The Single Control Transmitter

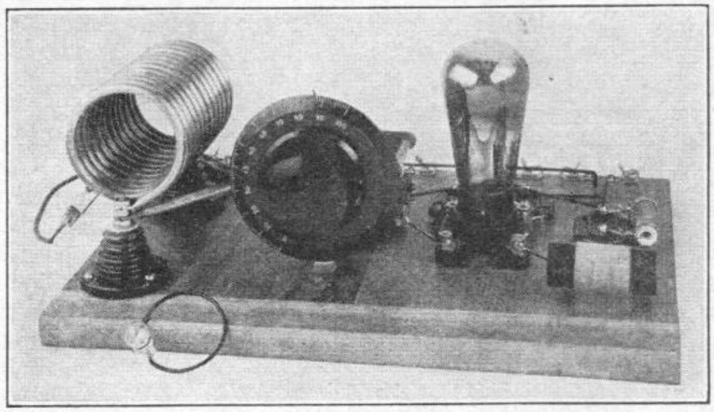
By George Grammer*

ONE of the great drawbacks of amateur transmission for the beginner is the multiplicity of controls and adjustments which seems to be necessarily attendant upon use of our present-day "standard" circuits. The poor chap is confronted by an array of things which have to be done to a transmitter to get the right kind of signal out into the ether; and if, as is often the case, he has only limited power and no indicating instruments at his disposal, with the nearest ham help miles away, he is truly up against it. It was with the hope of dispelling some of the bewilderment of this class that the little set to be described was built. In spite of its simplicity, it is a capital low-power outfit, suited to the requirements of the newest beginner or most proficient operator.

Omitting any consideration of oscillator-amplifier sets, our self-controlled transmitters usually have at the very least four, and sometimes more, adjustments which have to be made, no one of which is independent of the others. It may be argued that this in itself is no great disadvantage, since the aim is to find the best adjustment and then let the set alone — but it rarely works out that way. There is too much temptation to change something, especially after a few calls have gone unanswered. Then, too, there is the antenna ammeter, with its fiendish beckoning to drain the last drop of current from the set, in spite of what the monitor and our better sense tell us. Besides it takes long practice to get the "feel" of a set, and the new man wants results first and experience afterwards.

Despite the vociferous refutations which its adherents will no doubt immediately voice, the Hartley circuit with a high-C tank is a hard one for a beginner to adjust for reasonable output. The filament tap on the inductance is a critical and unsatisfactory proposition, especially on the higher frequency bands where the coils are physically small. The Colpitts circuit does not seem to be so popular with the newcomers, but is perhaps even worse than the Hartley from the standpoint of adjustment, because the two condensers in series make it impossible to change excitation without altering the frequency at the same time, and vice versa. It is true that a fixed feed-back ratio can be obtained by using three condensers, two in series and one, the main tuning control, across the whole coil, but this only partially eliminates the difficulty, and introduces an additional control.

There remains the familiar Armstrong circuit, the tuned-plate tuned-grid, which is about the easiest of the three to handle, since the excitation and output circuits are adjusted separately by means of condensers, and the two adjustments are comparatively independent.[1] There is also the additional advantage that series-feed plate supply may be used, lessening the work of the r.f. choke, a thing which cannot be done in either the Hartley or Colpitts without splitting the inductance — a messy job constructionally.



A FRONT VIEW OF THE TRANSMITTER

The plate coil is mounted at the left, the grid coil at the right. The resonance indicator is in the foreground.

In the tuned-plate tuned-grid circuit the plate tank circuit normally controls the frequency of oscillation, while the grid circuit, although having some effect on the frequency, functions chiefly as a control of excitation, thereby determining the output and efficiency. Furthermore, the grid adjustment is not particularly critical, and the same condenser setting will hold for a fair range of frequency change in the plate tank. This naturally suggests the use of fixed grid tuning for the band of frequencies over which it is desired to work. We don't know who first suggested the idea; the main thing is that it works, and works surprisingly well.[2] A suitable grid circuit will function over the entire 3500-kc. band, the

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[1] Operating Characteristics of Vacuum Tube Oscillators, *QST*, November, 1929.

[2] Director Woodruff of State College, Pa., has been using this type of oscillator for some time. He has made it quite well known as the "T.N.T." circuit. The low-cost push-pull transmitter described in the September issue of *QST* also used this type of oscillator. — EDITOR.

widest of our three most popular bands, with practically the same efficiency at all frequencies.

