national operation which for some weeks
boring British amateurs much concern
due to an unfortunate choice of words
the G.P.O. and that there was no intent
hanging the existing regulation respecting
operation, so we may expect the
ions in numbers.
wouldn't take an awful amount of luck
make the Amateur 'Round-the-World Re-
a reality this winter!

A Caution

HERE is danger, now that we have a
variety of wave-band allocations, that
we may split into a number of families
inhabiting one of those bands and
leaving nothing of the others. Until we
cover some simple method of working
where at will, most of us will not succeed
making our transmitters work efficiently.
Most of us cannot afford a multiplicity
of complete transmitters. The tendency,
will be for some of us to become isol-
ated on certain bands and others of us on
other bands.

We must avoid that. The easiest way is
every one of us to have a receiving
set that will cover all the amateur bands
and make it a regular practice to listen in
each band. In that way we can keep
touch with each other, see what the other
is doing, and find out what bands we
are most interested in ourselves. Then we
visit around, eternally speaking, and
continue one big family.

Notice to Our Newsstand
Readers

As announced in recent issues, The Traffic
Report and the “Calls Heard”
report have been eliminated from the
issue of QST because our non-
member readers in general are not particu-
larly interested in them. This results in
saving in expense which makes possible
publication of a larger and better QST.

These two departments are included in
the new edition of QST. Readers of the A.B.
L. are aware that they are both positive that you ought to be a mem-
er of the League. May we not direct you
the handy application blank appearing
in page 96 of this issue?

October, 1924

The Standard-Frequency Set at WWV

By Hoy J. Walls

Probably no radio station has ever rendered the American radio world so great a service as
that of WWV in transmitting the standard wave signals. Before these signals began both broad-
cast and amateur waves were uncertain and often wave meters disagreed violently. Since the signals
began those in the East have been able to make precision calibration on their own wave meters and
to pass the information on into the West.

WWV is here described by the man who has been most active in furthering the progress of
this service.

During the past year the Bureau of
Standards has been transmitting
standard frequency signals from
station WWV over a frequency
range from 125 to 2000 kilocycles.
These signals have been received with enthu-
siasm by all classes of radio operators. The
frequencies from 125 to 500 kilocycles have
proven useful to operators of Government,
commercial, and ship stations. Frequen-
cies from 500 to 1,300 kilocycles have
assisted materially in keeping
the broadcasting stations on their
assigned frequencies and the
frequencies from 1300 to
2000 kilocycles have enabled the
amateurs to keep within
their bounds.
The purpose of
this article is to
describe the appa-
ratus used at
the Bureau of
Standards for
transmitting
these signals.

The transmitting set is a
WW. continuous
wave set of the
"master-
oscillator power-
amplifier" type,
especially de-
signed to oper-
ate over a wide
range of frequen-
cies and to
permit rapid
change from one frequency to another. A
photograph of the set is given in Fig. 1.

On the upper shelf is mounted the master-
oscillator, modulator and speech amplifier
tubes and their associated tuning and other
apparatus. On the bottom of this shelf on
the left side of the frame is mounted the
variable condenser that is used in
coupling the master-oscillator to the grids
of the amplifier tubes. The next shelf
contains the amplifier tubes with their sep-
parate plate fuses and grid circuit. Under
these tubes on the next shelf are mounted the
antenna tuning condenser and one of the an-
tenna inductors. The bottom shelf holds the
antenna inductors. The bottom shelf holds the
antenna inductors, amplifier grid
battery, the modulator and
speech amplifier
grid batteries. On the floor di-
rectly under the
set is a large
condenser which
is used in the
antenna circuit, between the set and the ground,
to prevent grounding the direct-current
high voltage supply when the ground
connection is used. The
large inductors in the rear of the
set are used to load the
antenna circuit when transmitt-
ing on the low frequencies and the small
spiral inductor is used as the antenna
inductance for the extremely high frequencies.
On the panel are mounted all the tuning
controls and indicating instruments except
the antenna ammeter which is mounted on
the rear of the frame.

Fig. 1

A Radiating System That Would Make Almost Any Ham
Jealous. WWV Uses The Large Antenna for Transmitting
The Longer Waves of Their Standard Wave Transmissions
and the Small Antenna for the Short Waves.

Fig. 2

Published by permission of the Director of the
Bureau of Standards.

