COMMERCIAL RADIO

April
1934

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MODULATION
&
CARRIER

CONTROL
GRID
vs.
PLATE
CURRENT

OPEN-WIRE
PROGRAM
CIRCUITS

MEASURING
INDUCTIVE
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CAPACITIVE
IMPEDANCES

A MONTHLY JOURNAL DEVOTED TO THE
COMMERCIAL RADIO & ALLIED FIELD

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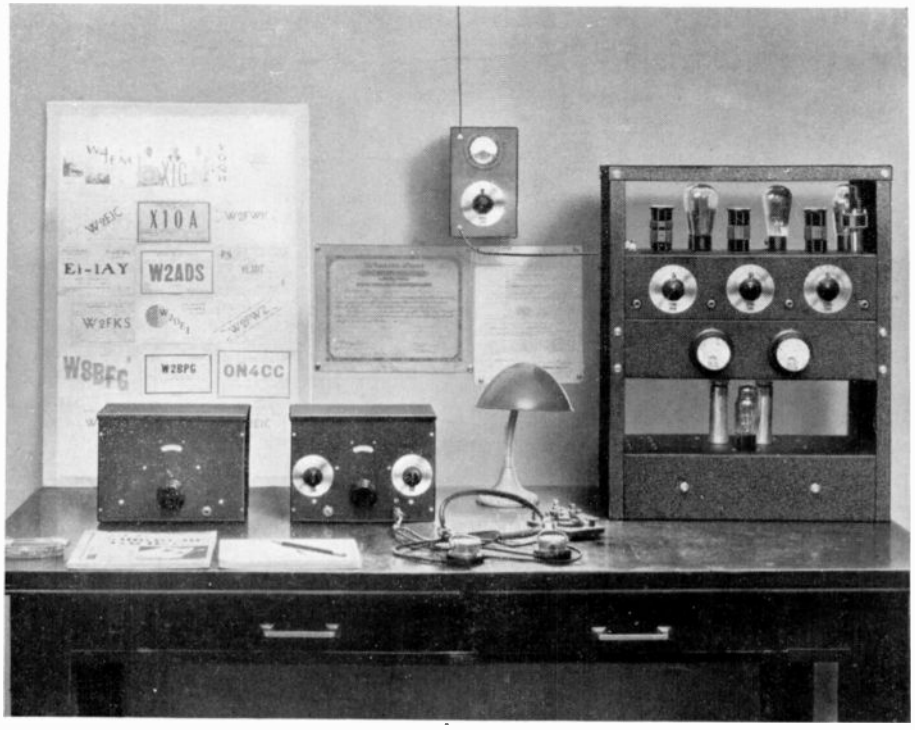

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THE GROSS "CW-25" Crystal Control Transmitter Kit

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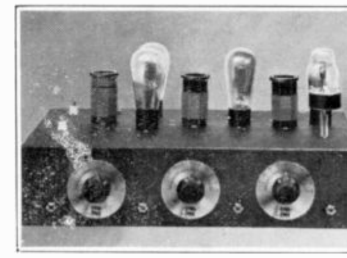

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VOLUME III NO. 8

Washington continues to be the center of interest these days, as it has been for many months past.

New legislation effecting everything in radio is being considered. Commercial stations are much concerned in pending legislation. Recent developments seem to indicate the passage of much that is being considered.

There are matters concerning responsibility of broadcasts; matters effecting working personnel; matters which will ultimately effect all sorts of government radio licenses.

While the usual pressure, both pro and con to laws under consideration is being brought to bear, it is fair to say that not much of the original thought in these contemplated changes is being effected.

The airways are looking forward to a new deal in the matter of revenue from government sources. The broadcast station managements are adapting themselves readily to changes. Summer shipping will give better opportunities for revenue. Codes are being more definitely defined, and broadened.

Just a little better in every field will soon revive our spirits of optimism, and commercial radio will be nicely working under newer and better conditions.

JAMES J. DELANEY,
Editor

L. D. McGEADY,
Business Manager

COMMERCIAL RADIO

(FORMERLY "C-Q")

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MODULATION AND CARRIER

By C. H. STOUP

Chief Engineer, Station WIL

BOTH powers equally important to broadcasting stations. A 100 watt station modulated 100 per cent produces the same strength of signal on the listeners loud speaker as a 1000 watt station would when modulated 31.6 per cent.

The modulator and modulated amplifier is the heart of the transmitter and their adjustments are critical and must be correct if 100 per cent modulation is to be obtained with less than ten per cent harmonic distortion.

Fifty per cent modulation is rather easy, however 100 per cent without overshooting the distortion limit, takes very careful adjustments all along the line and we are informed most broadcast stations are well satisfied when they reach 90 per cent modulation and stay within the distortion limits.

In plate or Heising modulation since the modulator and modulated amplifier combination is the heart of the transmitter, a few kinks to remove the kinks from this section should be in order.

If the modulator is to operate as a class A tube, the plate current should be midway between that obtained by zero and cut-off bias. The tubes most suitable for use as class A modulators are those having large undistorted audio output. They generally have low plate impedence and amplification factor and when operated as class A the output wave will have the same shape as the input wave or signal and must be able to supply a fifty per cent increase in the transmitter output power if the set is to have 100 per cent modulation.

The modulated tube must be worked as a class C amplifier and the bias must be approximately twice that required to give cut off bias and plate current saturation must be supplied by the excitation from the preceding stage. Class C modulated amplifiers require more excitation than similar amplifiers in C W telegraph transmitters and a surplus of excitation is very desirable.

Class C Amplifiers

It is just as necessary for the modulation to work into a load resistance of proper value for maximum undistorted modulation as it is for an audio output tube to work into the proper load value for maximum undistorted power output, therefore, there is a definite proper value of class C amplifier plate current for any modulator amplifier combination and the amplifier must be operated at this value of current if maximum undistorted modulation is to be obtained.

A fault with some transmitters is to operate the modulated amplifier with excessive plate current. This lowers the effective load resistance into which the modulator tube must work and means a low value of modulation without distortion. This overloading is sometimes called over-modulation.

The modulated amplifier bias should be that specified and nothing less. The excitation should be increased if necessary by increasing the output of the preceding stages.

It is considered good practice to use a transmitting grid leak in series with the generator or battery bias. The resistor sufficient to reach cutoff bias.

Maximum undistorted power output is obtained with a load resistance that equals two times the plate resistance of the tube.

In class C amplifiers, by making the load resistance high compared with the plate resistance of tube it is possible to reach near distortionless modulation, regardless of remaining adjustments, although the power output is sacrificed.

When modulated, class C amplifiers when properly adjusted will develop a 100 per cent modulated wave with very little amplitude distortion and no frequency or phase distortion.

Class B Amplification

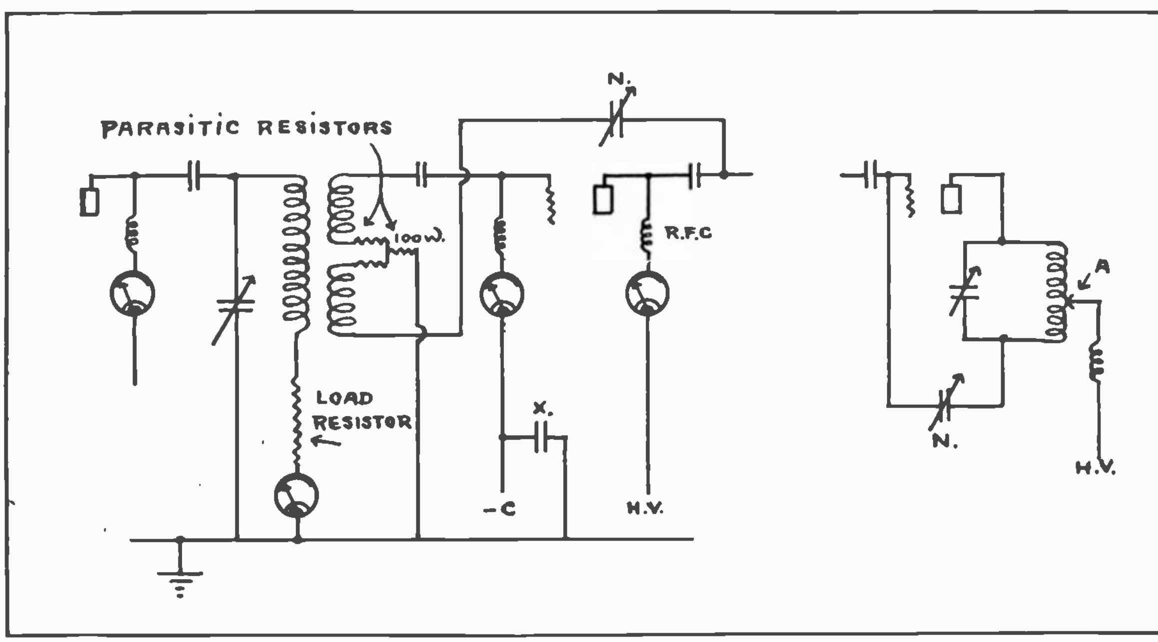
Class B amplification instead of class C must be used after the modulated stage to avoid distortion. While it is possible to use class A amplification after modulated amplifier, it is never done in practice because plate efficiency of class A amplification is much less than in class B.

To put a class B tube in operation:

First adjust grid bias to near cutoff point. Then obtain proper AC grid excitation. Use a convenient load impedence in the plate circuit and vary grid excitation until a milliameter in the grid circuit indicates there is a small DC grid current when the exciting voltage is modulated as completely as the apparatus will allow. Finally the load impedence is adjusted to give the highest plate efficiency. The load impedence should be twice the plate resistance of tube for maximum output. Lower values of load impedance giving less output than maximum at lower plate efficiency should not be used.

The safest way to adjust load impedence is to start with the greatest load impedence available. This is then reduced until plate losses become excessive or until the maximum output is obtained.

If plate losses are excessive at highest plate impedence that can be obtained, it is necessary to reduce plate voltage and



re-adjust the bias and excitation. If on the other hand the tube is not operating up to full capacity when the plate load impedence is the value giving maximum output, it is necessary to increase the plate voltage, bias and excitation.

It is impossible to get true class B amplification with grid leak alone. The approximate bias will be the plate voltage used divided by the amplification factor of the tube.

The adjustment of tank circuit should be for maximum tank current with minimum plate current (condition necessary for exact resonance). Each change in coupling or excitation to grid may necessitate retuning of tank circuit, likewise when antenna coupling or tuning is made.

Tuning

If there is not enough external resistance in the plate circuit to minimize the distortion the plate current ammeter will show an increase in reading on the loud signals. As the amount of resistance is increased the change in reading of the ammeter becomes less and less on loud signals, showing that distortionless amplification is being approached or is obtained.

