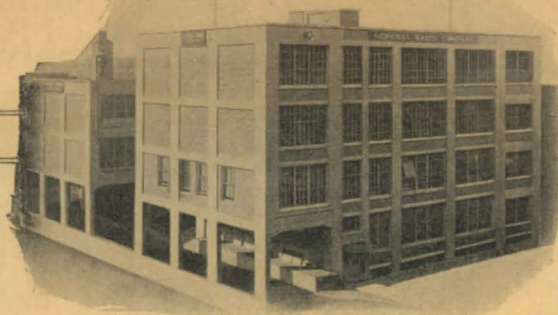


The GENERAL RADIO EXPERIMENTER

PL. 1 NO. 9

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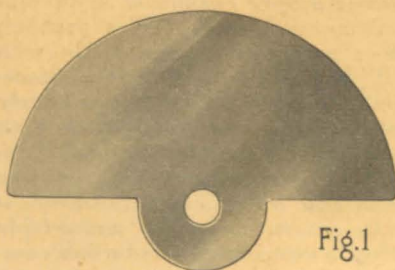
A Discussion of Condenser Plate Shapes

By C. T. BURKE, Engineering Department

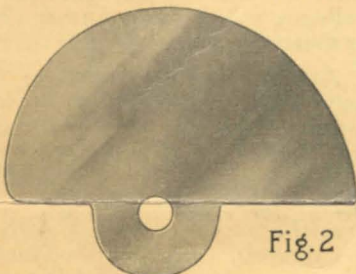
Variable air condensers are made with three general types of plate shapes, although there are many modifications of each type.

The first rotary variable condensers were made with "straight line capacity" plates. These plates were semi-circular in shape and are called straight line capacity because the curve of capacity plotted against dial divisions (angle of rotation) is a straight line. The relation between capacity, wavelength, and frequency are such that this plate shape tends to result in crowding of stations at the lower end of the capacity range. That is, there are more transmitting channels for each dial division at the lower end of the scale than the upper. This objectionable feature has led to a widespread use of other plate shapes.

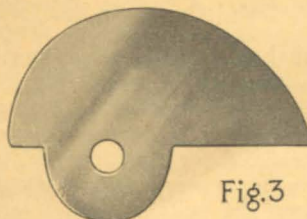
The straight line capacity plates have, however, one distinct advantage when used in single-control set-ups. Where it is desired to tune several circuits with one control, some form of capacity adjustment is nearly always necessary to compensate for different zero capacitances in the several circuits. If semi-circular, (straight line capacity) units are used, this adjustment can be made by slightly advancing one or more of the units. If this be done with condensers having other plate shapes, the capacities will become unbalanced as the control dial is advanced. This is due to the fact that if the plate shape is not "straight line capacity," the capacity variation per dial division increases as the condenser is turned toward maximum capacity, and the unit which was advanced gains capacity more rapidly



Straight Line Capacity



Straight Line Wavelength



Straight Line Frequency

than the others. This feature has caused at least one important manufacturer of uni-control receivers to return to the semi-circular plate shape.

It may be noted that the effect of "straight line wavelength" and "straight line frequency" condensers is strictly a slow motion action, hav-

ing a variable reduction, gradually lessening as the condenser is advanced. The same result can be and, in fact, has been accomplished by a slow motion dial so constructed as to automatically vary its reduction ratio to give the effect of a "straight line frequency" plate when used with a "straight line capacity" condenser.

The disadvantage of the semi-circular plate shape was first realized in connection with the construction of wavemeters. This was long before there were enough broadcast stations for the problem of station separation to be serious. As the relation between capacity and wavelength is not a direct proportion, a dial calibrated in wavelengths will not have equal divisions over its scale if a semi-circular plate shape is used. This not only makes the instrument more difficult to read, particularly as to the estimation of readings which fall between divisions, but involves difficulty in calibration, as the space between two points ten meters apart for instance, could not be divided into ten equal one-meter divisions. A plate shape which would give equal divisions for equal wave-lengths, i.e., "straight line wavelengths," was highly desirable, and a condenser with such a plate shape was first used commercially in the General Radio 124 wavemeter, introduced in 1916. When the multiplication of broadcast stations began, the straight line wavelength plate was introduced for condensers used in receivers, and became very popular, due to the better separation of stations resulting from its use.