Assistant Physicist, Bureau of Standards.
The general arrangement of the antennas used is shown in Fig. 2. The large flat top T antenna which is supported between the two towers is approximately 120 feet high and 200 feet long, and is insulated with molded composition insulators. Its natural frequency is approximately 750 kilocycles. The smaller T cage antenna which is supported between one of the towers and a mast on an adjacent building is 90 feet high and 80 feet long and is insulated at each end with five 4-inch porcelain insulators in series. The horizontal portion is a 6-wire cage, 24 inches in diameter, and the down-lead is a 4-wire cage 4 inches in diameter. Its natural frequency six points and is insulated with porcelain insulators. The two antenna leads and the counterpoise lead are brought into the operating room through holes in a plate glass window. A ground connection consisting of approximately 1000 feet of No. copper wire buried six inches in the ground directly under the small antenna in a rectangle approximately 150 feet long and 50 feet wide is also available.

When transmitting on frequencies from 150 to 300 kilocycles the large antenna is used together with the counterpoise and ground connected in parallel. No attempt is made to tune the counterpoise when used with the ground connection. For frequencies from 400 to 2000 kilocycles the small cage antenna is used with the counterpoise, in which case the latter becomes a part of the tuned antenna circuit.

The circuit diagram of the transmitting set is given in Fig. 3. The master-oscillator which is shown in the center of the diagram employs a 50-watt tube in a Hartley circuit made up of the inductance L and the capacity C. The inductance L consists of 30 turns of % inch edgewise wound copper ribbon on a former 9 inches long and 12 inches in diameter. The condenser C has a capacity of 0.0005 mf and is used for frequencies from 250 to 2000 kilocycles. To obtain lower frequencies it is necessary to parallel C, with two fixed condensers whose capacities are 0.002 and 0.004 mf.

Series feed is employed in a manner somewhat unusual in a Hartley circuit but quite common in other circuits. By introducing the plate voltage across a condenser in the filament tap the radio-frequency voltage across the choke coil L is reduced to a negligible value. This method as well as any series feed method has the disadvantage that all parts are “alive” with both the radio frequency and the direct current, and care must be taken while making adjustments with the plate voltage on. To prevent possible damage to the amplifier tubes should condenser C flash over, a large well insulated condenser (about 2.3 mf) is put in series with condenser C to prevent the direct current from the master-oscillator from reaching the grids of the amplifier tubes. The filaments of the “master-oscillator,” modulator, and speech amplifier tubes are lighted by direct current from a 21-volt, 12-ampere storage battery.

The power amplifier consists of four 250-watt tubes connected in parallel. Radio-frequency voltage from the master-oscillator circuit L, C, is fed through the condenser G, directly to the grids of these tubes. Small choke coils L, G, are used in series with the grids to prevent parasitic oscillations. A negative voltage of about 200 volts is used on the grids of the amplifier tubes. This voltage is obtained partly from dry batteries and partly the voltage drop across the resistance plate circuit. The use of such negative voltage on the grids of amplifier tubes causes considerable distortion on amplifier plate current which results in higher total efficiency but increases the intensity of the harmonics in some greater proportion than it does on the fundamental frequency. The amplifiers feed directly into the antenna circuit consisting of the inductors L, G, and the condensers C, G, F. The frequencies from 1000 to 2500 kc for the spiral inductors mounted on the receiver are used and the variable condenser F are used above the neutral point of the antenna. For frequencies from 400 to 1000 kc the inductor in the transmitting set is made of a number of turns of wire of about 60 turns each. This winding is placed between the two inductors mounted on the wall in the space between the inductors. The set is key for opening the amplifier grid circuit and shorting the amplifier tubes to block. The master-oscillator circuit is keyed by a short circuit from the keying circuit. This short circuit passes through the capacity of the grids and plates of the amplifier tubes into the antenna. This current causes a weak “back wave” which can be heard for several miles.

For frequencies from 75 to 500 kc, four 250-watt tubes are used in the power amplifier. For frequencies from 500 to 1500, three tubes are used, and from 1500 to 2000 kc, only two tubes are used. On the lower frequencies it is possible to operate four tubes in parallel in the amplifier and obtain output corresponding to their ratings, but on the higher frequencies the circuit arrangement used satisfies performance which is obtained with two amplifiers in parallel. In fact the output from the amplifier is obtained between 1500 and 2500 kc is greater than that on the even four tubes are used.

The high voltage supply to the transmitter set as well as the filament supply in grounded iron conductive and herein.

Fig. 1

The 1-kw. Master-Oscillator Power-Amplifier Set At WVV By Which Many Amateur Wavemeters Have Been Calibrated.
points and is insulated with porcelain ators. The two antenna leads and counterpoise lead are brought into the antenna room through holes in a plate 1/2 inch thick, the ground connection being made with a ground connection consisting of approximately 1000 feet of No. 4 wire buried six inches in the ground, which is connected to the antenna in a reel approximately 150 feet long and 50 wide is also available.