The lower the decrement of the grid tuning circuit, the more critical will be the grid adjustment. Consequently, for fixed grid tuning, extremely low resistance is not particularly desirable, since we want the tuning of this circuit to be broad enough

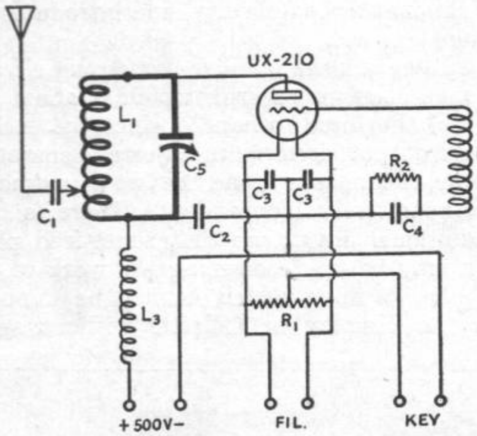


FIG. 1

L_1 — Plate Coil. See photograph.
L_2 — Grid Coil. See photograph.
L_3 — Radio frequency choke. Any commercial receiver-type short wave choke will do, or it may be made by winding 2 inches of No. 38 d.s.c. wire on a half-inch tube or wooden dowel.
C_1 — 2000 μμfd. (.002 μfd.) mica fixed condenser, receiver type.
C_2 — 2000 μμfd. (.002 μfd.) mica fixed condenser, receiver type if plate voltage does not exceed 500.
C_3 — 5000 μμfd. (.005 μfd.) mica fixed condenser, receiver type.
C_4 — 250 μμfd. (.00025 μfd.) mica fixed condenser, receiver type.
C_5 — 500 μμfd. (.0005 μfd.) variable condenser. Any good receiving condenser will be satisfactory.
R_1 — Center-tapped resistor, 75 to 100 ohms total resistance.
R_2 — Grid leak resistor, 10,000 ohms. Any small resistor rated at 5 watts or more will do.

Two General Radio or similar stand-off insulators will be necessary, as well as 7 Fahnestock clips, some miscellaneous small machine screws and nuts, and a few feet of bus wire. A UX-210 with suitable power supply should be used.

to hold over quite a range of frequencies. The necessary tuning capacity can therefore be supplied by the grid-filament capacity of the oscillator tube, the distributed capacity of the grid inductance, and the capacity of the associated apparatus. It remains merely to wind a coil of the proper size to tune to the frequency band on which it is desired to work. These coils will be described in more detail later.

So far we have a single control oscillator. There is still the antenna problem, probably the worst of all, with its usual coupling coil and tuning condenser or condensers, and the necessity for some form of misleading current indicator. Happily the solution was contained in an article on the single wire fed Hertz antenna in the September, 1929, issue of *QST*. This type of antenna and feeder system at one stroke eliminates the troublesome adjustments mentioned above and at the same time provides a radiating system of excellent efficiency. For the benefit of those who may not have a copy of the September issue, the antenna itself is the usual Hertz so popular with amateurs, the energy being transferred to it from the oscillator by means of a single wire, untuned, transmission line of any convenient length. As in the case of all Hertz antennas which are not cut to allow the insertion of tuning apparatus, the antenna length determines the operating frequency.

It can thus be seen readily that the transmitter to be described is not an oscillator alone, but includes an antenna system as well. The oscillator itself may, of course, be coupled to any of the usual types of antennas if desired, but the simplicity of adjustment and the "fool-proof" features are then lost.

CONSTRUCTION OF THE SET

The schematic wiring diagram is shown in Fig. 1, together with the constants, while the photographs show how the set looks when constructed. The layout chosen is one which allows short r.f. leads, although others equally good will no doubt suggest themselves.

The grid coils, L_2, are wound with No. 30 d.c.c. wire on 2½-inch lengths of 1-inch tubing, which may be of bakelite, paper, wood, or any other of the common insulating materials. After being wound the coils should be given a coat of Collodion or clear Duco varnish to keep them permanent. Two small brass angles, obtainable from any hardware store, serve as both connections and supports for these coils, the ends of the winding being brought out to small machine screws inserted at the ends of the coil forms.

The baseboard itself is a bread-board 13½ inches long by 10 inches wide. Two General Radio stand-off insulators are mounted at one end, as shown in the photographs, and serve as a support for the plate coil, L_1. These insulators should be placed 4½ inches apart between centers. This mounting is very solid mechanically, and allows easy changing of coils. If changes from one band to another are frequent, it might be advisable to use wing-nuts to fasten the coils down instead of the hexagonal nuts furnished with the insulators.

