of special interest in construction are indicated in the lettering of the diagram.—"Wireless Engineer."

SHORT-WAVE STATION CHANGES

NEW SCHEDULES . . . INTERESTING COMMENT

By NYDXL . . . Short-Wave Station Editor

IN this, our initial undertaking, the first task is to make additions to the list of short-wave broadcasting stations appearing in the July issue; this will be done with the aid of "dope" received from various stations, as well as from the International Short-Wave Club, which has active members in some 90 countries of the world. It is a most difficult problem to keep a S.W. list up to date, adding new stations, keeping the list free from obsolete stations, and checking up for changes in wave-lengths and schedules, since, for the most part, S.W. stations are very irregular in operation. An inaccurate list tends to discourage the listener, who fails to find a station on the air, according to its listing.

One of the outstanding additions would be that of PHI, of Huizen, Netherlands, which has returned to the air, on 16.88 m., after an absence of two years, and is heard daily except Tuesday and Wednesday, from 8-10 a.m. The input to the final stage is in the neighborhood of 130 KW, thus making PHI the most powerful S.W. broadcaster in operation.

The loudest fone at present (along with GSB and GSF) is the new German, DJD on 25.51 m. It is heard best between 3 and 6:30 p.m. daily. When definite programs are not being transmitted, very often a group of eight notes on the piano are repeated over and over, as an interval signal.

Another new and quite consistent station is HCJB of Quito, Ecuador, who has 250 watts on approximately 73 m. He is heard from 7:30 to 9:30 almost daily; most of the South Americans are not heard with anything like the volume they were during the winter season, but HCJB is heard even stronger! This station is, at times, R7, in the northeastern U. S. A., which is very good, the wavelength and power considered.

One of the more recent comers is XETE of Mexico City, operating on 31.25 m., daily from 6 to 11 p.m. This is the same wave on which one will find CTIAA, from 5-7 p.m., on Tuesday and Friday. This station employs 2 KW, and its owner is famous for his achievements as an amateur operator. Getting back to XETE—they are owned by the Ericcson Telephone Co. of Mexico, whose address is Box 1396, Mexico City; the station is licensed to operate also on 48.94 m., but they do not appear to have gone on that wave as yet. The engineer in charge, Sr. R. S. Bravo, is the operator of XIQ, whose fone has been heard so well, of late, on 7040 KC. This transmitted, with 250 watts power, has dx'ed 5 continents!

About two months ago, a new station, YV3BC, of Caracas, Venezuela, was heard daily between 5 and 7 p.m. with fine volume and quality. This station was silent for some time, while it was being moved to a new QRA, but has now returned to the air, and is heard very well, though irregularly, from 7-10 p.m., on either 31.56 or 48.90 m., with 250 watts. Reports should be sent to "Radiodifusora Venezuela", Hermann Degwit, Engineer. This station must not be confused with YVIBC, "Broadcasting Caracas", whose signals are heard daily on 49.10 m. or thereabouts, between 5 and 10 p.m.

Within the past month, on several occasions a new one, located in Bogota, Colombia, has been tuned in on 49.65 m. between 8 and 9:30 p.m. It is believed to be HJ3ABE.

HKE, of the Observatorio Nacional, Bogota, may be familiar to many hams working in the 40 m. band. This station sends out talks from 6:15 to 7:00 p.m. on Monday, and musical programs from 8-9 p.m. on Tuesday and Friday. The wave-length used is approximately 41.7 m., and the power close to 150 watts. A special frequency check on HKE would be appreciated.

The final addition would be that of GSE, Daventry, England, on 25.28 m., which is heard irregularly, transmitting to the zones to the East of England. More will be said of the Empire stations at a future date; meanwhile, the B. B. C. would appreciate reports on their programs which are beamed westward from 4 to 6:30 a.m., on GSF, 19.8 m., or GSG, 16.88 m., to the Australasian Zone. This is an experiment and the B. B. C. are anxious to know how this wave is heard on the West Coast.

PLE, on 15.93 is not a regular broadcaster, though they do test with Bolinas, Cal., at times—they are a commercial phone station, and have discontinued broadcasting.

The French station on 19.68, 25.20, and 25.6 has no call.

T14 NRH on 19.9 should be omitted, as he has gone off that wave.

W2XO on 23.35 should be scratched off. On a visit to the stations at Schenectady, it was found that 2XAD and 2XAF were the only S.W. stations which GE now have.

The call of the Moroccoan on 23.38 is CNR; they have gone off their 32.26 wave and are now on 37.33 m.

XDA is not on 25.5 now; there is a commercial near there (on 25.55 the last time heard) but the only music sent is for testing with Merida.

G5SW is now "extinct"—you have the call of that wave ok (GSD).

LSX, 28.98 is not now broadcasting, though they are testing irregularly with Rocky Point stations.

Cross off T14 on 29.3 m.

SRI (one) is now on 31.60 m.

HBL has been heard on 31.27; I do not believe them to be on 31.43 m.

VK3ME is no longer on 31.40.

PRBA on 31.58 has been discontinued.

That EH9OC on 32.00 is no longer a Swiss call.

HJ3ABF, listed as 39.4, is now near 48.00.

PRADO is on 45.31 **but not** 39.80.

X26A has long since been off.

CM5RY is no longer heard on 41.00.

DOA on 41.46 is a commercial call, and is undoubtedly off the air now.

VSIAB of Singapore has been jumbled with a Colombian QRA. (in the list)

CTIAA is not on the 42.9 wave now.

REN is not on 46.6 but 45.38.

I do not think that RV62 is on 46.72 now, since a list of stations from the Trades Union Council did not include it.

HCIDR is off 47.00—they are on a much higher wave, and with a different call.

HKS is now HJ5ABD.

HKC is not on the air now—at least not on fone.

HKA, likewise.

VE9CF of Halifax is now VE9HX.

JB on 49.40 and SAJ on 49.46 should be omitted.

It would be best, if you would eliminate that station called FL wherever it appears, since it is very little used.

The Moscow station is on 50.00—the one on 49.97 should be removed from the list.

The following should be removed from the list: 9XAM on 62.56 (no music or speech); DOA on 67.65; OHKZ on 70 (not Austrian call); DOA on 82.90. These are either dismantled or off the air at present. VE9DR on 25.47; VE9JR on 25.53; TGX on 33.50; YR on 40.20; ZTJ on 40.90; CN8MC on 47.35; TITR on 47.50; VE9CL on 48.85; CMCI on 49.50; VE9CL on 52.50.

OLD-TIMER'S CORNER

How many of last months questions did you answer correctly? Here are the answers:

(1) Army station operators using a "Fessenden Double Roller Tuner" turned a hand-crank when tuning-in stations because the handle was attached to "tuning coils," consisting of two cylinders, one of metal, the other of fibre. In turning the hand-crank, the bare wire, with which the tuning coil was wound (in a running-thread groove), was shifted to the metal cylinder from the insulated cylinder. As the bare wire was unwound from the insulated cylinder, and onto the metal cylinder, the inductance of the tuning coil was lowered and a consequent change in wave-length was the result. This crude tuning system was used in many stations. Imagine the fun . . . one hand on the cat-whisker of a crystal detector, the other on the tuning-coil crank, winding, unwinding, far, far into the night. Did someone say "those were the happy days?"

(2) The first feminine shipboard wireless operator resigned her post because of her utter disgust with the "language" used by operators on other vessels, who, years ago, were permitted to say what they pleased, and were often pleased with what they said.

(3) The "TITANIC" had but two operators. McBride was rescued; Phillips was lost. McBride was the stronger of the two. He proved this when, as he was strapping a life-belt on Phillips (who refused to leave the key), a stoker appeared in the radio room and attempted to remove the life-belt so that he could use it for himself. McBride took hold of a blunt instrument, struck the stoker over the head with it, and wrote "30" to the episode. The "TITANIC" was on her maiden voyage from England to New York when she struck an iceberg and went down. Phillips, the chief operator, stuck to his post even when the icy waters were up to his knees. The emergency transmitter, operated from batteries, was used almost entirely in the rescue work because of the failure of the generating system in the engine room, which was flooded quickly after the giant liner struck the berg. More than 1000 lives were lost, including all of the men who comprised the ship's band, and who played solemn music as the stern of the ship plunged beneath the waves.

(4) The International Distress Signal is . . . - - - . . . (three dots, three dashes, three dots). It is NOT S O S. (Page Mr. Ripley).

(5) S O S has no meaning of its own, in the form of symbols, abbreviations or words. It is a combination of characters, three long, three short and three long. It was chosen because of the uniqueness of the combination, which would be instantly recognizable to all who heard it. In answering this question, when taking the examination for license, it should be stated that the International Distress Signal is . . . - - - . . . and not S O S.

(6) "C Q D" was replaced with "S O S" because it was entirely too difficult to recognize from the ordinary run of characters or traffic signals. "C Q D" was the abbreviation for "Come Quick, Danger."

(7) Commercial operators who went on strike in 1914 were replaced by inexperienced, rank greenhorns, who were shipped by the carload from eastern radio schools. Bewildered, many of these men failed to copy five words per minute when given shipboard berths. They were escorted from the train depot to a hotel, where they were kept under constant guard, until assigned to ships. They were given free transportation, accommodations and meals; they were taken to the docks in taxi cabs and were guarded until the vessel had cleared the wharf. The strike failed, but some of the older operators whose service records were unblemished were later given an increase in pay to $40 per month, which was about the prevailing wage scale then paid to waiters—less the waiters' tips. An amusing incident in connection with the strike was the threatening of a messenger "boy" for the radio operating company. Believing that he, too, was a strikebreaker, the union men gave chase to the "boy" who was puffing a long, black cigar when the chase began. Stumbling on a curbstone, the messenger boy swallowed the hot cigar. This boy later became the owner of a thriving radio store. (Name on request.)

(8) The prominent radio amateur who brought about the conviction of Public Defender Frank Egan of San Francisco is Ignatius McCarty. A brother of the late Jack McCarty who was one of the early inventors of the wireless telephone, Ignatius, or Ignatz, as he is known, devised a means of concealing a dictophone in the offices of a doctor friend of the convicted public defender. Connected to a leased telephone line, the dictophone brought to the ears of Captain of Detectives Charles Dullea the news that a Jessie Scott Hughes was to be murdered. But the detective bureau made light of the plans, until the news was flashed that the Hughes woman had been found dead. Checking back on their notes, they recalled the conversation which took place in the doctor's office and the arrest and conviction of the public defender followed.

(Continued on Page 45)

Circuit Analysis of New Patterson Amateur-SW Receiver

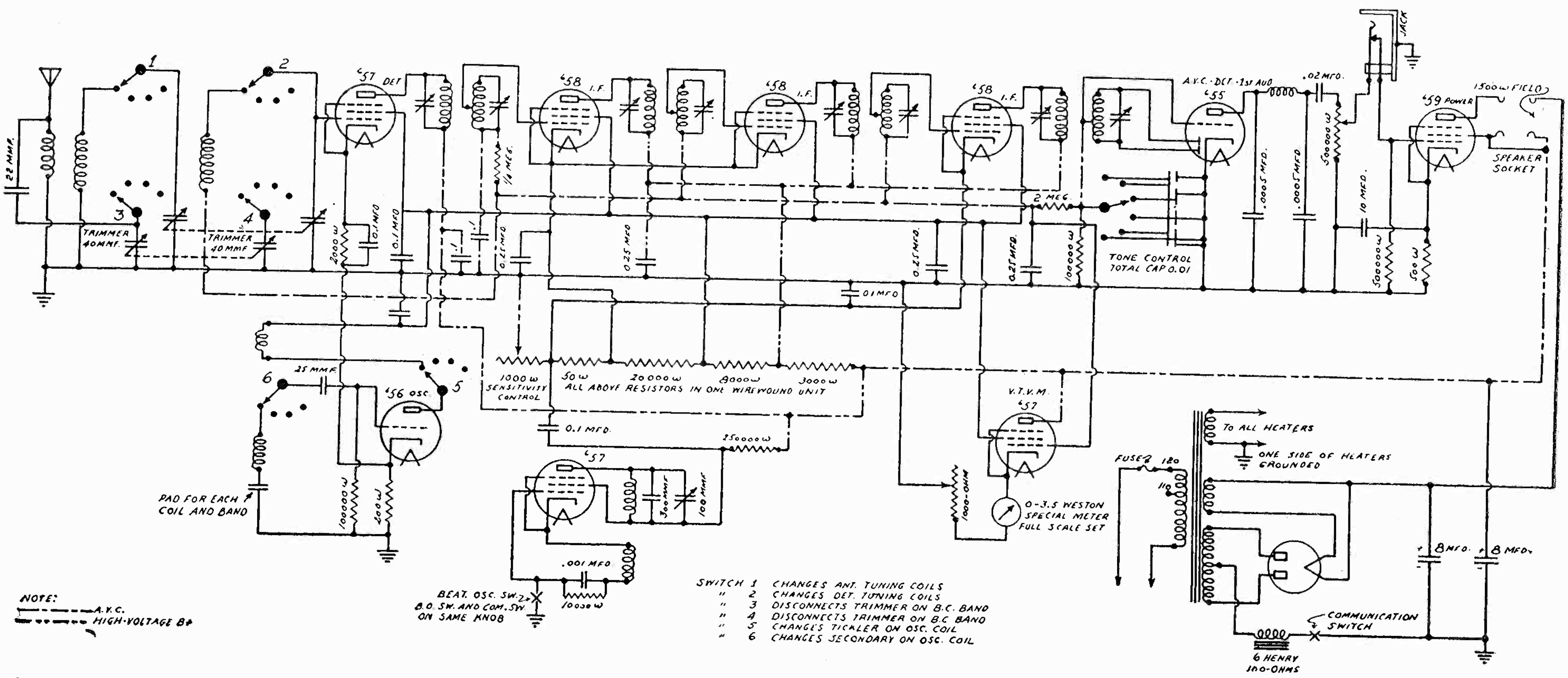
By RAY GUDIE*

IN discussing the various parts of the circuit, we will begin with the antenna. This consists of a tuned antenna circuit, inductively coupled to a tuned first detector. This same arrangement of band-pass is used on all frequencies and gives the best image ratio and noise-to-signal ratio of any system we have tried. The reason we do not use an r.f. stage is due to the extreme electrical shielding necessary to obtain worth-while gain from such a stage. From numerous tests, we have found that a 58 tube in the i.f. stage, if biased sufficiently high so that it will not block when a powerful local station is received, is not sufficiently sensitive for extremely weak signals. By using an extreme amount of oscillator current in the first detector circuit we have been able to keep it from blocking, even when duplexing near a powerful transmitter.

The signal frequency oscillator consists of at the same time. By properly balancing the coils they track over the total range in each band.

The i.f. section comprises three stages using 58 tubes as amplifiers and a 55 as second detector. The first detector unit has a very loosely coupled circuit. The #2 and #3 i.f. are identical and are coupled so that the sharpest peak with maximum signal transfer is obtained. The 4th i.f. is over-coupled, because the secondary feeds the diode portion of the 55. The grid of the i.f. stages are taken from a center-tap in the secondary. This helps decrease the load across the secondary, sharpening the peak. There is a slight loss in sensitivity using this method, but because three stages are used, more than ample gain is at the user's disposal. A variable gain control, with a screw-driver slot for setting, is on the inside of the cabinet. The intermediate frequency is very weak C.W. signal into the back-ground. For the amateur who is interested in working very weak C.W. stations, loose coupling of the beat oscillator to one of the diode second detector plates is recommended. This does not produce as clean a signal on a real loud C.W. station, but it will compare with the best battery operated T.R.F. on a very weak signal. The noise-level of the super is lowered when using this method.

The vacuum-tube voltmeter uses a 57 tube with 250 volts on the plate and 75 volts on the screen. A milliameter, with its scale calibrated in R's is inserted in the cathode circuit through a variable 1000-ohm resistor. The grid of the tube is connected to the A.V.C. control and a varying input voltage on the diodes of the second detector will cause an increasing negative voltage on this A.V.C. bus in proportion to the signal strength. This negative voltage on the grid



four sets of coils in the conventional tickler feed-back circuit. By inserting a 22Mmf. condenser in the grid circuit of the oscillator, we are able to get a rising characteristic of the oscillator current. In other words, the oscillator puts out approximately four times more energy on 20 meters than it does on the low frequency end of the broadcast band.

The switch arrangement uses a six-section, four-position switch. Two of these, sections #3 and #4, are used merely to disconnect the two-gang trimmer condenser when the switch is in the broadcast position. This is not necessary, but it is convenient. The set will track exactly over the broadcast range, no matter in what position the trimmer has been set. Section #1 changes the antenna coil, section #2 changes the first detector coil and sections #5 and #6 change the oscillator coils. Each band has its own complete set of coils. Considerable difficulty was encountered in placing the coils so that the leads of the antenna coil and the first detector coil would be of the same length, because on the higher frequencies the difference of a half-inch in length of the hook-up wire will change the trimmer condenser 15 or 20 Mmf. The trimmer condenser is a single gang, split stator, 40 Mmf. each unit. This trims the antenna and first detector circuit

* Chief Engineer, Patterson Radio Co.

around 432 k.c. This was chosen because in measuring the noise level in numerous places it was found to be considerably quieter than 465 or 525 k.c.—465 k.c. has its disadvantages because it is too close to the ship band of 462 k.c. No matter how "tight" a set may be, some interference will leak through from the antenna circuit into the I.F. stages. In some localities it may be necessary to shift the i.f. frequency one way or another, three or four kilocycles, if it falls on a nearby commercial station frequency. The second detector circuit is a conventional push-pull diode using a 55 tube, and the triode position is used as a first audio. A head-fone jack is inserted in this circuit behind the volume control. The volume control is located between the plate of the 55 and the input of the 59.

The power output tube is a 7-prong 59, using cathode biasing and by-passed with a 10 Mfd. condenser. The output transformer is located on the speaker and is connected to the set with a 4-wire cable.

The beat oscillator is of the autodyne type and uses a high "C" tuned plate circuit. There are two methods of coupling. That shown on the diagram couples through the cathodes of the i.f. and reproduces a musical pure D.C. note. This method has its disadvantages because it has a tendency to push a of the 57 tube in the V.T.V.M. circuit causes a varying current flow through the milliameter. The meter reads the same no matter how the volume control is adjusted.

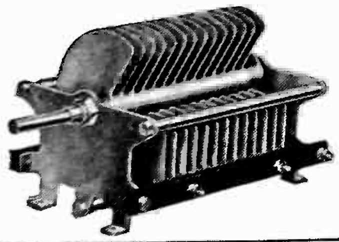
The filter system consists of a 5Z3 rectifier tube and a 6-henry input choke is used in the negative lead, the speaker field being used as a second choke, with a pair of 8 Mfd. condensers on each side. This is sufficient filtering to reduce the hum-level in the speaker to zero. No trace of hum can be heard on the ear-fones.

The operation of the set is very simple. The amateur band settings are furnished with each set. In other words, the 80-meter fone band can be received by setting the Master dial at 90 with the wave change switch on the 30-75 meter position. The band-spread dial will then give a 90-degree spread over the 100 k.c. fone band-spread dial. It is only necessary to shift the wave-change switch to the 75-200 meter position and to set the Master dial at 10; then the 100 k.c. fone portion will cover 30 points on the band-spread dial and the C.W. band will cover 60 points. The 20-meter band covers about 70 points on the band-spread dial. The fone portion can be spread out to 43 points. This is accomplished by setting the fone band to start on the bottom of the

(Continued on Page 31)

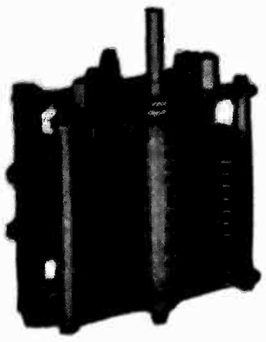
CARDWELL CONDENSERS

RECEIVING — TRANSMITTING — NEUTRALIZING

"The Standard  *of Comparison"*

Transmitting Condensers

FOR LOW AND MEDIUM POWERED INSTALLATIONS.



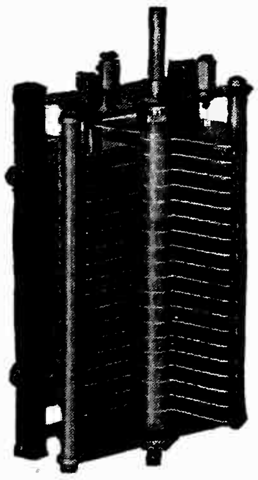
164-B

GENERAL SPECIFICATIONS

(Excepting construction designs 16B, 166B and 1666B)

Overall Mounting Space, Inches Square..... 4.00
Radius of Rotor Plates, Inches 1.44
Area of Rotor Plates, Square Inches........ 3.243
Area of Stator Plates, Square Inches........ 3.819
Insulation Contact with Stator, Sq. In...... .40
Shaft Diameter, Inches.................. .25
Shaft Length, from backs of panel, In....... 1.00

Material of Plates.......................Aluminum
Material of Frame.............Brass, nickel plated
Material of Insulation—Radion (Mycalex Extra)
Contact—Rotor to Frame......Self Cleaning Brush
Stator Assembly Method......Pressed and swedged
Rotor Assembly Method........Staked and pressed
Frame Assembly Method...........Machine Screws



T-199

INDIVIDUAL CHARACTERISTICS

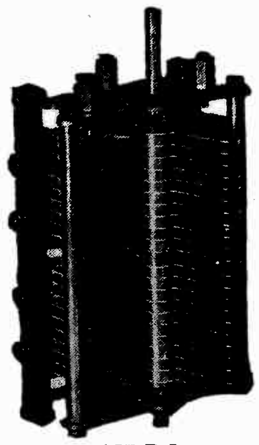
See also "Midway" and 16B Transmitting condensers
Pay particular attention to symbols referring to footnotes.

Max. Cap. Mmfds.	Min. Cap. Mmfds.	AirGapBet. Rotor and Stator Pl.	C to C Rotor or Stator Pl.	Type No.	List Prices	Plate Thickness	Number of Plates	Depth (back of panel)
250	15	.030"	.110"	*141B	$ 3.00	.0253"	11	2½"
480	21	.030"	.110"	*123B	4.00	.0253"	21	3"
960	31	.030"	.110"	*137B	5.00	.0253"	41	4"
220	23	.070"	.190"	164B	4.00	.0253"	21	4"
440	42	.070"	.190"	147B	7.00	.0253"	43	5¾"
330	41	.084"	.248"	†T199	10.00	.040"	37	6½"
650	68	.084"	.248"	†DT199	22.00	.040"	73	11¼"
242	32	.100"	.280"	†520B	10.00	.040"	33	6½"
525	65	.100"	.280"	†521B	21.00	.040"	67	11¼"
110	31	.171"	.422"	†T183	9.00	.040"	23	6½"
228	50	.171"	.422"	†DT183	18.00	.040"	45	11¼"

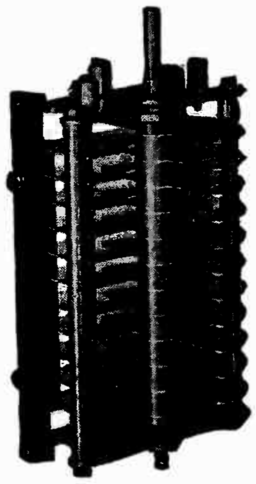
NEUTRALIZING CONDENSERS

Max. Cap. Mmfds.	Min. Cap. Mmfds.	AirGapBet. Rotor and Stator Pl.	C to C Rotor or Stator Pl.	Type No.	List Prices	Plate Thickness	Number of Plates	Depth (back of panel)
23	10	.171"	.422"	†511B	3.00	.040"	5	3"
50	17	.171"	.422"	†513B	6.00	.040"	11	4"
56	20	.230"	.540"	†515B	10.00	.040"	15	5¾"
34	11	.171"	.392"	†415B	5.50	.025"	15	4½"

(This condenser, Type 415B, built into our Midway "Featherweight" frame)—



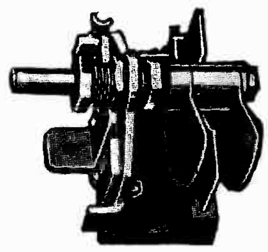
157-B
(Split Stator)



T-183

Type 519 for 852 tubes (see illustration) Max. cap. 5 mmfds. Min. 2.8 mmfds.