As the turns of the primary winding are decreased the set-up ratio of the transformer is increased and therefore the load is increased. In any tube circuit, if the load resistance is too high, the plate current will be high without an increase in antenna current.

For best adjustment of antenna inductance start with minimum number of turns and gradually increase until proper loading is obtained but never to a point where increased plate current does not increase the antenna current. The coupling of the power amplifier stage to antenna is quite critical. There is only one set position for maximum transfer of energy, i. e., max antenna current and plate of the PA tube not too hot.

The power amplifier tube draws more plate current when antenna tuning is near resonance, and the change in plate current as plate circuit tuning condenser is moved through resonance should be smooth. A sudden sharp change in plate current generally indicates tube is breaking into oscillation and may have to be better shielded to eliminate.

Listen to program with a monitor on zero beat and much can be learned. The signal should be clean cut and clear.

Downward modulation is caused by a reduction in power output with modulation when there should be an increase in power output. It may be due to any of the following:

Insufficient class C amplifier bias of modulated amplifier.

Insufficient class C amplifier RF excitation.

Excessive class C amplifier plate current causing overloading of the modulator.

In a linear amplifier following the class C modulated amplifier, downward modulation will result with 100 per cent modulation if the carrier excitation to the linear amplifier is greater than that which it can handle for peak loads.

Downward modulation may be the indication of a defective modulator tube.

If the bias on the class B tube is less than that required for cut-off downward modulation may result.

Until recently DC generators made the most satisfactory power supply for grid bias especially for high power RF amplifiers and in particular class B amplifiers. Recent developments in rectifiers have placed them in the satisfactory class.

Parasitic Oscillations

Get parasitic oscillations out first before Neuting and Tuning.

Disconnect the power amplifier from the preceding stage.

Set the PA tuning condenser at maximum. Set Neut condenser at minimum.

Change Neut condenser from minimum to maximum and if meters do not change all is O. K.

Parasitics result from stray couplings and resonant circuits, connecting wires etc and absorb energy. They are particularly troublesome with large tubes because of high mutual conductance and high electrode capacities and long leads used. They can be killed with copper shielding, resistances in different parts of circuit or with about twenty turns of wire in a coil placed near the grid terminal.

Neutralizing

Remove plate supply from tube.

Touch neon tube to grid or plate terminal of tube and adjust tuning condenser until tube glows with Neut condenser set at minimum.

Increase value of neutralizing condenser until neon goes out and for finer adjustment, adjust tuning condenser again also the Neut condenser.

Now — swing the tuning condenser through resonance and watch the grid meter. If any flicker in grid meter make slight adjustment to Neut condenser until there is no change in the grid meter reading when tuning condenser is turned through resonance. The tube in circuit is then neutralized.

Adding resistance in the grid circuit opposes the feed back and also loads the plate circuit of the preceding stage.

In case the tube will not Neut, add a bypass condenser as shown by "X" in the sketch and if it changes grid or plate meter readings—the RF choke is not good and it may be impossible to neut until the choke is replaced with a good one of the proper number of turns. It may also cause trouble by feeding through the bias generator and getting into other circuits.

In case you can't find the old neon tube set the Neut condenser at minimum. Tune tank condenser until you get a dip in the grid current meter. This indicates the plate circuit is tuned to the preceding stage and also shows the tank circuit is drawing power. This is proof the tube is not Neuted as the dip in grid meter shows the plate circuit is absorbing some energy. Neuting will prevent the plate circuit from absorbing energy and can be obtained by proper setting of the Neut condenser.

If necessary reduce the C bias on tube being Neuted in order to get a good scale reading on the grid meter. C bias must be returned to original value after the capacity of tube is balanced.

The fewer Neut turns used at "A" in sketch the larger the Neut condenser must be and the greater loading effect it will have on the preceding stage.

The quality of transmission can be readily checked by listening on the vacuum tube monitor tuned to zero beat with the carrier.

The speech and music should be clear and distinct even with the monitor tube oscillating. If the speech sounds mushy it is a very good indication of frequency modulation.

Radio Commission Warning

In view of the ever-increasing sales of combination broadcast and shortwave radio receiving sets to the public, the Federal Radio Commission today issued a statement calling attention to provisions in the Radio Act of 1927, regarding the secrecy of certain radio messages and the heavy penalties provided for violations.

Section 27 of the Radio Act of 1927 provides:

"No person receiving or assisting in receiving any radio communication shall divulge or publish the contents, substance, purport, effect, or meaning thereof except through authorized channels of transmission or reception to any person other than the addressee, his agent, or attorney, or to a telephone, telegraph, cable, or radio station employed or authorized to forward such radio communication to its destination, or to proper accounting or distributing officers of the various communicating centers over which the radio communication may be passed, or to the master of a ship under whom he is serving, or in response to a subpoena issued by a court of competent jurisdiction, or on demand of other lawful authority; and no person not being authorized by the sender shall intercept any message and divulge or publish the contents, substance, purpose, effect, or meaning of such intercepted message to any person; and no person not being entitled thereto shall receive or assist in receiving any radio communication and use the same or any information therein contained for his own benefit or for the benefit of another not entitled thereto; and no person having received such intercepted radio communication or having become acquainted with the contents, substance, purport, effect, or meaning of the same or any part thereof, knowing that such information was so obtained, shall divulge or publish the contents, substance, purport, effect or meaning of the same or any part thereof, or use the same or any information therein contained for his own benefit or for the benefit of another not entitled thereto: *Provided*, That this section shall not apply to the receiving, divulging, publishing, or utilizing the contents of any radio communication broadcasted or transmitted by amateurs or others for the use of the general public or relating to ships in distress."

Heavy penalties are provided in Section 33, of the same act, for violations of its provisions. That section reads:

"Any person, firm, company, or corporation who shall violate any provision of this act, or shall knowingly make any false oath or affirmation in any affidavit required or authorized by this act, or shall knowingly swear falsely to a material matter in any hearing authorized by this act, upon conviction thereof in any court of competent jurisdiction shall be punished by a fine of not more than $5,000 or by imprisonment for a term of not more than five years or both for each and every such offense."

Reports reaching the Commission indicate that the public is increasingly intercepting police and other shortwave communications. Only in rare instances, it is believed, is this information abused. However, it was brought to the attention of the Commission that a young man in Baltimore intercepted a police call on a shortwave receiver in his home and noti-

(Continued on **Page 16**)

OPEN-WIRE PROGRAM CIRCUITS

By R. A. LeCONTE

Member of Technical Staff, Bell Telephone Labs.

CABLE circuits, because of their reliability and freedom from outside disturbances, are eminently suited for the extensive networks employed to carry the broadcast programs of the country. A cable program system, with amplifiers and other auxiliary apparatus, capable of transmitting a band from 35 to 8000 cycles, has already been made available. There are wide stretches of country, however, which can be covered at the present time only by open-wire lines. Programs have been transmitted over such lines since the early days of broadcasting but the facilities originally employed were adaptations of existing message circuit apparatus, rearranged and supplemented to provide for a frequency band covering only the range from about 100 to 500 cycles. These circuits gave creditable performance for moderate distances. Modifications were made later which somewhat improved these facilities but although immediate relief was thus obtained, it seemed desirable to develop a new open-wire program system which would have general transmission characteristics comparable with those of the cable circuits.

The noise level on open-wire circuits is appreciably higher than on cables, and to maintain a satisfactory signal-to-noise ratio, therefore, a stronger signal must be transmitted. To provide for this, the new open-wire program amplifier, known as the 14-B, employs tubes of higher load carrying capacity than the cable amplifier, and arranges them in a push-pull circuit, as shown in Figure 1. High grade coils with permalloy cores having large inductances, and resistance coupling between stages made it possible to obtain a small low-frequency delay. The employment of a push-pull circuit made it easier also to obtain a high-inductance output transformer, since the magnetizing effects of the two plate currents tend to cancel each other. As a result of these two features, the delay of the open wire amplifier is only about six-tenths of a millisecond at fifty cycles. The gain of the amplifier, which is about 33 db, is constant within ± 0.1 db between 35 and 10,000 cycles.

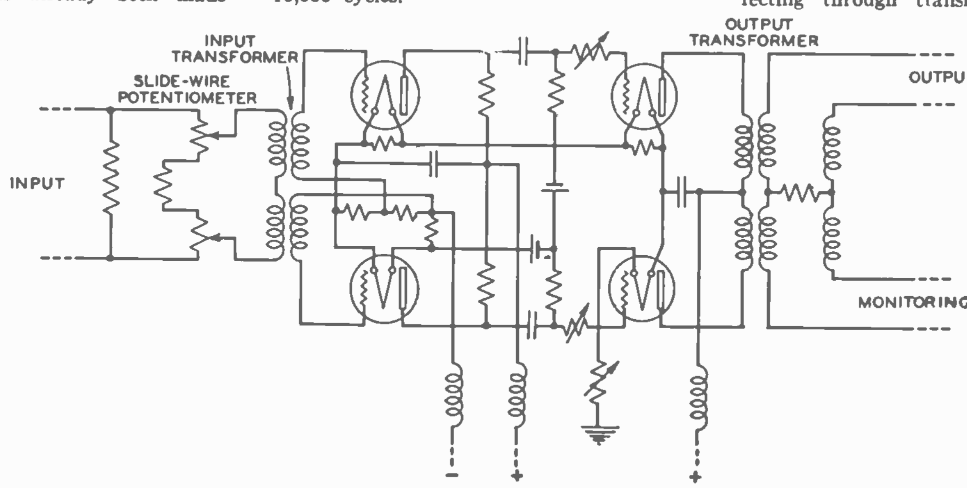


Fig. 1—The 14-B amplifier uses tubes in a push-pull circuit and provides for monitoring through a dissymetrical hybrid coil

A monitoring connection is provided through a dissymmetrical hybrid coil. This permits the signal to be transmitted from the output of the amplifier to both line and monitoring circuit, but because the number of turns on the line windings is large compared to that on the monitoring windings, the loss due to the monitoring circuit is only a few tenths of a decibel. Also, the voltage at the monitoring terminals when connected to a 600 ohm circuit is 30 db down from the voltage delivered to the line. The use of the hybrid coil arrangement has the advantage of preventing an accidental application of testing current, or short circuit at the monitoring terminals from appreciably affecting through transmission.

The amplifier equipment is mounted on one side of a steel panel, as shown in Figure 2, and all connections are on the back. Since it is essential that there be no interruptions of the program, both front and back of the panel are provided with metal covers which protect the tubes and wiring from mechanical hazards.