The plate coils themselves are ¼-inch soft copper tubing, wound around a pipe 2⅜ inches outside diameter. The ends of the coils are flattened in a vise and drilled to fit over the machine screws in the G.R. insulators. The 3500-kc. coil should have the turns so spaced that when finished it will just fit on the insulators without having the ends bent out, as is done on the coils for the higher frequency bands. The spacing between turns on the 7000-kc. coil is about 3/16-inch, and on the 14,000-kc. coil about ⅞-inch. After the coils are finished they should be polished with fine steel wool, thoroughly cleaned with alcohol, and given a coat of clear Duco greatly diluted with "thinner," to keep them bright.

The tuning condenser, C_5, in this case a 21-plate Cardwell, is mounted on small brass angles of the same type used for mounting the grid coil. Connections between the condenser and the coil are made by pieces of copper tubing, since the leads in the tank circuit must be as heavy as the inductance itself. The connection to the insulator at the front of the baseboard should be from the rotary plates, that to the rear insulator going to the stationary plates. This puts the "hot" end of the coil at the back of the set and reduces the effect of hand capacity.

The plate by-pass condenser, C_2, is mounted close to the tuning condenser on the baseboard. The radio-frequency choke, L_3, is just behind it. The filament by-pass condensers, C_3, are directly behind the tube socket, while the grid condenser, C_4, and leak, R_2, are to the right of them. The condensers in this set, which are Sangamos, are mounted flat by means of machine screws running up through the baseboard. The antenna insulating or blocking condenser, C_1, is mounted on the left rear corner of the board, one side going to a Fahnestock clip for the antenna connection, the other to a piece of flexible wire 8 inches long terminating in a small spring clip which fastens on the plate coil. The filament center-tap resistor, R_1, is mounted directly on top of the filament by-pass condensers.

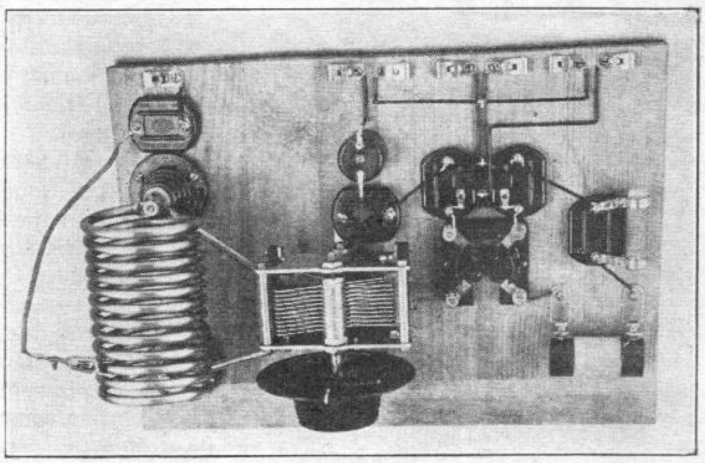
All connections are run to the rear of the board where they terminate in Fahnestock clips. From right to left in the photograph, the first two clips are for the key, the second two for filament supply, and the last two are for minus and plus high voltage, respectively. The wiring of the whole set is quite simple, and in case it is to be duplicated no difficulty should be experienced in following the diagram and photographs.

THE ANTENNA

The antenna is a very important part of the outfit, and the dimensions must be correct. The chart, Fig. 2, shows how to determine the right length to use for the working frequency chosen, as well as the proper point at which to attach the feeder. For the 7000-kc. band, multiply the frequency by 2 and divide all dimensions by 2; for 14,000-kc. multiply the frequency by 4 and divide all dimensions by 4.

The same antenna may be used for all three bands by making it the proper length for the lowest frequency used. It must be noted, however, that a length must be chosen so that the harmonics will fall within the limits of the higher bands if the band-changing feature is desired. For instance: If the antenna is to be used on all three bands, the length must be between 132 and 135½ feet, since only the harmonics of frequencies between 3500 and 3600 kc. will fall within the limits of the 14,000-kc. band. Similarly, if the antenna is to be used on 3500 kc. and 7000 kc. only, the length must be between 130½ and 135½ feet, since only the harmonics of frequencies between 3500 and 3650 kc. will be in the 7000-kc. band.