A very compact three plate condenser with extra wide spacing. One rotor plate is easily removable, if so desired, leaving a two plate variable with airgap adjustable. Provided with positive, non-mutilating rotor lock. Mycalex insulation is used. Designed for panel or shelf mounting. Type 519.....$3.60 list



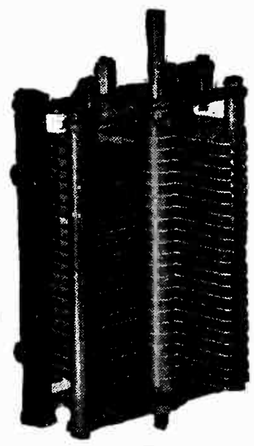
Type 519

SPLIT STATOR CONDENSERS

Max. Capacity, Mmfds. Sections in Mult.	Sections in Series	Per Section	Min. Cap. per Section Mmfds.	Air Gap Bet. Rotor and Stator Plates	Plate Spacing Rotor or Stator C to C	Type	List Prices	Plate Thickness	Number of Plates (ea.) Sec.)	Depth (back of panel)
1000	250	500	21	.030"	.110"	*156B	6.00	.0253"	21	4"
160	40	80	14	.070"	.190"	197B	5.00	.0253"	9	4"
420	100	210	18	.070"	.190"	157B	8.00	.0253"	21	5¾"
100	25	50	16	.171"	.422"	†512B	10.00	.040"	11	6½"

(Any other condensers listed on this page can be supplied split at $1.50 extra list.)
*Standard receiving condenser spacing.—Suitable for low powered transmitters.
†Rotor and stator plates have rounded edges and are highly polished overall.

—ALSO MADE TO SPECIAL REQUIREMENTS—SEND PARTICULARS—



147-B

FIXED CONDENSERS (see illustration opposite)

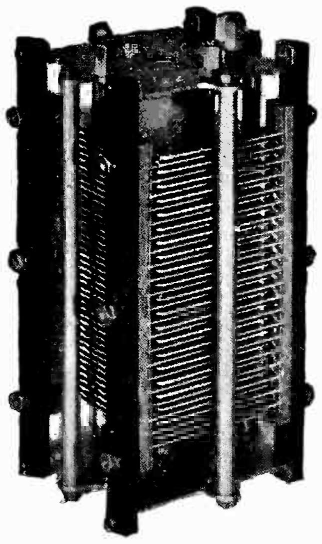
CAP. Mmfds.	AIR GAP	PRICE	TYPE	Plate Thickness	No. Plates	Depth (Back of Panel)
250	.070"	$ 4.50	501	.040"	12	2½"
420	.070"	7.00	502	.040"	20	3¾"
1000	.070"	10.00	503	.040"	48	7½"
220	.1535"	15.00	504	.040"	22	5½"

Can be furnished for special capacities on order. Will be furnished with three extension posts for panel mounting unless mounting brackets are specified.

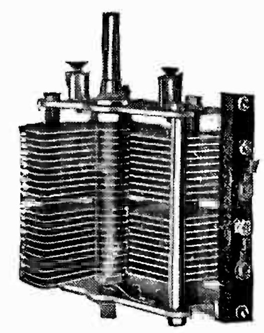
For baseboard mounting any of these condensers can be supplied with a pair of mounting brackets at an additional cost of 25 cents (list). Condensers are ordinarily equipped with three extension posts for panel mounting in the usual manner.

Vernier attachment can be supplied when desired.

A standard locking device for rotor can be supplied for all condensers listed above. 60c. list.



503 (Fixed)



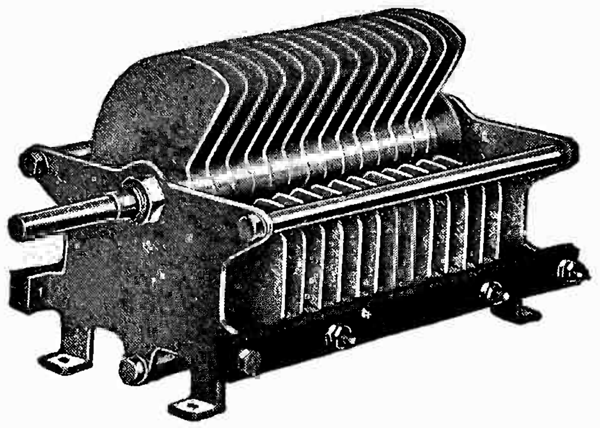
156-B
(Split Stator)

THE ALLEN D. CARDWELL MANUFACTURING CORPORATION
81 PROSPECT STREET, BROOKLYN, N. Y.

CARDWELL

CONSTRUCTION DESIGN 16B

TRANSMITTING CONDENSERS



(A special bulletin is available describing Construction Designs, 166-B and 1666-B High Voltage Condensers. Send for it if interested.)

This model is primarily intended to meet requirements where condensers for moderately high voltages are indicated of a size between our Construction Design 166-B and our smaller condenser designs such as T-183, T-199, etc.

It is possible to furnish in the Construction Design 16-B, greater air gaps, and higher capacities in relation to air gaps, than could well be done using our smaller transmitting condenser design as mentioned above, and still retain adequate structural strength and a proper balance between the various elements. Likewise condensers of low capacity with air gap equivalent to that used in our standard 166-B may be furnished in this construction design.

The 16-B can be supplied with promptness and within reasonable limits as to capacity and breakdown voltage. Standard air gaps (actual air gap between adjacent rotor and stator plates) are .168 inches and .294 inches, but condensers with air gaps of .231, .122 and .090 inches can be furnished on special order. **We solicit inquiries for special sizes.**

The figures given below indicate a few possible sizes. The number of plates determining increase or decrease in capacity can be accommodated to suit special requirements, provided that an overall depth behind panel of 11", as indicated for Type No. 3276, is not exceeded.

May be furnished with Split Stator, if desired. (Add $3.00 to list price of Single Condensers).

Construction Design 16-B Type Nos.	Max. Cap.	*Air Gap	No. of Plates	Depth Behind Panel (Overall)	List Price
3279	315 mmf.	.168 in.	31	9 9/32"	**$32.00**
3280	147 "	.168 "	15	5 13/16"	**23.00**
3281	84 "	.168 "	9	4 1/2"	**20.00**
3276	160 "	.294 "	25	11"	**30.00**
3277	80 "	.294 "	13	6 7/8"	**22.00**
3278	47 "	.294 "	7	4 13/16"	**20.00**

NOTE: Static shields are furnished only on condensers having .294" air gap.
*Actual air gap between adjacent rotor and stator plates.
All plates have well rounded edges and are highly polished overall.
Standard insulation is Mycalex

GENERAL SPECIFICATIONS

Thickness of Plates.......... .050 inches
Material of Plates.......... Aluminum
Radius of Rotor Plates.......... 2¼"
Panel Space Required (Rotor Plates extended).......... Width 6⅛". Height 5⅜"
Contact—Rotor to Frame.......... Contact Disc—Double Arm Brush
Material of Frame.......... Brass—Nickel Plated
Frame Assembly Method.......... Hex. Head Cap Screws and Lock Washers
Shaft Diameter.......... ⅜ inch
Shaft Material.......... Stainless Steel
Material of Insulation.......... Mycalex

Suggestions for Selecting Transmitting Condensers

The "Voltage Breakdown" method of rating transmitting condensers has recently been abandoned by The Allen D. Cardwell Manufacturing Corporation due to the manifold confusion and errors that it has brought forth. It is very inaccurate, as the average user has no way of estimating the voltage he will have across his condensers, and there are so many variations in the quantity to which this may extend, due to the multiplicity of circuits, positions, and kinds of current, that it is not to be wondered at that the user gets the wrong condenser more often than the right one. **Reference to the tables following will indicate the condenser which may be expected to withstand the maximum current anywhere in a transmitter using tubes shown.**

CARDWELL TRANSMITTING CONDENSERS SUITABLE FOR STANDARD TYPES OF TUBES

(For neutralizing purposes see other table)

TYPES OF TUBES					
—65 —10 or smaller	—852 —03A —860 —11	—04A	—61 —49	—51 —06	—63 —58 —07
*A	Use Type T-199 or T-183 or Cons. Design 16-B Type No. 3279	Use Type T-199 or T-183 or Cons. Design 16-B Type No. 3276 or Type 166-BR (High Voltage Condenser.)	Use Type 166-BR (High Voltage Condenser) or Cons. Design 16-B Type No. 3276 — For Push-Pull Amplifiers See Next Column ☞	Use "*C or D"* or Type S 1852-R (HV Condenser) / For Push-Pull Amplifiers using -49, -61 or -06 Tubes use 16-B—Type No. 3279 with Split-Stator or S 1852-R with Split-Stator or DT183 Split	See *D

*A—Any Cardwell .030" Airgap Condenser (See Receiving Condensers, also "Midway" Condensers).
*C—Special Model of 166-B Cardwell Condenser, (state capacity required).
*D—Special Model of 1666-B Cardwell Condenser (state capacity required). (High Voltage Condenser)

NOTE: It is assumed in all cases that the plate voltage to be used is that specified by the manufacturer of the tube.

CARDWELL TRANSMITTING CONDENSERS SUITABLE FOR NEUTRALIZING STANDARD TYPES OF TUBES

—10	—03A —11	—52	—04A
"Balancet" Type 607-A "Midway" Type 401-B or Type 408-B	"Midway" Type No. 408-B or 515-B if two tubes in parallel or Type 415-B "Midway" Condenser."	Use Type No. 519.	512-B or 513-B or Cons. Design 16-B Type No. 3278.

—07 —58	**Construction Design** 1666-B. Type S-1855 or S-1683R (High Voltage Condensers). Send for folder.
—51	Special Condenser (not listed) of **Construction Design** 166-B, 7/16" airgap. Cap. 70 mmfds. Type No. S-3120. Price—$60.00 (list). Send for folder.
—49	Special Condenser, (not listed) of Construction Design 166-B, 7/16" airgap. Cap. 70 mmfds., Type No. S-3120. Price, $60.00 (list), or, special Cons. Design 16B with split stator. Send for folder.

THE ALLEN D. CARDWELL MANUFACTURING CORPORATION
81 PROSPECT STREET, BROOKLYN, N. Y.

CARDWELL MIDWAY CONDENSERS

FEATHERWEIGHT

RECEIVING — TRANSMITTING

LIGHT WEIGHT COMBINED WITH MAXIMUM STRENGTH

The MIDWAY is a small and compact variable air condenser which, without doubt, should find considerable application for many purposes where extremely light weight and reduction of bulk are desirable in receivers, transmitters and oscillator-amplifier outfits. Condensers of this description having a breakdown rating sufficient for transmitters using up to 75 watt tubes may be had in capacities as high as 150 mmfds. A panel surface of only 3"x2⅛" is required and the condensers weigh only 4 to 7 ounces.

Because the MIDWAY is necessarily light in construction to meet the requirements for which it is intended, in aircraft equipment, portable sets and the like; our responsibility for its structural strength has been met by particular attention to the design of this condenser. Wide surfaces at joining points in the frame insure rigidity, while cap screws and studs securely held by lockwashers and nuts afford permanent, steady tension at all important points. Only deliberate tampering will loosen this assembly.

There are no swedged rivet or eyelet heads to become slack or inert because of long continued strain due to vibration or shocks or because of temperature changes causing expansions or contraction of the insulation. Ruggedness and strength have not been sacrificed to any expedient making for cheapness of manufacture.

Aluminum is used throughout with the exception of bearing or contact surfaces, making extreme lightness of weight possible. The small amount of steel used is well cadmium plated.

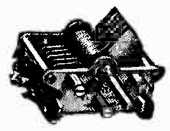
Mycalex insulation can be furnished at a small extra cost.

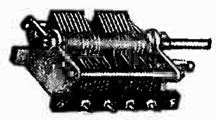
RECEIVING

(Also suitable for low power transmitters using '10-type tube)
(.031" Airgap)

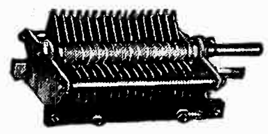
Type	No. Plates	Depth Behind Panel	Max. Cap. Mmfds.	Min. Cap. Mmfds.	Weight (Approx.)	List Prices	2-Gang List	Split Stator List
401-B	3	2 9/16"	26	7	4 oz.	**$2.10**	**3.60**	
402-B	5	2 9/16"	50	8	4¼ oz.	**2.20**	**3.80**	
403-B	7	2 9/16"	70	9	4½ oz.	**2.30**	**4.00**	**3.60**
404-B	11	2 9/16"	105	10	5 oz.	**2.40**	**4.20**	**3.80**
405-B	15	2 9/16"	150	11	5½ oz.	**2.50**	**4.40**	**4.00**
406-B	25	3 9/16"	260	13	6 oz.	**2.75**	*See note	**4.40**
407-B	35	3 9/16"	365	14	7 oz.	**3.00**	below	**4.80**

407-BS (.020 Airgap) 2 gang, 375 mmfds. per sec. Depth 3⅞" **$5.50** list.
407-CS (Semi-SLW) 2 gang, 360 mmfds. per sec. Depth 3⅞" **$5.50** list.





Gang or Split Stator Midway

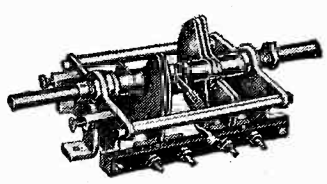


413B Midway

GENERAL SPECIFICATIONS

Overall mounting space — 3x2⅛ inches
Shaft diameter — ¼ inch
Shaft length (from back of panel) — 1 inch
Material of insulation—Radion (Mycalex extra)
Material of plates —Aluminum
Material of frame —Aluminum
General construction, quality and design—exactly as identified with other CARDWELL Condensers.

Midway "Featherweight" Band-Spread Condenser



Type 517
Type 518

Made in two stock sizes each consisting of a low capacity section and a high capacity section built into the famous Midway "Featherweight" frame. Each rotor is controlled by a separate shaft. A ball bearing between the inner ends of the two shafts, in addition to end plate bearings, insures against end play and permits smooth and uniform operation. This condenser, like our other Midways (see page numbered 8), is extremely light and compact. This model is arranged for either shelf or panel mounting. Has a positive non-mutilating rotor lock on high capacity section

Type No. 517—25 mmfd. section and 50 mmfd. section $4.25 list.

Type No. 518—25 mmfd. section and 100 mmfd. section $4.60 list.

Other combinations may be had on special order.

Write for quotations

TRANSMITTING

(Rotor and Stator plates of Transmitting Condensers have edges well rounded and are highly polished overall, thus eliminating corona losses and increasing breakdown voltage.)
(Suitable for transmitters using up to 75-watt tube)
(.070" Airgap)

Type	No. Plates	Depth Behind Panel	Max. Cap. Mmfds.	Min. Cap. Mmfds.	Weight (Approx.)	List Price	2-Gang List	Split Stator List
408-B	5	2 9/16"	22	6	4 oz.	**$2.60**	**4.60**	**4.40**
409-B	7	2 9/16"	35	9	4½ oz.	**2.80**	**5.00**	**4.50**
410-B	11	2 9/16"	50	11	5 oz.	**3.20**	**5.80**	**4.60**
411-B	15	3 9/16"	70	13	5½ oz.	**3.60**	*See	**5.00**
412-B	21	3 9/16"	100	15	6 oz.	**4.00**	note	**5.30**
413-B	31	4 1/2"	150	18	7 oz.	**5.00**	below	**5.90**
415B	15	4 1/2"	34	11	7 oz.	**5.50**		

(High Voltage Neutralizing Condenser—.171" air gap)

*TWO GANG CONDENSERS—Prices shown are for condensers having in each section a capacity equal to that of the single condenser listed on the same line to the left.

SPLIT STATOR CONDENSERS:—Prices shown are for condensers having in **each section** approximately **one half** of the capacity shown on the same line to the left.

WHERE NO PRICE IS SHOWN for two gang condensers, a condenser with double the capacity of the single is not regularly furnished. Special condensers will be supplied to order but not over 200 mmf. per section for Midway 2 gang receiving condensers (excepting types 407-BS and CS) or 70 mmf. per section for transmitting Midways.

WHEN ORDERING BY TYPE NUMBER, state whether single, double or split stator condenser is wanted.

FOR SEMI-SLW TUNING: Both Receiving and Transmitting Midway Condensers may be had on special order with shaped plates for semi-SLW tuning. Capacities will be decreased approximately 5% from capacities given in these tables.

SUB-PANEL OR SHELF MOUNTING: Mounting angles can be supplied for sub-panel mounting of condensers. Price 25c per pair list.

ROTOR LOCKING DEVICE: For use where dial or knob adjustment from front of panel is not required.

Will fit any "Midway," "Standard" size, or "Balancet" Cardwell condenser.

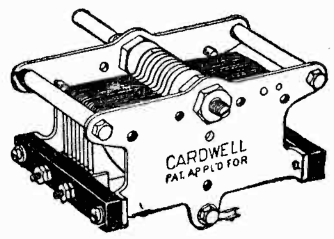
ROTOR LOCKING DEVICE

Price each **.60** (list)

THE ALLEN D. CARDWELL MANUFACTURING CORPORATION
81 PROSPECT STREET, BROOKLYN, N. Y.

CARDWELL CONDENSERS

RECEIVING TYPE, Airgap .030″
(Also suitable for low-powered transmitters using No. 10 type tubes)
(See Also "Midway" Condensers)

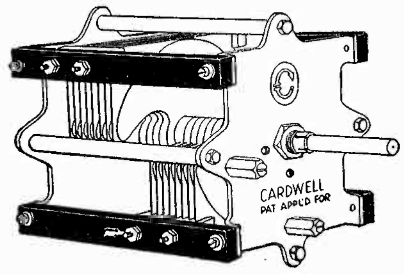


Above illustrates standard Type "B" condenser. This is "single end" type. Rotor plates are semi-circular.

THE TYPE B (SLC) CONDENSER
—Single—

No. Plates	Max. Cap. (Rated) Mmfds.	Min. Cap. Mmfds.	Type No.	Depth Back of Panel	List Price
3	50	11	159-B	2⅜ in.	**$3.00**
5	100	12	188-B	2⅜ in.	**3.00**
7	150	13	154-B	2⅜ in.	**3.00**
11	250	15	141-B	2⅜ in.	**3.00**
*17	375	18	152-B	2⅞ in.	**3.50**
21	500	21	123-B	2⅞ in.	**4.00**
41	1000	31	137-B	4 in.	**5.00**

Intermediate Capacities (Not Listed) may be had on special order also **double** and **triple** condensers.

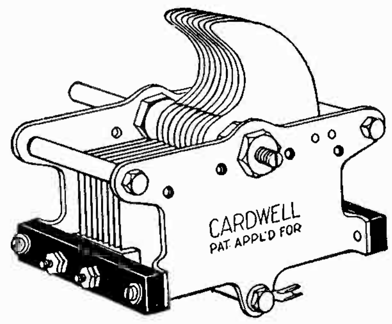


Typical construction of "C" type (Semi-SLW) balanced rotor type gang condensers. Gang condensers may also be had "straight-in-line" on special order, if desired both "B" (SLC) and "C" (Semi-SLW).

THE TYPE C (SEMI-SLW) CONDENSER
—Single—

o 3	50	10	191-C	2⅜ in.	**$3.00**
o 5	90	11	167-C	2⅜ in.	**3.00**
o 7	140	13	168-C	2⅜ in.	**3.00**
o 13	250	15	170-C	2⅞ in.	**3.00**
o*17	350	16	171-C	2⅞ in.	**3.50**
o 25	500	18	173-C	4 in.	**4.50**
o 71	1500	38	176-C	5⅞ in.	**10.00**

*May be obtained in double and triple units from stock. Others on special order.
oMay be obtained for right or left rotation. (Add "L" or "R" to type number according as clockwise or counter clockwise rotation to increase capacity is desired.)
(The Type "C" Condenser with a tuning curve commencing with straight frequency and changing to straight capacity is ideal for use in tuned radio frequency circuits.)

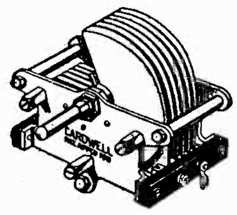


171-C

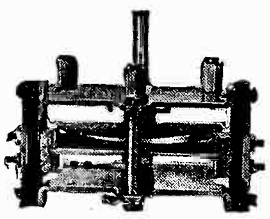
DUAL
Type 217-C (list) $6.00
TRIPLE
Type 317-C (list) $8.00

.00035 Mfds. (Each Section)

TYPE "E" TAPER PLATE CONDENSERS



The Taper Plate Type "E" Cardwell Condenser, which introduced the Ideal Tuning Curve midway between straight wavelength and straight frequency, was the first logical answer to the demand for a condenser which will give ample separation on all wavelengths.
In the type "E" condenser, a stiffness is obtained which has been heretofore unequalled and calibration or the log of a set using these condensers will remain absolutely the same for all time. **This condenser is particularly well adapted for short wave receivers due to the extreme rigidity of the plates which eliminates all tendency towards so-called "wobbulation."**



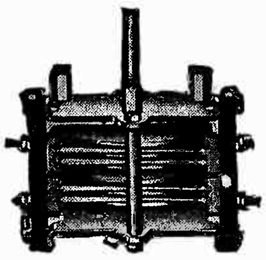
201-E

The Stator Plate is adjustable to afford maximum capacities from 50 to 10 mmfds. (Constant minimum, 7 mmfds.)

PRICES
TYPE "E" CONDENSERS

Type No.	No. Plates	Min. Mmfds.	Mam. Mmfds.	Depth Back of Panel	Price
*201-E	2	7	50 *See Footnote 10	2⅜ in.	$4.00
†202-E (Split Stator)	10	6 (Series)	300 (Sections in Multiple) 75 (Sections in Series) 150 (Per Section)	4 in.	4.75
191-E	3	10	75	2⅜ in.	4.00
167-E	5	13	150	2⅜ in.	4.00
168-E	7	14	220	2⅞ in.	4.25
169-E	11	17	350	2⅞ in.	4.75
192-E	15	21	500	3¼ in.	5.00

*Stator plWte adjustable see illustration.
†See illustration.
Double units, not listed above, special and subject to quotation.
Single units with extended shaft and coupling for single control of gangs, $1.50 extra, list.

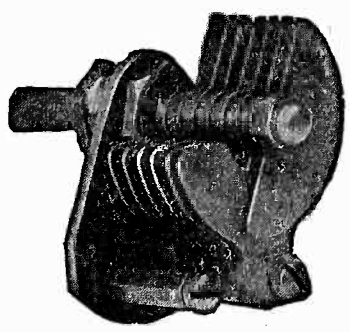


202-E

A Split Stator taper plate receiving condenser with common rotor — stators insulated from each other. (Useful for tuning Pusher Pull circuits.)

THE Cardwell "BALANCET"

The Cardwell Balancet is a superfine condenser of unusually compact size which may be used for neutralizing, balancing, vernier, and for many other purposes. In mechanical strength and efficiency it is equal to the regular tuning condensers. A quarter inch shaft and concentric one hole mounting permit the use of any knob or dial.



Single Capacity, Mmfds.				Dual Capacity, Mmfds.			
Type	Max.	Min.	List Price	Type	*Max.	†Min.	List Price
603-A	5	3	$1.00	606-A	5	2	**$1.75**
605-A	15	6½	1.25	610-A	15	2	**2.00**
607-A	25	7	1.25	614-A	25	3	**2.25**
609-A	35	7	1.25	618-A	35	3	**2.25**
611-A	40	7½	1.50	622-A	40	4	**2.50**
613-A	50	7¾	1.50	626-A	50	4½	**2.50**

*Each side. †Series connected.

The dual models have two stator sections so arranged that a decrease in the capacity of one side is coincident with an increase on the other, and double and triple section condensers can be very easily synchronized with only one vernier knob. **Rotor locking device can be furnished.**

THE ALLEN D. CARDWELL MANUFACTURING CORPORATION
81 PROSPECT STREET, BROOKLYN, N. Y.

Auto Antenna Hints and Detailed Instructions for Eliminating Generator and Ignition Noises

A LOW capacity shielded lead-in wire should be used. The shield must be grounded as close to the antenna post as possible. Keep lead-in wire as short as possible. When under-hood mounting is found necessary, the antenna post may pick up motor noise, in which case it will be necessary to shield it. The lead-in wire should be brought down to the body post nearest the end of the receiver that has the antenna post so as to keep the lead-in wire as short as possible. The shielded portion of the lead-in should extend from the receiver to a point approximately eight inches from the aerial proper and the shielding must be grounded at this point to the metal framework of the car by soldering a piece of wire to the shield and fastening the wire under a convenient screw head.

There are various types of antennae, but the recommended type is the roof antenna. Many automobile manufacturers install antennas in the roof of the cars at the factory. The lead-in wire is usually coiled up under one side of the instrument panel.

Insist upon having a good antenna. An automobile radio is no different than a house radio in that good reception can only be had by use of a good antenna.

Roof antennas should be kept at least three inches away from all metal parts of the body, and from the dome light and dome light wires. The wires running from the dome lights or corner lights should be shielded, and the shielding securely grounded to the metal of the body and to the dome light case, by soldering a wire to the shield and fastening the wire under a convenient screw head. This can be easily accomplished while the top liner is lowered for antenna installation. When installing roof antennas in cars with tops supported by wooden roof bows, use No. 16 mesh copper screen.

Some cars have the top deck supported by poultry wire, which is grounded to the body. This will necessitate the cutting out and removal of three inches of the poultry wire all of the way around between the wire and the body and away from the dome light and the dome light wires. The poultry wire can then be used as an antenna. A large antenna is always advisable, and should be at least three feet square (nine square feet), or a like number of square feet in some other shape. In most automobiles at least twelve square feet can be installed.