Since the transmission characteristics of

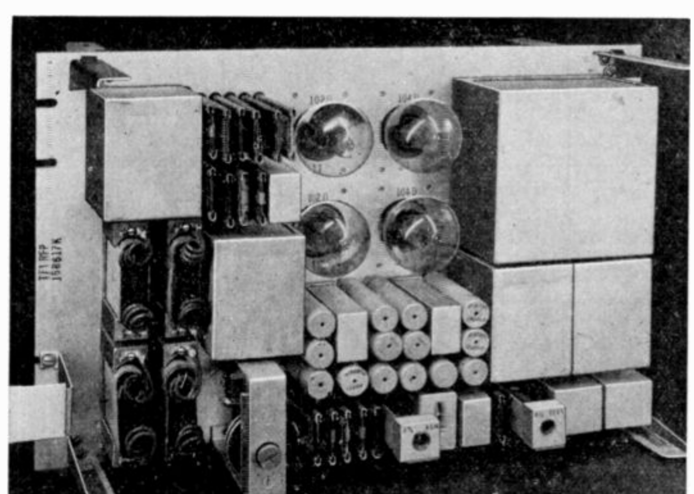


Fig. 2—The elements of the amplifier are mounted on one side of a steel plate, and overall covers, not shown, protect both the equipment on the front and terminals on the rear

the line are not the same for all frequencies, equalizing networks are always required, which in general are similar in function to those used with the cable circuits. These networks must be able to provide equalization for any of three gauges of wire and for a variety of repeater spacings, as well as for various weather conditions.

At frequencies above 1000 cycles, the general shape of the attenuation curve is the same for all normal variations of these three factors, but differs in slope. This makes it possible to employ a single equalizer composed of four sections. By selecting one or a combination of the four sections, suitable equalization for any existing attenuation slope may be secured. The choice of sections is obtained by operating keys on the equalizer panel.

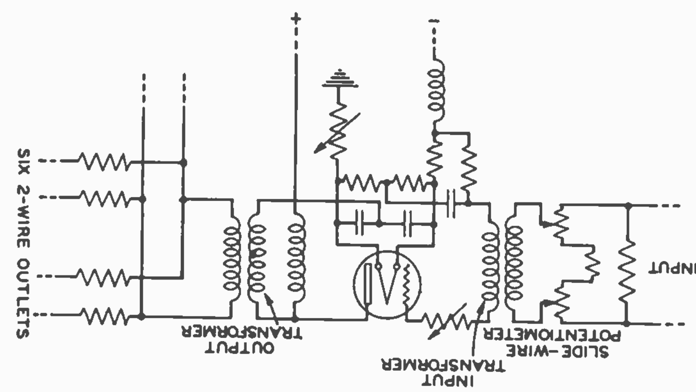


Fig. 3—The 11-F amplifier makes up for the loss occasioned by the insertion of a distributing network which is required when several taps must be made

At frequencies below 1000 cycles, however, the shapes of the attenuation curves, although in general similar for various amplifier spacings and weather conditions, differ for the three gauges of wire. Three low frequency equalizers are therefore required. Each has several sections. A basic section provides the equalization over the complete frequency range for the repeater section of minimum length while the other sections are selected by keys to secure the proper slope for various amplifier spacings and weather conditions.

In contrast to cable facilities, open-wire circuits introduce practically no delay distortion, and since the associated amplifiers are designed for low delay distortion, delay correction is not needed where the line carries only the program circuit.

Usually the pair of wires carrying a broadcast program is also used for carrier telephone communication. The carrier frequencies on this pair are prevented from interfering with the program by suitable filters, and by eliminating carrier channels which would occupy the same frequency band as the programs. Other pairs running along the same pole line, however, may also have carrier telephone circuits, and, since the lower carrier telephone channel may overlap the program channel in frequency, a certain amount of cross-induction from them is unavoidable. The cross-induction currents are ordinarily low in level compared to the full signal strength of the program and would not be noticeable. The various frequency components of the program, however, are not all at the same level: those of higher frequencies are generally much lower in level than those of the lower frequencies. Cross-induction is sufficiently below the level of the low-frequency components of the signal to have no noticeable effect, but this wide separation in level between cross-induction and signal may not hold for the higher frequencies in some cases.

To make the level separation satisfactory for the high as well as the low frequencies, arrangements have been provided so that predistorting net-works may if desired be inserted in the program channel before amplification at the transmitting end of the line, which attenuate the lower frequencies sufficiently to bring them approximately to the level of the higher frequencies. The entire band of frequencies is then amplified to the transmitting level at which it passes over the line and through the various amplifiers. At this level the cross-induction effects are far enough below the signal to be negligible. At the receiving end of the line other networks, called restoring networks, are inserted in the program circuit, which produce a loss in the high frequency signals equivalent to that sustained by the low frequencies at the transmitting end. This network thus restores all parts of the transmitted signal to their correct relative levels, but since it attenuates the cross-induction as well as the signal, the cross-talk is as much below the signal now as it was before the attenuation, and is therefore of unobjectionable magnitude.

Program circuits differ from telephone circuits in that provision must be made to tap off connections at various points. A program originating in New York may be transmitted all the way to the Pacific Coast on a nation-wide hookup with taps at many intermediate points to branch networks or to local broadcast stations. At important key points the connections may be changed at frequent intervals and the program associated with various combinations of sections of networks and nearby stations. An arrangement for accomplishing this where the switching is complex has already been described. At many points, however, the connections are of a semi-permanent nature, and the chief requirement is that the bridging of

(Continued on Page 24)

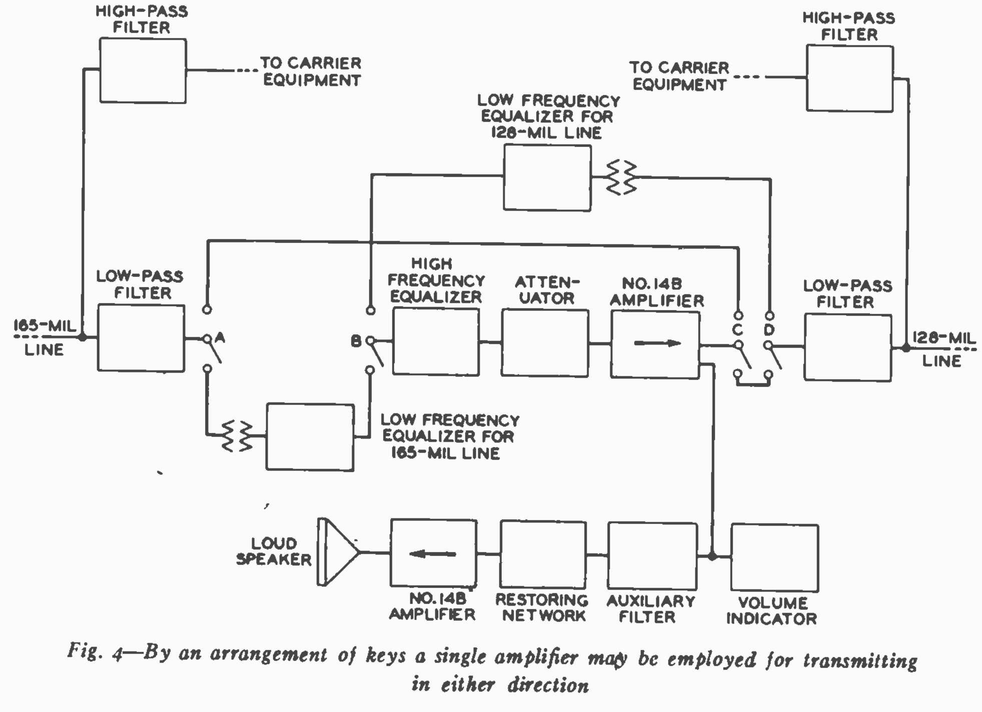


Fig. 4—By an arrangement of keys a single amplifier may be employed for transmitting in either direction

"The Control Grid vs. Plate Current"

By BENJAMIN WOLFE

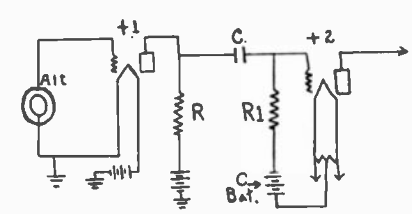
In discussing the elementary action of the control grid within a vacuum tube, the three element tube will be described and used for examples. It is the writer's desire to show in a fundamental manner how the control grid controls the flow of plate current and its effects upon the plate current when subjected to excitation. The control grid in the three element tube is located between the filament and plate.

It should be understood that electron flow is current flow; and since the plate is supplied with a positive potential it attracts the negative electrons from the filament. It now depends upon how the tube is to be used, as to whether or not we desire more electrons to go to the plate or less. Without going into a deep discussion of various types of amplifiers as well as classes, it may be said that certain classes of amplifier circuits require a positive bias, while others require a negative bias.

Assume that a negative bias is applied to the control grid of the vacuum tube. The negative grid causes an increase in the negative space charge of the tube. This is so because the grid being negative would repel the electrons that are being emitted from the filament, and reject them back towards the filament causing an increase in space charge and a consequent decrease in plate current, for a given plate voltage. The plate voltage drop extending within the tube, with this sort of a grid bias is so abrupt that it reaches zero point even before it reaches the grid of the tube. Any electrons that go to the plate must have sufficient velocity to break through the negative high space charge as well as through the negative grid and also through the zero plate voltage point. The zero plate voltage point being negative in respect to the filament from that particular point and positive from that point to the plate. However as we approach the plate the positive charge becomes more and more evident, hence it creates a certain strain upon the electrons that break through this zero plate voltage drop point and attracts them to the plate. It should however be understood, that as the plate voltage is increased, the grid bias remaining constant, more electrons will be transmitted to the plate. This being due to the fact that the higher positive plate potential, the greater it counteracts the negative space charge, hence permitting a greater flow of electrons. The effects of saturation point being discussed in a previous article. With a given plate potential, the negative bias on the control grid can be increased to such a point as to prevent any flow of electrons to the plate and completely block the tube. If the control is biased negatively, the flow of grid current is prevented.

A positive grid causes a decrease in the negative space charge of the tube. This takes place because the grid is much closer to the filament than the plate, and when the grid is made positive it attracts the electrons to it, hence reducing the space charge. As the grid is made up of fine wires with space between them some of these electrons cling to the grid, but most of them go to plate, since the plate is always at a higher positive potential than the grid; in normal tube operation. A very high positive charge on the grid of a tube has the effect of drawing a large amount of grid current. This consumption of grid current subtracts from the total plate current. If the positive charge on the grid is made high enough, it will draw grid current so high, that little or no electrons will reach the plate, obviously reducing the plate current to zero. The grid current making its return through the grid return circuit. Although in various classes of present day amplifiers in use a positive bias is applied to the control grid (class B & C), it is only done so within certain limits which in turn produce normal plate operation. In the case of a positive grid the positive plate voltage drop within the tube is much more gradual in its decline and will penetrate much further into the space charge. On a volt for volt basis however, the grid will have a much greater effect on counteracting the negative space charge than the plate, since the grid is much closer to the filament than the plate.