The point at which the feeder is attached to the antenna is important. The data in the chart should be followed exactly. Once the operating frequency is chosen, draw a horizontal line across the chart for that frequency. The points of intersection of this line with the curves will give the proper antenna length and the distance from the center of the antenna at which the feeder should be attached, respectively. These distances should be measured as accurately as possible, preferably with the antenna stretched tight, as it will be when erected.

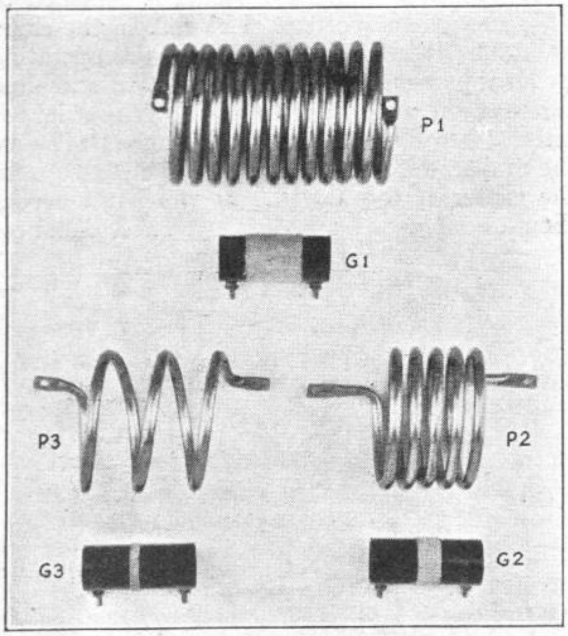


LOOKING DOWN ON THE SET
The arrangement of the parts and wiring can be plainly seen.

The antenna and feeder should be No. 14 wire, preferably enamelled. The feeder can be any length, since its length has no effect on the dimensions for the antenna given in Fig. 2. Another point, which will be appreciated by the fellow with limited space at his disposal, is that the antenna itself need not be stretched in a straight line, although it is better to have it as straight and clear of surrounding objects as possible. The feeder can, of course, be bent as may be convenient, although it should be kept several feet away from roofs, walls, etc. Both antenna and feeder should be stretched tight so they will not be affected by wind.

TUNING

It is not until the time comes to start the process of tuning up that the real simplicity of the set begins to be apparent. The coil sizes shown are correct for use with a UX-210 with about 500 volts on the plate. A radio-frequency ammeter in the feeder is of little utility, because the current with a UX-210 operating at usual input (25 to 50 watts) will be in the neighborhood of only 50 to 100 milliamperes. A plate milliammeter is a good thing to have but not entirely necessary. If the dimensions for the grid and plate coils are followed exactly, as they must be if best results are to be secured, the plate current will be just about what it should when the set is properly



THE PLATE AND GRID COILS

A description of these coils is contained in the text, while the number of turns on each is given below.

Coil	*Band*	*Turns*
P-1	*3500*	*12*
P-2	*7000*	*5*
P-3	*14,000*	*3*
G-1	*3500*	*60*
G-2	*7000*	*25*
G-3	*14,000*	*9*

tuned to the antenna frequency. While the set will oscillate over a wide frequency range with each set of coils, the sizes specified for the grid coils are such that the optimum output and efficiency will be obtained in the respective amateur bands. The length of the antennas determines the transmitter frequency so closely that if it is built correctly and the oscillator tuned to it, it is almost impossible to be out of the band, even if no frequency meter is available. However, a frequency meter and monitor are as helpful with this set as with any other, and it is strongly recommended that they be used.

The problem, therefore, is to tune the oscillator to the antenna. Only one very simple piece of apparatus is necessary for this, the flashlight bulb and loop of wire shown in the photograph. The process is as follows: With the antenna clip disconnected from the plate inductance, press the key and bring the loop near the end of the plate coil at the front of the set. The plates of the tuning condenser should be about 4/5 of the way in, assuming the set is to be used on 3500 kc. (With the coils and condenser described, the center of the 3500-kc. band will be at approximately 85 on the condenser scale, 7000 kc. at 75, and 14,000 kc. at 45. The condenser has a straight line capacity curve.) The lamp should light, indicating that the set is oscillating, and the loop should not be brought too close to the coil or the filament will burn out. It will probably be found that the lamp will light when the condenser is turned over about 50 per cent of its scale.