When transmitting on frequencies from 400 to 2000 kilocycles, the large antenna is used with the counterpoise which is attached to the ground connection. For frequencies from 400 to 2000 kilocycles, the antenna circuit is used with the counterpoise, in which case the latter becomes part of the tuned antenna circuit.

The circuit diagram of the transmitter is given in Fig. 3. The master-oscillator, which is shown in the central region of the transmitter, employs a 50-watt tube in a Hartley circuit made up of the variable inductor L, the variable condenser C, the indicator lamp and 50 turns of 1/4 inch edgewise copper ribbon on a form 9 inches long and 12 inches in diameter. The condenser has a capacity of 0.0005 microfarads and is used for frequencies from 250 to 2000 cycles. To obtain lower frequencies it is necessary to parallel C with two fixed condensers whose capacities are 0.002 and 4 mfd.

Series feed is employed in a manner somewhat unusual in a Hartley circuit but is common in other circuits. By inserting the plate voltage across a condenser and tapping the radio-frequency across the choke coil L, is reduced to negligible value. This method as well as the series feed method has the disadvantage that all parts are “alive” with both radio frequency and the direct current, and care must be taken while making adjustments with the plate voltage on. To prevent possible damage to the amplifier tubes, the condenser C should be charged flash over, as well insulated condenser (about 2.8 mfd) is put in series with condenser C to prevent the direct current from the master-oscillator from reaching the grids of the amplifier tubes. The filaments of the master-oscillator, modulator, and speech amplifier tubes are lighted by direct current from a 21-volt, 12-ampere storage battery.

The power amplifier consists of four tubes connected in parallel. The plate voltage from the master-oscillator circuit L, C is fed through the condenser C directly to the grids of the amplifier tubes. Small choke coils L, are used in series with the grids to prevent parasitic oscillations. A negative voltage of about 200 volts is used on the grids of the amplifier tubes. This voltage is obtained partly from dry batteries and partly from the voltage drop across the resistance R, in the plate circuit. The use of such high negative voltage on the grids of the amplifier tubes causes considerable distortion in the amplifier plate current which results in higher total efficiency but increases the intensity of the harmonics in somewhat greater proportion than it does the output on the fundamental frequency. The amplifiers feed directly into the antenna circuit consisting of the inductors L and L, and the condensers C and C. For frequencies from 1000 to 2000 kc the small spiral inductors mounted on the rear of the transmitting set and the variable condenser C are used above the natural frequency of the antenna. For frequencies from 400 to 1000 kc the inductor mounted in the transmitting set frame is used and fine adjustment is secured by means of the variable inductor L, which is mounted back of the antenna ammeter. A single-pole double-throw switch is provided for placing either the variable inductor L, or the variable condenser C in the antenna circuit. Lower frequencies on the inductors mounted on the wall in the rear of the set are connected in the antenna circuit as loading coils. Series plate feed is employed in the amplifier for much the same reasons as were given in the master-oscillator circuit. The set is keyed by opening the amplifier grid circuit and allowing the amplifier tubes to block. Since the master-oscillator circuit is not keyed some current from this circuit passes through capacity between the grids and plates of the amplifier tubes into the antenna. This current causes a weak "back wave" which can be heard for a few miles.

For frequencies from 75 to 500 kc, four 250-watt tubes are used in the power amplifier. For frequencies from 500 to 1500, three tubes are used, and from 1500 to 2000 kc, only two tubes are used. On the lower frequencies it is possible to operate four tubes in parallel in the amplifier and obtain outputs corresponding to their ratings, but on the higher frequencies with the circuit arrangement used satisfactory performance is not obtained with more than two amplifier tubes in parallel. In fact the output from two amplifier tubes on frequencies between 1500 and 2000 kc is greater than when three or even four tubes are used.

The high voltage supply to the transmitting set as well as the filament supply are all in grounded iron conduit and hence the capacity between the wires carrying the plate and filament supply to the set and the ground is appreciated. This results in some grounding of the counterpoise through this capacity and introduces considerably more resistance into the antenna circuit. Because of this condition greater output can be obtained on some frequencies by disconnecting the bypass condenser C. However if the antenna circuit could be insulated from the set by employing inductive coupling rather than conductive coupling higher efficiency would probably be obtained but it would result in tuning apparatus which for this work would be somewhat cumbersome.