Every antenna should be checked for ground in the following manner: Using a continuity tester consisting of a low range high resistance voltmeter (1.5 or 3.0 volt scale) in series with a dry cell, touch one lead from the continuity tester to the antenna and touch the other lead from the continuity tester to the body or other grounded portion of the car. If any reading is obtained, even though very small, the antenna is grounded and cannot be used for an aerial until the ground is removed.

If a continuity tester is not available, connect 200 volts of "B" battery in series with a 200 volt, 1000 ohm per volt, sensitive meter. Touch one lead from the meter to the antenna and touch the other lead from the batteries to a grounded portion of the car. If the sensitive meter reads more than two volts, even when the roof of the car is damp, it indicates that the antenna is grounded. The ground must then be removed.

Under car antennas are not recommended, but where it is impossible to install a roof antenna, an antenna formed by placing not less than four square feet of copper screen between two pieces of water-proof material, such as leatherette, and sewing it in, will work satisfactorily. The water-proof insulating material is then fastened to the frame of the car. It may be necessary to make the antenna in two pieces in order to obtain four square feet of screen. Care must be taken to make sure that the screen is not or cannot become grounded to the frame of the car. Test for ground in the same manner as instructed for roof antenna.

Adjusting the Antenna Circuit

The antenna circuit must be adjusted to be in perfect resonance with the particular antenna to which the receiver is connected. Tune in the station on which the receiver will be operated. A distant location, or a point of low signal strength, will permit the best adjustment, for a weak signal produces the sharpest resonance point. With a small insulated handle screw driver, turn the antenna adjusting screw to the right or left slowly to the position of maximum volume. Once made, the adjustment need never be changed unless the antenna system is altered, or the receiver is operated on a different kilocycle frequency.

Method of Eliminating Generator and Motor Noises

There are three kinds of interference that have their source under the automobile hood. They are caused by:

1. Generator commutator sparking.
2. High tension spark discharge.
3. Low tension breaker point arcing.

1. **General Commutator Sparking.** The brushes on the generator cause an interference "whine" which increases in pitch as the motor is speeded up. A 1 mfd. condenser is used for filtering out this "whine." Fasten this condenser to the frame of the generator or cut-out housing. Connect the condenser lead wire to the terminal on the generator side of the cut-out.

2. **High Tension Spark Discharge.** The high tension spark discharge can be eliminated practically 100 per cent by means of the spark plug suppressors and the distributor suppressor. Place one spark plug suppressor on each spark plug, and the distributor suppressor on the center high tension terminal of the distributor. It might be well to clean all of the spark plugs, and to properly adjust the points to spacing recommended by the car manufacturer. In cases where the idling of the motor is affected by the suppressors, it is advisable to increase the spark plug air gaps an additional .004 of an inch over the recommended spacing.

3. **Low Tension Breaker Point Arcing.** The low tension breaker point noise is the hardest to cure. With the spark plug and the distributor suppressors in place, all of the remaining interference generally comes from the low tension breaker points. Try connecting the lead of a .25 mfd. condenser on the primary terminal of the ignition coil which runs back to the ammeter and battery through the ignition lock. Mount the condenser to a good ground close to the coil. If this does not reduce the noise, try reversing the primary leads to the ignition coil.

Where the ignition coil is mounted on the instrument panel, the high tension lead from the coil should be shielded. This shielding need not extend farther than through the bulk head into the motor compartment, where it should be grounded directly to the motor head.

The metal shielding covering the speaker cable should be securely grounded to the bulk head or to the frame of the car.

Radiation from the dome light may be checked by turning the dome light on and off or by removing the dome light wire from the ammeter and grounding this wire to the metal dash instead. If the interference decreases, the dome light leads are radiating into the antenna. Proper shielding, as outlined under the "Antenna" section, will eliminate this source of interference. Sometimes it is necessary to place an additional .25 mfd. condenser or one of greater capacity, from one terminal of the ammeter to the metal dash. Where an under-car antenna is used, it may be necessary to by-pass to ground one or the other of the tail light wires with a .25 mfd. condenser.

To check for additional low tension interference, operate the receiver with full volume while both the antenna and the antenna shielding are completely disconnected from the receiver. If a .25 mfd. condenser, or one of greater capacity, connected from ammeter to the metal dash, does not eliminate the remaining interference, try grounding the following controls to the frame of the car; choke, throttle, spark, starter, speedometer cable, gas gauge, etc. Also try by-passing to ground with a .25 mfd. condenser, the following objects: electric cigar lighters, electric windshield wipers, electric gasoline gauge, electric clock, hot water heater, fan motor, stop light switch, etc.

Try shifting the aerial lead-in wire, speaker cable and battery cable lead to the different positions. Also try grounding these leads at different points. It may be necessary to ground the hood at two points on each side by winding bare wire or thin metal around lacing which prevents the hood from contacting the metal underneath the lace.

Special Instructions for Ford V-8

To eliminate spark coil interference in Ford V-8 automobiles, remove from the cable running into the high tension conduit on the driver's side of the motor, the red wire that goes to the distributor head and the yellow-black tracer wire that goes directly to the cut-out box on the generator. Shield the red wire and the yellow-black tracer wire separately with metal shielding and bond the two shielded wires together by soldering them every three inches. Ground the two bonded wires to the copper carburetor supply line by taping them to it. At the distributor connect a .25 mfd. condenser between the terminal to which the red wire fastens and the ground. Connect another .25 mfd. condenser between one side of the ammeter and the ground.

—Courtesy Engineering Dept.,
Sparks-Withington Company.

New Littlefuse Retainer

The No. 1061 fuse container, manufactured by Little Fuse Laboratories, meets the demand of manufacturers of auto and battery operated radio sets for a fuse mounting that would not take up any additional room in a set and still be readily accessible for servicing and renewals. It is hung directly in the line between the storage battery and the radio power supply. A tension spring furnished perfect contact to the fuse, which is fully protected by a fibre casing. The 3AG-type automotive fuse fits the holder.

THE COMPLETE SHORT-WAVE RADIO COURSE

A Complete Course in Short-Wave Radio, Simply Told. Non-Mathematical. Beginners, Experimenters, Amateurs, Advanced Set Builders, and All Those Interested in Short-Wave Radio Will Be Enthused Over This New Course Which Considers Radio From An Entirely Different Point of View. A Modern Radio Course Which Includes Short-Waves and Ultra-Short-Waves. Follow It Every Month In This Magazine.

LESSON THREE

Experiments With Electric Currents

IN the last experiment with electrons we made a strong field at the end of a stick by fastening three electrons close together. We put the end of this stick near three other electrons which were fastened close together on the table. (Please look at the drawings of Fig. 6 again). While we held the end of the stick near the electrons on the table we let the three electrons go free. As soon as the electrons were let loose, they quickly rolled away from the strong field at the end of the stick. From this experiment we learned that electrons can be made to flow by means of a strong field. When electrons flow there is said to be an **electric current**.

In our experiments we used electrons as big as marbles. But it should always be remembered that real electrons are so small that you can never see them even with the most powerful microscope.

We have learned that a current is made up of electrons and that the strength of a current depends upon the number of electrons flowing. It is interesting to know that billions and billions of electrons are necessary to make even the smallest electric current. So to understand electric currents better let's try some more experiments and use a larger number of electrons and see just what a real current is and what it does.

This time we are going to make some pretty strong electric currents. Stronger currents will make it easier to see what happens. If we see what currents are and what they do it will be easy to understand them. If we understand electric currents we will understand electrical things and radio sets and tubes.

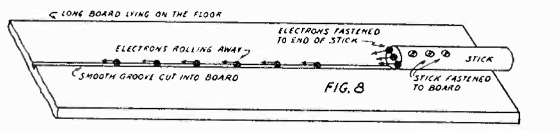
When we made the electrons flow in our last experiment we were not very careful to see that they all flowed along together. We did not make any path for the electrons to flow along. There was nothing to keep them moving together in a line. Electrons have to move along together to make a current. And to keep them together you have to make some kind of a path for them to go along. Is it not easy to see that they will go in almost any direction if we do not make some kind of a path or a "track" for them? If the electrons do not flow together they will not make a **current**.

Think of the flow of water. There would not be a **current** of water unless you made some kind of a path for the water to flow along. To make such a path, we could dig a small ditch for the water to flow in. We could also make a pipe for keeping the water particles together. The ditch or the pipe keeps the water so that all its particles flow along together. When all the water flows along in this way there is a **current** of water. In the same way, to make an **electric current** the electrons have to go along some kind of a path, together. To keep the electrons flowing together, we have to make a path for them to flow in.

For instance, we could cut a groove in a board for them to run along. This groove will hold them in and keep them flowing together. So let's cut a groove in a board and try rolling a few electrons along this groove. If we do this, we will see that they run easily along the groove. The groove makes a path for them. When electrons roll together in the same direction along the groove they make a **current**.

To try some really interesting experiments, it will be best to use a long board and cut a groove along its whole length; we will then have a long path for the electrons to roll in. If the groove in the board is long, we can use many more electrons and have plenty of room for them. We can try some more experiments and see something new. For instance, we can make the electrons roll along fast, slow down, or stop if the board is long enough. When we tried the experiments before, we sometimes had to keep the electrons from rolling off the table. With a long board with a groove in it we can let them roll as far as we want and see what they do.

We made a stick with three electrons fastened to the end of it to use in the last experiment. Take this stick and fasten it to the board as shown in Fig. 8. Fasten the



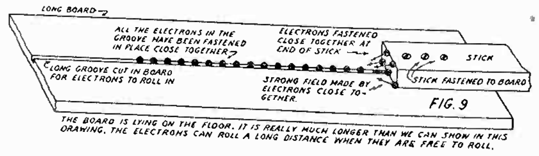
This is the same experiment we did before. This time we make use of a board with a groove in it so the electrons will stay together and flow in a straight line. When the electrons are set free they roll away from the end of the stick along the groove in the board.

three electrons in the groove in the board. Fasten them as near to the end of the stick as you can. Then loosen them one at a time, hold them in place like you did before, and then let them all go free at the same time. You will see the same thing happen that you saw before. The electrons will speed up and roll away from the end of the stick. But this time they have a path to flow in and so they will all flow along the groove. There will be an **electric current**. The groove in the board keeps the electrons flowing just the way we want them to. So if you want electrons to flow together and stay together all you have to do is to make a path for them to flow along. It is easy to make an electric current if a path is made for the electrons to flow in.

Now that we have seen how we can make electrons follow paths that we make for them, let's try some experiments using more electrons. If we use more electrons we can make stronger fields. With stronger fields we can make stronger electric currents. And if we make paths for the electrons we can make the currents flow in any direction we want them to.

Instead of fastening three electrons to the end of a stick like we did before, let's fasten five of them to the end of a bigger stick. If we do this, and fasten the electrons close together, we will have a stronger field. With a stronger field we can make a large number of electrons flow. We can make stronger currents flow with a stronger field.

Fasten the stick with the five electrons on the end of it to the long board which has the groove in it. This is done as shown in Fig. 9. After the stick has been fastened to



At the right in the above drawing, five electrons have been fastened close together on the end of a small piece of wood. This wood is fastened to a board which has a long straight groove in it for the electrons to then roll in. After the wood is fastened to the board, several electrons are fastened close together in the groove as shown. It is hard to get the electrons near the end of the stick because the field is so strong. The electrons in the groove also all push on each other so it is hard to fasten them close together. But with the help of our friends we finally get all the electrons fastened close together in the long groove as shown in the above drawing. The field is very strong at the end of the stick. There is a strong push on the electrons in the groove.

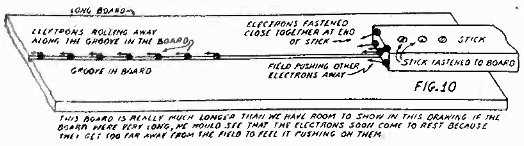
the board, fasten a number of electrons close together along the groove and near to the end of the stick. It will be hard to get the electrons near the end of the stick because the field is very strong. But push hard and get the electrons close together, as close to the end of the stick as you can. All of the electrons will push on each other and you may have some trouble getting them close together. So it will be best to have some of your friends help you. They can hold the electrons while you fasten them down along the groove. With a little patience you will be able to get the electrons pretty close together. Take a look at Fig. 9. This drawing shows how the electrons should be fastened down. Be sure to fasten them down tightly. If you are not careful about this they may break loose and roll away.

After all the electrons have been fastened to the board as shown in the drawing of Fig. 9, we can try a very interesting experiment. The fields are much stronger now. We are using many more electrons close together. Now we can see how real currents flow and what they do.

Let's do the same thing we did before. Loosen all the electrons in the groove. Don't touch the electrons on the end of the stick. Leave them there. As each electron in the groove is loosened, hold it there. Loosen the electrons one at a time and hold each one of them in place until all of the electrons are loose. When they have all been loosened, let them all go free at once. See the drawing of Fig. 10.

What happens? Look! How fast they go! All the electrons suddenly speed up and roll very fast along the groove in the board. The field that pushes them is very strong now. This strong field makes the electrons speed up quickly and flow away. How fast they go! We made the groove in the board just right because all of the electrons flow along it no matter how fast they go. None of them get out of the groove. That's a real current! The electrons act like they were going somewhere and there are a large number of them moving along the groove. That is just like a real electric current. The groove keeps them together and they all flow along the path made for them. In this way they make a strong electric current.

If we used a long board with a groove all the way along it we would see that the electrons begin to slow down after they have rolled along for a long distance. We would also see that they get farther apart as they keep rolling along. This is true because the electrons push on each other. The push between them makes them move away from



The electrons close together at the end of the stick make a strong field. The electrons in the groove will not move until they are loosened. To make a current flow, loosen each electron in the groove one at a time and hold it there until all the electrons in the groove have been loosened. After all the electrons in the groove have been loosened, they are all set free at once. The strong field at the end of the stick then can push on these electrons and make them speed up suddenly and move away along the board. All the electrons will flow in a straight line because they have to roll in the groove in the board as shown in the above drawing. This experiment shows how a strong field can make a current flow.

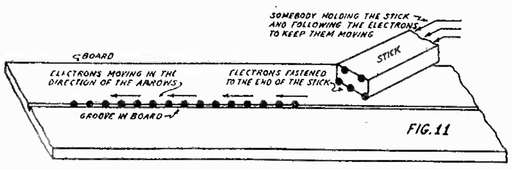
each other. They will move apart until they do not feel the push between them anymore. They will move pretty far apart as they roll along. After a little while all the electrons will have come to rest.

Before coming to rest they will have rolled for quite a distance. They have rolled so far that they cannot feel the strong field at the end of the stick anymore. A field gets weaker and weaker as you go away from it. So after you are a good distance away from the field you will not be able to feel it. For this reason the electrons will finally slow down and stop. When they have stopped you will see that they are pretty far apart. They have kept rolling along until they can no longer feel the strong field at the end of the stick. As they rolled along they also moved away from each other. So when they have finally stopped rolling they will be apart from each other and also pretty far from the place that they started to roll away from.

How To Keep Electric Currents Flowing

We made a real current that time. But the electrons soon came to rest. If we wanted to keep them going we could follow along behind them with a strong field. We would have to keep a strong field near them all the time if we wanted them to keep going.

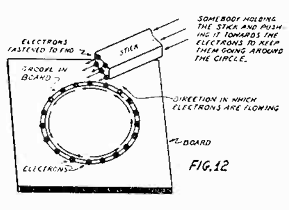
We have made a strong field. With it we made a pretty good current flow along the groove. But as soon as the electrons get away from the field they move apart and slow down. These are very interesting facts which make us think about electric currents. Probably we will wonder how to keep the current flowing for a long time. How can we keep the electrons moving along the groove? One way would be to move the strong field along behind the electrons as shown in the drawing of Fig. 11. But that



If we wanted to keep a current flowing, we could follow along behind the electrons and keep pushing them along with the strong field at the end of the stick. In this way we could keep a current flowing. To keep a current going for quite a while we would have to have a very long groove for the electrons to flow in.

is a lot of work. So let's find a simpler way to keep the current flowing. To make any real use of currents we have to keep them going as long as we need them. And sometimes we need them for a long time. How can we keep an electric current flowing?

If we made a groove in the board go around in a circle it would be much easier to keep a current flowing. So let's use a wider board and cut a circular groove in it like in the drawing of Fig. 12. After we cut this groove, let's put a large number of electrons in it. These electrons will stay as far away from each other as they can, because they



Let's take a wide piece of wood and cut a round groove in it like you see in the illustration. After we have cut the groove, let's put a lot of electrons in it. Because the electrons push on each other and try to stay apart from each other as much as they can, they will come to rest at equal distances apart around the groove. If we wanted to keep the electrons rolling around the circle, all we would have to do would be to keep pushing them around with a strong field. The best way would be to just stand in one place and keep giving the line of electrons a push. Every time the electrons try to slow down give them another push to keep them going. An electric current is flowing around an electric circuit when the electrons are kept going around and around.

push on each other. The way they will look after we have put them in the groove and have come to rest is shown in the drawing of Fig. 12. They will come to rest at equal distances apart along the groove.

To start the electrons moving around the circle all we have to do is to give them a push with a strong field. This we can do by suddenly pushing a stick, with electrons fastened to the end of it, near the electrons in the groove. Of course, we have to "aim" the stick so it will push the electrons along the groove. If we did not aim the strong field so it would push the electrons along the groove, we might push some of the electrons out of the groove.

After we have given the electrons a couple of pushes they will start going around the circle. Soon they will begin to slow down. When they begin slowing down, we can give them another push. In this way we can keep them going around the circle. If every time they try to slow down we give them another push, we can keep them going around as long as we want.

We do not have to follow the electrons around to keep them going, now that we are using a circular groove. We have made a complete path for the electrons to flow along and come back. All we have to do now is to stand in one place and give the line of electrons a push every time they begin to slow down. To give the line of electrons a push, suddenly push the end of the stick at the line of electrons and take it away quickly again. When the electrons start slowing down again, give the line another push. Be careful to aim the field so you push the electrons along the groove. If we keep doing this, giving the electrons a push every time they begin to slow down, we can keep the current flowing around the circle as long as we wish.

It is not necessary to have a circle for the electrons to flow around. We could cut a groove in a board any shape that we wanted. For instance, we could make it square with rounded corners. You have probably seen small toy trains and the tracks they have for them to run on. These tracks are of different shapes. But all of these train tracks are made so that the train comes back again. The train just goes around and around along the track. If the track did not come back, the train would soon come to the end and run off. If you wanted to keep the train going without having it come back again, you would have to make a very long track. That would not be easy to do. A long track costs too much, and we would not have a place to put it.

It's the same with the "tracks" we need for electrons. It is best to make a track for them so they can keep going along and coming back. You could make a long track for them but it is best to make a round track, or some other good shape for a track, that is easy to make, so the electrons can keep going around and around.

In the drawing of Fig. 12 we made a circle for the electrons to keep going around. So we can say that they keep rolling "around the circle." A different word is used to explain electric currents that go around in a circle. Anything that keeps going around a circle can be said to be going around a **circuit.** If an electric current is flowing around a circuit the circuit is called an **electric circuit.**

An electric circuit is a closed path for electrons to flow in. It is not necessary to have a circle for the electrons to flow around to call it a circuit. So long as the electrons can keep flowing along the path and come back again, the path is called a circuit. A circuit has no breaks in it. A circuit can be any shape. For instance, it can be square with rounded corners, or it can go around in the shape of an egg or a football. It could be any shape and still be called a circuit. But to be a circuit it must be a **closed path.** The electrons must be able to flow around it. **An electric circuit is any closed path that electric currents can flow in.**

Later it will be shown that electric circuits are always used for electric currents to flow in. Electric circuits for real electric currents are made by using copper wires. There are usually two wires in an electric circuit. The electrons flow around the circuit through the wires. If one of the wires making an electric circuit is broken, the circuit is said to be "opened," or there is said to be **open circuit.** If the broken wire is again connected, the current can flow again. Connecting the wires "closes" the circuit. It is often necessary to open or close circuits to stop or start an electric current. "Switches" are used to open and close electric circuits to stop or start the flow of electric currents.

Electrons Are Not Used Up

When the electrons go around the circuit shown in the drawing in Fig. 12, none of them are lost. If we stop giving them pushes, they will slow down and come to rest but there will be the **same number** of electrons that we had when we started. This is true because we are always careful to "aim" the strong field so that none of the electrons get out of the groove. No electrons are lost in real electric circuits. They speed up, slow down or even stop. There are **changes in speed** in the flow of electrons but none of them are lost. A wire acts like a groove does. It keeps the electrons together and none of them can get away. **Electrons are not used up in an electric circuit.**

Radio Exports Increase

Increase in exports of American radio during April, 1933, is reported by the Electrical Division of the U. S. Department of Commerce. The April exports were $1,510,897, compared with $1,397,861 for March. There was a reduction, however, as compared with exports in April, 1932, which were $1,875,716.

May Excise Tax

The Internal Revenue Bureau reports collections during May, 1933, of the federal 5 per cent excise tax on radio and phonograph records amounting to $110,747.70, according to official statement just released in Washington. The May collections on mechanical refrigerators were $376,188.35.

Analysis of the Supertone AC-DC Universal Short-Wave 2-Tuber Using 25Z5 Rectifier

THE Supertone Products Corporation has released a new three-tube short-wave receiver in which the 78, 43 and 25Z5 tubes are used. This receiver is of the 110-volt AC-DC Universal type, compact and portable.

The circuit diagram is shown here. Operated with a tuned "doublet" antenna infinitely better results will be secured.

A 78 tube is used in the detector circuit. The 78 is not generally recommended as a grid-leak detector but it will give entirely satisfactory service when used as shown in this simple receiver circuit. This receiver is for beginners. Its utmost simplicity makes it ideal for those who are content with nothing short of A.C. operation. The socket connections are clearly indicated in the diagram. The actual operating arrangement shows the suppressor of the 78 tube connected to its cathode and also to the negative side of the B supply.

The cap of the 78 is the control-grid connector. The screen is connected to the bias voltage terminal of the 43 output tube.

Coils used in this receiver are of the conventional type, other than the tickler or regeneration winding which should have twice the usual number of turns for satisfactory operation.

The plate output is coupled through a choke to a by-pass condenser which allows the rectified current to pass to the grid of the 43 output tube. The 43 is a pentode and gives high output for a relatively small input voltage.

A pair of headphones can be connected directly in the plate circuit of the 43 tube but the plate current is high enough to cause damage to a good pair of phones and it is therefore suggested that a 1-to-1 output transformer be used between the 43 tube and the headphones. This output transformer prevents the plate current from entering the headphones.

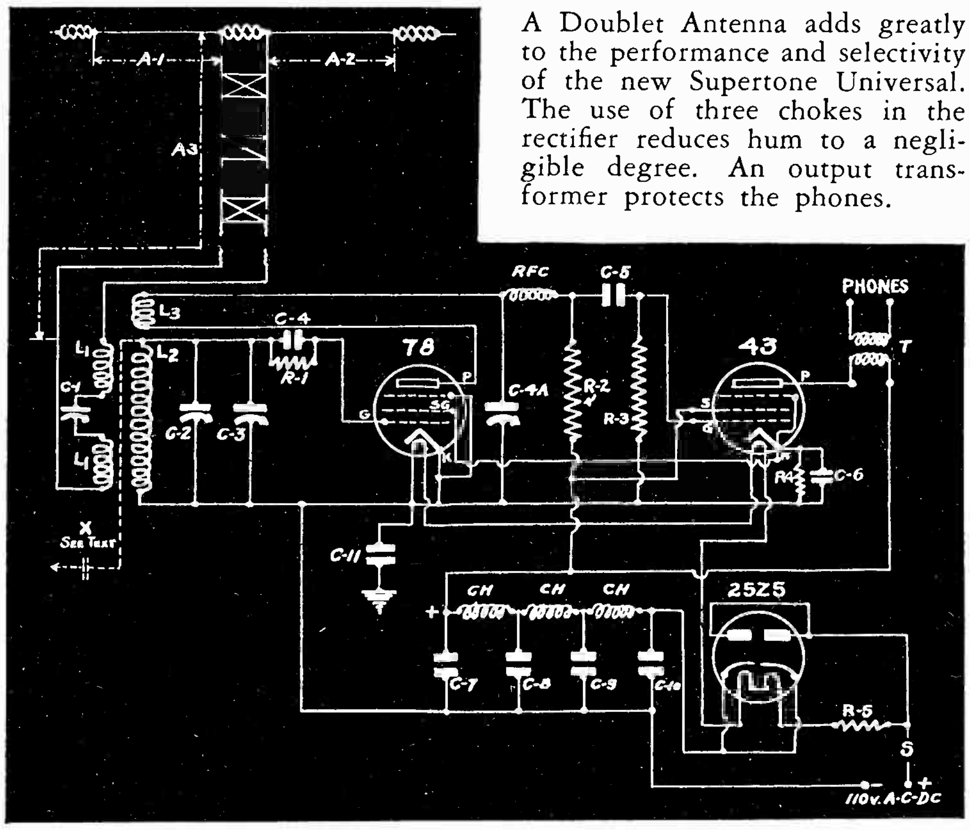
The heater, or filament supply circuit, deserves special mention. It will be seen, from the diagram, that the filaments of all of the tubes are in series and that they are of the heater type. Therefore, the heater current can be either A.C. or D.C. without change in connections, but the positive side of the D.C. line (if used) should always be connected to the positive input terminal of the receiver. The 43 and 25Z5 tubes each have 25-volt filaments, which draw 0.3 ampere, while the 78 has a 6.3 volt filament which also draws 0.3 ampere. When added, these filament voltages total 56 volts. The normal A.C. or D.C. line voltage is from 110 to 115 volts and if the filaments are to be operated in series 55 to 60 volts must be "absorbed." This is accomplished by the resistor R-5, which should have a resistance of 200 ohms and current-carrying capacity of at least 25 watts. The proper filament voltage will then be delivered to all tubes, regardless of the normal fluctuations in line voltage.