When the control grid has no applied potential it is termed "Zero Grid", the return generally being made to filament negative or ground. A control grid within a tube which has no external return connections at all, is generally termed "Free Grid". With this type of grid as electrons go from filament to plate, some electrons may be absorbed by the grid wires and the only possible way for them to leak off is through the insulation of the tube itself. In this way however, a certain amount of self bias takes place. However under ordinary conditions the bias would not be very large. With this sort of grid an increase in filament emission will cause an increase in



negative grid bias and an increase in plate voltage would cause a decrease in negative bias on this grid. A tube employing this sort of grid is very seldom used, as under certain conditions it is subjected to blocking the flow of electrons.

From the foregoing we may say that the "Grid Bias Voltage" is the DC component of the grid voltage. It is used to determine the actual "Grid Voltage-Plate Current" curve of the vacuum tube. In order that amplification take place, an excitation voltage must be impressed upon the control grid. This excitation voltage may consist of an alternating radio frequency voltage or audio frequency or a combination of both. Hence the grid excitation is the alternating current signal component acting upon the grid of a tube. This grid excitation adds and subtracts algebraically to the grid bias. For instance assume a fixed negative grid bias of -12 volts. Assume that our grid excitation signal has an effective AC value of 10 volts. On the negative half of the exciting cycle the total voltage on the grid will be -22 volts, however on the positive half of our exciting cycle the actual voltage on the grid will equal -2 volts. The grid will always have a certain negative bias, since under the conditions stated it never actually swings positive. This varying grid excitation voltage will vary the plate current which in turn causes a varying acoustical output.

In order that undistorted amplification may take place in a three element tube, the tube must be operated on the straight portion of the plate current-grid voltage curve, or as near linear as possible. This simply means that the grid excitation voltage must cause the plate current variations to take place within the straight line characteristics of that curve. Their various effects in causing a tube to amplify will be taken up in a fundamental manner. In order to produce maximum undistorted amplification the output impedance should equal twice the filament to plate resistance of the tube.

The grid voltage-plate current curve is a curve which indicates the actual operating characteristics of the tube. It shows all of the Ip variations for various grid excitaions. It indicates the portion of the plate current curve where it blends into a straight line for a given grid exciting voltage variation, and shows how much excitation variations in voltage it will take to produce this straight line characteristics. By operating the tube so that the incoming signal variations will vary within the limits of the straight portion of the plate current curve, it will cause the plate current to assume identical variations. Hence permitting undistorted amplification to take place.

It is now the desire of the writer to show in a fundamental manner just how grid excitation being applied to the control grid will cause a vacuum tube to amplify signals.

In the diagram to the left we have an ordinary schematic of a resistance coupled amplifier. "Alt" merely represents an alternating EMF being applied across the grid and filament of the tube. Assume that the DC voltage applied to tube one's plate is equal to 150 volts, but the steady DC plate current is such a value that it cause an IR drop of 50 volts, across R, and therefore only 100 volts is actually applied to the plate of the tube. When a positive variation of grid excitation voltage is impressed upon the grid circuit, the resistance from filament to plate is decreased and the plate tends to draw more current. However the resistance R remains the same value, and the more current through R means a greater voltage drop across R. Assume that the plate current increased so much on the positive variation of the grid excitation that it caused a ten volt drop across R, in addition to the already existing 50 volt drop. Obviously this would cause another 10 volt drop in the plate voltage, which would now equal 90 volts. On the other hand, on the negative alternation of the grid excitation, the resistance from filament to plate is increased by the same amount it had been decreased, and naturally the plate current is decreased

(Continued on Page 31)

A Self-Contained Bridge for Measuring Both Inductive and Capacitive Impedances

By H. T. WILHELM

Member of Technical Staff, Bell Telephone Labs.

PREVIOUS designs of impedance bridges have followed two trends. The one has been to build a self-contained unit for measuring either inductive or capacitive impedances. This form has the advantage of high precision and of convenience of operation. The other tendency has been to use a separate balance unit which may be employed with external standards of capacitance, inductance and resistance. This arrangement permits maximum flexibility since any type of impedance can be measured by merely changing the standard. Recently, however, a bridge has been developed which combines the advantages of the self-contained unit with the convenience of being able to measure both inductive and capacitive impedances with a single bridge. This great advantage in convenience and ease of manipulation has been obtained without appreciable sacrifice of precision by providing three types of bridge circuits that may be secured by a simple rearrangement of a small number of elements. The type of circuit most convenient for the impedance being measured is obtained by the operation of a few keys.

In addition to the usual two ratio arms the bridge incorporates only standards of resistance and capacitance, a fixed resistor, and two fixed capacitances. These may be grouped to form a comparison bridge, Figure 1, for the measurement of capacitative impedances, an Owen bridge, Figure 2, for the measurement of inductive impedances where the ratio of inductance to resistance is large, and a resonance bridge, Fig 3, for measuring inductive impedances where the ratio of inductance to resistance is small. Of the two circuits for measuring inductive impedances, the Owen bridge is preferable since it is direct reading for inductance, and the balance is independent of frequency. However, the resistance range is limited practically by the range of the condenser standard, making it necessary to use the resonance bridge circuit to supplement the Owen bridge. It will be noticed that in all three circuits the ratio arm R_{BC}, and the resistance standard R_{AD}, are unchanged in position; the capacitance standard C_1 and the fixed capacitance C_0 may be either in the arm AD or in the arm DC; while the ratio arm resistor R_{AB}, the fixed resistor R_F, and the fixed capacitance C_{AB}, although unchanged in position, may be cut into or out of the circuit as desired. These changes in circuit arrangement are accomplished by the manipulation of a few keys as may be seen in the schematic of the complete bridge of Figure 4.

This simple and compact arrangement was possible largely because each of the three optional bridge circuits is of the parallel type. An impedance is a complex quantity which has the effect, when an alternating potential is impressed across it, of limiting the current that flows to a definite value and of shifting the phase of the current with respect to that of the voltage across it. To completely specify the value of an impedance, therefore, there must be given not only a total impedance in ohms, but an angle of phase shift. Since the impedances usually measured, however, are generally to be used in circuits with other impedances, and it may be necessary to calculate the total impedance of the circuit, it is more convenient to evaluate an impedance not by its magnitude and phase shift but by giving the values of the pure reactance and resistance which connected together would have the same impedance and produce the same phase shift. Such equivalent circuits may be built up by connecting pure resistances and reactances either in parallel or in series, but the value of the components of each in the two cases are different, of course. This is illustrated in Figure 5.

In dealing with capacitive impedances, the parallel type of equivalent circuit is most convenient because capacitive impedances are usually connected in parallel, since the total capacitance is easily obtained from the parallel values of the individual capacitances. For measuring capacitive impedances therefore, the comparison bridge circuit of Figure 1 is employed, and the equivalent parallel values of capacitance and resistance are obtained directly from the two standards in the arm AD. With this arrangement the fixed resistor R_F is employed to bring the resistance component within the range of the standard, and the fixed capacitor C_0 is used to balance the residual capacitances of the capacitance standard and of the fixed resistor.

Inductive impedances, on the other hand, are usually connected in series, and as a result the most convenient equivalent values of inductance and resistance would be the series values. To measure equivalent series values of inductances either would require the bridge to incorporate inductance standards, which are large and

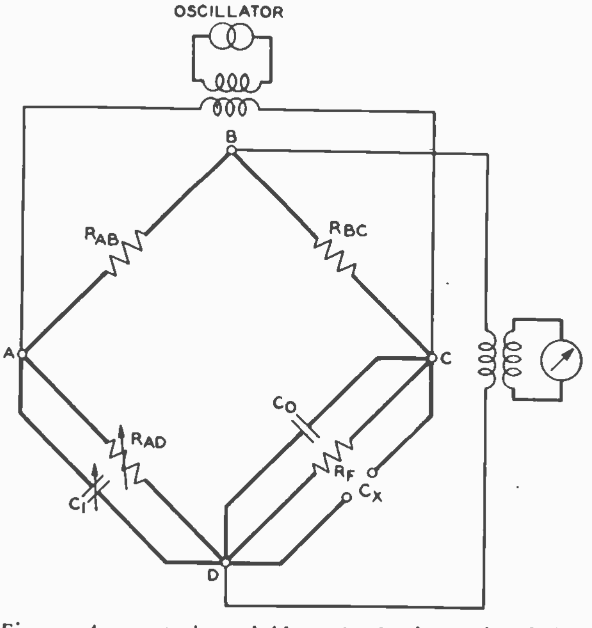


Fig. 1—A comparison bridge circuit is employed for measuring capacitive impedance

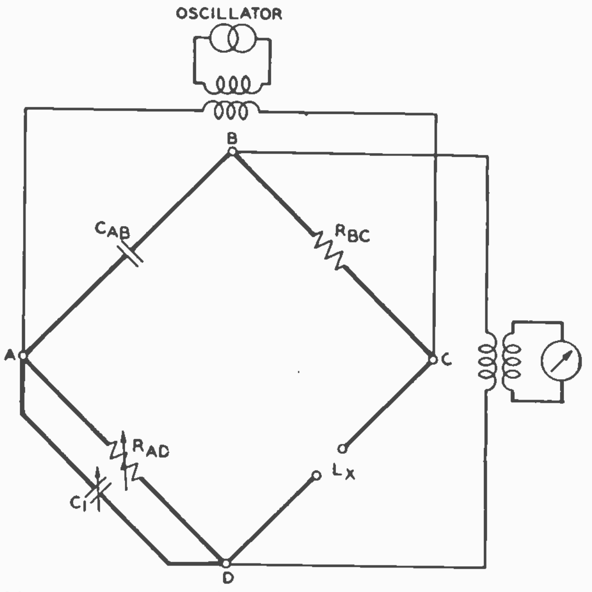


Fig. 2—An Owen bridge circuit is employed for measuring inductive impedance of high Q

thus not desirable in a self-contained unit, or would greatly complicate the shielding and switching arrangements. The new bridge has been designed therefore to measure the parallel values of the equivalent circuits in all cases.