In tuning the transmitting set to any desired frequency the master-oscillator circuit, which has been calibrated and adjusted so that the tube is operating satisfactorily, is set at approximately the desired frequency. The capacity of the coupling condenser C is reduced, the antenna inductance set on the approximate value and low voltage is supplied to the plates of the amplifier tubes. The antenna circuit is then tuned to resonance with the "master-oscillator" circuit by varying either the capacity C, or the inductance L, depending on whether the desired frequency is above or below the natural frequency of the antenna. When resonance is reached, it is indicated by a maximum reading of the antenna ammeter A, and a minimum reading of the plate ammeter A. The capacity of the coupling condenser is increased and full voltage applied to the amplifier tubes. The set is then adjusted for maximum output by varying the amplifier plate inductance and the coupling condenser. Fine adjustments are then made in the tuning by means of a variable condenser in the master-oscillator circuit and by a small variable inductor in the antenna circuit. When large changes are made in frequency...
it is necessary to change the capacity of the coupling condenser C. On frequencies from 125 to 300 kc a capacity of approximately 0.001 mf is used; for frequencies from 500 to 1000 kc 0.0006 mf is used, and for frequencies from 1000 to 2000 kc the capacity is reduced as the frequency increases from approximately 0.0006 mf to approximately 0.0003 mf. If this capacity is too large an overload is placed on the master-oscillator which may stop that circuit from oscillating and damage the tube if the plate voltage supply is not quickly disconnected. When making adjustments on low power it has been found desirable to reduce the capacity of the coupling condenser C1 to about half the normal value since much more power is drawn from the master-oscillator circuit when low voltage is used on the amplifier plates than when high voltage is used.

When telephony is desired the modulator and speech amplifier shown on the left of Fig. 3 are connected in the circuit by means of two switches, one in the plate circuit and the other in the filament circuit. The modulator is a 50-watt tube similar to the "master oscillator" tube. The speech amplifier is a 5-watt tube. In order to secure good upward modulation the set is first adjusted for maximum output and then the output reduced to one-half. If, by example, it was possible to obtain a maximum output of 20 amperes of "carrier" it would be necessary to decrease the amplifier and master-oscillator plate inductance until this output was reduced to 10 amperes to secure good modulation.

The antenna current produced by the set varies from about 8 amperes on 125 kilocycles to about 35 amperes on 700 kilocycles. It then decreases to 7 amperes at 1500 kilocycles and to 1.5 amperes at 2000 kc.

A complete frequency calibration of the transmitting set has been made so that the settings may be quickly changed from one frequency to another. Previous to all standard frequency transmissions the set is tuned out on all frequencies included in the schedule and the settings checked by means of a standard wavemeter. The primary standard wavemeter is then used during the transmissions as a final check on the settings. It is quite possible by means of fine adjustment controls to set the transmitting set on the desired frequency and measurements with the wavemeter show that the master oscillator keeps the frequency practically constant during the transmission. The small variations in frequency that are noticed can be traced partly to variations in the filament supply voltage which are at times as much as from 5 to 10 percent, and partly to the swinging of the antenna. While the frequency variations caused by the swinging of the antenna have been considerably reduced by the use of the master oscillator, they are not entirely eliminated because of the slight coupling that exists between the antenna and master-oscillator through the amplifier tube capacities.

The performance of the set has been satisfactory. During the year in which it has been in operation the Bureau has received reports of its reception from all U. S. radio districts, Canada, Cuba, England and Italy. Most of the reports show that the received signal intensity is greater the higher the frequency.

Department of Commerce,
Washington, D. C.

Canadian Amateurs Get Short Waves Too

JUST one month after our Department of Commerce announced the bands of short waves for amateur use, our Canadian General Manager Russell advised the Canadian amateurs that the same bands have been assigned to Canada, until further notice. The Canadians are required to use pure C.W. but loose-coupled transmitters are not required nor do they have to make application to use these waves.

There is no question but that some of the hoggish commercial interests will protest these assignments to both our countries, yet we must insist that we have our seaman have as much right to experiment down there as they have, which is all they are doing at present. The short waves are valuable, no question about that, but we don't think they should become the exclusive property of some selfish commercial interest, at least not until after they know what they want. The frequency bands are such that there must be some room for amateur work without interference with any commercial work. Last month we mentioned some of the daylight DX on short waves and we have seen a big jump in amateur activity since the quiet hours were abolished on short waves.

F.H.S.

Short Wave Daylight Transcons

Attention, Gang! Get set for some Sunday daylight Transcons on short waves. The dates probably will be November 9th and 16th. You have plenty of time to get ready by then, but get hipped up for your best daylight DX and be ready on the 75 and 80 meter band. Details next month.

F.H.S.

At the left is the 2 meter 0 5 meter 0 and condensers. Beyond that is the D.C. instrument used to measure the home-made transformer at the right Bradleystat at the right end of the circuit of the filament transformer.