In this receiver the 25Z5 tube is used as a rectifier on A.C. and as a valve on D.C. It will permit full-wave rectification on A.C. and supplies pulsating D.C. to the filter, which smoothes out the supply current and makes it available for noise-free plate operation.

The filter circuit uses three chokes and four condensers. The chokes have an inductance of about 30 h. each and the condensers are the 8 mfd. dry-electrolytic type. One of the A.C. line wires is sometimes grounded and therefore no direct ground should be connected to the receiver. The ½ mfd. condenser, C-11, is recommended to safeguard against burn-out of the receiver if the power line is accidentally grounded through the receiver wiring.

The set should be mounted on a small metal sub-base with a metal front panel. The under side of the metal sub-base permits mounting of all parts used in the power circuit, leaving the upper "deck" clear for mounting the r.f. components. The 78 tube must be shielded, otherwise detector oscillation will be unstable.

One portion of the circuit diagram (dotted lines, marked "X—See Text"), shows the use of a conventional single wire antenna, connected to the secondary coil of the receiver through a 2-plate series condenser which is made from two pieces of brass or aluminum, each piece about 1 inch square, and the two plates separated from each other ⅛ in. The other portion of the diagram shows the use of a tuned-doublet antenna which will greatly improve the selectivity of the receiver. It is the equivalent of a stage of r.f. amplification ahead of the detector, from the standpoint of overall performance. This antenna system is recommended for use with all short-wave receivers.



A Doublet Antenna adds greatly to the performance and selectivity of the new Supertone Universal. The use of three chokes in the rectifier reduces hum to a negligible degree. An output transformer protects the phones.

List of Parts for Universal Short-Wave Receiver

A1-A2—Doublet Antenna Wires, each wire 33 ft. 3-in. long.
A-3—Transposed Lead-in (Feeder) 2 wires, each 66 ft. 6-in. long, transposed every 2 feet with Fleron Transposition Blocks.
C-1—.0005 Condenser. (500 mmf.)
C-2—.00014 Condenser. (140 mmf.)
C-3—2-plate Midget. (Band-Spread)
C-4—.0001 Fixed Condenser. (Mica)
C-4A—.0005 Midget Variable Condenser (500 mmf.)
C-5—0.1 mfd. 200-volt non-inductive by-pass condenser.
C-6—.2 mfd. 200-volt non-inductive by-pass condenser.
C-7, C-8, C-9, C-10—8 mfd., dry electrolytic condensers.
C-11—0.5 mfd. Paper Condenser, 200 volts.
R-1—5 meg. grid leak.
R-2—¼ meg. leak.
R-3—½ meg. leak.
R-4—500 ohms, 2 watts.
R-5—200 ohms, 25 to 50 watts.
CH—25 mil., 30 henry chokes.
T—1 to 1 output transformer.

Coil Data for Supertone Universal Short-Wave Receiver

1½-IN. DIAMETER COIL FORMS

Coil L1—Two windings, 8 turns each, on 1½-in. dia. form. This coil rests on top of secondary (L2)

1500-3300 kc.—
30 turns #26 enameled wire. Tickler. (L3)
56 turns #26 enameled wire. Secondary (L2)

3100-6500 kc.—
18 turns #26 enameled wire. Tickler. (L3)
23 turns #26 enameled wire. Secondary. (L2)

6200-13000 kc.—
10 turns #26 enameled wire. Tickler. (L3)
11 turns #20 enameled wire. Secondary. (L2)

13000-30000 kc.—
6 turns #26 enameled wire. Tickler. (L3)
4.5 turns #20 enameled wire. Secondary. (L2)

All Coils Separated 1/16-inch.

●●●

"Perpetual" Tube-Tester

THE steady profession of new tubes introduced during the past year has made practically all existing testing apparatus obsolete—and eight prong tubes already in prospect will make even the latest conventional type testers obsolete.

To meet the need for a set tester which will not be put out of the running entirely—or require expensive and radical changes at comparatively brief intervals—the engineers of the National Radio Institute and the staff of the Philco Radio & Television Corporation have designed and developed the N.R.I.-Philco All-Purpose Set Tester.

This is a tester which will defy changes in radio design and engineering—and be as good ten years from now as it is today. It will test any D.C. or A.C. (25, 40 or 60 cycles)—or any battery set and their tubes when the set is connected to the source of supply. This tester goes back to fundamentals, and provides for the isolation of the defective circuit and quick detection of the defective part. Point to point voltages analysis can be used or total chassis analysis by the point to point resistance method is possible.

The tester is entirely self-contained, and despite its versatility and completeness, the total weight when going on the job is only 12 pounds.

Operation of "Radio's" Laboratory 520KC Super

By RICHARD C. BARRETT

WHILE the operation of the Crystal-Filter Super is essentially single-dial control, nevertheless there are several points which require careful explanation before the layman or even the experienced amateur can be sure of obtaining maximum results from the receiver.

The points of aligning and adjustment will be taken up in their proper order, from the time the receiver is completely wired until it is ready to operate.

ALIGNING INTERMEDIATE AMPLIFIER

THE first adjustment is to get the i.f. stages aligned with crystal frequency. This is best done by setting up the crystal to be used in the receiver in a simple crystal oscillator circuit as shown in Fig. 1.

This is nothing more than a simple crystal control transmitter, working on a frequency of 520 k.c. A wire connected to the terminal marked "Output" is loosely wrapped around the grid lead to the second i.f. stage tube, and after the crystal oscillator is brought into resonance, the trimming condensers on L6 are adjusted until there is a decided "hiss" in the speaker. The wire from the oscillator "Output" terminal is then moved over near the grid lead to the FIRST I.F. tube and the same process repeated, until the "hiss" in the speaker is at its loudest. At this point in the adjustments, the BFO is turned on and adjusted to the hiss for "zero beat." All of these adjustments are made with the crystal out of the receiver.

The crystal is now removed from the test oscillator and inserted into the receiver in the proper socket. The coils are placed in the r.f., detector and oscillator sockets and the receiver tuned to a fairly weak signal. With the crystal shorted out of the circuit, the final adjustments are made to the i.f. trimmer condensers for maximum signal strength in the loud-speaker. The crystal is now placed in the circuit by opening switch S-1, and the volume control turned up to compensate for the loss in gain of the receiver due to the series connection of the crystal in the i.f. filter circuit. The received signal is then tuned-in on one side of zero beat about 1,000 cycles and the phasing condenser C13 is then adjusted until the signal is at a minimum, or completely disappears. The receiver is then completely adjusted for true single-signal reception, and the background noise will be very low while the signals will be quite high in comparison.

The most important point in making these preliminary adjustments is to get the intermediate frequency transformers right on the "nose" with the frequency of the crystal. It is suggested that an output meter be used across the speaker terminals of the receiver, if the owner has such an instrument handy. However, the method outlined above will, if care is exercised, bring about equally good results.

The trimming condenser C14 across the secondary of the first i.f. transformer will act as a selectivity control and can be set to give any desired degree of selectivity required, the most selective position naturally being when the circuit is in resonance.

It is particularly stressed that the i.f. transformers be aligned prior to placing the crystal in position, because the extreme sharp-selectivity curve which the crystal places into the i.f. amplifier so overshadows any individual selectivity of any particular stage of i.f. that the results will be misleading and will not appear as true operation.

COIL WINDING DATA
160 Meters

RF Coil, L1	Detector Coil, L2	Oscillator Coil, L3
Secondary 55 Turns #24 DSC, close wound.	Same As L1	Grid Winding 45 Turns, #24 DSC, close wound.
Primary 10 Turns #30 DSC, close wound.		Plate Winding 18 Turns #30 DSC, close wound.

R.F. Detector and Oscillator Coils

THE plug-in coils, if wound according to instructions, will automatically line-up properly. Any inconsistency can be corrected either bv "pruning" the coil or with trimming condensers on the tank tuning condensers C2, C4 and C6. These tank condensers should tune approximately together over the full dial range, and although there will be found two spots on the settings of the oscillator tank condenser where the same signal will come in, the spot which corresponds to the setting of the r.f. and det. tank should be selected.

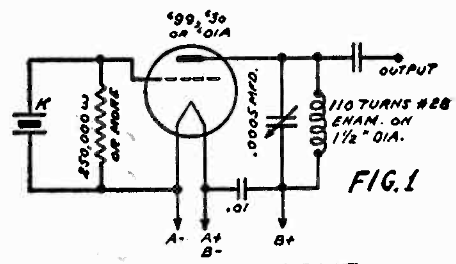


FIG. 1

CRYSTAL TEST CIRCUIT

Best procedure is to set these tank condensers to the center of the band desired, whereupon the main tuning control will give full band-spread over the whole dial, or fraction thereof.

Output

THE output is arranged to work into the primary of any input transformer on a dynamic speaker, or directly into a magnetic speaker. Where headphone reception is required or desired, an adequate output transformer with a step-down ratio should be used in this position between the output terminals and the headphones.

Due to the peculiarity of the construction of the 2B7 tube and the associated circuits, it is impossible to plug-in headphones in the second detector circuit; therefore the need of the special output matching transformer to cut down the volume level to a point low enough for headphone reception.

Next month will be shown how to add Automatic Volume Control for phone reception, along with several other additions making for improved performance and greater sensitivity of the receiver.

Some Considerations in the Design of High-Power Stages

(Continued from Page 7)

This condition can probably be completely remedied by the use of primary or grid-block keying. C bias can be obtained from an eliminator if batteries are not feasible. The same eliminator is used to furnish bias to all stages in the writers station, and while not equal to batteries from the standpoint of safety, is much superior to the use of resistance bias, whose margin of safety is questionable.

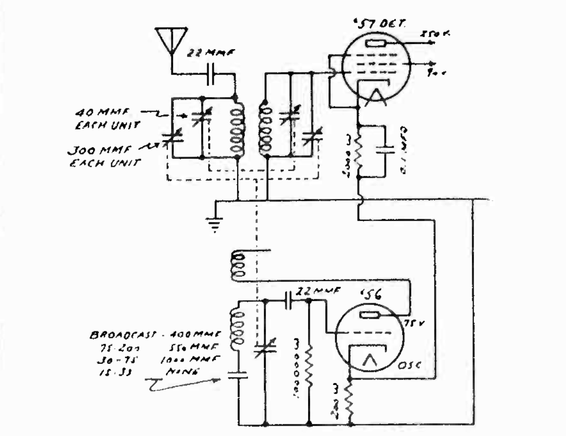
A unit of the type described in this article has been in constant use for the past year and has given extremely satisfactory service. Inputs in the order of six hundred watts with all tubes in the transmitter running cool (on both 7 and 14 Mc bands), mutely attest the advantages of a compromise design.

Patterson Receiver

(Continued from Page 22)

band-spread curve. The band-spread condenser has 5 Mmf. capacity at 40 degrees, and at 100 degrees has 23 Mmf. This allows a nice spread of any desired band. The 40-meter C.W. band covers 85 points.

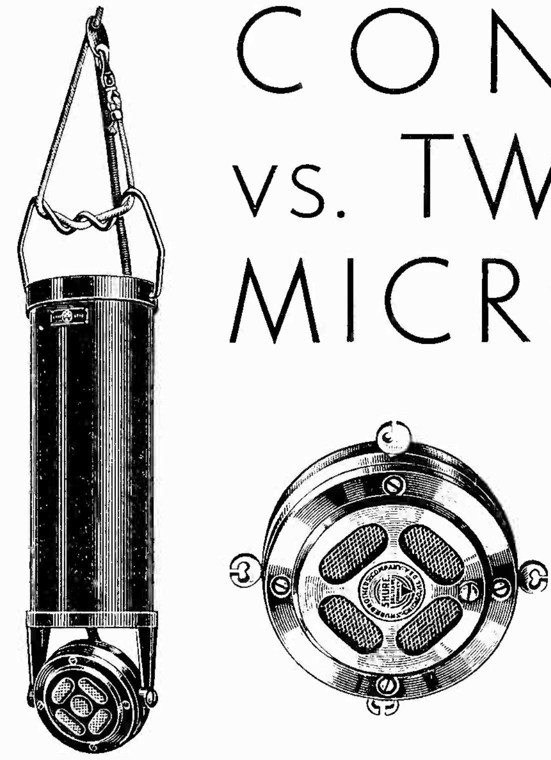
The automatic volume control functions at all times and is of the delayed type with just sufficient delay so that there is no great swing between dots and dashes of C.W. communication. The beat oscillator current also helps to keep the A.V.C. action slower. On fone signals it is sufficiently fast, however, to hold a 20-meter fone station steady from R3 to R99 plus.



Input circuit diagram of Amateur Model. The 6 section switch changes all coils shown for the different frequencies. Only one set of coils are shown on the large diagram.

On the broadcast band the set will cut about 7 k.c., and is sufficiently sharp to tune the carrier out of a broadcast station. Although the high's are missing in the music, everyone who has heard the set comments on the fine tone quality. The variable condenser used is of 300 Mmf. total capacity. This may seem rather small to the ordinary user, but it will give a better coverage of the broadcast band with very little lee-way on either end of the dial. The police stations are received on the 75-200-meter band, permitting use of the complete 0-100 rotation of the dial for the broadcast portion.

CONDENSER vs. TWO-BUTTON MICROPHONES*



If cost were no consideration, all engineering questions would be decided purely on the basis of technical merit. Cost, however, is almost always a determining factor—a fact which has considerable influence on the choice of microphones for many purposes. Until the present time, the higher cost of the condenser type transmitter has resulted in the placement of two-button carbon microphones in innumerable installations where the condenser microphone would have produced far superior results.

The recent development of a quality condenser microphone in the same price bracket as the best two-button carbon type instruments, now makes it possible to base microphone selection on the particular features of each individual sound installation.

Both condenser and carbon microphones have been known since the early days of the telephone art. Each possesses definite advantages and disadvantages due to the widely different basic principles. As a result, each has a fairly well defined though overlapping field of application. The purpose of this article is to compare the characteristics and features of each type as an aid to the sound engineer in the selection of the proper microphones.

Operating Principles

The carbon microphone depends for its operation on the varying resistance of a carbon element or button cell in accordance with the sound pressure against the diaphragm. A local battery causes current to flow through the carbon element. As the pressure on the diaphragm fluctuates due to the sound waves in the air, corresponding fluctuations in resistance occur in the carbon which thus changes the battery current through the circuit. The resulting current may be considered as the sum of a steady d.c. component, plus an a.c. component which is an electrical replica of the sound pressure variations. Usually this current is caused to flow through the primary of a transformer and the variable component produces an alternating speech voltage in the secondary which may be impressed on the amplifier or line.

Two forms of the carbon microphone are prevalent, the single-button and the two-button or "push-pull" type. The conventional telephone transmitter is somewhat similar to the single-button microphone—so called because the device contains only a single carbon element on one side of the diaphragm.

The carbon element, or button cell, is composed of several thousand small granules which are specially prepared from a selected grade of anthracite coal by a complicated process involving heating and screening. These granules are confined in a cup-like chamber resting against the center of the diaphragm. As the diaphragm moves in toward the button, the granules are compressed thus reducing the resistance and increasing the current flow. When the rarefaction or low-pressure portion of the sound wave reaches the diaphragm, the diaphragm moves away from the button and reduces the pressure on the granules. This increases the resistance and causes the current to decrease through the circuit.

The two-button microphone likewise operates by changing circuit resistance, but there are two carbon elements, one on each side of the diaphragm. These elements operate exactly out of phase, thus providing an electroacoustic push-pull arrangement in which all the even harmonics generated in the microphone itself cancel out, if the circuit is reasonably well balanced. A transformer with a primary center tap is of course necessary to complete the balanced circuit.

The special advantage of the push-pull system lies in the fact that it at least partially corrects for the non-linearity of the sound pressure-current characteristic. This is almost exactly analogous to the case of push-pull vacuum tubes which may individually operate on somewhat curved characteristics without appreciably distorting the output. Naturally, no such effect is possible with the single-button microphone.

High grade two-button microphones are provided with air-damped stretched diaphragms in order to obtain a uniform or flat transmission-frequency characteristic. The metal diaphragm will resonate at a certain frequency determined by its mass and tension just as the pitch of a musical string depends on its size and the extent to which it is stretched. This diaphragm resonance increases the output of the microphone at the resonant frequency and introduces a peak into the response curve, causing over-emphasis of that portion of the musical scale or frequency. Consequently, it is necessary to stretch the diaphragm until the resonant frequency is placed at the upper end of the audible frequency range. The amplitude of the resonant peak is reduced by air damping. This is accomplished by providing a damping plate placed very close to the diaphragm. The air space next to the plate cushions the diaphragm and contributes a mechanical resistance which has the effect of extracting energy from the diaphragm when vibrating at high frequencies. The result is similar to the effect of introducing resistance in an electrically resonant circuit.

It is obvious that the output level of a carbon microphone depends on the amplitude of vibration of the diaphragm. The stretched diaphragm of the two-button microphone limits the motion to rather small excursions and hence the microphone output level is relatively low. This is compensated by additional gain in the amplifying system. On the other hand, the diaphragm of the single-button microphone is arranged to permit considerable motion since the device is intended to produce relatively high output levels. The low diaphragm tension, however, places the resonance well down in the frequency scale so that the fidelity characteristic is inferior to that of the stretched diaphragm type instruments.

The condenser microphone operates on a radically different principle. If a condenser of varying capacity is connected to a source of potential, the charging current will vary in accordance with changes in capacity. The diaphragm of the condenser microphone constitutes one of the plates of the variable condenser, while the back plate, which is separated from the diaphragm by a film of air about one one-thousandth of an inch thick, acts as the other plate. The condenser microphone is in reality a variable air condenser, the capacity variations being produced by the changing distance between the diaphragm and the back plate as the diaphragm vibrates in response to the sound pressure fluctuations before it. The capacity of the condenser thus formed is approximately 200 micromicrofarads and the maximum variation in capacity is only about 0.01 per cent. Once the condenser is charged, no current will flow in the circuit as long as the capacity remains constant. If the capacity increases, the condenser will be capable of holding a greater charge, and a charging current will flow until the greater charge is accumulated. Similarly, the condenser must lose a portion of its charge if the capacity decreases and this produces a flow of current in the opposite direction until equilibrium has been established. Due to the minute changes in capacity which take place during the normal operation of the condenser microphone, the variable charging currents which flow are extremely small, with the result that the condenser element itself has a very low order of sensitivity as compared with other microphones. Obviously, the lower output must be compensated for by the use of additional amplification.

For a number of reasons, it is not feasible to lump all of the necessary gain in the main amplifier of the sound system. In the first place, it is not practical to transmit such minute currents as are produced by the condenser element over lines of any appreciable length due to the probability of inductive interference. It is thus necessary to amplify the signal level close to the point of origin so that any stray interference will be negligible. Secondly, the capacity shunted across the condenser element must be kept down to an absolute minimum or the output will be reduced and the higher frequency components highly attenuated. The most practical solution of these difficulties is to incorporate an amplifier as an integral part of the microphone assembly. As a result, the connecting leads between the element and the grid of the first tube are only a few inches long at most and the lead capacity and exposure to noise field are practically eliminated.

The head amplifier consists of one or more stages with sufficient gain to bring the signal level up to approximately that of a two-button microphone. Batteries are usually employed as the source of the polarizing voltage for the condenser element and for filament and plate supply for the amplifier tubes. This is to obtain the ultimate in quiet operation, although by careful design and the use of heater-type tubes, it is possible to construct a satisfactory power supply unit operating from the A.C. line. It is not necessary that the batteries or power supply be located close to the amplifier; the usual practice is to locate them out of the way, connections to the amplifier being completed through the same multiple-conductor cable which carries the amplifier output line. The final stage of the head amplifier is provided

* Reprinted from the Shure Technical Bulletin.

with an output transformer. Frequently the secondary of this transformer is wound in two sections which may be paralleled for 50-ohm output or seriesed for 200 ohms, both of which impedences are frequently encountered in mixer or speech-input circuits.

The condenser microphone diaphragm is made of a special alloy metal approximately one one-thousandth inch thick, which is thinner than the material used for carbon microphones. This provides the optimum combination of sensitivity, uniform frequency response and mechanical strength. The principles of air damping and stretching have already been discussed in connection with the two-button microphone.

With these principles in mind, we can now proceed to compare the two types of microphones as to characteristics which have a bearing on the selection of the most suitable type for the sound system.

Output Level

Most high quality two-button microphones produce on the average an output level lying between -30 and -50 db when operated under the usual pickup conditions. For the purposes of this article, the reference level is assumed to be 6 milliwatts (0.006 watts). The output level, however, depends on the condition of the buttons, on the button current and, of course, on the actual value of the sound pressure.

As explained previously, condenser microphone amplifiers are usually designed so that the output of the transmitter-amplifier system is about the same as for the two-button carbon microphone. In some cases, sufficient gain is provided to raise the output level above that of the carbon type transmitter. A representative value may be taken as -30 db.

Fidelity

The response curves of high quality condenser and two-button carbon microphones show practically negligible differences in frequency characteristic. This is largely due to the fact that stretched, air-damped diaphragms are employed in both types of transmitters.

Frequency characteristic curves on microphones seldom portray the true performance under working conditions. There are a number of reasons for these discrepancies. Tests are generally made under standard acoustic conditions and these conditions are almost never duplicated in actual practice. For instance—the results obtained from measurements when the microphone and sound source are located in an acoustic transmission line or "tunnel," would hardly hold for the case of a microphone located in free space. It is never possible to assume that a variable frequency sound source of constant pressure will deliver a constant sound pressure at the microphone diaphragm, for reflection, absorption and resonance due to surrounding acoustic conditions always introduce an unknown element. It should be remembered, however, that the human ear, if it were located at the pickup point, would likewise sense the effects of the acoustic conditions, so that these facts in no way imply improper functioning of the microphone itself.

The single-button microphone is intended for applications where high output is more important than a uniform frequency response. The response range is much more restricted and there is usually a diaphragm resonance peak rather low in the frequency scale. Hence the device is suitable in connection with headphones which in themselves are not capable of wide range reproduction, but would not be satisfactory on high quality systems for loudspeaker reproduction of music or voice.

Noise

All carbon microphones produce some "hiss" or carbon noise. In well designed microphones, the "hiss" has a very low level, but it is always present to a greater or lesser degree. Part of the noise is due to thermal agitation inside the carbon granules, but the greatest noise disturbances are caused by local heating where the granules are in contact. As current passes through the button, some heat is produced which tends to drive gas out of the more or less porous surface of the granules. This results in random variations in the resistance of the button, giving rise to a non-periodic noise. This noise lies principally in the upper portion of the frequency range.

The condenser microphone is almost entirely free from background noise, for there are no variable contacts such as those in the buttons of the carbon transmitters. The principal sources of noise in the condenser microphone are found in electrical leakage between back plate and diaphragm, dirt or foreign matter in the air gap, thermal agitation in resistors in the amplifier circuit and tube noises. By careful design, the noise level may be reduced to a value far below that of the carbon microphone. This is one of the principal advantages of the condenser microphone, and is a feature which has been responsible for the widespread use of the instrument in sound recording work.

Permanence of Calibration

For many purposes, such as in acoustic measurements, it is very important that the transmission characteristics of the microphone remain constant over long periods of time. While the two-button carbon microphone has been developed to a high state of perfection, the inherent nature of all loose-contact devices results in some degree of instability. Under certain conditions, the granules may cohere with consequent reduction in the resistance of the buttons and loss of sensitivity. Excessive current may cause burning of the diaphragm or granules with attendant loss of sensitivity. The carbon granules also tend to age with use, manifested by an increase of resistance and loss of sensitivity. Aging is due to abrasion of the surface of the granules or a relative displacement of the particles due to vibration or mechanical shocks.

