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Station 1BCG

A Paper Presented by George E. Burghard at meeting of Radio Club of America, Columbia University, Dec. 30, 1921.

Here is a complete description of a station that has shattered all kinds of amateur records. 1BCG has been heard in places where a "1" never got before; it has handed messages three nights running to the Pacific Coast; it has been copied solid in Scotland; heard in Holland on a tuned-plate regenerator and detector-two-step; and has just been reported by a ship's operator as QRK at dock in Hamburg, Germany, on the ship set.—Ed.

BEFORE going into the description of station 1BCG it may be well to consider for a moment the history of transatlantic amateur communication.

The idea of transmitting American amateur signals to the Continent originated with one of the prominent members of the Radio Club of America before the world war when Mr. L. G. Pacent presented the matter for the consideration of the board of direction. Nothing definite was accomplished, however, and when Mr. Thomas Styles went to France after the war, Mr. Pacent suggested that the club erect a station to attempt communication, but the proposition was abandoned as too costly at the time. Some time after this Mr. Philip Coursey of "The Wireless World" took up the matter with Mr. White of the Wireless Press with like result, everyone being sceptical as to the success of the affair. Then Mr. M. B. Sleeper, at that time radio editor of "Everyday Engineering", took the idea up in earnest and laid the plans for the first amateur transatlantic test but was later forced to give it up. The American Radio Relay League took up the task at Mr. Sleeper's request, where he left off, and the first test was run under their auspices. The periods of transmission, however, were too short and no signals were heard in Europe. Then it was decided by the League to have another test the following winter, making the periods of transmission longer, and to send a representative to England to receive the American signals. Mr. P. F. Godley was selected as the logical man to go to England. He sailed for England in November, 1921, and it is here that the story of 1BCG begins.

On November 18th six members of the Radio Club of America at an informal meeting decided to build a transmitting station that would be heard in Great Britain. The six men were E. H. Armstrong, E. V. Amy, John F. Grinan, Walker Inman, Minton Cronkhite, and G. E. Burghard.

Various locations for the station were suggested and it was finally decided to build at Greenwich, Conn., on the site of Mr. Cronkhite's station 1BCG. Thru the courtesy of Mr. E. P. Cronkhite the necessary land and facilities were obtained. The antenna and transmitter were designed and decided upon and work was begun at Greenwich on November 19th. The staff worked night and day in snow and rain until finally on November 30th the antenna and counterpoise were in place. The transmitter, which at that time was of the self-rectifying type, was also well under way and the first signals were sent out at 10:40 p.m. November 30th, with expectedly poor results. Much trouble was experienced from then on until on Dec. 5th it was decided to supplant the A.C. system with a D.C. master-oscillator set.

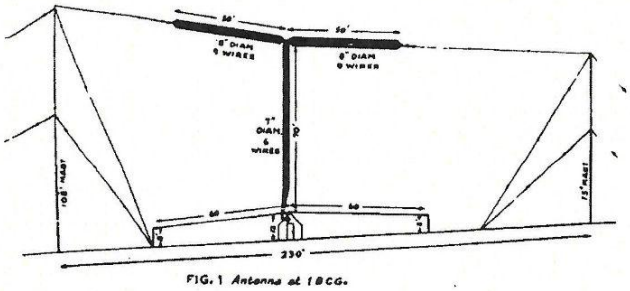


FIG. 1 Antenna at 1BCG.

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This system, which will be described in detail later, was made permanent and was used in the transatlantic tests and is still in use at 1BCG at the present time.

The antenna system used is of the type T cage with a radial counterpoise. The dimensions are as shown in Fig. 1. The antenna proper is hung between two pipe masts 230 feet apart and 108 and 75 feet high, respectively. The two horizontal sections of the cage are each 50 feet long, 18 inches in diameter, and consist of eight phosphor-bronze wires. The vertical section is 70 feet over the top of the counterpoise, 7 inches in diameter, and consists of 6 wires. The counterpoise wires can be seen in relief stretching from the top of the transmitting shack which was located directly under the middle of the antenna, thus placing the transmitter in the center of the system. A bird's-eye view of the counterpoise is shown in Figure 2.

As can readily be seen the system is divided into two fan-shaped halves, each containing 15 wires all of equal length, i.e., 60 feet, and radiating from the transmitter as a center. The reason for this division of the counterpoise is of no importance since it was intended to prevent harmonics in a predesigned system which was never put into practice. The natural period of this system of antenna and counterpoise from actual measurement proved to be between 190 and 195 meters.