When the series values of inductance

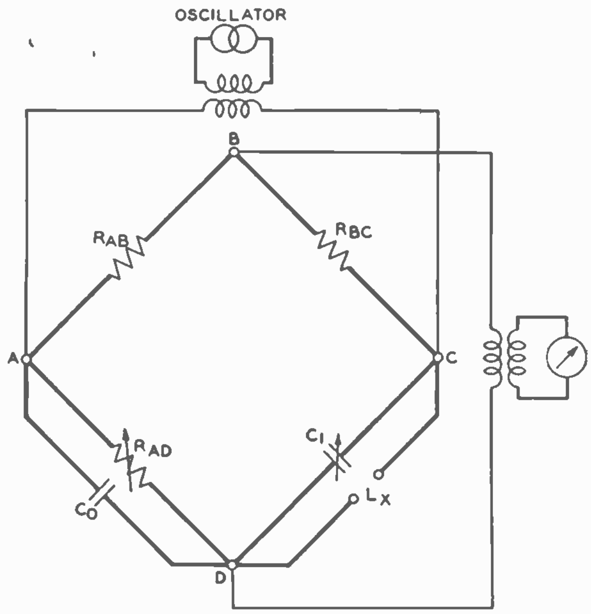


Fig. 3—A resonance bridge circuit is used for measuring inductive impedance of low Q

and resistance are required, they may readily be computed from the two transformation formulae, namely

$$R_s = R_p\left(\frac{1}{1+Q^2}\right)$$

$$L_s = L_p\left[1-\left(\frac{1}{1+Q^2}\right)\right]$$

Where $Q = \frac{R_p}{2\pi f L_p}$

and where the subscripts s and p indicate series and parallel respectively. It will be noticed that the computations involve the use of Q, which is the tangent of the angle of phase shift. In order to simplify computations, tables have been made giving values of $\frac{1}{1+Q^2}$ for values of Q from .001 to 100.

The bridge incorporates a voltmeter indicated in Figure 4, arranged to read the voltage across the impedance being measured, which is always convenient and is essential for some purposes. The bridge is arranged for making measurements on impedances which have one terminal grounded or which are balanced to ground. Complete shielding is incorporated as is

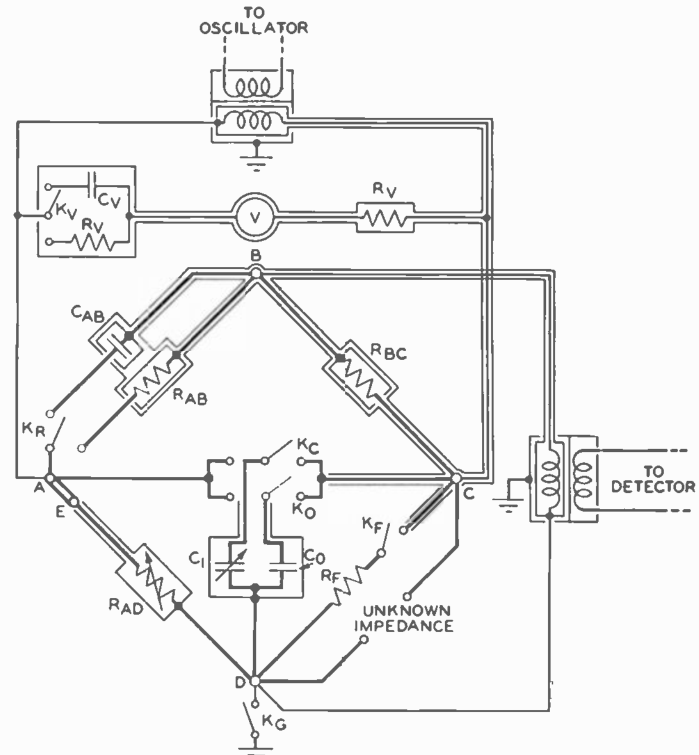


Fig. 4—A few keys provide for the necessary changes in circuit as shown in this schematic of the complete bridge

indicated in the illustration. This bridge is useful for investigating the impedance of various transmission circuits, such as subscriber loops, as well as for measuring the impedances of individual pieces of telephone apparatus. The convenience of a multi purpose bridge should make it a desirable form for laboratories which require a single bridge for a wide range of measurements.

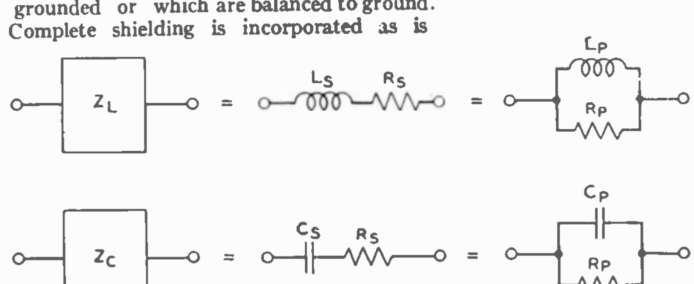


Fig. 5—Any impedance may be represented by either of two equivalent circuits—one with pure reactances and resistances in series, and one with them in parallel

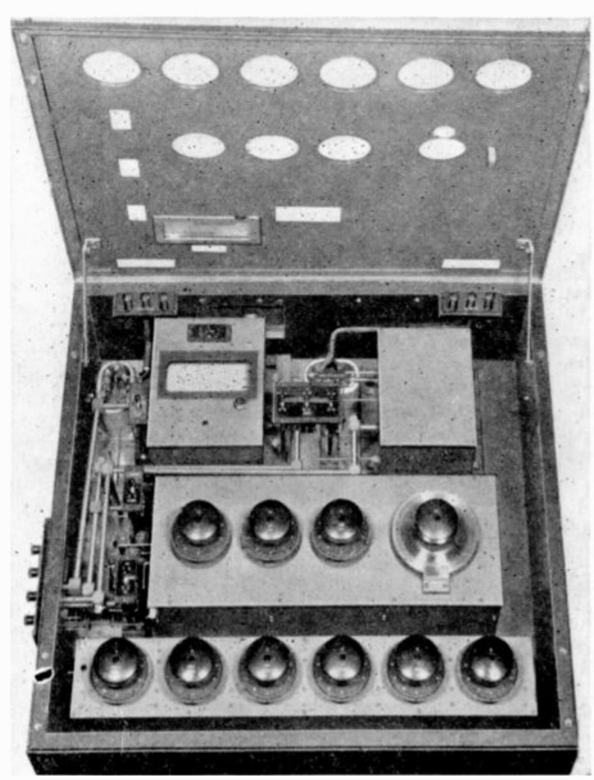


Fig. 6—Interior of the multi-purpose bridge

THE PITT-WESTINGHOUSE GRADUATE PROGRAM*

By H. E. DYCHE and R. E. HELLMUND

Recognizing that some of the highest types of graduate engineering instruction is to be found in a few of the larger research and industrial organizations, the University of Pittsburgh (Pa.) and the Westinghouse company during the past several years have co-operated in a joint program of graduate study for certain designated employees of the company. Besides being of distinct benefit to the individual employee, this work has had a highly stimulating influence upon the faculty members of the university connected with it, and the results have been most gratifying to the industry.

TO THOSE who have been identified with engineering education in the Pittsburgh (Pa.) district for the past 25 years, the formal presentation of the University of Pittsburgh—Westinghouse graduate program in 1927 was a logical step forward in higher education. It is interesting to note that in 1910 2 highly significant events took place: (1) The University of Pittsburgh introduced the co-operative system of undergraduate engineering education on a plan somewhat different from that in use at the University of Cincinnati; (2) Mr. B. G. Lamme, then chief engineer of the Westinghouse Electric and Manufacturing Company, was formulating an intensive program of educational work for the highly selected group of engineering graduates received by the Westinghouse company each year. These 2 ideas, apparently unrelated, have been adopted during the years by many educational and industrial institutions. It seemed, therefore, an obvious move to correlate these activities under the general direction of the graduate school of the University of Pittsburgh, and it is now widely known in educational circles as the University of Pittsburgh—Westinghouse graduate program.

The following quotation is taken from a recent publication of the graduate school of the University of Pittsburgh:

" . . . it is realized that a general undergraduate education was never designed, and never should be designed, to prepare individuals for immediate, highly specialized service. First must be laid the broad foundation without which graduate work would be but a mockey. But the foundation once laid, the peculiar service which a graduate school can render becomes self-evident."

This quotation is cited primarily to show the breadth of view held by Dr. L. P. Sieg, dean of the graduate school of the University of Pittsburgh since 1925. Doctor Sieg maintains that some of the highest type of graduate instruction is to be found in a few of the larger research and industrial organizations. As already indicated, this idea has been accepted for years by many engineering faculties in undergraduate training, in some form of co-operative work. It remained, therefore, to work out a similar plan to assimilate some of the higher grade industrial instruction available in the Pittsburgh district. Considering the usual method of pedagogic administration in many graduate schools, it is not surprising that this plan has created widespread discussion.

It is realized that there are not many places equally favored by the circumstances cited and it therefore is not possible to establish a similar practice at all universities; but the salient features of the arrangement so eminently are suited to meet the basic requirements of a postgraduate engineering education that similar plans elsewhere, even on a smaller scale, should be well worthwhile.

In discussing the fundamentals of an adequate engineering education, it is well to recognize the fact that the requirements for the engineering profession are different from those of some of the older professions. Frequently the latter are regarded as being essentially professions of learning; and since the methods of the universities are naturally the outgrowth of practices evolved in the older professions, there is an inclination to overemphasize the importance of book learning in engineering training. Now, regardless of how important knowledge may be in any walk of life, including engineering, of course, it nevertheless should be recognized clearly that the engineering profession is primarily a profession of creation and accomplishment and that the training of engineering students and of the younger engineers therefore should be directed toward developing in them above all else a desire and ability to create and accomplish. It is extremely important, then, that in addition to imparting the necessary knowledge, particular stress be laid upon developing in the student during the most formative period of his life such traits as initiative, action, imagination, analytical ability, and independence of thought; in other words, accomplishment through knowledge rather than knowledge in itself should be stressed throughout the entire course, beginning even during the undergraduate program as far as at all possible. However, no matter how carefully the curriculum may be planned and how thoroughly the college work carried out, it will have to be admitted that it is at best very difficult to give to the student in a purely university atmosphere that training in developing initiative, resourcefulness, action and responsibility which is required in actual practice. Consequently, there is a distinct danger in extending the engineering college course beyond the usual 4-year program, except for those who expect to make research or teaching their life work. The inevitable conclusion is that postgraduate work on subjects that cannot be covered adequately during the undergraduate course should be carried on by engineers after entering the profession.