The antenna clip should now be put on the plate coil four or five turns from the front end (the end connected to the rotor of the condenser). Hold the loop steady a few inches from the coil, and swing the tuning condenser over the upper portion of the scale. As the dial is turned the lamp will get dimmer, and if the loop is held far enough from the inductance a point will be found where it will go out. Moving the condenser beyond this point will make the lamp get brighter again. *The point at which the lamp goes out is the point at which the oscillator is tuned to the antenna.* Now move the antenna clip toward the front end of the coil one turn at a time, swinging the tuning condenser, as before, each time a change is made. The dip will always occur at about the same place on the condenser, but as the clip is moved toward the front of the coil it will be less pronounced. Continue this until the dip is just perceptible. Then move the clip back toward the plate end of the coil one turn, tune as before and, as a final adjustment, set the condenser at slightly less capacity than the point at which the dip occurs. The signal should be checked at this point by means of a monitor or by tuning the regular receiver to a lower frequency band, as the final adjustment of the tuning condenser sometimes has a very noticeable effect on the tone. There should be just enough detuning to make the frequency stable and the note clear.

The tuning for the 7000- and 14,000-kc. bands is done in a similar manner, except that the clip should be moved only a fraction of a turn at a time. The number of coupling turns will vary somewhat, depending on the frequency used and whether the antenna is being operated on its fundamental or on a harmonic. In general, about 3 turns will be sufficient on the 3500-kc. band, 1 on the 7000-kc. band, and 1/4 to 1/2 turn on the 14,000-kc. band.

Since a Hertz antenna will work quite well within a narrow band of frequencies about its fundamental, tuning over a small range of frequency is permissible. For this reason, it is possible to have the frequency fall outside the limits of the amateur bands if the antenna length chosen is near one of those limits and the tuning is not exactly correct. This is especially true when operating on 7000 or 14,000 kc., particularly when tuning to a harmonic of the antenna, the resonance peaks on the harmonics not being as sharp as on the fundamental. A frequency-meter or calibrated monitor is therefore highly advisable.

Although this set was built primarily with the idea of working out something which would offer the minimum of constructional and operating difficulties, there has been no undue sacrifice of efficiency for the sake of simplicity. In fact, with so few controls, the chances are that a higher overall efficiency will be obtained than could be expected from the average amateur transmitter in which there are so many opportunities for maladjustment. It is not offered as a panacea for all transmitter ills, but despite its lack of complications it will compare favorably with any set of equivalent power capable of producing a "1929" signal.

A SUGGESTION FOR BEGINNERS

While monitors and frequency meters are every bit as essential to the operation of all good amateur stations as the receiver and transmitter, most beginners, sad to relate, put off constructing them until they get tired of guessing at what they are doing. This generally occurs months, and in some cases even years, after the transmitter has been functioning with apparent success. Since we know that the number starting off hopefully with only a receiver and transmitter is going to be quite large, we shall offer a few suggestions on getting started which do not require the use of a monitor and frequency meter, although it is strongly recommended that they be constructed at the earliest opportunity.

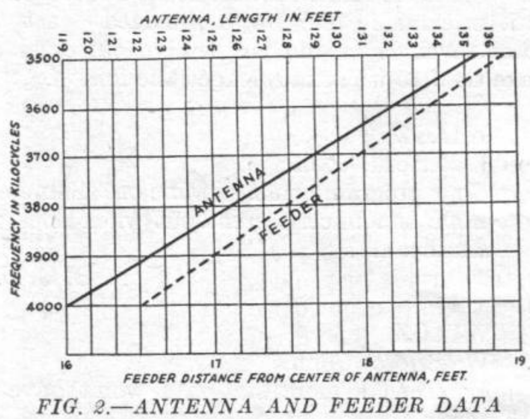
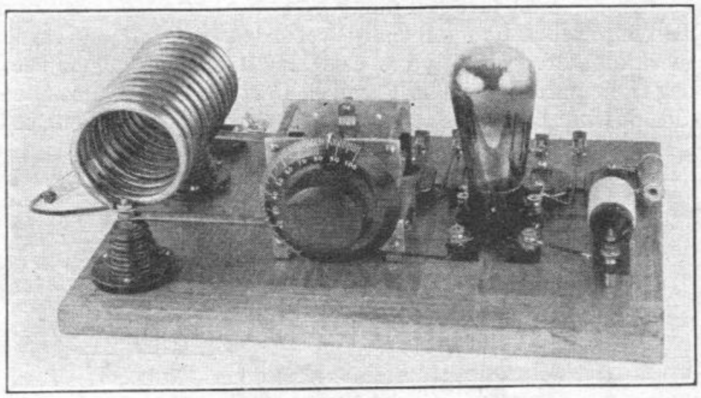


FIG. 2.—ANTENNA AND FEEDER DATA

While the above curves are for fundamental operation in the 3500-kc. band, they apply equally well to 7000 kc. by dividing all dimensions by 2, and to 14,000 kc. by dividing all dimensions by 4, simultaneously multiplying the frequency by the same factor.