The resistance of the antenna and counterpoise thru a range of wave lengths from 200 to 330 meters was found to be as follows:

Wave Length Meters	Resistance Ohms
200	40
210	31
215	18
225	16
230	15.5
240	14
270	12.5
290	17
310	12
330	9

Unfortunately no further readings were taken but since the working wave length of the station was 230 meters a fair idea of the antenna efficiency can be obtained from the figures at hand. The sudden rise in

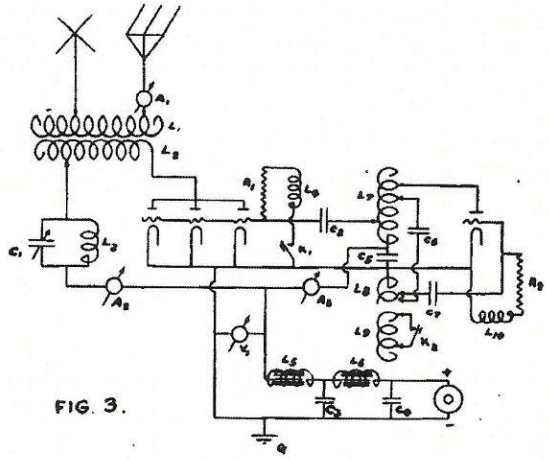


FIG. 3.

Constants for Fig. 3

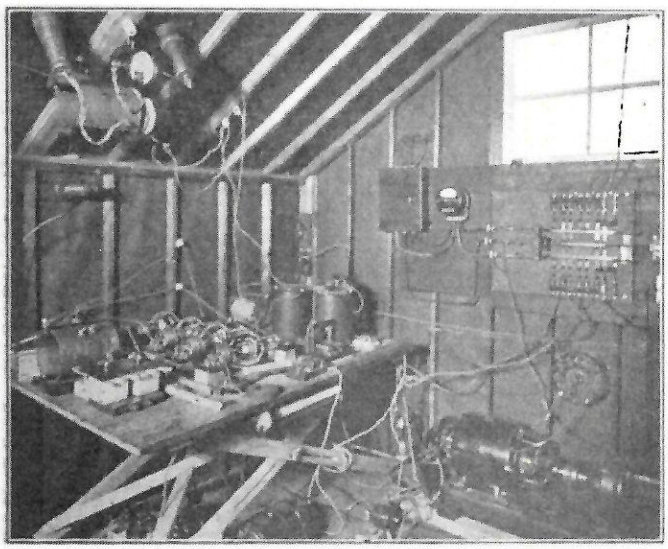
A_1.....0-15 thermo-couple ammeter
A_2.....0-3 ammeter
A_3.....0-500 milliammeter
C_1.....variable
C_2.....0.002 mfd.
C_3.....0.250 "
C_4.....0.0017 "
C_5.....0.250 "
C_6.....0.001 "
C_7.....0.002 "
L_1.....5½ turns, UL-1008
L_2.....36 turns, 5" diam.
L_3.....3 millihenry choke
L_4.....3 millihenry choke
L_5.....9 henries
L_6.....9 henries
L_7.....16 turns, UL-1008
L_8.....3 turns, UL-1008
L_9.....3 turns, UL-1008
L_{10}.....3 millihenry choke
R_1.....2500 ohms
R_2.....1000 ohms
V_1.....3000 volt meter
K_1 K_2.....relay signalling keys

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resistance at 290 meters was later found to be due to the receiving antenna which had a fundamental wave length of approximately 290 meters.

No real earth ground was used in the station except to ground the filaments of the transmitting tubes, and for receiving; this consisted of several four-foot ground stakes driven into the ground.

The design of the transmitter centered about one main idea, the production of that type of 200 meter wave which would be most effectively handled by the superheterodyne method of amplification and that type of audible signal which would be most effective on the combination of the telephone and the human ear.



Interior view of the station.

To meet the first condition, that is, the electrical requirements of the superheterodyne, a pure undamped wave must be used. It is obvious that the superheterodyne with its great selectivity and highly resonant system cannot give its maximum response when there is any discontinuity or variation in amplitude in the transmitted wave. Undamped waves must be used, waves of a type which can be obtained only from a vacuum tube oscillator with a continuous current plate supply.