The condenser microphone is not subject to any of the above shortcomings, and retains its sensitivity and frequency response characteristics over long periods of time. Aging of the tubes of course modifies the amplifier gain, but this takes place so slowly that it is not of importance. It might be mentioned that special compensation for differences in barometric pressure is essential in maintaining the separation of the diaphragm and back plate constant under all conditions. In well designed condenser microphones, this feature results in equalization of the normal

(Continued on Page 44)

The A-B-C of Modulation

(Continued from Page 15)

latter type of modulation has been found to be very satisfactory, and if properly constructed and adjusted the above-mentioned troubles can be eliminated.

Modulation methods that vary the direct current input to the radio-frequency amplifier tubes can be operated on either the r.f. tube's grid (grid modulation); its screen grid (screen grid modulation); its plate circuit (plate modulation), or a combination of either the grid and plate, screen-grid and plate, etc.

Grid modulation is accomplished by varying the mean grid bias on the tube and thus affecting the plate resistance and the power output of the tube. The mean grid bias on the tube is varied by impressing simultaneously, on the grid of the tube, both the radio-frequency input wave and the audio-frequency impulses from the speech amplifier. The audio-frequency power requirement is relatively low, but the relation between grid-bias variation and radio-frequency output is linear over but a small part of a tube's characteristic curve, with the result that distortionless modulation is limited to approximately 35 per cent when using a single modulated amplifier. However, if two tubes are used in the modulated r.f. stage and biased to operate under similar characteristics to a Class B audio power output stage, great power can be obtained with distortionless modulation in excess of 100 per cent. (This system will be discussed at great length in the fourth article of this series).

Screen grid modulation is accomplished by varying the mean potential of the accelerator grid of tetrode transmitting tubes. It is very much similar to grid modulation in its characteristics, but greater power is required for the speech amplifier and the relation between the screen voltage and power output is not a true linear curve. However, with a screen-grid r.f. amplifier tube, excellent modulation characteristics can be secured by using a combination of both screen-grid and plate modulation by the Heising Constant Current System. (This will be discussed in the third article of this series.)

Finally, we have plate modulation. This is accomplished by varying the mean plate potential of the modulated r.f. amplifier. Parallel plate modulation, or constant current modulation (better known as Heising modulation), is the most commonly used of all types of modulation systems. It has the great disadvantage that the speech amplifier must operate at a very high volume level and the modulator tubes must have exceptionally high undistorted audio power capacities. The tubes are very expensive, and here lies the greatest disadvantage of plate modulation. Since the advent of Class B audio systems, the cost of tubes for the same power is greatly reduced, but the increase in the cost of Class B audio transformers and components (not to speak of the inherent instability and lower quality of Class B) has not eliminated the disadvantages of plate modulation. Don't be misled, however, because plate modulation has its many advantages, such as high quality (when properly adjusted), high carrier output and great stability.

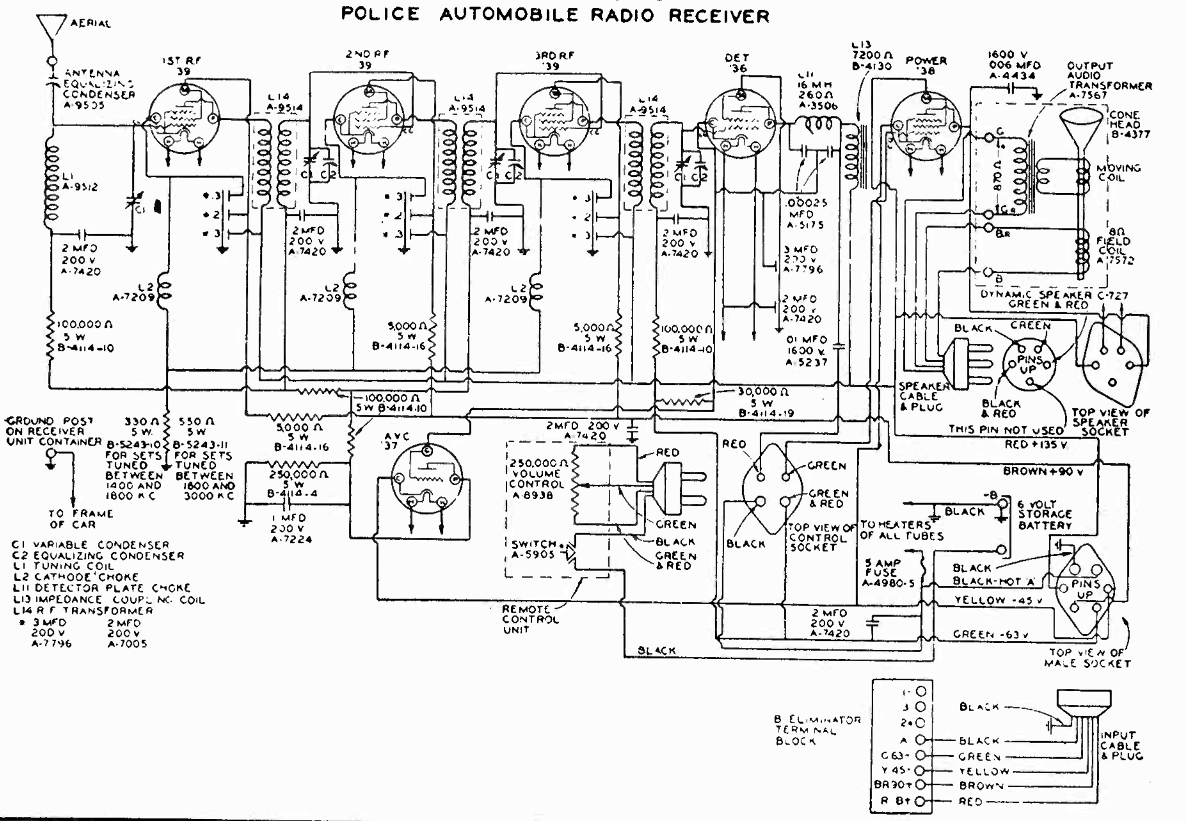
Modulators and Modulated Amplifiers

An explanation of Class A, Class B and Class C amplifiers is timely. A Class A amplifier is one that operates so that the plate output wave is essentially the same (except in amplitude) as the exciting

(Continued on Page 44)

Circuits and Descriptions of Factory Receivers

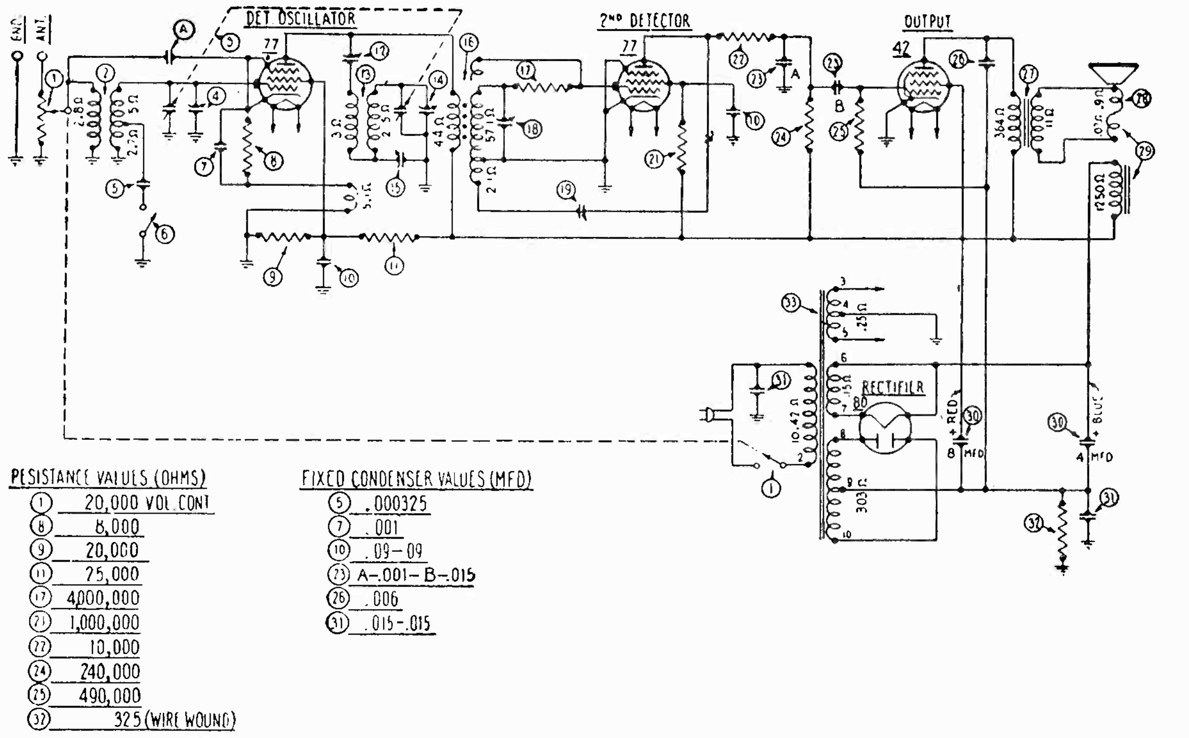
SPARTON MODEL 43
POLICE AUTOMOBILE RADIO RECEIVER



Sparton Model 43 Police Auto Receiver

THIS model is designed especially for the reception of police signals and was designed from practical experience with police and sheriff's departments. Sparton is the most widely used police receiver. They are of the trf type, as this circuit has proved more reliable than superheterodynes for police automobiles. Road and weather conditions sometimes effect the adjustment of I.F. transformers in a super. The new Sparton model uses delayed automatic volume control, the only kind that will prevent paralyzing the receiver when heavy burst of static or other electrical discharges occur, as are often encountered in city driving. The Model 43 has a calibrated scale and can be set for any frequency between 1500 and 3000 kc. It automatically locks in place when set. "B" supply is furnished by a motor generator which is standard equipment. The r.f. coils have large shield cans, with heavy copper shields. This heavy double shielding reduces engine or other interference. The antenna is coupled to the receiver by a variable condenser. The receiver employs 3 stages of high gain r.f. and the tubes are biased to permit low "B" consumption.

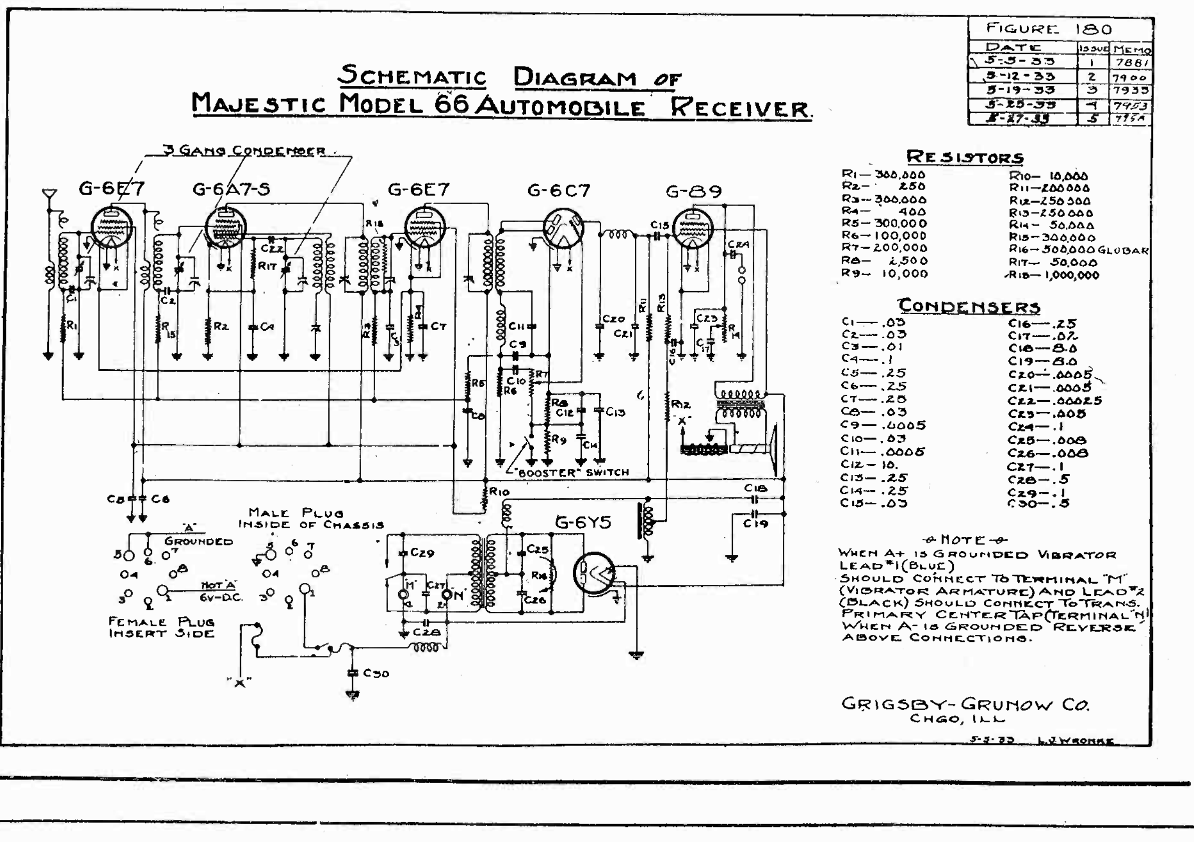
Tubes used: 3 type 39, one 36, one 37, one 38. Battery drain at 6 volts; tubes, 1.8 amps.; dynamic speaker, 0.7 amp.; "B" eliminator, 2 amps.; total, 4.5 amps.



NOTE (A)—This capacity obtained by pair twisted wires

Philco Model 57 4-Tube Superheterodyne

THIS receiver combines standard broadcast and police reception and employs the new Philco tubes with pentode output. The same superheterodyne circuit is used for standard broadcast and police reception. The intermediate frequency for tuning the I.F. transformers is 460 KC. The power consumption of the receiver is 46 watts. It uses the following tubes: 77 detector-oscillator; 77 second detector; 42 output; 80 rectifier. 235 volts on the plate of the power tube. 6.3 volts for all tube filaments.



Majestic Model 116 Auto Radio

THE CIRCUIT—The Majestic Model 116 is a six-tube superheterodyne with dual operation of two of the tubes. The tubes used in the various stages are as follows: First detector and oscillator, G-57A-S; first intermediate frequency amplifier, G-58A-S; second intermediate frequency amplifier, G-58A-S; second detector and first audio frequency amplifier, G-75; output audio amplifier, G-89; and full-wave rectifier, G-6Z5. For protection to the radio receiver and the car battery against any possible damage due to shorts or grounds, both the primary circuit of the "B" supply, and the tube filaments and field coil circuit have a ten ampere fuse in series with them. These two fuses are located on the control unit.

AUTOMATIC VOLUME CONTROL—It is equipped with an automatic volume control system which does away with blasting and fading.

This is accomplished by the space current drop of the G-75 diode detector plate circuit across a resistor, the negative potential of which is applied to the grid of both the intermediate frequency amplifiers to control their amplification.

THE DURO-MUTE POWER SUPPLY—The Duro-Mute Power Unit is composed of a transformer and a vibrator assembly unit which supplies the high voltage necessary for the efficient operation of the receiver.

The efficiency of this assembly is greatly increased inasmuch as the vibrator assembly unit itself is mounted directly over the transformer and receives its magnetic impulses from the core of the transformer making it unnecessary to provide additional excitation for the vibrator, thereby increasing its percentage of efficiency to a high degree.

The vibrator is so designed that when connecting to the battery, it is not necessary to consider the polarity of the battery of the car in which the radio is to be installed.

A special rectifier tube is employed in the rectifier system and is of the 6.3 volt heater type.

Technical Data On Model 66 Majestic Auto Radio

THE circuit is largely conventional but has some unique features. It is a superheterodyne using an intermediate frequency of 175 K.C. The circuit sequence is as follows: One stage of tuned radio frequency amplification, composite modulator and oscillator, one stage intermediate frequency amplification, diode detector, one stage of low level audio amplification followed by the power output stage. Full automatic volume control on three tubes is obtained resulting in an excellent characteristic with respect to input signal voltage.

DELAYED AUTOMATIC VOLUME CONTROL

The audio detection and Automatic Volume Control are obtained from the diode circuit by the "delayed rectification method". In this method the diode plates operate at somewhat negative bias so that no A.V.C. results until a certain signal level has been reached. This results in much higher outputs at low signal levels than in the ordinary methods of A.V.C. since the set is left in its most sensitive condition until reasonable power output has been obtained. In the old methods of A.V.C. any input signal at all starts to decrease the sensitivity of the set.

TUBES

The G-6E7 used as a radio frequency and an I.F. amplifier is a screen grid tube of characteristics somewhat similar to the type G-58 used in home receivers. It is spray shielded and the spray is connected by itself to one of the prongs of the base. This allows the shield to be directly connected to ground rather than to the cathode as heretofore. This is a definite advantage since when the spray is connected to the cathode it must be carefully insulated from the chassis pan in most cases, due to the fact that the cathode is not operated at ground potential.

The G-6A7S used in the composite detector-oscillator position is the new Pentagrid converter recently developed. This tube presents definite advantages over tubes previously used in this service, in that the automatic volume control may be allowed to operate on it, thereby allowing a far better degree of control than heretofore.

The G-6C7 is a double diode triode similar to the G-55 and G-75 types but having an amplification factor intermediate between them. It has the advantage over the G-55 of having considerably more gain and has none of the power handling deficiencies of the G-75.

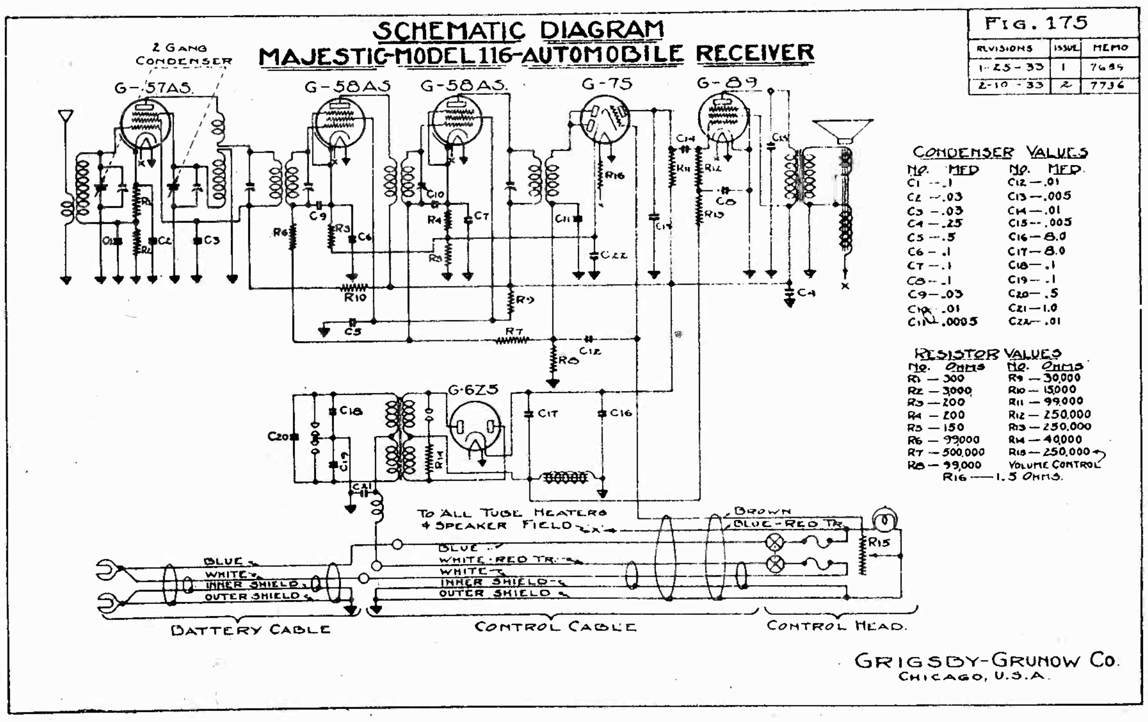
The G-6Y5 rectifier tube is a full wave, spray shielded, mercury vapor rectifier. Its use materially cuts down the amount of high frequency interference between the "B" supply and the receiver.

"B" SUPPLY

The MAJESTIC Duro-Mute vibrator as used in the Model 116 series has been re-developed and enlarged to handle adequately the power demands of the receiver.

The vibrator head and transformer are enclosed in two rectangular cans with a one-quarter inch thick sponge rubber between them. These cans serve as a double electrical shield and the rubber insulation serves to dampen the mechanical "buzz" to a negligible level. All parts and circuits associated with the eliminator are completely shielded from the radio set proper by the use of partitions and covers.

On earlier receivers using interrupter "B" supplies, it has been necessary to protect the vibrator during the starting period when arcing is prevalent by the use of spark gaps, relays, or other trick devices of this nature. There are definite disadvantages to all of these methods. The power supply system used in the Model 66 overcomes this difficulty in a unique fashion. A special resistance unit is shunted across the secondary of the output transformer. This has the property of changing its resistance as the voltage applied across it is varied. At a voltage of 500 volts, the resistance is approximately 500,000 ohms, while at 2500 volts, the resistance decreases to about 2500 ohms. In this manner the exceedingly high peak voltages which occur during the starting period of operation are effectively reduced, since at these voltages the unit is low in resistance. After the receiver is in an operating condition and drawing its normal load, the peak voltages are low and the unit presents a very high resistance to the flow of current through it.



AC9GH—By COL. CLAIR FOSTER

YOU go up the Yangtse River 600 miles from Shanghai. The Yangtse is quite a stream; even away up at Hankow it is a mile wide. Then you take a small steamer up to Yo Chou and on into Tung Ting Lake. You cross the lake—about forty miles. Then you take a still smaller boat up the Changsha River about forty miles. You finally come to Changsha with its surroundings of low hills. You will go out to "The Island," sometimes spoken of as "Yale in China." By now you are away back in the Province of Hupeh. Look it up on a map; and when you see how far you are from the safe haven of Shanghai you won't be tempted to spell it "Whoopee."

Here there is a mission where the Chinese are taught one of the countless ways of getting to Heaven. The Chinese have a well-worn path of their own that they have been using for thousands of years but we Americans are determined to show them some of the new trails we have blazed. Nobody has come back from Heaven to report which of the many trails is the best. However, each trail-blazer sincerely believes that his is; and he backs his conviction with zeal and work and self-deprivation that brings the missionary himself, at any rate, closer to God. In this mission resides and labors one Harold L. Graham, a cultured and versatile American, who is known widely to radio amateurs as AC9GH.

Now take a mental voyage in another direction from Shanghai. Sail 500 miles northward in the Yellow Sea to the Shantung Peninsula. Around the point of this land and about 80 miles in the direction of Peking you come to a bay and the city of Chefoo. Here dwells another well-known amateur, Dr. William Malcolm, AC3MA, who has been for years the port physician of Chefoo. In several notable crises AC3MA has been Chefoo's only contact with the outside world. I have copies of letters of grateful appreciation writen to Dr. Malcolm by high officials of the British, French and other governments. In due course RADIO will give you the story of this Canadian doctor who converses by radio with his many friends in various parts of the world when he is not ministering to suffering humanity.

One of his friends (and mine), is Graham, AC9GH. Graham has been in radio only about five years. He entered the game through reading of Malcolm's working the Portuguese cruiser, "Adamaster," at 1200 miles by keying the howling oscillations of his receiver. Graham, through this outstanding performance of Malcolm's became the first missionary "ham" and the first amateur to get on the air in the interior of China. With his low-power CW set he has worked 40 countries and all continents. With his flea-power fone set (using a 47 crystal oscillator and a 46 amplifier, modulated by a 227 followed by another 46, all with current from two 6-volt batteries), he has held successful voice conversation all over China.

Graham last winter had an interesting adventure. He is one of the few amateurs who dislike to talk in the first person. But he did give an outline of the occurrence to Malcolm and Malcolm is permitted to relate the story. We'll let him tell it in his own words.

Dr. Malcolm speaking:

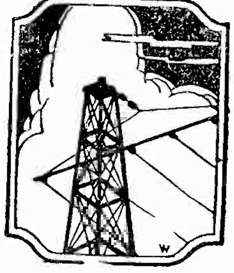
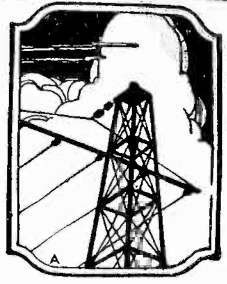
"An American company in Shanghai sold a transmitter and receiver to the Chinese Governemnt for use in far-off Ko-Ko-Nor, in Thibet, where there was fighting in progress between the Chinese and Thibetans. The manufacturers sent an engineer with the outfit to put it into operation. This man was unable to make the transmitter function. He returned to Shanghai and another engineer was rushed up by airplane. This second man labored with the set for several weeks without making it work. Whereupon the military chieftain, a Mohammedan general, threw the engineer into gaol with the laconic ultimatum, 'When machine work you come out.' The ways of the Oriental are inscrutable to the Western mind. One would think that if the engineer could accomplish nothing out of gaol he could do less in. But while the engineer was inefficient as a radio man he made a perfectly good hostage. He sent a frantic wire back to Shanghai describing his troubles and ending with, 'Don't send an expert; send a practical man.' The general manager bethought himself of Amateur Graham in Changsha, already far in the direction of Thibet, and entreated Graham to undertake the trip.