In the first place, the frequency band on which every new man should make his first bid for the world's attention is that between 3500 and 4000 kc. The glorious super-DX possibilities of the 7000- and 14,000-kc. bands may have been extolled by an ardent ham friend, but in his enthusiasm he probably forgot to mention the freakishness of 14,000 and the congestion on 7000 kc. There is much good DX to be done on 3500. There is also the advantage, of prime importance to the beginner, that it is easy to get a set working right on this band. The interference is comparatively negligible and signals are dependable at all seasons. In addition, there is the opportunity for pleasant QSO's and rag-chewing, traffic handling, participation in Army and Navy communication work; in fact, all the joys of operating as opposed to DX hunting. It is an ideal band for learning correct operating practices and improving code speed.



A REAL BEGINNER'S VERSION

This one was built from the instructions given above by our Headquarter's Mail Clerk, Ralph Beaudin, as his first transmitter. Just to show that it is not necessary to make an exact copy of the original model, he has incorporated a few original ideas of his own. A National tuning condenser is used instead of a Cardwell and the grid coil is made plug-in by using G.R. jacks and plugs. Needless to say it works every bit as well as its forerunner.

A good way to start out is to build a set such as is described above, making the plate and grid coils for 3500 kc. A UX-210 tube should be used with about 500 volts of the nearest thing to pure d.c. it is possible to get. If for any reason such a plate supply cannot be had, some form of rectified a.c., or as a last resort, unrectified a.c. may be used. The investment in a power supply is quite an item to some of our younger members who have more eagerness to get on the air than cash to do it with. 180 volts or even less supplied by a B battery or eliminator will tide over the period between desire and fulfillment for such as these. If the UX-210 is out of reach at first, a UX-201-A may be substituted with practically as good results at low plate voltages. Some other types of tubes will also work in the set without any changes being necessary, but if the grid-filament capacity of the tube is very much different from that of a UX-201-A or UX-210 a change in the number of turns in the grid coil may be necessary. It is better to stick to the UX-210 or UX-201-A.

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Arctic Auroral Radio Interference

(Continued from page 20)

It would be a fine thing for radio if some expedition could and would major in that work. In passing, let it be said that observations of the type described require much dashing in and out from warm hut to sub-zero weather and will fare best when some definite planning is done in advance.

For instance, in our own case we had to do things on the spur of the moment. When the aurora would manifest its interest in radio, it was necessary to wake up the aerologist, Mr. Kallquist, and ask him to rush out into the penetrating cold night and take angles on the displays with a theodolite. That meant hasty dressing and only too often we had to evolve our own technique as we went. The observations were not always successful, because we were not at all sure of our course of operations. We were keenly aware that our other routine work interfered with explorations in this field of radio. If the reader will examine the illustration of the hut he will note that the entrance is like a tunnel, and actual practice demonstrates that while this style is best for general expeditionary work in Greenland, it is not adapted to the before mentioned rushing in and out, for the reason that one tends to stand erect before the passage is completed and the consequences of attempting to raise the building Ajax-wise seriously disturb one's mental notes.

The author has mentioned all this to show that he firmly believes a properly planned expedition, with coördinated observations being carried on at other points, will offer really interesting and important contributions to the radio art. It is indeed significant to point out that contributions such as those outlined in this and a previous article [3] were spare time by-products of a meteorological expedition.

The author wishes to acknowledge his debt of gratitude to Mr. Clarence R. Kallquist, of the U. S. Weather Bureau, whose efforts and enthusiasm assisted greatly in gathering this data. The Radio Corporation of America and the Burgess Battery Co. both lent valuable apparatus which made the work possible, thus sharing any credit for discoveries made or scientific services rendered.

The Single Control Transmitter

(Continued from page 29)

The antenna should be 127½ feet long. There seems to be considerable confusion among beginners regarding the terms "antenna" and "feeder." The function of the antenna is to radiate energy in the form of radio waves; that of the feeder is to transfer this energy from the set to the antenna without itself radiating. The antenna is a wire all by itself, and must, when of the type described above, have a certain, definite length, this length being determined by the operating frequency chosen, as shown by the chart, Fig. 2. The feeder, which can be thought of as a lead-in wire, must be fastened to the antenna at a certain,