To meet the second condition (the combined electrical characteristics of the telephones and the physiological characteristics of the human ear) a current must be produced in the telephones which corresponds with the natural period of the diaphragms and which remains constant within the narrow limits permitted by the resonance curve of the diaphragm and the physiological characteristics of the ear. There must be no variation in this frequency which will disturb the mechanical resonance of the diaphragm, nor flutter in note which will disturb what may be called the physiological resonance of the ear. The permissible limits of variation in frequency for a 1000 cycle note are well under 100 cycles. Hence for heterodyne reception at 200 meters or 1,500,000 cycles, a variation of frequency of less than 1/100 of one percent would be extremely disturbing to the operator and a variation of 1/20 of one percent would be sufficient to carry the note into an inaudible frequency.

The whole proposition therefore comes down to the construction of a vacuum tube transmitter producing undamped waves of an absolutely constant frequency which stays constant with an instantaneous application of a load of 1 K.W. There is but one type of transmitter which can possibly meet this condition—the master-oscillator-amplifier type with a motor-generator for the plate supply.

The general layout of the transmitter is illustrated by Figure 3. Four type U.V.-204 Radiotrons were used, one as the master oscillator, three in parallel as amplifiers. The filaments of these tubes were connected in pairs of two in parallel and each pair was lighted by A.C. obtained from the ordinary type of filament-lighting transformers. The plate supply was ob-

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tained from a double-commutator 2200 volt 1.5 K.W. continuous current generator with A.C. drive.

The master-oscillator circuit employed was of the standard split inductance type with a fixed tuning condenser of the rather large value, for 200 meter work, of .001 mfds. The inductance consisted of a helix of 25 turns of copper strip wound edgewise, having a diameter of about 6" and a length of 9". This choice of constants was arrived at largely on account of an accident to several condensers of smaller

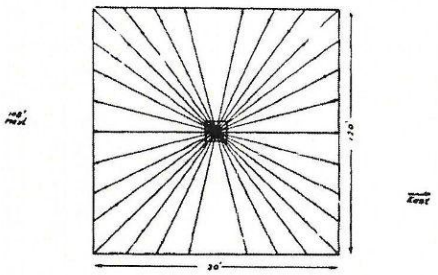


FIG. 2 Counterpoise at 1BCG

capacity in the master oscillator circuit on the first night of the tests. The only available condensers capable of standing the required voltage were two .002 mfd. mica condensers which were connected in series to give .001 mfds. The other constants of the circuit were then adjusted to fit this capacity. The usual grid condenser, with a high resistance leak and choke coil connected between grid and filament, was used.

The amplifier consisted of three tubes with their respective grids and plates connected in parallel. The grids were connected thru a series condenser to a tap on the plate side of the master-oscillator inductance. The usual grid leak and choke coil were connected between grid and filament. The plate circuit was coupled to the antenna thru a two-coil oscillation transformer. The primary or plate side of this transformer consisted of a coil of 36 turns of litz, having a diameter of 5" and a length of 3½". The secondary or antenna coil consisted of about 6 turns of edgewise-wound strip 6" in diameter. The plate circuit of the amplifier was tuned by means of a capacity consisting of three .005 mfd. variable air condensers connected in series to withstand the voltage. The path for the continuous current in the plate circuit was completed by a choke coil connected across the three condensers.

The filter circuit consisted of a two stage series inductance, shunt capacity filter, both inductances being placed in the positive generator lead. These inductances were of the open-core type, wound with No. 22 B. & S. wire, each having an inductance of 9 henrys and a direct current resistance of 85 ohms. The capacity of the two shunt condensers was .25 mfds. each.

The method of signalling used was as follows: The master-oscillator was connected permanently to the generator and ran continuously whenever the motor-generator was running. Its circuit was never broken. Signalling was accomplished by means of two magnetically-controlled keys. The first opened the grid leak circuit of the amplifiers. The second simultaneously shortened the wave length of the mater-oscillator about 5 meters by short-circuiting a couple of turns of a coil in inductive relation with the master-oscillator circuit. Under steady operating conditions this transmitter maintains 6 amperes in the antenna with an input of 990 watts into the plate circuits of all four tubes. The power in the antenna for this current is 558 watts, corresponding to an antenna resistance of 15.5 ohms. This gives a plate efficiency of about 56% with 2200 volts on the plates. On account of various breakdowns in different parts of the apparatus this output was not obtained and the set was not in condition for steady operation until 1:10 A.M. of December 9th.

There are some points of interest about the set which are novel. Probably the most important is the stability of the master-oscillator. This is due to the type of oscillating circuit and the relatively large power of the master-oscillator, and to the tuning of the plate circuit of the amplifier which permits the neutralization of the reaction of the amplifier on the master-oscillator system. This is accomplished by adjusting the tuning of the amplifier plate circuit and the coupling with the antenna until the plate current of the master-oscillator tube remains unchanged when the key is closed.