Although many universities have established postgraduate evening courses, seldom is it found that the individual student avails himself of more than 1 or 2 courses, or that such work is extended over a very long period after graduation. The only way in which this condition can be improved is by offering proper incentives for postgraduate work, preferably in the form of additional university degrees. If these incentives are to be effective and accomplish the maximum results, they must be such as to stimulate an appreciable number of engineers to greater effort than that involved in 1 or 2 casual graduate courses. In this connection, there is one fundamental which should govern the establishing of standards for offering degrees or similar incentives of any kind, and that is that the standards should be such as to bring about the maximum total effort in the profession and therefore result in maximum accomplishment as a whole. It is all very well to establish a high standard; but if the standard is so high that only exceptional students can reach it, little good will be accomplished. The same is true if the conditions are such that the possibilities are open only to students in favorable financial circumstances. In short, the conditions and standards governing the obtaining of degrees should be such that the goal is possible of attainment by a reasonably large number of the abler members of the profession. Furthermore, degrees in engineering should be conferred as rewards for originality and accomplishment rather than for the accumulation of knowledge alone, if they are to take cognizance of the requirements of the engineering profession.

The University of Pittsburgh-Westinghouse graduate program recognizes these fundamentals, as shown in the following regulations published by the graduate school of the University of Pittsburgh:

"By agreement between the Westinghouse Electric and Manufacturing Company and the graduate school, certain courses in the educational program of the company are identified with the school. Those in charge of the administration and of the instruction of these courses have regular appointments on the staff of the University of Pittsburgh, and hence credits earned in these courses are recorded under the regulations as resident credits. Regardless of the number of credits earned in the Westinghouse courses, there must be gained for the master's degree a minimum of 10 credits in regular University courses and 6 thesis credits.

"1. Courses are open, except by special permission, only to designated employees of the Westinghouse Electric and Manufacturing Company who are graduates of accredited colleges or universities.

"2. Registration, including the payment of fees, shall be effected at the University of Pittsburgh.

"3. No student may take any of the Westinghouse courses for credit in the graduate school, unless he has in advance the approval of the dean of the graduate school and of the head of his major department.

"4. A registration fee of $5 for each registration is required regardless of the number of courses taken. For the Westinghouse courses, there is no tuition charged, but for the courses offered by the resident staff of the University of Pittsburgh, the regular tuition charges are levied. Upon the granting of a degree, the regular graduation and publication fees are also assessed.

(Continued on Page 20)

*Reprinted from "Electrical Engineering" January, 1934

THE MARTIAN MARVEL

By VOLNEY G. MATHISON

THERE is a great deal of talk nowadays about wireless with Mars," remarks the goofy lookin' old gazooney who had chosen to come and sit alongside me on the park bench. "It is about time these piffling radio experts were waking up to the fact that Mars has been trying to attract our attention for hundreds of years."

"Humph! There ain't been no signals from Mars bustin' th' diaphragms of my Baldwins yet!" I snorts. "That's only newspaper flub wrote fer th' consumption of half-witted dumbbells who don't know th' diff'runce between a Cunningham tube an' a porcelain cleat!"

I gets this off real caustic like, because that was the way I was feelin'. Here I'd been sittin' in Golden Gate Park gulpin' fog for three hours keeping a date with a jane who never showed up—and now comes this queer-lookin' old gink talkin' Mars an' radio. About all you hear talked about nowadays is moonshine an' radio, but this bird's line evidently is Mars an' radio.

"I quite agree with you that the assertions of popular scientific writers in regard to Mars are based upon unproved hypotheses," says this park-roaming mystery alongside me, solemn like. "Nevertheless, some of their suppositions are correct—amazingly correct. I *know!*"

He spits this out sharp—so sharp that I kind of half slide an' half jump around on the bench, running a sliver through my pants an' a good ways into my hide.

"Ouch!" I says; an' I starts to get up to pull the thing out.

"That is no way to speak to a gentleman, sir—especially to me, the great Baron Koubansky!" exclaims the old freak, jumpin' up. "I tell you, I know!" He grabs me by both shoulders and shoves me back onto the bench so hard that the sliver navigates about another half-an-inch deeper.

"Listen" he hisses. "I have been there!"

"Where!" I gasps, "Mars?"

"Yes," he answers, tense like. "Yes, I have been to Mars."

Well, when I hears that I begin to get peeved.

"Look here, old rattlebrains!" I blows up, "My mental apparatus don't tune them waves you're radiatin'. Anybody that believes they've been up to Mars needs th' same thing them homebrew victims roostin' on lonely coral rocks down in th' South Seas need who hear radiophone music an' signals an' things without no receivin' sets—namely, a nice little sheaf of one-way tickets to th' nuthouse!"

I thought that would shut up the old goof.

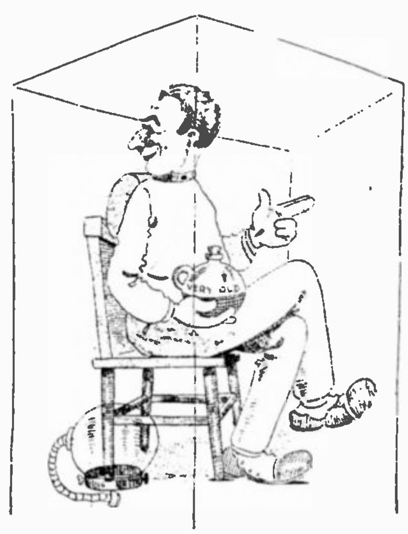
"Such a remark, my dear sir, is not in keeping with the broadminded spirit of the times," he says, quiet like. "In order to convince you of the error of your scoffing words, I shall extend you an invitation that has never before been offered to a human being on this earth. I am going to ask you to accompany me on a short trip to Mars."

"I'm very much obliged to you, my dear Gaston," I responds, sarcastic like. "I shall be delighted to take a little spin with you this evenin' up to th' dear old planet Mars."

"You are ridiculing me, apparently," says old Koubansky with some dignity. "You shall soon perceive your ignorance. Come!"

We get a car to Van Ness Avenue; then another to Ingleside. When I see where we're bound, I begins to get uneasy, because this Ingleside is all dark forests and gullies, with a few woodcutters' shacks here an' there. Besides I had got to thinkin' maybe this old lunatic actually did have some kind of flyin' apparatus after all.

"Say, look here, goofy," I says at last, as we get off the car, "if you really are lookin' for some Boob McNutt to break his neck tryin' to help you navigate some crazy contraption across a few million miles of space, then you can count me out. I went up in a homemade flyin' machine once—"



"Well, here goes," I says. "If your Martian wireless ever reaches th' earth, tell 'em I died happy."

"Your decision, sir, is premature," replies old Koubansky, kind of worried like. "I assure you that my invention has little in common with the generally-accepted principles of aeronautical science."

"I knew it!" I groans. I considers ditchin' the bird right then, but still I had a kind of sneakin' curiosity to see what he had.

Up in a gulch in the wildest and darkest part of Westwood we come to Baron Koubansky's hangout, a small shanty hid among the trees, and back of that a wooden structure about twenty feet square and thirty high, with neither windows nor roof, but with a small padlocked door in one side. The Baron unlocks this, we go in; then he closes the door and switches on a light.

Standing on some large beams and held upright in a heavy timber frame is a kind of cross between a lighthouse and a giant steel torpedo. The thing is about twelve feet in diameter and twenty-five feet high; the top end is pointed like the shell of a big gun, and the base is rounded like the thick end of a' egg. In the side, near the lower end are four heavy glass ports. Between two of these ports I make out the seam of a door, but otherwise the monster is all smooth solid steel.

"Sulphurous saints!" I gasps, clean dazed. "Is this thousand-ton chunk of decarbonized Bessemer supposed to fly?"

"It does fly, as you term it," replies old Baron Koubansky, calm an' proud like. "Here you see, sir, the first and only reversed-gravity rocket in the world!"

"Reversed what!" I sputters.

"Reversed-gravity rocket, I said," replies Baron Koubansky. "The secret of its flying power lies in a wonderful ray which I have recently discovered—though I find that it has long been known on Mars where it is called the Zit ray—by means of which the force of gravity can be controlled, reduced to zero, and even completely reversed. In this rocket are five Zit ray generators, the largest of which acts upon the entire lower part of the steel shell and serves to drive the rocket away from any source of gravity, as for instance the earth. The energy of the other four generators is directed into the upper part of the rocket; and through their reacting upon various heavenly bodies other than the one from which the rocket is being propelled, enables the torpedo to be steered in any desired direction. The ray-controlling apparatus is so delicate that this three-hundred-ton shell can be made to weigh less than one ounce, or at will its entire mass can be set in opposition to gravity."

"I don't know if I get you right," I tells him. "Do you mean to say that when you open up them Zip rays full power you can make this steel rocket weigh three hundred tons less than nothin'?"

"That' sir, is approximately the idea," replies old Koubansky. "The action, however, is much more powerful. At full strength, the rays cause this shell to be repelled from the earth with a force of nearly sixty thousand tons. This decreases with the distance, of course, but ample power is always available, because one is constantly meeting other bodies from which additional repulsion may be obtained."

Maybe you don't think I was feelin' pretty dizzy by this time.

Stickin' a kind of socket wrench into a hole in the steel shell, the Baron gives it a couple of turns; whereupon the door in the side of the rocket swings open. This door is about ten inches thick, an' looks like it belongs on some wireless corporation's safe.

"Come," says Koubansky, polite like, "let us be on our way."

"Nothin' doin!" I exclaims, backin' off. "I ain't goin' in there!"

"Why, my dear sir, is it not yet apparent to you that my reversed-gravity rocket must be perfectly safe!" says the Baron, real pained like. "And think of the possibilities of this trip! You can obtain the constructional details of the wonderful Martian radio system and patent them in every country on earth—except Japan. Why, you will become the most famous man in the world!"

"Not while old kid C. Chaplin is still able to amble around, I won't," I comes back. "And say, if these here electron magicians on Mars have been signallin' us so long, how come we can't hear 'em? I know a bird with more vacuum tubes than brains who listens every night with a twelve-step amplifier on every wave from twenty thousand to a hundred thousand meters—an' all he gets is mush from N-P-G!"

"The answer is very simple," replies the Baron. "In order to tune in the Martian signals one would require a set of inductances of such—but wait until you see the transmitting station and you will understand. Now let us be getting started."

"No thanks," I tells him, real determined like. "I don't mind a little trip to Borneo or Copenhagen, but this here Mars is too far."

"Listen!" whispers old Koubansky. "It you knew what they have to drink on Mars—"

"H'm, you didn't mention that before," I says, thoughtful like. "Is it good stuff?"

"It is, assuredly," he answers. "Principally real old rye."

"Well, I don't know," I says, reluctant like. "I've walked twenty miles fer bum home-brew—"

"I am glad you have decided to come," says the Baron. "Step in."

Feelin' like I ought to know better than do such a fool thing, I goes in, passing through another heavy inner door.

"Both these doors close hermetically tight," says the Baron. "This prevents the air inside the rocket from escaping when we get up out of the atmosphere. A simple oxygen generator keeps the air in here in good condition. The rocket also is provided with electric heaters and is lined with a heat-holding material for protection from the fearful cold of interstellar space."