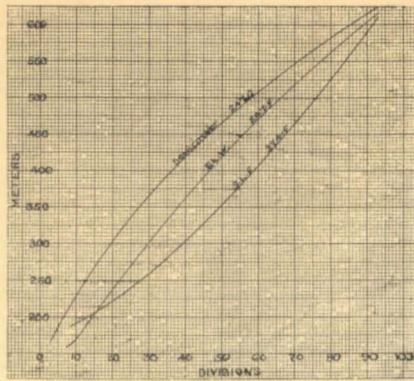


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The above chart shows the calibration curves for the three distinct types of General Radio condensers, the maximum capacity of each type being 500 MMF

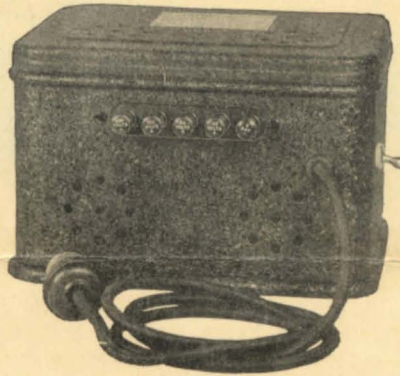
Broadcast stations continued to multiply, however, until all channels in the wavelength range allotted to broadcasting were filled. The transmission channels were assigned on the basis of uniform frequency rather than uniform wavelength separation, and, as they all became occupied, the difficulty of crowding a great many more than half the stations into the lower half of the dial again rose. The obvious step was, of course, the "straight line frequency plate" shaped to give equal frequency divisions over the dial. This plate shape not only improves the distribution of stations over the dial, but is the only type of condenser which can be used in a single-control super-heterodyne, where there is a constant difference of frequency between the two circuits being tuned.

Certain objections, however, have prevented this type of condenser from achieving the wide popularity which was promised for it. In order to obtain a "straight line frequency" variation, an extremely low minimum capacity is required. The stray or "zero" capacity of most receivers is so large as to defeat this requirement and to prevent the realization of a true straight line frequency variation. Another objection was the large physical dimensions of most of the straight line frequency condensers, due to the fact that this plate shape is very inefficient in its use of space. Then, too, there is the fact that in the conventional type of condenser, there is a rotation of but 180° in which all stations must be included. Spreading out stations on the lower portion of the dial necessarily results in crowding them closer together on the upper. It so happened that the policy of the government in assigning channels was to

give the high powered stations channels in the upper portion of the wave band, and the crowding together of

these stations, generally having the better programs, proved disadvantageous.

Voltage Regulation of Plate Supply Units



One of the most bothersome problems in connection with the design of power supply equipment is that of voltage regulation. This problem does not arise in connection with "B" batteries as their internal resistance is quite low and a relatively large current may be drawn without appreciable drop in terminal voltage. The resistance of the rectifier tube and filter circuit, however, is sufficient to cause an appreciable drop in voltage. This is further complicated by the fact that resistances must be used to get intermediate voltages, which cause further drops at these terminals.