"The man of peace departed on his errand of war. The trip was made in the dead of winter, calling for extra-heavy clothing, topped off with flying-suit and helmet. Graham had to travel four days by train and one by plane, followed by two days of hard going by motor car over old camel trails. The journey was uneventful except for the trifling incident of getting stuck in the snow on a mountain pass 13,000 feet above sea-level. On arrival at Ko-Ko-Nor the positive and negative high-tension leads were found reversed, a transformer burned out, the antenna so arranged that it couldn't have functioned anyway, and the set haywire in a few other departments. The set really was in no worse condition than the goal reserved by the Chinese general for radio experts.

"Graham virtually rebuilt the station.

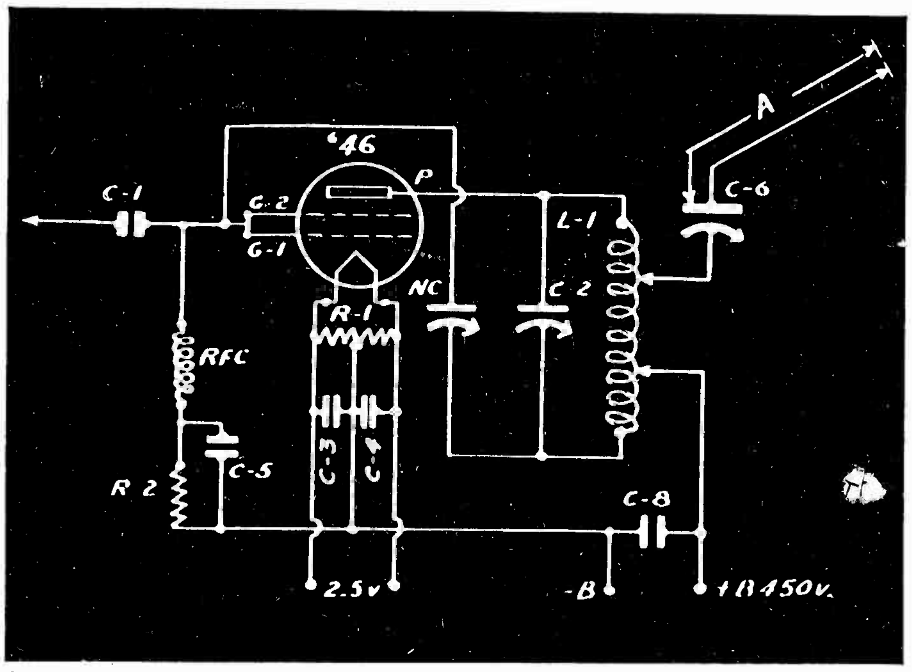
(Continued on Page 41)

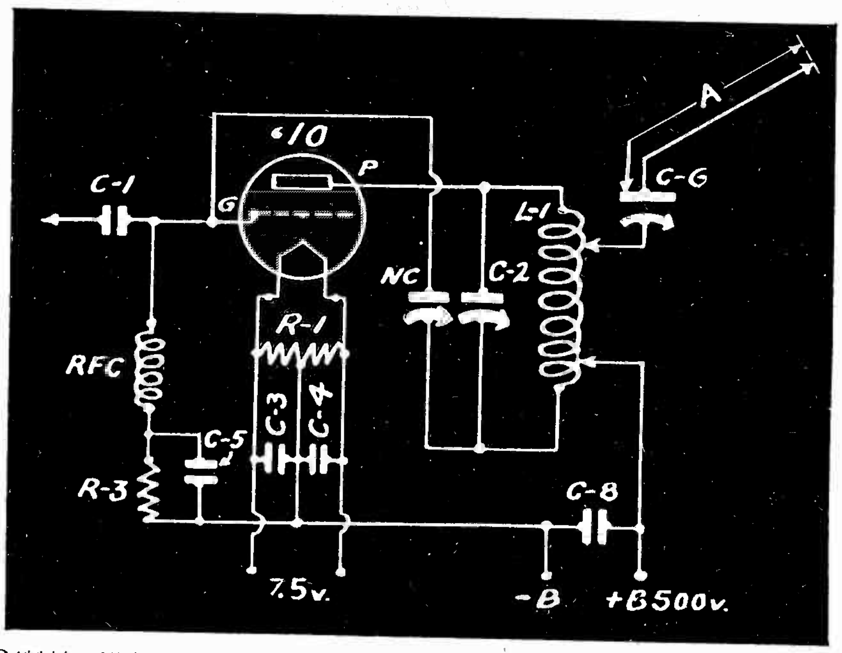
for The RADIO NOTE BOOK

Buffer Stage Circuit Diagrams Showing the 46, 47, 210 and 865. Next Month's Note Book Page Will Bring You Another Group of Interesting Circuits.

LAST month's RADIO NOTEBOOK page gave circuit diagrams and list of parts required for four types of Crystal Oscillators. Anyone of these oscillators can be used to "feed" any one of the four types of BUFFERS shown in the circuit diagrams below. When fed by an oscillator the buffer serves as an AMPLIFIER, if no additional stage is added to the buffer. In short, an oscillator and a buffer comprise a two-tube transmitter, the buffer serving as the output, or amplifier stage. But when another stage is added to the buffer, the buffer serves as a "blocking stage" to prevent the r.f. current from the amplifier from feeding back into the oscillator. The 865 buffer stage, shown in one of the diagrams below, uses a special screen-grid tube. This tube is excellent for use in a buffer stage but is not well adapted for use as an amplifier. The '46 and 210 buffer stages should be used if the transmitter is to feed the antenna direct from the buffer stage. The advantage of the 865 as a buffer is its ease of neutralizing, no neutralizing condenser being required when this tube is used. On the other hand, the 865 is an expensive tube and for this reason is but little used. Greatest power-output, if a buffer is used as an amplifier in a low-power two-tube transmitter, is attained when the 210 tube is used, fed by a 47 or 59 oscillator. The neutralizing condenser, for any of the circuits shown below, can be an ordinary receiving-type 13 plate midget variable, or a larger-plate condenser with from 5 to 7 plates. The grid and plate leads in all circuits should be short and direct. The plate coil can usually be secured directly to the plate condenser. Next month's RADIO NOTEBOOK page will show four types of DOUBLERS. Radio-telephone circuits will be shown in a later issue.





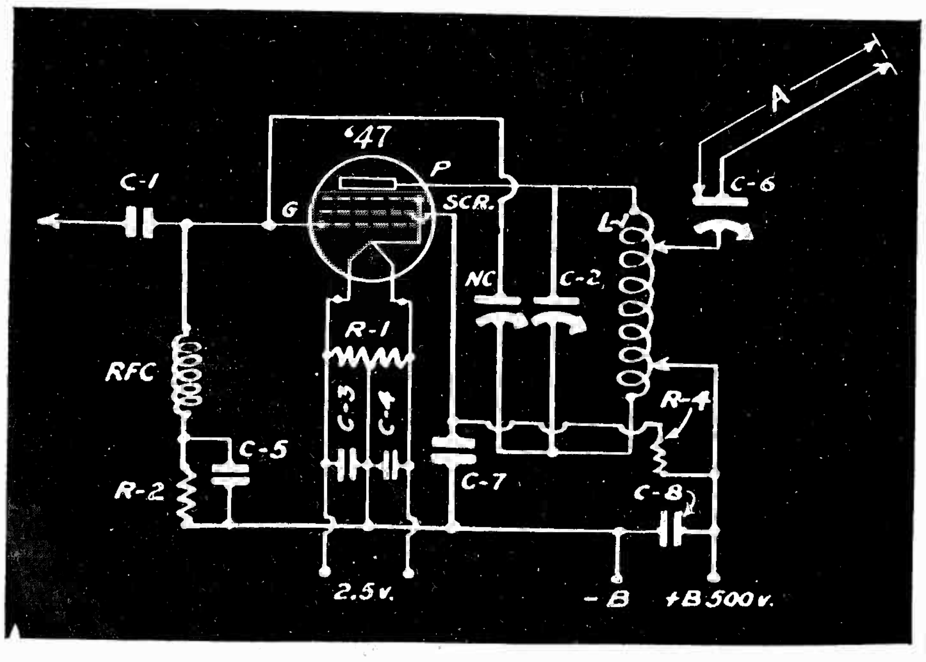
UPPER LEFT: '46 Buffer Stage. UPPER RIGHT: '210 Buffer Stage.
LOWER LEFT: '47 Buffer Stage. LOWER RIGHT: 865 Buffer Stage.

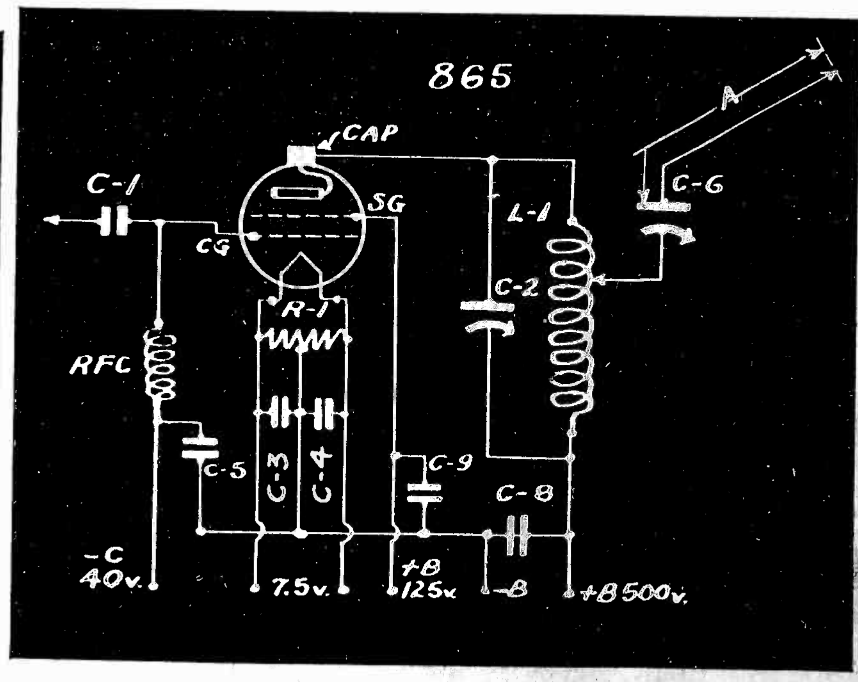
The condenser and resistor values are the same for each circuit, except as otherwise noted.

A—Antenna.
L1—Plate Coil.
C1—.0005 mfd. fixed mica condenser.
C2—.0001 mfd. to .00035 mfd. variable condenser (receiving type).
C3, C4—.002 mfd. fixed mica condenser.
C5, C7†, C8, C9*—.01 mfd. fixed mica condenser.
C6—.00035 mfd. variable condenser (receiving type).
NC—Neutralizing condenser, 13 plate midget variable receiving type or 5 to 7 larger-plate receiving type.
R1—20 ohms, or larger, center-tapped resistor (if filament winding of transformer has no center-tap).
R2**—10,000 ohm, 50-watt resistor.
R3***—20,000 ohm, 25-watt resistor.
R4****—25,000 ohm, 10-watt resistor.
L1—Plate coil, 20 turns No. 14 enameled wire, wound on 2-in. diameter form, with tap taken at 3rd turn from lower end of coil.
RFC—Transmitting-type r.f. choke coil.

A separate "C" voltage supply is advisable when the 865 tube is used. Ordinary "C" batteries are best suited for the purpose. The positive "C" terminal of the batteries is connected to the negative "B" lead of the buffer circuit. The screen-grid cap at the top of the 865 tube is the PLATE terminal, the control grid and screen grid connections being brought to the tube prongs.

* C-9 is used only in 865 Buffer circuit.
** Used only in 46 Buffer circuit.
*** Used only in 47 and 210 Buffer circuits.
**** Used only in 47 Buffer circuit.
† Used only in 47 Buffer circuit.





QUESTIONS FREQUENTLY ASKED ABOUT

SUPERHETERODYNES

ANSWERED IN UNDERSTANDABLE TERMS

QUESTIONS ON VARIOUS SUBJECTS WILL BE ANSWERED EACH MONTH

By The Technical Editors

Question—How do detectors used in modern superheterodynes differ from those used in early receivers?

Answer—The early superheterodyne receivers generallv used grid-leak detection. Next came "power" or "plate-rectifier" detection using three-electrode tubes or "triodes." The latest detectors use two electrodes for either half- or full-wave detection and are called "diodes." They permit high undistorted power output.

Question—When receiving a radio-telephone signal in a superheterodyne, is the modulation originally present in the carrier retained in the intermediate frequency circuit?

Answer—When a modulated carrier is received and passed through the mixer tube to the intermediate frequency amplifier the intermediate frequency is modulated exactly as was the carrier frequency. However, if continuous-wave telegraph signals are being received, they will generally remain inaudible in the second detector output circuit unless they are heterodyned by a suitable beating oscillator which is tuned to the intermediate frequency plus or minus the audio-frequency beat-note desired. The second detector converts the incoming signal, which has first been converted by the mixer, amplified in the I.F. stage and heterodyned by the beating oscillator, into an audio-frequency signal which may be heard in the speaker or headphones as telegraph symbols.

Question—How is image frequency interference eliminated in a super-heterodyne receiver?

Answer—By providing great selectivity in the radio-frequency stages functioning at the frequency of the received signal (pre-mixer) and in the mixer circuit. This may be accomplished by using loose coupling between stages in the "pre-mixer" amplifier. Another method is to use a tuned "rejection" circuit tuned by a variable condenser operated by the main tuning control. This rejection circuit is so designed that it will at all times be tuned to a frequency differing from the received carrier frequency by twice the intermediate frequency. The rejection circuit is placed in the grid circuit of the radio-frequency amplifier tube and "rejects" or offers a high impedance to the passage of a signal differing from the desired signal by twice the intermediate frequency.

Question—Whv do modern super-heterodyne receivers generally feed from the second detector plate directly to the grid of the power tube without the intervening audio-amplifier stage generally used in early receivers?

Answer—The plate rectifier detector, with properly biased grid, provides a useful audio-frequency output of several volts. This is usually high enough so that the second detector tube will swing the output tube grid sufficiently to give a good audio signal in the output device. This eliminates the need of the formerly-used extra stage of audio-frequency amplification which often gave trouble due to high hum level, microphonics, feed-back, etc., and which also required additional apparatus and equipment. With "diode" detection, such as that used in the very latest receivers, enough audio-frequency output is available to permit elimination of an intervening audio stage. However, some receivers do employ a first audio stage which is incorporated in the "diode-triode" type of tube which also serves as the second detector.

Question—Whv, in a superheterodyne, with all its sharply-tuned resonant circuits, is there no cut-off of the higher audio-frequencies due to filter action with the poor quality which would naturally result therefrom?

Answer—Such cut-off occurs in improperly designed receivers, both radio-frequency and superheterodyne. In the superheterodyne, the performance is usually considered satisfactory if the selectivity permits reception of signals within 10 K.C. of each other. The actual selectivity depends upon several factors such as the decrements of the tuned circuits and the coupling between stages. However, the attenuation at the signal frequency of the higher modulation frequencies is not great enough to adversely effect the quality beyond permissible limits. Serious distortion may be prevented by slightly broadening the tuning of the circuits or by using a "band-pass" tuning system in the high-frequency amplifier. The same problems occur in the intermediate frequency amplifier and here the reaction between tuned coupled circuits may be made to provide the necessary broadening of tuning and without too much attenuation of the modulated radio-frequency signal. Alternatively, a band-pass system may be used and may be made relatively flat over a broad frequency range yet tuned sharply enough to prevent the passage of unwanted signals.

Question—Is it possible to build a tuned-radio-frequency receiver that will be as sensitive as a superheterodyne?

Answer—It might be possible to build such a receiver but the cost and difficulties of operation which would be introduced would make it less satisfactory than the superheterodyne. The chief difference between the two types of receivers is in the functioning of the detector circuits and their relative sensitivities.

A tuned r.f. receiver gives a response in the telephone or loudspeaker which varies as the square of the received signal strength while a superheterodyne, which acts as a continuous-wave receiver due to the inclusion of the oscillator tube, gives a loud-speaker response which is directly proportional to the received signal strength. The superheterodyne receiver rightly has received its popularity due to its ability to bring in weak signals louder and more satisfactorily than any other type of receiver yet developed. Its sensitivity and its high degree of selectivity make it the most reliable type of receiver for almost any purpose.

Question—Can a superheterodyne receiver be designed to eliminate interference between two distant radio stations which are operating on frequencies so close together that they beat with one another to produce an audio-freqneucy "whistle"?

Answer—Such interference cannot be eliminated in the usual type of superheterodyne because the selectivity of the tuned circuits is not sufficiently great to permit elimination of the unwanted station's carrier. Such an interfering signal can be eliminated by incorporating a quartz crystal in the intermediate frequency amplifier of a superheterodyne. Such a crystal will increase the selectivity to such an extent that the receiver will respond to a frequency band only a few hundred cycles wide, thus increasing the selectivity to the necessary degree. In such a receiver (the Stenode) a specially-designed audio-frequency circuit must be used to restore the tone quality of the received signal by giving over-emphasis to the higher audio frequencies to compensate for the attenuation of these frequencies in the preceding circuits.

Question—Why is the "Autodyne" or self-heterodyne not more widely used in superheterodyne receivers?

Answer—An Autodyne circuit is, due to its nature, detuned from the received signal by a frequency equal to that of the beat note desired. The response of the usual tuned circuit to a signal when it is detuned from the signal for example by 1000 cycles, which may be considered an average beat-note, is but little reduced. However, if the tuned circuit were adjusted to a frequency differing from the desired frequency by 175 K.C. (a common intermediate frequency) the response to the desired signal would be greatly reduced and poor sensitivity would result.

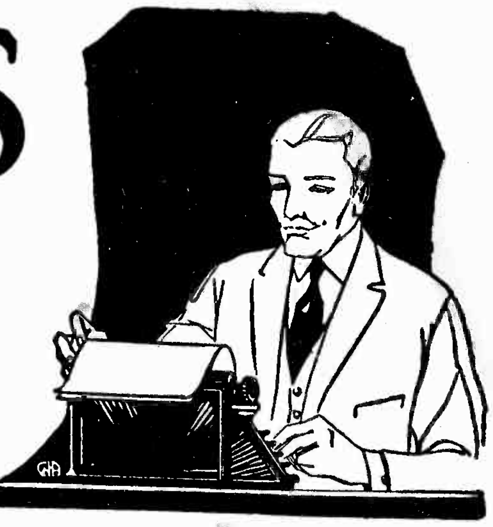
Question—Why have loop aerials, which were so popular with earlv superheterodynes, been generally discontinued?

Answer—Loop aerials were clumsy and unsightly and could not be readily mounted in the space generally available. The use of tuned-radio-frequency amplification ahead of the mixer tube also had much to do with the abandonment of the loop aerial. It would be difficult to design a large air-spaced loop-type inductor, due to its distributed and mutual capacity characteristics and other factors, which could be tuned by one section of a ganged condenser, such as is used in the modern receiver, and which would allow the loop circuit tuning to track with that of the remaining circuits controlled by the ganged condenser. The directive properties of the loop aerial, valuable for radio-goniometer service, make it impossible to receive signals from all directions with equal intensity without changing the direction of the plane of the loop.

Question—Would there be any advantage in building a superheterodyne with a push-pull intermediate amplifier?

Answer—No. The particular advantage of the push-pull amplifier is that it permits cancellation of certain harmonics which would be present in the output of a single tube. Such harmonics do not present a problem in the intermediate amplifier.

QUERIES *and* REPLIES



READERS ARE INVITED TO SEND IN THEIR QUESTIONS. THOSE OF GENERAL INTEREST WILL BE ANSWERED IN THESE COLUMNS.

Question—I have been told that heater-type tubes are better than filament-type tubes as audio-frequency amplifiers in high-quality systems because they cause less distortion. Please explain—**D.L.F., New York City.**

Answer—The superiority of heater-type tubes when used in speech-amplifier circuits is due to the fact that in this type of tube, sometimes called an "equi-potential-cathode" tube, the cathode is at a uniform potential with respect to the grid over its entire surface. In the filament-type tube the bias is taken as effective from the negative end of the filament. However, the effective bias varies along the length of the filament due to the voltage drop in the filament resulting from the flow of filament current through it. This variation in effective grid-bias along the length of the filament produces some distortion. Since there is no filament current flow through the emitter proper in the cathode-heater type of tube the effective bias is the same for all parts of the emitter and distortion due to variation in effective bias is eliminated. In heater-type tubes there are no disturbances set up in associated circuits due to transient variations in the filament (heater) current because the cathode is insulated from the filament and is heated only by heat radiated from the filament. It takes an appreciable time after current is started through the filament for the cathode or emitter to reach a temperature sufficiently high that it will supply the electrons which constitute the plate current. The relatively slow variation in cathode temperature with respect to variations in heater temperature allows the tube to be operated on an alternating current supply without the introduction of the relatively high alternating current frequency to the circuits associated with the tube. In other words, changes in heater temperature do not cause changes in electron emission in the cathode-type of tube as they would in the filament or directly-heated type of tube. Heater-type tubes are also considerably less microphonic and therefore less trouble is caused by shock or jar in a high-gain audio frequency amplifier using heater-type tubes in the preliminary stages.

Question—I have treated the inside of a radio cabinet with half-inch hair felt to try to get away from cabinet resonance, but it does not seem to help. What is best for use in a radio cabinet to correct such trouble.—**B.K.I., Macon, Georgia.**

Answer—Hair felt is generally unsuited for acoustical purposes except for reducing vibrations transmitted through walls and partitions. Hair felt absorbs most of the high-frequencies but does not absorb as many low-frequencies. Cabinet resonance is usually pronounced at the lower frequencies and felt padding will accentuate the trouble due to its absorption of the high-frequencies. Rock wool, Celotex, balsam wool or canec an inch or more in thickness when glued or cemented to the inside of a radio cabinet, especially when mounted on large unsupported flat surfaces, will usually materially better the tone quality of a broadcast receiver. The precaution is hardly worthwhile in the very small receivers which can be found on the market.

Question—I have heard that it is possible to use an interstage transformer as an output transformer by partly dismounting it and winding a new secondary. How can this be done for a dynamic speaker?—**K.J.F., Joplin, Missouri.**

Answer—An interstage trnasformer primary winding roughly matches in impedance the plate impedance of a tube. When the secondary winding is removed by cutting through the layers of wire one by one with a sharp knife a single layer of about No. 20 or 24 enameled wire can be wound over the primary. This new winding can be connected to the speaker and will allow the set to operate until a factory replacement can be obtained.

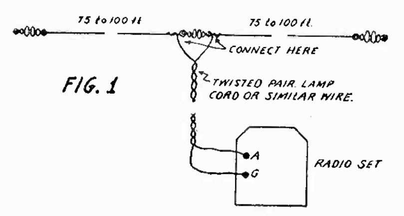


FIG. 1

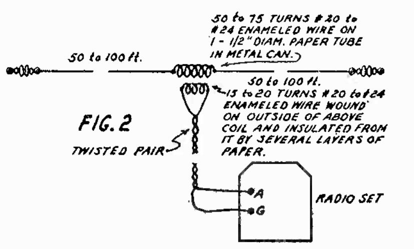


FIG. 2

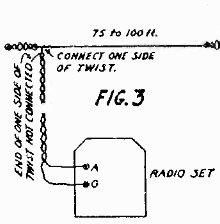
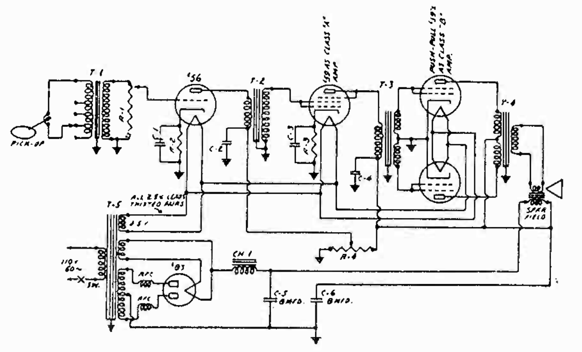


FIG. 3

Question—Please show diagram of an amplifier suitable for phonograph-record reproduction.—**F.L.S., Jacksonville, Fla.**

Answer—See accompanying diagram.



List of parts for Phonograph Amplifier:

- T-1 Transformer matching pickup impedance, and coupling to tube grid
- T-2 Interstage audio transformer
- T-3 "Class B" input transformer, to push-pull class B grids
- T-4 Output transformer
- T-5 Power supply transformer
- R-1 250,000-ohm tapered variable potentiometer
- R-2 Grid bias resistor, 1000 ohms, 2 watt
- R-3 Grid bias resistor, 1000 ohms, 2 watt
- R-4 20,000 ohms, with taps for 180 volts
- C-1, C-3 1/2 mfd. noninductive, 150-volt test
- C-2, C-4 1 mfd., 400 volts
- C-5, C-6 8 mfd. Electrolytic.