He turns on a light, whereupon I find myself in a round steel-walled room, which is all choked up with motor-generators, high-tension transformers, centrifugal pumps, copper pipes, and steel cylinders. Set in among this complicated apparatus are five strange-looking glass tubes about six inches in diameter and three feet long, with rows of smaller tubes containing silver-like elements branching out on each side like a fish's backbone. In the center of the rocket stands a small table with a U-shaped top; and a leather swivel chair is set in between the legs of the U. This table and the panels it supports are covered with clusters of dials, meters, verniers, gauges, and control wheels, while fitted into six black tubes, one coming from overhead, one from underneath, and four running horizontally from the sides of the rocket, are six sets of adjustable lenses, in front of which is an elaborate arrangement of tiny mirrors and gold threads mounted over six finely-engraved silver scales.

"Most of the controls you see on the table and panels are for building up the five Zit rays, which are generated in the glass tubes," says the old degravity wizard. "Each ray has two power controls, one of which varies its force in ton units, and the other in pounds. The lenses and mirrors are used in the navigation of the rocket."

"If you will seat yourself here," he continues, pointing to a second chair, which stands over a large glass port in the iron floor, "we shall be getting on the way."

Feelin' right uneasy an' excited like, I sits down.

Old Koubansky switches on a shaded light over his control table, turns off the others; then taking his seat he throws in some switches on the panels. There is a clicking of automatic starters, and motor-generators begin to hum. Pretty soon five little blue lights flash up on the control table. As the Baron continues his manipulations, the big glass tubes slowly fill with a glowing silver-colored vapor, which gradually clears away again leaving half-a-dozen soft rainbow-colored lights flickering and waving in the tubes.

"Now!" mutters old Koubansky—and I hold my breath.

The motor-generators take on a deeper hum; the fluttering colors in the tubes suddenly turn to a hot flaming green; and then I feel the springs in the seat of my chair quiver a little. We were on the way!

Looking down through the port in the floor about a minute later I see the lights of San Francisco and all the bay cities twinkling below—and getting smaller and farther away every second.

"Sufferin' Jeremiah" I gasps. "This thing must be travellin' like a speed-bullet!"

"No, only about ten miles a minute," answers old Koubansky, looking up from his controls. "We have to go slow here, otherwise the friction of the air would burn us up. When we get out of the atmosphere we shall come up to our regular running speed, which is about ninety thousand miles a second."

"Oh!" I says, kind of sickly like. "Is that all."

"Why, no," replies Koubansky. "I could double that, if you are in a hurry."

"No, not a'tall, thanks," I replies, hasty like. "I got lots of time."

"The atmospheric pressure indicator has dropped to zero," mutters the Baron; and he reaches for his controls. The hum of the motor-generators again changes to a deeper note, while the green flames in the tubes grow more brilliant and become shot through with streaks of purple. The needle of a meter which reads from zero to two-hundred slowly begins to rise.

"The influence of the Zit rays practically neutralizes the gravity of our bodies as well as that of the rocket and its parts," says the Baron. "Otherwise we could never withstand this rapid acceleration."

In about a quarter of an hour, the needle of the meter has climbed to ninety-four, where it steadies up.

"Now we are properly started," says old Koubansky, contented like. "It may interest you to know that this cold desolate vastness through which we are shooting at a speed of ninety-four thousand miles a second is not so empty as some imagine, but is quite thickly scattered with pieces of dead rock of every conceivable dimension from mere star dust to hurtling masses weighing thousands of tons. These rocks interfere a great deal at times with the navigation of the rocket, but thanks to the powerful repelling action of the five Zit rays, we can never collide."

Taking a look out of one of the side ports, I see the moon off abeam, her dead volcanic craters and mountains of solid ice showing up plain; then I glimpse down through the floor port at the earth, which has shrunk up to about the size of an ordinary full moon, with the continents of North an' South America lookin' like two ham-shaped shadows. Old Koubansky sits mutterin' over his mirrors an' lenses while every now and then the rocket takes a kind of sheer—probably dodgin' them flyin' rocks an' interstellar brickbats.

About half-an-hour later, the Baron begins shuttin' down his tubes. Glancing down through the bottom port again, I see a big round disk, which looks about ten miles across, comin' up at us fast.

"Mars!" I exclaims. "I can make out th' canals—"

"No, not canals—cables," says Koubansky. "You have been deceived by the popular supposition that the lines on Mars visible in powerful telescopes are canals. As a matter of fact they are systems of immense cables wrapped around the planet, thereby forming a sort of gigantic dynamo armature producing powerful electrical currents."

"Excuse me," I says meek like. "I never thought of that."

"The Martians drew power from these cables hundreds of years ago," resumes the Baron. "They soon discovered, however, that the magnetic drag was slowing the planet down and would eventually bring it to a stop; and so they had to abandon the system. At present they produce millions of kilowatts of energy through the disruption of atoms in peculiarly constructed vacuum tubes. I should explain to you that these people on Mars have been in existence approximately eighteen thousand years longer than the inhabitants of the Earth."

"Then we must still be in th' ring-tailed-baboon stage, alongside of them," I remarks.

"We are coming down in the wrong place," mumbles old Koubansky, suddenly getting busy at his lenses. "I shall have to get reactions on Venus and Jupiter and set over farther."

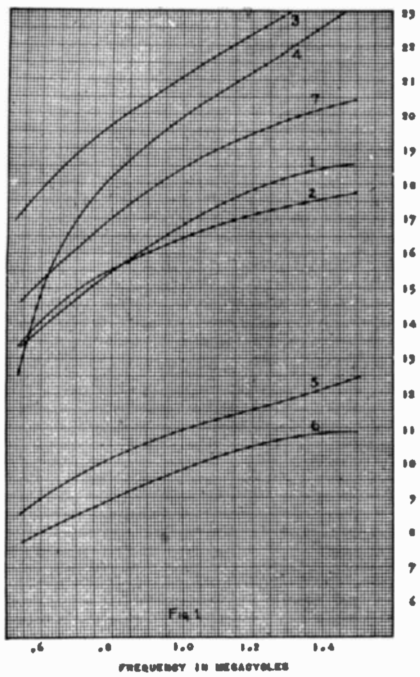
Looking through the floor port, I see a white, sunlit city shootin' up at us; then in a few minutes we slip down through a hole in the roof of a big building and land inside as soft as if on a velvet cushion.

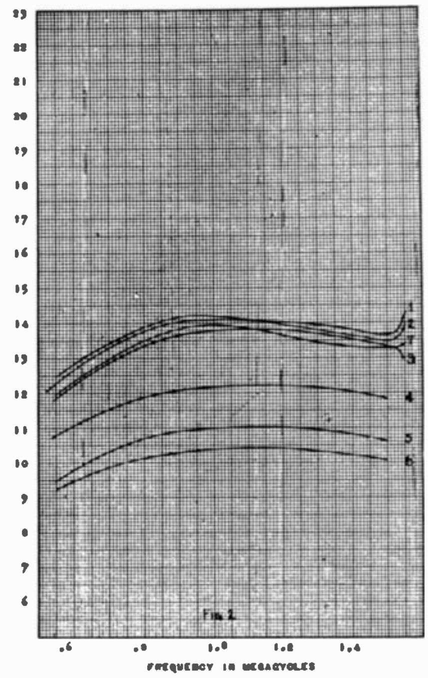
"We are now in a landing station used by the mail and express flyers from Venus," says Baron Koubansky, shutting off his tubes and generators. "Owing to the small size of this planet, its gravity and atmosphere are only about one-fifth that of the earth, and if we were to venture out into such thin air unprotected, we should instantly bloat and burst open. The opening overhead through which we descended is therefore closed and the chamber containing the rocket is pumped to fifteen pounds. Then we shall get out and put on pressure maintenance suits."

"You talk about mail trains from Venus," I remarks. "If these birds are flittin' around like that, how come they never call on us?"

"The Earth's gravity would mean instant death to a Martian," replies Kou-

(Continued on page 26)





OSCILLATOR PERFORMANCE WITH PENTAGRID CONVERTERS

By ROGER M. WISE

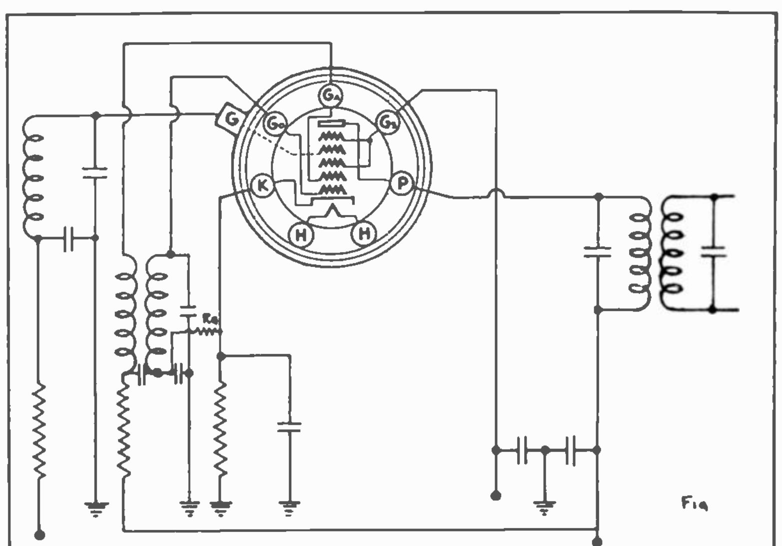
Chief Tube Engineer

Hygrade Sylvania Corporation

THE oscillator circuit in receivers employing electron coupled Pentagrid Converters, such as the 2A7, 6A7, and 1A6, requires very careful design if entirely satisfactory performance is to be obtained. This is particularly true in connection with all-wave models.

As is the case in any superheterodyne receiver, it is desirable to obtain as nearly as possible uniform oscillation strength over the whole frequency band. This is rather difficult in conventional types of circuits in which no compensation is incorporated, due to the fact that it is not easy to secure sufficient coupling at the low frequency end of a given band without over-coupling at the high frequency end. A very good means for checking the strength of oscillation over the frequency band is provided by a DC microammeter inserted in the grid leak (Rg) circuit. The product of the current and the resistance will give a voltage proportional to the oscillator voltage. Several curves are given in Figure 1 indicating differences between Type 1A6 tubes purposely picked to show a rather wide spread of characteristics.

There are two methods commonly used for maintaining substantially uniform oscillation strength over the whole frequency band. These are shown in Figures 3 and 4. The circuit shown in Figure 3 incorporates a means for increasing the coupling at the low frequency end of the band by utilizing the series padding condenser of the oscillator circuit for obtaining increased coupling at the low frequency end of the band. This makes possible the use of an inductive feed back at the high frequency end, which is not sufficiently close to cause the generation of parasitic oscillations, while at the same time it allows sufficient feed-back at the low frequency end to maintain a good degree of uniformity. This is particularly true for the domestic broadcast band where the series padding condenser used is of the correct value for maintaining proper alignment when intermediate frequencies in the range between 175 and 456 kilocycles are used.