At first, variable resistances were universally resorted to in order to set the voltage at each terminal to the desired value. This arrangement proved open to several objections. In the first place, it added several controls to those already on the receiver, a distinct disadvantage at a time when the trend is toward simplification and elimination of adjustments. A further objection was that very few users of the power units had a suitable voltmeter for adjusting the voltage. A very high resistance voltmeter is required for this purpose, as the ordinary voltmeter used for checking "B" battery voltages, draws sufficient current to change the voltage of the plate supply greatly. As a result, the voltage of these instruments having adjustments was in most cases set at the wrong value. This is not so serious of itself, as present day tubes do not usually require a particularly critical adjustment of plate current. There was a strong temptation, however, to

make excessive use of the voltage control in an effort to clear up trouble having its source elsewhere. It proved, unfortunately, that many of the variable resistances offered for this work were not equal to the strain of almost continual adjustment, and trouble developed due to the noisy action of these devices.

These considerations made the elimination of the variable resistance highly desirable. While this arrangement does not permit an exact adjustment of voltage, if the resistances are properly proportioned, it is possible to hold the voltage at any terminal within fairly narrow limits over the range of current likely to be drawn from it.

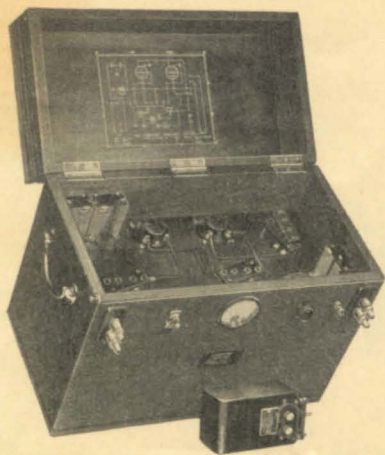
In a plate supply designed for this purpose, the resistance across the output circuit is relatively low, so that a considerable current is drawn from the rectifier when no tubes are connected. When tubes are connected to the plate supply, the series-parallel circuit resulting, consisting of tubes and the output resistance of the filter, is very complicated. Briefly, however, as tubes are inserted into the circuit the "bleed" current through the low tap resistance decreases, and part of it flows through the tubes. Thus the drain on the rectifier and its output voltages does not change as much as it would were the variable high resistance system used. The result is greatly improved regulation. In fact, it is possible to have a lower voltage drop per mil at the lowest tap than occurs in the overall voltage, despite the greater resistance of the circuit from which it is drawn.

A plate supply designed along this line will fit the needs of a great number of cases without adjustments of any kind. In the few cases which it does not fit, the adjustable factor may easily be added.

Another advantage of the low output resistance is that it limits the rise in voltage when the load is turned off, lessening the possibility of damage to filter condensers. This design, combined with a judicious choice of condensers, has practically eliminated the problem of condenser puncture.



The Type 415 Laboratory Amplifier



The sensitivity of a great many laboratory measurements can be increased by the use of a properly designed amplifier. An amplifier also makes possible the substitution of a visual for an auditory balance of bridge circuits operating at 800 to 1,000 cycles. This feature is of advantage, for example, in connection with the 383 capacity bridge. When this instrument is set up for factory test work, a vacuum tube voltmeter may be used as an indicator, which greatly simplifies the setting of tolerances. An amplifier is necessary also in making observation by means of an oscillograph such as the General Radio Type 338, where the circuit conditions must not be disturbed by the measuring equipment.

In the Type 415 amplifier, the necessary equipment and batteries are contained in a single cabinet of stout construction. The audio coupling units are mounted on our Type 274 plugs so that any type of coupling unit desired may be used. This feature makes possible a quick determination of the relative merits of different types of amplifying systems. The output of the second tube may be connected directly to the output terminals or by means of a plug base to any form of output coupling device desired. Four-plug plates may be obtained which may be used for mounting various types of coupling units.

The battery space is sufficient for four 22-volt "B" batteries, one 4.5-volt "C" battery and three 1.5-volt "A" cells. The amplifier is designed for use with WX-12 or UX-199 (CX-12 or CX-299) tubes. A voltmeter in the panel provides for proper adjustment of the filament voltages.

The price of the Type 415 Laboratory Amplifier, exclusive of tubes, batteries and transformers, is \$40.

How Good Is "GOOD"?

How good is "good"? What are the requirements of a good amplifier?