Question—Please show how I can reduce noises picked-up by my antenna. What can be used in place of transposition blocks where space is limited?—**J. B. F., Auburn, N.Y.**

Answer—An antenna consisting of two wires of equal length, each 75 to 100 feet, the far ends of which are supported by insulators and the near ends of which are brought to opposite sides of an insulator and connected at the center insulator to the two conductors of a "twisted pair," such as lamp cord, can be used to obtain quite satisfactory reception. The other ends of the conductors of the "twisted pair" will be connected to the aerial and ground posts of the receiver as indicated in the accompanying sketch, Fig. 1.

Another method is to connect the near ends of the two halves of the antenna to the terminals of a small coil and then to inductively couple the receiver to the antenna by means of another coil to which are connected the conductors of the twisted pair. This arrangement is shown in Fig. 2.

When the lead-in, or feed line will be very long and it is not possible to put up two long wires for the antenna fairly good results can be attained in some cases with a single wire antenna and a "twisted pair" lead-in with one of the "twisted pair" conductors left disconnected at the antenna end. When this arrangement is used interchange the antenna and ground connections at the receiving set to determine which order of connection gives the best results. This type of installation often helps to eliminate or reduce interference from motors and other local sources of noise.

Question—What is the reason that tubes that have been used as rectifiers in sound system amplifiers are unsuited for subsequent use as amplifiers?—**D.L.H., Austin, Texas.**

Answer—Some types of sound amplifiers used in theatre sound projection systems, notably the Western Electric 42-A and 43-A, employ the same type of tubes in both amplifier and rectifier positions. When used as rectifiers the grids and plates of the tubes are connected in parallel. When oxide filament tubes are used as rectifiers in this manner a considerable amount of electron-emitting material is deposited on the grids from the filament. This does not make any difference if the tubes are used as rectifiers exclusively. If, however, an attempt is made to later use these tubes as amplifiers distortion will be introduced into the system due to emission of electrons from the grids. Tubes which have been used as rectifiers should therefore not be used as amplifiers.

The Superheterodyne—Its Theory and Operation

A One Year Course of Instruction—Lesson Three

By D. B. McGOWN

WE ARE going to discuss four general types of receivers. The first of these is the simple **non-regenerative detector** with or without audio frequency amplification. The second is the **regenerative detector** with or without audio amplification. The third is the **tuned radio-frequency** type and the fourth is the **Superheterodyne.**

THE simplest type of tube receiver is the non-regenerative detector, consisting of a three-element tube together with circuits in which no provision has been made for return of energy from the output or plate circuit to the input or grid circuit. Such a receiver will allow the reception of modulated, or telephone, signals but cannot be used for satisfactory reception of code signals sent out by a transmitter such as that we have described. Such code signals would sound like a series of clicks and could not very well be interpreted. Hence we must provide some way of making such signals intelligible. This type of receiver is relatively low in sensitivity and cannot be used for satisfactory reception over long distances. The circuit for a receiver of this type may be represented by the diagram in Fig. 3. With such a receiver the telephone response will be proportional to the square of the signal strength. If the signal in the phones is to be twice as loud as the received signal must be four times as great. For double the telephone response from a given transmitter we would have to be located considerably closer to the transmitter since the signal strength from a transmitter varies inversely as the distance from the transmitter.

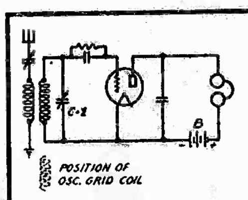


FIG. 3

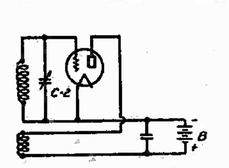


FIG. 4

NOW suppose we arrange a second vacuum tube in a circuit such as that in the diagram of Fig. 4. Here we have arranged for feed-back of energy from the output or plate circuit of the tube to the input or grid circuit by connecting a coil in series with the plate circuit and coupling it to the coil in the grid circuit. Such a tube system will oscillate or will act frequency of the currents generated by it can be varied over a considerable range by varying the capacity of the condenser C2 connected across the grid coil.

Now suppose that the transmitter from which we wish to receive signals is sending out "unmodulated" signals on a frequency of 1,000,000 cycles or 1,000 kilocycles (kc.). We have said that satisfactory reception of such a signal with the simple non-regenerative detector can not be had. Suppose that we adjust our detector circuit (Fig. 3) to respond to the transmitted signal of 1,000 kc. and that we place the grid coil of our oscillating system (Fig. 4) quite close to the grid coil of the detector circuit (with variable coupling if desired). We will find that as we vary the capacity of condenser C2 in our oscillator (Fig. 4) we will hear a clear whistling note as the frequency of the local oscillator approaches that of the transmitting station (1,000 kc.). The frequency of this note, and hence its pitch, will depend upon the adjustment of C2. The closer the local oscillator frequency approaches 1,000 kc. (the frequency of the transmitted signal) the lower will be the pitch of the note. Under these conditions we can successfully receive "unmodulated" signals (called continuous wave or c.w. signals). Reception of telephone or modulated signals will be very unsatisfactory. This will later be discussed in more detail.

LET US SEE what happens when we couple the circuits of Figs. 3 and 4. We may represent the 1,000 kc. signal input to the receiver by the curve "A" of Fig. 5. Suppose the output of our local oscillator is adjusted to 999 kc. We may represent the oscillator output by curve "B" of Fig. 5. If we examine these curves we will notice that part of the time the current set up in the receiver

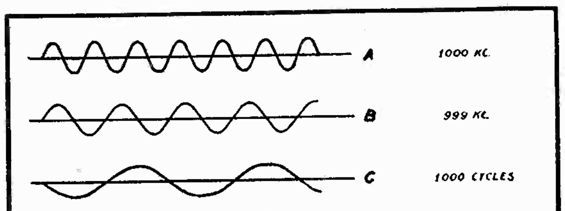


FIG. 5

circuit by the transmitter and the current of the oscillator are both positive. When both are positive, the "waves" add; part of the time, however, one is positive and the other negative, so they cancel each other and can be said to be cancelling. If both of these frequencies are introduced into the detector input circuit simultaneously a current having a frequency of 1,000 cycles will be produced in the plate circuit of the detector. This 1,000-cycle current will produce an audible note in the headphones. The 1,000-cycle frequency is, it will be noted, equal to the arithmetical difference between the received signal of 1,000 kc. and the local oscillator frequency of 999 kc. An audible note of 1,000 cycles could also be produced by adjusting the oscillator frequency to 1,001 kc. as the difference between the two frequencies would again be 1,000 cycles.

When two frequencies are introduced simultaneously into a circuit one is said to **heterodyne** the other or **beat with it** to produce a third frequency which is equal to their difference. A receiver in which a locally generated frequency is made to heterodyne or beat with the received frequency to produce an audible or a lower frequency, for subsequent amplification, is called **heterodyne** or **beat** reception. This fundamental action takes place in ALL **superheterodyne** receivers.

We have said that in the simple detector circuit the telephone response is proportional to the square of the signal strength. This does not hold true for the heterodyne method of reception. With beat reception the telephone response is proportional to the strength of the incoming signal. That is, to get twice as loud a signal with beat reception we only have to increase the effective signal strength to twice its original value. Such an increase in the effective strength of the received signal could be effected by greater transmitter power, greater pick-up given by a longer aerial, closer coupling, etc.

The proper use of the heterodyne method of reception allows practically equal signal strength in the phones for signals actually differing very considerable in their energy content. C. W. signals from stations of only moderate power can be heard over great distances, whereas "spark" signals would be lost and inaudible. Weak telephone or modulated signals can be picked up using the heterodyne method of reception even though they may be badly distorted.

IN THE system of reception which we have just examined a separate tube and associated apparatus were used to produce a signal which would beat with the received signal in the detector circuit. It is possible, however, to make a single tube function as both oscillator and detector in a self-heterodyne or "autodyne" circuit. Such a circuit is shown in

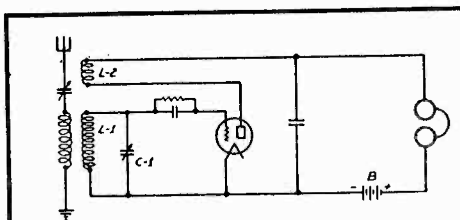


FIG. 6

the diagram of Fig. 6. The simple detector circuit of Fig. 3 has been modified by connecting a coil in series with the plate or output circuit of the tube and coupling this coil to the grid or input circuit so that energy is fed back from the plate circuit to the grid circuit. Whenever energy is thus fed from the plate circuit to the grid circuit **regeneration** is said to be present. Regeneration, if increased until the losses in the system are overcome, will result in oscillation. The use of this circuit allows reception of both phone or modulated c.w. signals, when the circuit is regenerating but not oscillating, and c.w. signals when the circuit is oscillating. Modulated c.w., or phone, will be distorted somewhat if the circuit is oscillating.

The action which takes place in a regenerative circuit may be described as follows: Currents are set up in the receiver antenna system at the frequency of the transmitter. The receiver antenna system is coupled to the input tuned circuit of the tube, consisting of coil L1 and condenser C1 (Fig. 6). The circuit L1, C1 is tuned to the frequency of the incoming signal. The alternating voltage induced in the tuned circuit L1, C1, by the antenna system is impressed on the grid of the tube and produces changes in the plate circuit of the tube at the frequency of the input tuned circuit and the incoming signal. The plate current flows through the coil L2 which is in series with the plate of the tube. L2 is coupled to L1 so that the current flowing in it induces in circuit L1, C1, a voltage **in phase** with that present in the circuit, the received signal. The coupling of L2 and L1 is made sufficient to produce regeneration without oscillation, for phone reception. A condition is established in which the received signal is amplified enormously due to the regeneration. This condition is unstable and a slight change in conditions may throw the circuit into oscillation and badly distort telephone signals. For c.w. reception the coupling between the plate and grid circuits of the tube is made just sufficient to cause oscillation. Under these conditions condenser C1 is adjusted so that the circuit oscillates at a frequency differing just sufficiently from that of the signal to be received to produce an audible beat note. The signal will be heard as a clear whistling note.

(Continued on Page 42)

SOUND

"Radio" Includes This New Monthly Departmental Feature Because of Its Close Alliance With the Radio Art. Conducted by D. B. McGown, Who Was Long Associated with the Sound and Projection Engineering Divisions of Western Electric, (E. R. P. I.), the Reader Will Find In These Columns Complete Information On Many Heretofore Unpublicized Developments

CHAPTER TWO

AFTER the original sound has been transformed into an electric current, it may be recorded on film or disk, as previously described, or it may be used to modulate a high-frequency electric current which will generate a radio wave. In all cases, it is then necessary to provide some means of reproducing this sound as a faithful likeness of the original. In the film and disk recording processes, a permanent record is made of the sound and it may be reproduced as many times as desired without any particular regard for the time period between the original recording and the final reproduction. Radio reproduction is almost instantaneous, the time elapsing between the generation of the sound and its reproduction being only that time which the radio wave takes to travel, at a speed of 300,000,000 meters per second, through space from the transmitting antenna to the receiving pick-up.

Sound records on disk and film are permanent, while the radio transmitter makes no record at all. For this reason, film and disk recording problems are considerably greater than those encountered in a radio system. In disk and film recording, many foreign and non-electrical elements are present, any of which may introduce distortion.

In the film method of reproduction, the film, moving at a uniform rate of 90 feet per minute, passes a narrow slit of light which is focused through a lens system from a steady and unvarying source such as a small electric bulb operated on direct current. The light passes through the film and is made to vary in intensity in exact accordance with changes in density of a photographic image on the film which is the sound record or "sound track." This transmitted light of varying intensity then passes into a photo-electric cell which produces a feeble electric current varying in value in accordance with variations in the intensity of the light it receives. The current from the usual photo-electric cell is extremely small and it is passed into a vacuum tube audio frequency amplifier in which its value is increased. This amplifier, usually called the "P. E. Cell" amplifier, raises the level of the feeble current by from 20 to 50 d.b. Its output is controlled by a volume-control pad, usually called a "fader" because it can be used to rapidly and noiselessly fade or change over from one reproducing machine to another. Its use is necessary in a theatre, where reproduction of picture and sound must be continuous. Leaving the fader, the sound currents are further amplified by voltage and power amplifiers and thence led through an output panel, or matching network, to the loudspeaker horns. In sound theatre projection work, these horns are mounted back-stage behind the motion-picture screen, or "picture sheet," and the sound appears to the audience to come from the scene of action, giving an illusion of reality.

The process is quite similar in the disk method of reproduction. The sound record on the disk is converted into feeble electric currents by a small magneto generator called a "reproducer." This includes a permanent magnet and a diaphragm or armature of soft iron to which is attached a sharp-pointed needle. The current is set up by the motion of the iron armature caused by the needle following the "sound path" on the disk. This current is a reproduction of the original sound current. The output from the reproducer is controlled by a fader as in the film reproduction process and the output from the fader is passed through a similar amplifying system to the loudspeakers.

The value of the initial sound current obtained from a reproducer actuated by a disk is much greater than that obtained from a photo-electric cell actuated by light from a film so that a preliminary amplifier, such as the "P.E.C." amplifier used with film, is not needed in disk reproduction.

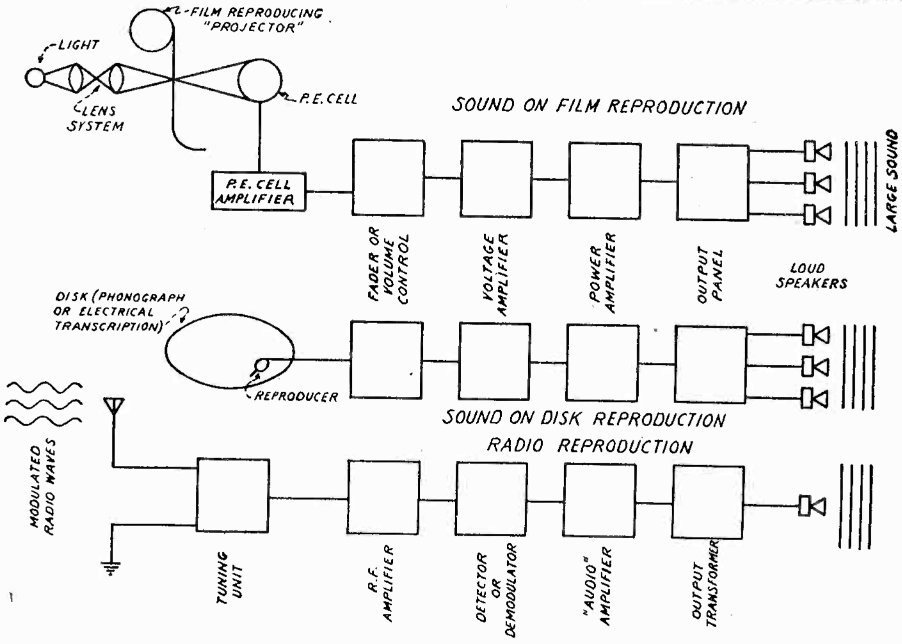
Disk reproduction has many uses. It is used, for instance, in the common phonograph, which is more or less familiar to everyone, as well as in the production of sound to accompany the projection of a motion picture. The processes of reproduction are identical in each case except for the fact that when disks are used to supply sound for a motion picture great care must be used in starting and threading the combined motion picture and sound projector for exact synchronism between sound and picture. Naturally, synchronism need not be considered with phonograph reproduction but in sound-picture reproduction it is of paramount importance. A specially prepared disk is used for sound-motion-picture work. Whereas the usual phonograph disk rotates 78 times per minute and the needle starts from the outer edge of the record and works inward on a spiral, the sound record rotates 33⅓ times per minute and the reproducer starts at the inner edge of the spiral and travels outward. By maknig the motion picture records quite large (16 inches in diameter) or by making the turns of the spiral very close together (12 inch record) the motion picture type record is made to play for about ten or eleven minutes before it has to be changed. It allows projection of a standard 1000-foot reel of motion picture film without change of record. The start at the center permits very easy setting of the needle to a predetermined "start" mark and consequent establishment of synchronism between sound and film. Once the disk and picture are correctly started, they will remain in synchronism until the reel is ended if they have been properly prepared and are properly operated.

The same type of records, either 12-in. or 16-in., turning at 33⅓ R.P.M., are used in broadcasting stations for "electrical transcriptions" and their operation is exactly the same as that of the theatre records. Not having been made in synchronism with a motion picture, they need less elaborate equipment. Having been prepared especially for broadcasting, their subject matter is usually unsuitable for other classes of reproduction. For the broadcasting of electrical transcriptions the input amplifier system at the broadcasting station is switched from the microphone to the output of the disk pick-up, which output then goes through the same processes and then modulates the radio-frequency carrier, just exactly as if the sound was generated at the broadcasting station.

We have seen that in both film and disk reproduction we first convert sound energy into electrical energy, amplify or increase the intensity of this electrical energy and control its level in several steps by means of equipment which can be broadly segregated into basic units such as fader, voltage amplifier, power amplifier, etc., and then reconvert the amplified electrical energy into sound energy. We have found that film and disk reproduction are identical except for the differences in the means of initial conversion of sound energy into electrical energy and in the extent of amplification of the eletcrical energy required.

A radio receiver can be segregated into basic electrical units very similar to many of those present in film and disk recording equipment. However, in the case of a radio receiver, the initial input is in the form of electrical energy and we are concerned with the amplification and control of this energy and with its conversion into sound energy. We shall give the name "Radio Reproduction" to the complete process of picking up electrical energy, amplifying and controlling it and converting it into sound energy.

In radio reproduction, the antenna system



What the Illustration Represents

THE moving film varies the light to a photo-cell, thus generating a weak sound current, and the disk generates a small current by moving the needle of the reproducer. The weak sound current is then varied in volume by the fader, from which the voltage amplifier is fed. After raising the level in the voltage amplifier, the power amplifier increases the power to operate the loudspeakers, which are fed through the output panel. The loudspeakers then generate a sound similar to the original.

In the radio system, the weak modulated radio frequency currents, (radio waves) are picked-up in the aerial and tuned to resonance in the tuning unit. The radio - frequency amplifier increases the voltage level of these currents, which are rectified or detected in the detector or demodulator, the output of which is a low-level audio-frequency sound current. This is amplified in the audio-frequency amplifier, fed to the loudspeaker through the output transformer, and the loudspeakers re-create the sound.

intercepts a feeble radio wave which sets up small alternating current in the antenna. This current is a radio-frequency, alternating current modulated by the audio frequencies which are finally to be converted into sound energy. If the antenna and the receiving system are tuned to the frequency of the signal intercepted, the "running unit" passes the energy from the antenna system to the radio-frequency amplifier. The radio-frequency amplifier is a "voltage amplifier." This amplifier may be equipped with a volume control unit corresponding to the fader in the theatre system. A volume control must, of course, be included in the system to obtain the desired level of final sound energy but it need not necessarily be placed in the r.f. amplifier. It can be located in any one of several positions in the circuit. After passing through the radio-frequency amplifier, in either a superheterodyne or t.r.f. receiver, the modulated radio-frequency current is detected, or demodulated, and the radio-frequency component is removed leaving an audio-frequency current whose variations in amplitude correspond to variations in intensity of the original sound. Leaving the detector, this audio-frequency electrical energy is further amplified, or increased in intensity. The audio-frequency amplifier following the detector may be a power amplifier or a combination of a power amplifier with one or more stages of voltage amplification. The output of the final or power stage in the audio-frequency amplifier is passed into an output transformer or similar coupling device and thence into a loudspeaker. The speaker reproduces the original sound.

Radio reproduction is the simplest of the three basic types of reproduction to accomplish with a minimum of distortion. The tone quality of the average broadcast station, commonly called its "fidelity," is extremely high and distortion introduced by the equipment in such a station is almost negligible. Many radio receivers, especially the cheap "midget" types, are very unsatisfactory from a fidelity viewpoint. The greater proportion of trouble from poor tone quality can be eliminated by proper design and construction of receiving equipment. Such design would be ahead of present general public demand and appreciation.

Recording of sound on either film or disk introduces a number of problems that are not encountered in radio transmission or reception and a large number of problems that never come up in public-address work at all.

In film recording, we have sound current that is amplified to such an extent that it will do a certain small amount of work. For example, this current may operate a device which will turn a light ("light valve") on and off—or it may operate a tiny moving miror (a "vibrator")—or it may be made to vary the brilliancy of a gas-filled lamp (a "recording lamp" or Aeolight). These various methods of utilizing the sound-current output of the amplifier are commercially called respectively the "Western Electric Lightvalve System," the "RCA Photophone System" and the "Fox-Case System."

In the Western Electric System, a tungsten-filament lamp, operated on D.C., provides a constant source of illumination. The light from this lamp is focused by a lens system on a loop of duralumin tape which is mounted between the poles of a powerful electromagnet and the edges of which are almost, but not quite, closed. When sound-current is supplied to the loop, or light-valve, the duralumin strips move and allow more or less light to pass. The degree of movement of the strips is dependent upon the amplitude, and the frequency of movement is dependent upon the frequency, of the sound-current. The amount of light and the frequency with which the valve opens and closes therefore varies as the amplitude and frequency of the sound-current vary.

The light that passes through the light-valve is then focused by another lens system and the image from this lens system is focused upon a moving photographic film in a "film recording machine," or sound camera. In this way, a light image which varies in exact accordance with the sound-current, and hence with the sound picked up by the microphone, is transmitted to the film and recorded thereon.

In the RCA Photophone System, the original light source for recording is either a small arc lamp or a very brilliant incandescent lamp, the light from which is focused on a tiny mirror. This mirror is suspended in the field of an electromagnet. The sound currents cause the loop supporting the mirror to twist in the magnetic field with the result that the light reflected from the mirror travels laterally, or from side to side. This light from the mirror is focused on a moving photographic film through a lens system with the result that an area of the film, varying in accordance with changes in amplitude and frequency of the sound-current and hence the original sound, is exposed.

The Fox-Case System uses a gas-filled "flashing lamp" which is mounted very close to the moving film. The recording lamp flashes in exact accordance with the sound-current supplied to it. The light from the flashing lamp passes through a small light-collector lens which terminates in a very narrow slit. This slit or aperture is mounted so that the moving film passes very close to it but does not touch it. The light passing through the slit "exposes" the film and thus makes a record upon it similar to that made in the Western Electric process.

In the Western Electric and Fox-Case Systems the light reaching the film is of variable intensity and the sound track produced looks like a series of light and dark bands or lines of varying intensities. In the RCA System the light reaching the film is of uniform intensity so that the density of the image formed on the film is constant. However, in the RCA System, the area of film exposed is continuously variable and the sound track looks like a jagged wavy curve. The frequency with which the peaks and depths occur varies with the frequency of the sound-current while the heights and depths of the peaks and hollows, or in other words the "amplitude," varies with amplitude of the sound-current.

The sound track made in the Western Electric and Fox-Case Systems is called a "variable density" sound track while that made in the RCA System is called a "variable area" sound track. Both systems have their advantages which will be discussed more fully in future articles.

After the latent image has been produced on the film, i.e., after the film has been exposed, it is necessary to develop and fix the image in the same way that the image on any photographic plate or negative is developed and fixed. Similar developers, hypo and washing and drying methods are used. The resulting film is called the "negative" and a print must next be made from it on another film which becomes the "positive." The image made on the positive film during printing is a latent image and the positive film is subject to the same type of developing, fixing and finishing as the negative. The positive print is a reversal or reciprocal of the negative, that is, the light portions of the negative appear as dark on the positive and vice versa. This is the case with all prints made from photographic negatives.

Disk recording is quite complex and does not stop with the recording on wax. The "wax," by the way, is a specially prepared mineral soap. The wax is electro-plated after the impression on it has been traced by the cutting stylus. From the first electro-plating, which is a "negative," other electro-plated impressions are made. The final record, the familiar black disk, is made by pressing a dry, hard, gummy substance, chiefly gum shellac, into the crevices of the electro-plated "stamper" which is a die-like copy of the orignial record is negative. The final record appears as an actual reproduction of the original wax. It is hard and durable and capable of being played many times without sufficient wear to cause loss of quality while the original wax would have been ruined if played more than a very few times. The pressing process requires careful preparation of the pressing stock which is molded at high temperature in a very heavy hydraulic press to produce the commercially perfect and final record.

The film process is liable to many more variable influences than the disk process. On the other hand, the film process is chemical in nature and such influences are as easily, if not more easily, controlled than those present in the disk process. The sound on film, or "sound track" as it is called, is almost always taken in synchronism with the action which is taken by the picture camera. There is usually a complete set of "sound" and "picture" negatives made for each "take." The sound track is almost universally recorded on "positive" or special "sound" film stock. This is different film from that used for picture photography and requires different handling in processing. Generally, the positive, or sound track, stock used as sound negative is of much finer grain in the emulsion, or sensitive surface, than that used for picture work. This fine grain must be preserved throughout the processing or "surface" or grain noise will appear as a rushing sound. Accurate temperature control of the processing baths must be maintained and the solutions must be kept of definite strength at all times. Washing water must be kept clean and free from foreign substances, both chemical and physical, and extreme care must be exercised in drying and storing the developed film lest it be scratched or otherwise damaged.