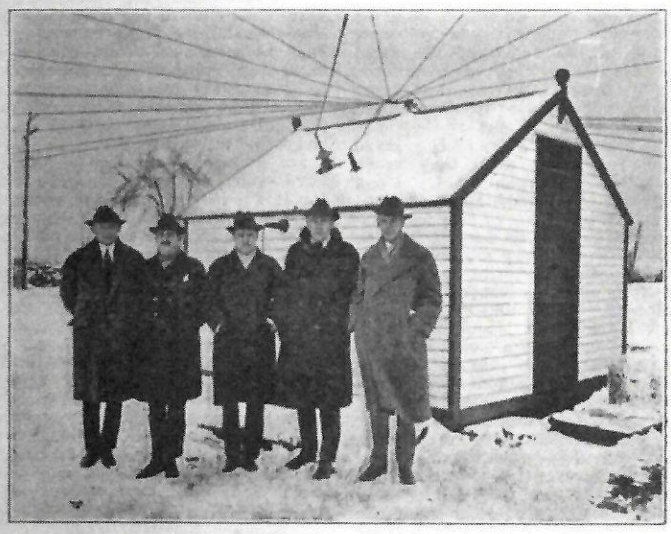
In addition to this effect the series tuning system in the amplifier plate circuit has the very important advantage of increasing the transfer of energy to the antenna circuit when the antenna coil has but a few turns. It therefore assists in operating the antenna system close to its fundamental wave length.

It is interesting to note here that great difficulty was experienced in the first few days of operation in obtaining reliable information regarding the steadiness of the note. This was due to the fact that signals from 1BCG were sufficiently strong to affect and alter to a considerable degree the frequency at which receiving sets with-

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in a radius of fifty miles were oscillating. This resulted in a bad note. The solution to this difficulty was found by setting up a self-heterodyne detector in the station with 150 volts on the plate, without a stopping condenser, and with a tuning circuit of small inductance and large capacity. By adjusting the frequency of this circuit to one third of the frequency of the station, beats were obtained between the fundamental of the station and the third harmonic of the receiver. This enabled the frequency of the station to be observed perfectly. Observation on a windy night, when the notes of all C.W. stations heard were varying so badly as to be almost unreadable, showed the frequency to be absolutely unaffected by the motion of the antenna. The reports on this set from all parts of the country show beyond question that radiation of this kind is superior to very many times the energy radiated from the ordinary types of C.W. transmitters.

In connection with the actual operation of the station it will be interesting to quote from the engineering log in order to give an idea of the difficulties encountered: "Dec. 6th—During the evening the master oscillator is connected up. Two amplifiers in use. Tubes running very hot. A CQ was sent out at 3:30 A.M. and condensers boil over." "Dec. 7—One tube is found to be defective leaving only one amplifier. While we are adjusting the master-oscillator for cooler operation many stations are heard sending in Transatlantics. Finally sent CQ to Godley with 3 amps. in antenna. More tubes arrive—set is in operation until condensers in the master-oscillator circuit heat up so that it is advisable to shut down." "Dec. 8—Much trouble is experienced with condensers in master-oscillator circuit. Tested for adjustment all nite. 1:12 A.M. finally got condensers fixed with 6 amps. radiation and worked until 6:35 A.M. All OK now". From this it can be seen that the station was actually not in operation until the 9th of December and in the short period of three weeks to date has accomplished some amazing long-distance feats.



The station building at 1BCG and five of its owners. Left to right, Messrs. Amy, Grinan, Burghard, Armstrong, Cronkhite. Mr. Inman is missing in this photo. Note the counterpoise radiating from the top of the station, and the lead-in from it and the antenna.

1BCG's signals have been heard in practically every state in the Union; in Scotland on Dec. 9, 10 and 11; England, Holland, Porto Rico; Vancouver, B. C.; California and Washington. The greatest distance covered is to Amsterdam, Holland, approximately 3800 miles, mostly over water, and 2600 miles over land to Smith River, Calif. Last but not least 1BCG has established new records by sending three complete messages to 6XAD in Avalon, Catalina Island, Calif., and one 12-word message to Ardrossan, Scotland, at 9:45-10:00 P.M. Dec. 11, 1921; all with an input of 990 watts and wave length of 230 meters.

Photographs of 1BCG, thru the courtesy of Mr. J. Edw. Brown, of 1BKA, Glenbrook, Conn.

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