It will be readily conceded by all that a perfect amplifier is one which will cause a reproducer to set up in a room exactly the same combination of sound waves as existed in the room where the transmitter microphone was placed. The reproduced sounds depend on a great many factors beside the amplifier, and the original sound may be changed either before it enters or after it leaves the amplifier. Before reaching the receiving audio amplifier, the sound passes through a microphone, several amplifiers, often several hundred miles of telephone line, a few or hundreds of miles of space, the radio frequency amplifier and detector. Each successive element of the system has an opportunity to alter the characteristic of the original sound, and most of them take advantage of it to a greater or less degree. The composite effect of these elements in the system includes both addition and subtraction.

In considering the amplifier, we are then confronted by the fact that the product delivered at the amplifier input terminals is no longer capable of reproducing the sound waves existing at the microphone. Even a "perfect" amplifier per se, then, can not deliver a perfect output. The amplifier cannot replace that which has been lost. Possibly, however, it can partially remove the sounds which have been added, without removing any of the original sound. Many of the noises added to the signal as it traverses the transmitting and receiving systems occur at relatively high frequencies, above 5,000 cycles. The experiments of Dr. Harvey Fletcher of the Bell Telephone Laboratories have demonstrated the fact that frequencies above 4,000 or 5,000 cycles may be eliminated from speech and music without noticeable effect. It seems then desirable that the amplifier be so designed as to cut off at about 5,000 cycles, and that such an amplifier would give more nearly perfect results than a "perfect" amplifier.

Under present conditions, the signal probably suffers more between the time it leaves the amplifier and the time it strikes the ear than it does before reaching the amplifier. That is to say, the loudspeaker is probably a greater source of frequency distortion than all the rest of the system.

The loss of the lower frequencies is due principally to the inability of many loudspeakers to reproduce frequencies much lower than 200 cycles. It does not seem to be generally realized how high this

actually is, in many cases around 200 cycles. The sensitivity at low frequencies of two of the best types of present day speakers was checked at 60 cycles, by means of an oscillograph. The oscillograph was first connected to the input and the input signal adjusted for an exactly sinusoidal wave form. The oscillograph was then switched to a pickup and the sound wave in the room was seen to be of 120 cycles frequency. A stiff connection was made between the speaker and the pickup, and a 60 cycle wave appeared, showing that while the speaker was vibrating at 60 cycles, no measurable energy was being radiated at that frequency. Another test with a different type of speaker showed that the full output of a UX-210 tube was required to get an audible sound at 60 cycles.

Someone has made the suggestion that since reproducers are more or less peaked at the middle or upper frequencies, transformers should be designed to have a corresponding hollow. This is upsetting the perfect amplifier with a vengeance. It would seem more logical, however, for the loudspeaker manufacturer to equip his instrument with a filter to cut off the peaks of the curve in somewhat the same manner as telephone lines are "equalized." If the amplifier were made to match the speaker, it would be necessary to discard the entire amplifier every time an improvement was made in reproducers.

To the manufacturer of coupling units, the problem of "how good is good" presents itself in a very practical manner. How far down in the low frequency region is it reasonable to go? How much of this band, which does not now exist in the input to the amplifier, and could not be reproduced if delivered to the speaker, should the amplifier be capable of passing? It boils down to: "Is the public willing, and justifiably so, to pay more for a transformer that will amplify as low as 30 cycles than for a transformer capable of amplifying frequencies of the order of 100 cycles, when no actual gain in quality of reproduction results from the higher cost?"

Fortunately, the low frequencies that our present reproducers will not radiate are not lost. These frequencies are reproduced in the ear from their harmonics and the fundamental pitch of the note is not lost, although if the cut-off of the amplifying and reproducing systems is too high, it loses "naturalness." It is to the detector action of the ear that most of the bass notes we hear are due, and they come from no farther out the "vasty" ether than the ear of the listener.