In most cases, after the disks or films have been first prepared, it is necessary to "cut" the sound and photographic material in such a way that a complete and coherent story may be presented both in picture and dialog. These steps will be discussed after the various electrical systems have been more thoroughly examined.

AC9GH

(Continued from Page 35)

Most of the time was spent in rebuilding the burned-out transformer. In three days from the time he arrived the station was on the air, with Graham working not only the front-line trenches but also hams in India and all over China. So, now, when you hear AC4AA you will know what it is, where it is, and how come."

Now, I cannot agree with Graham's statement to the doctor that the journey was "without incident." Four days on a Chinese railway, a day in a plane over frozen China, two days in a car on camel trails covered with snow, being stuck in drifts 13,000 feet above sea-level! I cannot imagine as "without incident" such a journey and the accompanying thoughts of the man who was making it. To me this is one of the dramatic episodes of amateur radio. A man young enough in the game to be called a greenhorn, wise enough to be appealed to as an expert by the commercial men who had built the transmitter; knowing the ways of China well enough to picture his own predicament if he in turn should fail to make the "machine" work, and yet with the confidence and courage to make the attempt; informed

(Continued on Page 42)

The Superheterodyne—Its Theory and Operation

(Continued from Page 39)

BEFORE going into the subject of the superheterodyne proper let us discuss briefly the subject of amplification practice. There are three general types of amplification in use. The first of these is radio **frequency** amplification, that is, amplification at the frequencies at which signals are received from the transmitting stations. The second is **audio frequency** amplification, that is, amplification at frequencies audible to the human ear. The third is **intermediate frequency** amplification, that is, amplification at frequencies intermediate between radio frequencies and audio frequencies.

In general it is possible to design a circuit for a greater degree of amplification on a single predetermined frequency than it is to design a circuit to produce maximum amplification over a relatively wide band of frequencies. It is also less difficult to build an amplifier system which is stable for operation at low frequencies or a single low frequency than it is to build an amplifier system to operate at high frequencies. Difficulties due to stray coupling, distributed capacities and tube interelectrode capacities increase as the frequency of amplification increases and unusual precautions in placement of parts and wiring are necessarv. Since a low-frequency amplifier operating on a single predetermined frequency is relatively easy to build and to maintain in a stable condition when adjusted for maximum gain; since it is not critical to minor variations occurring in normal use, such as tube changes, battery voltage changes, etc., its use in a receiver system is very satisfactory.

Suppose, for example, that we have built a low-frequency amplifier consisting of several tubes together with their associated tuned circuits, adjusted and designed to operate at a single fixed frequency of 50,000 cycles (50 kc.). This frequency has been chosen for purposes of illustration as it is a frequency for which it is comparatively easy to build a satisfactory amplifier. Our problem is to find a way to use this 50 kc. amplifier in a receiver.

Suppose we retain the circuits shown in the diagrams of Figs. 3 and 4. We can replace the head phones in the circuit of Fig. 3 with the primarv of a transformer designed to operate at 50 kc., the secondary of this transformer being connected to the grid circuit of the first tube in our 50 kc. amplifier. Now if the signal we wish to receive is 1,000 kc. and we tune our local oscillator (Fig. 4) to either 950 kc. or 1,050 kc. we shall produce in the plate circuit of the detector a beat or heterodyne frequency of 50 kc. which is equal to the difference between the received and beat frequencies. The circuit arrangement is given in Fig. 7. X and Y are the points in the circuit to which the low-frequency input transformer has been connected to replace the headphones in Fig. 3.

AC9GH

(Continued from Page 41)

enough to know that the whole history of amateur radio has been one of oppression and despoilment by commercial people, and yet with the exalted charity to turn the other cheek and render a service to one of that calling.

I asked Graham over the air who built this transmitter. He wouldn't tell me; he thought it would be unfair. He will be passing through California next winter and the gang here will have the pleasure of meeting. Perhaps we can induce him to tell us some of his soliloquies on that wild trip to Thibet.

L-E-T-T-E-R-S TO THE EDITOR

Editor, "RADIO"
Dear Sir:

The new regulations of the Federal Radio Commission, which become effective on October 1st, will be of material benefit to amateur radio. Adequately filtered DC will then be necessary for operation on all frequencies lower than 14,400 KC. This means that real selective receivers will be the order of the day, receivers with band-pass audio systems, peaked audio systems, single-signal systems, all of which depend upon DC for their effective operation. With receivers of this type soon to be generally used, the transmitted DC signals must be steady, or they will not be easily readable on the above types of receivers. Even a highly-efficient regenerative receiver, whose selectivity is dependent upon its oscillating condition, and the proper tuning of the receiving antenna, this DC signal requirement means that even more amateurs can soon operate in our present bands without undue interference.

Those of us who have been using highly individualistic plate supplies, either by means of generators, 3-phase, 6-phase, or other means of modulation, will reluctantly give up our beautiful 150-, 300-, or 500-cycle overtones on DC, and join in with a pure DC signal.

Steadiness of hand, regularity and consistency in sending, and an even flow of Continental will be necessary, otherwise confusion will result. It will be difficult to recognize the station by its signal, because all DC notes sound pretty much alike. Thus the operator with the steadiest signal and the steadiest "fist" will secure the best results.

(Signed) Don C. Wallace, W6AM-W6ZZA.

ZL'S ON 80, WITH A SINGLE '45
Editor, "RADIO":

I was just poring over Mr. Bane's article in the July issue and the dope is FB. I also noticed the article about ZL's coming in on 80 meters. Just thought I'd drop you a line and tell you that this morning (July 7th) I was QSO ZL4AQ and ZL3FJ on 80, using my big 45 with 16 watts input. Got QSA4R6 for 4AO and QSA3R4 from 3FJ. That makes me QSO all ZL districts on 80m this year with an input of 16 watts into a single 245 Hartley, said xmitter all mounted on top of a receiving variable with the tank and antenna coil wound on 1½-in. tubing and with No. 18 wire. Have been QSO ZL1AR four times up there and worked ZL1GV and ZL2JQ once. Have cards from 1AR and 1GV and 2JQ on the way, also guess 3FJ and 4AO will undoubtedly send theirs. 73's.

W6FFP,
931 Orange Ave.,
Fresno, Calif.

NOTICE!

THE BIG 1933 SHORT-WAVE MANUAL BY W6AM is loaded with much heretofore unpublished information of great value to every radio man. Get a copy now! 250 illustrations. Published by "RADIO". $1.00 per copy, postpaid. Order from—
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Condenser Vs Two-Button Microphones

(Continued from Page 33)

pressure on both sides of the diaphragm, so that there is no tendency for the diaphragm to "bulge" and alter the effective air gap. If there were no such compensation, changes in temperature or pressure of the atmosphere would alter both the sensitivity and frequency response characteristics.

Maintenance Problems

Due to the nature of the carbon buttons, all carbon microphones require repairs if transmission is to be kept up to standard. Renewal of the carbon granules about once each year is necessary due to natural aging. Current surges through the buttons may cause the granules to cohere, which will require a more frequent renewal of the carbon. Moisture also tends to "pack" the granules. These repairs cannot be made by the sound engineer or operator and it is always necessary to return the microphone to the factory. Repair costs can be minimized by observing the following precautions—

1. Always turn down the current control before disconnecting the microphone.
2. Never move the microphone with the current turned on.
3. Do not exceed the recommended button-current rating. While these limits vary with different manufacturers, it is ALWAYS true that low current gives maximum granule life.
4. Protect the microphone from mechanical shocks. If the granules become packed, tap the frame GENTLY with a rubber-tipped pencil. NEVER use force.

On the other hand, the condenser microphone very seldom requires maintenance work that cannot be carried out in the field. The condenser head itself seldom needs attention if the product is carefully designed. The condenser element—as contrasted with carbon buttons—is immune to the permanent effects of ordinary mechanical vibration and moisture. It is only necessary to place the condenser microphone in a dehydrating chamber or in a warm, dry place after exposure to high humidity to completely restore it to its original operating condition. About the only replacements required are occasional replacements of batteries and amplifier tubes.

Portability

The carbon microphone is especially well adapted for portable equipment. This is due to the fact that the device is complete in itself and requires only one, two or three dry-cell batteries for current supply. The carbon microphone is also light and takes up little space.

The condenser microphone, however, requires a high-voltage supply for polarizing the diaphragm and for amplifier plate supply and a low-voltage source to operate the amplifier tube filaments. These accessories add to the weight and bulk of the complete equipment. The transmitter unit requires more space than the carbon microphone due to the space occupied by the integral microphone amplifier. As a result, the condenser microphone is less readily portable than the carbon microphone. For this reason, two-button carbon microphones are widely used for portable remote control broadcast pick-ups and for a great deal of public address work where the equipment is frequently moved from place to place.

To summarize—the principal advantage of the two-button microphone is its portability. To offset its relatively greater bulk, the condenser microphone offers among its advantages, low background noise, permanence of calibration, and relative freedom from maintenance difficulties.

Easily Constructed Crystal Holder

(Continued from Page 16)

is specially prepared. Carefully dip two opposite edges of the crystal in clear Duco or lacquer so that a margin of about ⅛ in. is evenly coated. By dipping to ⅛ in. depth in the lacquer and very slowly withdrawing it at an angle, one edge first, and then the other, very little excess lacquer will remain. By holding the crystal upside down for a moment, the lacquer will reverse its direction and deposit quite evenly. Do one edge at a time, allowing each to dry first, before handling.

Place the crystal in the holder as described before and tighten the screws. By placing one's thumb over the upper plate and pressing it down on the crystal one is able to tell when the screws are tight enough. The bakelite base should be tapped out well for these three adjusting-screws so that they will turn freely. It is then possible to tell by the "feel" of the screw-driver how the plates are bearing on the crystal. When the adjusting screws "seat" on the upper plate one cannot turn a screw as much as a quarter turn without breaking the crystal. Before tightening the screws (after they "seat"), plug the holder in an oscillator circuit and observe the plate current meter for oscillation. Then gently screw up the three adjustment screws until the crystal is held in the holder but is still oscillating freely.

The drawings show a holder for a 1 in. x 1⅛ in. crystal. If your crystal is of different dimensions, the sizes of the upper and lower plates can be changed slightly. Make the lower plate about ⅛ in. less in width and length than the crystal, so that there will be a 1/16-in. margin of crystal overlapping all around. This is for the purpose protecting it from possible fracture from high-voltage discharges at its edges. For low-voltage work, or "single-signal" superheterodynes, the lower plate can be made equal in size to the crystal. (Any potential greater than 300 volts on the plate of the oscillator tube is considered **high voltage** for a crystal.)

If thicker crystals than 3/32 in. are to be used, the three adjustment-screws should be longer than ½ in. The brass springs should be long enough to keep the upper plate against the screw heads.

Old-Timer's Corner

(Continued from Page 21)

(9) Amateurs were forbidden to curse the commercials, and vice-versa, after the Radio Act of 1912 was signed. In early days it was common occurrence to tell the commercials what the amateurs thought of them, and their high-brow high-power high-falootin' high-hatishness. But, alas, the tide has turned. We now hear them busting-up our amateur bands and we must content ourselves with a mumbled *!$#??&. Well do we recall the load of bricks that the second-trick operator at old "PH" carried up the hill to the radio shack, tucked handily beneath the operating table and then invited the amateurs to visit the station. The Irish confetti did not serve its intended purpose because the amateurs smelled an Ethiopian in the lumber.

(10) Early commercial radio-telephone traffic was delivered by messenger instead of by radiophone because the voice from the stations barely covered a few city blocks. A station was built in San Francisco, another in Oakland, across the bay. "Bugs" McCarty was at the "megaphone," shouting himself hoarse, supposedly radiophoning message after message to Operator Douglas at the Oakland station. Prospective stockholders clustered about the genial McCarty, amazed at the possibilities of the new invention. But on the other end of the line nothing would come out of the headphones but the diaphragms. In the meantime, copies of the prepared messages were on their way to the Oakland station by messenger who, with the aid of ferry-boat travel, helped make radiotelephone history.

(11) The "Northumberland Jigger" is the oscillation transformer (inductive coupler) used on the British Marconi 1½-k.w. 60-cycle, non-synchronous transmitter.

OLD-TIMER'S QUESTION

1—**What kind of a contrivance was the "Resonaphone"?**
2—**Why was it necessary to keep the clockwork wound up on some of the old-time radio receivers in order to hear signals?**
3—**With certain types of receivers it was necessary to sharpen the detector on an oil stone. Why was this necessary?**
4—**What type of detector worked better if a permanent magnet were kept near it?**
5—**What was the power limit for amateur transmitters prior to 1912?**
6—**What were "X's?"**
7—**Why did Dr. Lee DeForest display burnt-out audion bulbs in his exhibit at the Panama Pacific International Exposition in 1915?**
8—**What did a Chicago judge tell the defendant during a hearing in 1906 in connection with the investigation of a stock flotation when the defendant told him that the human voice could be transmitted by radio?**

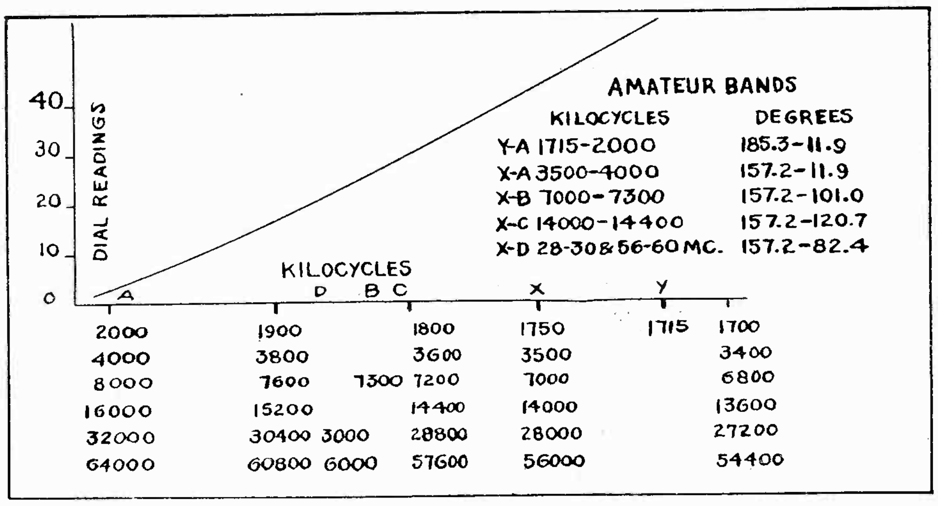
(See Answers in Next Issue)

Frequency Meters

(Continued from Page 10)

receiver and frequency meter ready, so that changes due to heat will be eliminated.

If the standard signal is transmitted at 4000 Kc. the procedure for calibration is to tune-in the signal in your receiver, then turn the frequency meter vernier condenser to the roughly determined 2000 Kc. point until a beat note is heard in the receiver. Adjust to zero beat and note the exact dial setting of the meter. This is repeated for the remainder of the standard frequencies, always using the second harmonic of the frequency meter to beat against the standard signal. Should the standard transmission be in the 40-meter band, the fourth harmonics of the frequency meter are used for beating. Under no circumstances should the tank condenser setting be changed after the meter has been calibrated. Because of the harmonics generated by the oscillator tube in the electron coupled frequency meter, it is required only to calibrate for the 1715 to 2000 Kc. range and then use the harmonics of these points for all other amateur bands. After enough points have been obtained, at least five, the curve should be drawn along the lines suggested in Fig. 6.



• **FIG. 6—A novel arrangement of the Calibration Curve. All required data is available at a glance.**

Add-A-Stage Beginner's Transmitter

(Continued from Page 13)

which location the amplifier plate tuning condenser is finally adjusted.

Keep your eye on that oscillator stage. Check, and re-check it constantly, to see that it is always oscillating.

If this discussion seems difficult for you to understand, merely try the method, step by step, following this information as you tune the transmitter, and you will soon get the knack of neutralizing.

Now that the stage is tuned, the next thing to do is to plug-in the rectifier tube in the power supply unit that feeds the amplifier stage.

Hold the glow lamp over the plate coil of the amplifier stage and rotate the plate circuit condenser until **maximum** brilliance is indicated by the lamp. The transmitter is now tuned to resonance.

Then place the antenna coil near the plate coil, the spacing between the two coils being about one inch. Tune the antenna feeder line condenser until maximum indication is shown, either by a thermo-couple meter in the antenna feeder, or by maximum indication of the milliammeter in the amplifier stage. When the antenna is coupled to the plate coil of the amplifier stage the meter will show increased plate current. This is because the antenna is drawing energy from the plate circuit of the amplifier stage. With 500 volts on the plate of the amplifier tube the milliammeter will read about 50 to 60 milliamperes.

All circuits should then be carefully re-checked by slowly rotating both plate condensers until maximum indication is shown by the antenna meter. You are now ready to "take the air."

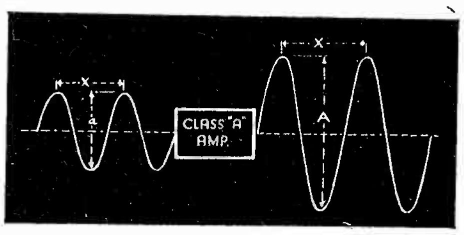
It will be noted from the circuit diagram that the filaments of both the oscillator and amplifier tubes are controlled by a separate switch. This is to keep the filaments burning while receiving, so that the tubes are always "warm" and ready to take the sudden load which is applied when the other switch is thrown to supply the plate current to the tubes. This method also prevents damage to the tubes and makes for longer tube life.

The next issue of "RADIO" will show how to add a doubler stage to this transmitter so that it can be used to operate in the 20 and 40 meter bands. A later issue will show how to modulate this outfit for radiotelephony, on the 160-meter band.

The A B C of Modulation

(Continued from Page 24)

grid input wave. Referring to Fig. 2, a small sine wave is shown entering the tube. It comes out with exactly the frequency (represented by distance x) but greater in amplitude. The ordinary audio amplifier



A Class "A" amplifier is one that gives, in its output circuit, a wave of the same frequency and shape as the input wave, but the wave may be larger in amplitude. X is the frequency in diagram and A-a represent the input and output amplitudes respectively.

tubes in your radio at home are Class A amplifiers. The greater majority of modulator tubes are operated Class A. (More about that later.)

The Class B r.f. amplifier (not to be confused with the Class B a.f. amplifier or modulator), is used in transmitters when it is desired to take the modulated radio-frequency and amplify it to higher power. This type of amplifier is biased so that the power output of the amplifier is proportional to the square of the exciting grid voltage. In this type of amplifier, the tube operates over the whole linear portion of the grid voltage-plate current curve, and has for its static operating point the low current end of the curve. Thus, when a 100 per cent modulated wave is impressed upon the grid, the grid is impressed with a voltage twice the value of the unmodulated carrier voltage and therefore the plate current is increased to twice its value. The power output increases as the square of the plate current but since the plate current is a function of the impressed grid voltage, the power output increases as the square of the grid voltage and thus we have Class B operation of the amplifier.

A Class C amplifier is very similar to a Class B amplifier, but instead of impressing the modulating signal on the grid of the tube, only the input radio-frequency voltage is impressed on the grid, and the modulating voltage is impressed on the plate. However, instead of using the linear portion of the plate current-grid voltage curve of the tube, the plate current-plate voltage curve is used. It is the purpose of the modulator to vary the plate voltage of the Class C amplifier from twice the normal unmodulated value to zero, and, like the Class B amplifier, the output is increased as the square of the plate current and as the function of the plate voltage. Therefore, a Class C amplifier is one that operates so that the power output varies as the square of the plate voltage.

Various types of modulators are used to increase the plate voltage from twice its normal value to zero. The most satisfactory and most practical is the Class A modulator. The best Class A modulator tubes are those that usually make good audio output power amplifiers. They usually have comparatively low plate impedance and amplification factor, but usually have a higher value of mutual conductance. Such tubes as the 47, 45, 50, 845, 849, 211E and 212D fall in this class. Then there are the Class B modulator tubes which are used in balanced push-pull arrangements. The Class B modulator is similar in principle to the Class B r.f. amplifier, but quite different in operation. The exciting voltage is at audio frequency, instead of a modulation frequency varying above and below the unmodulated carrier wave. The Class B audio amplifier must be a push-pull balanced circuit for fidelity and quality, and more important is the fact that the Class B audio amplifier works into a load which is (or should be) non-resonant, whereas the Class B r.f. amplifier works into a tuned impedance.

The second article of this series, which will appear in the next issue, will give complete data on plate modulation, and both Class A and Class B Modulators.

What's the Matter With Amateur Radio?

(Continued from Page 5)

cials! Can you beat that! Perhaps we thought to gain the good will of the commercials by passing over to them our nice fat roll and keeping only a few nickels for carfare. Or perhaps it was proposed as a demonstration of the high standard of ethics that is the pride of the amateur body. Being no judge of ethical conduct, I can't say.

Manifestly it would have been improper and unjust for the amateurs to have tried to hold the whole area below 200 meters. Other classes of citizens could make good use of a share of that space; but we need not have been so ostentatiously lavish. By way of proof of our prodigality put on a pair of phones and tune over the whole area covered by our after-you-my-dear-Alphonse gesture. You will find great spaces as silent as the grave where a dozen of the present amateur bands could be parked unnoticed. Here and there you may observe what is a rare phenomenon these days—a station sending a message for which some reckless spender had given up real money. But mostly, all you'll hear is commercial stations, manned short-handed by ex-amateurs, sending (by machine) endless strings of V's, because the law says any channel allocated must be put to its best possible use. And I'll grant that making V's is the "best possible use," for there is not now and never has been justification for putting one-tenth of these short-wave commercial stations on the air.

No, we needn't have been so lavish. The comic Lady Bountiful, like the stage tramp, always rates a laugh.

Having, ourselves, painted for the whole world a picture of the amateurs as a group of children gazing at the butterflies, is it any wonder that at the opening of the International Convention of 1927 one of the first delegates to address himself to the amateur problem said he believed no frequencies that were useful for communications should be assigned to amateurs! This is not a figment of my imagination; those are his exact words. But our own Government wouldn't accede to this. The amateurs are a great national asset, in both peace time and war, and that truth is well known. But the commercial representatives did succeed in cutting the already too-narrow amateur bands down to one-third of their former width. Then they chucked the amateurs of all foreign nations on top of us. There were 17,000 amateur stations in the United States; since then the Federal Radio Commission has licensed 18,000 new ones and has thrown them all into the same hell-holes of interference for good measure.

Just here it is reasonable for the lay-reader to exclaim, "But can it be that among 35,000 licensed amateurs it is impossible to find a handful of discerning men of worldly experience and courage!" Well, I'll tell you, Lay-Readers, in the early days of the short waves the commercials grabbed our most astute members as fast as they could. That's how the commercials learned the short-wave art. This is literally true, as even the commercials will admit—under torture. And as the commercials capitalized the expert knowledge of these amateurs, they issued millions of dollars worth of securities based largely on their own statement of the value of the short-wave channels they took from the Amateurs and for which they paid our Government nothing. And these securities were bought at high prices in the stock market by gullible fellers like lay-readers. Now ask me another question reflecting on the intelligence of us amateurs, will you?

More and more commercial short-wave stations were built, and more and more men were hired from the amateur ranks. And once in the employ of the commercials the lips of these men were sealed, and their hands were tied. But what remains to them is still their best inheritance—their spirit of amateur fellowship. That never dies; "once a ham, always a ham." Although they cannot talk and cannot act, they still may think. They think with us, a moral support of inestimable worth and weight.

I am not blaming the commercials for the present plight of the amateurs. I am not blaming anybody; I am merely reciting the situation and citing the cause. I am not even deploring the circumstance that the amateurs haven't the incentive of Big Business—the almighty dollar, at once the motive for ruthless action, the powerful offen- sive weapon in mundane affairs and the any saver when caught with the goods. We is something better and more enduring. the peace of our souls we have the sciousness that we are after nobody e rights and nobody's money. And that as our own offensive weapon we have the support of the people; and it is the people, the real owners of the public domain of the air, that will cast the final ballot.

There is a power that lies inhere every just cause. If it were not for the amateurs would have been swept the air long ago. We read now sign the very air that that pathetic Lady Bou ful "relinquished for commercial devel ment." What we took for Bigness no lon with appears awesome. Mere size no longer s bolizes either ability or probity. Much of mere Bigness is already on the scrap-heap and much more is in the wheelbarrows. The plain citizen—and that's the class we amateurs belong to—is coming into his own.

"What's the matter with amateur radio?" Not a thing. All we need is a place to put it.

Service Man: "That's the last time I'll ever tell a lady her resistance is weak."