Fig

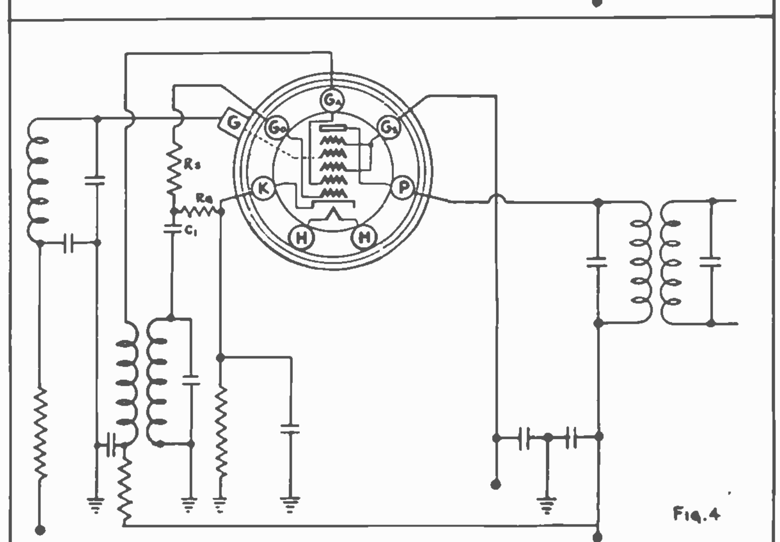


Fig. 4

It is not always thought desirable by the manufacturer to use a series padding condenser as shown in Figure 3, and in those cases it is necessary to utilize some other method of maintaining uniformity of oscillation. This is particularly true when specially shaped condenser plates are used in the oscillator section as is quite often done. Figure 1 shows the approximate amount of variation of oscillator strength over the broadcast band for a typical circuit of this sort. It will be noted that the strength of oscillation at the low frequency end is considerably weaker than at the high frequency end of the band. If adequate coupling is used to bring the low frequency oscillation strength up to a sufficient value, parasitic oscillations are quite apt to occur at the high frequency end due to over-coupling. An interesting circuit (Figure 4) shows a very satisfactory means of overcoming this condition by inserting a suppressor resistor Rs of 500 to 1000 ohms in series with the oscillator grid. This will reduce the strength of oscillation at the high frequency end due to the fact that the capacity reactance of the input circuit decreases as the frequency increases. This limits the oscillator amplitude at the higher frequencies to a greater extent than at the low frequency end of the band. The curves in Figure 2 show the improved uniformity in oscillation strength obtained from the same tubes as those used in taking the curves in Figure 1 after incorporating simple modifications similar to those shown in Figure 4.

An additional point of interest in connection with the tube performance is revealed by the fact that greater ease in starting oscillations may often be secured by returning the grid leak to ground instead of to the cathode. With changes similar to those indicated above Type 6A7 tubes which required at least 150 volts on the oscillator anode under conditions of Figure 9 required an anode voltage of only 25 volts to give satisfactory performance in the circuit of Figure 4.

Radio Commission Warning

(Continued from Page 6)

fied law violators that officers were coming to arrest them. The young man himself was taken into custody and found guilty in a police court for violating police regulations.

Congress has given serious consideration to a bill providing that "no person shall use, operate or possess, in any vehicle within the United States or any place subject to the jurisdiction thereof, any short-wave radio receiving set without a permit."

Provision is made for permits to be issued by District Attorneys, to applicants, who must furnish two affidavits executed by bona fide residents of their districts, vouching for the good moral character of the applicants.

Police officials in some cities are in favor of such legislation as they claim their work in apprehending criminals and in protecting law-abiding citizens, in some instances, has been interferred with by persons who intercepted messages intended solely for the police.

However, the Commission is hopeful that no such legislation will be necessary as it would have a tendency to hinder ex-

(Continued on Page 17)

Department of Commerce Seeking Perfection for Radio Range Beacons

A COMPREHENSIVE effort, both practical and theoretical in character, to increase the efficiency and reliability of radio range beacons by eliminating multiple or split courses that have developed as a radio phenomenon in mountainous country, has been started by the Aeronautics Branch. Multiple courses are additional "on course" signals received at points where "off course" signals should be heard. In level country this phenomenon does not exist.

Rex Martin, Assistant Director of Aeronautics in charge of air navigation, who is supervising the investigation, has declared that multiple courses constitute what appears to be the last problem to be solved in perfecting the radio range beacons which have been operated for several years by the Department of Commerce to provide directional guidance to airmen.

The practical phase of the investigation will center around a special radio-equipped Commerce Department airplane and two Department experts, L. C. Elliott, airways patrol pilot of the air navigation division, who discovered the multiple courses, and D. M. Stewart, electrical engineer of the Bureau of Standards. This expedition has been sent to the mountainous country of the West to conduct flight research in the multiple-course problem.

On the theoretical side, Mr. Martin has requested the co-operation of the presidents of 71 colleges and universities throughout the United States. In his letters to the presidents, Mr. Martin said:

"It is thought that you might assign someone to this problem or suggest that it be carried out in connection with graduate work, inasmuch as the principles involved pertain fundamentally to radio wave propagation. Your assistance is therefore solicited in obtaining information which you feel would be advantageous in bringing about an early and successful conclusion to the problem involved. Any action which you may take in this connection will be greatly appreciated."

Discovery of Multiple Courses

Multiple courses were first discovered in March 1932, by Mr. Elliott while investigating another radio phenomenon in the form of shifting courses at night. This trouble is being eliminated by the installation of a new type antenna. Warnings were sent to all aircraft operators after the multiple courses were definitely established. Cautionary measures were issued to the Army Air Corps on February 13, 1934, for the special benefit of those pilots who would be assigned to fly the mail.

Mr. Martin was preparing for the investigation of the problem last September when he suffered severe injuries in an airplane accident. The subsequent hospitalization and convalescence period delayed this work.

Studies of the multiple course condition made since its discovery by Mr. Elliott have revealed that it exists both with the loop antenna and with the T-L type and that there seems to be very little difference as to the number of multiple courses or the area covered. In general, it has been found that within a distance of 10 to 15 miles from the radio range station, the multiple course effect is not sufficient to prevent the use of the range beacon. However, at distances greater than 30 miles from the transmitter, there have been many instances of 5 or 6 courses. The spread of these courses or the width of the band of the courses may be many times that of the normal course and in some cases has been known to cover an angle of as much as 18°.

However, the band of courses usually confines itself to a width of approximately 10° at a distance of 50 miles from the transmitting station. The spread or the angle over which these courses exist varies with the distance from the transmitting station. For example, the radio range may have one 2° course, which may extend 10 miles from a station and then at this point will split into 2 or 3 courses covering an angle of 4° or 5° and again may split at a distance of 30 miles from the station and split into a band covering 8° to 10° and at 50 miles, courses may continue to split, covering an included angle of 10° to 12°.

Arrangement Not Predictable

Attempts already made to correlate the splitting of courses with surrounding terrain have not proved successful and it is not yet possible to predict the arrangement of split courses that will prevail at any station. When a course is directed down a valley which is bound by regularly defined mountain ranges at either side, the splitting of courses is found to be most evident. Courses seem to split up worse under this condition than any other condition which has been experienced. On the other hand, if the courses are projected perpendicular to a range of mountains or several ranges of mountains which are regularly defined, a negligible amount of splitting occurs.

When courses are projected across mountain ranges at an angle, it has been found that they will split at the mountain peak and continue to split, depending upon the number of ranges traversed. In regions where the mountains are irregular, which is generally the case, the results obtained vary widely and cannot be anticipated.

In general, it is believed that the major difficulty occurs in connection with reflections from mountains. This reflected energy either adds to or subtracts from the energy which is propagated in a direct line, depending upon the difference in path lengths and the phase shift at the reflecting surface. Multiple courses are often found to be crooked while in numerous other cases they are found to be remarkably straight and will lead a pilot directly to the station.

It may also be pointed out that these multiple courses may appear in the following manner: Bounded on both sides by the same characteristic signal; bounded on one side with an "A" and on the other side with the "N" as would normally be expected; and the reciprocal of this condition with the "A" and "N" on improper sides of the course. In some cases courses have been found to appear and disappear without continuing into the station from which they emanated, but as a general rule they can safely be used for homing purposes.

BROADCAST STATION NEWS

"Broadcasting Network Service" is the title of a new 60 page book issued by the Long Lines Department, of the American Telephone & Telegraph Company for general distribution. A small paragraph in the front book explains quite concisely the contents of the book and reads "The Bell System's part in the development of wire networks for radio broadcasting". The book is divided into four parts, General and Historical; Operation of Networks; Plant and Costs; and Advance Planning. A request on your letterhead will bring a copy to you while the supply last.

New Radio Chain

On February 16th, the North American Broadcasting System started operation. This chain consisting of nine stations located in five states.

The stations co-ordinated are WHAD Milwaukee, WCLO at Janesville, WHBL at Sheboygan, WHBY at Green Bay, WKBH at La Crosse, WOMT at Manitowoc, WIBU at Poynette, WTAQ at Eau Claire, WRHM at Minneapolis, giving coverage in Wisconsin, Minnesota, Northern Illinois, Iowa, and Western Michigan.

Employment Increase Registered

For the last six months of 1933 the employmen of broadcast technicians has increased 11.9 per cent, and weekly payrolls increased 21.1 per cent, according to information recently released by the NRA Code Authority. The total weekly payroll for broadcast technicians for the middle of December, 1933, is given as $71,243.61, full time employment being given to 2006 men, of which more tnan half get $35 or more per week.

The comment was brought out by the indictment and conviction to three months in jail of Judson Morris and J. A. Strauss, who were arrested on January 20, 1934, charged with illegal operation of a radio station at Joyland Park, near Lexington, Ky. with transmission power of 7½ watts, on a frequency of 900 kilocycles, using the call letters WLKY, without a license from the government.

ADMINISTRATOR ASKED "HOW ABOUT IT?"

March 28, 1934

Mr. William Farnsworth,
Deputy Administrator,
National Recovery Administration,
Washington, D. C.

Dear Sir:

As the representative of the broadcast technicians of New York City, I have been instructed to protest against the delay in reopening the Broadcast Industry Code for consideration of the provisions dealing with technician's hours and wages.

The Code approved by President Roosevelt specifically calls for a report on these matters within ninety days after December 11, 1933. This hearing is already more than two weeks overdue. To our knowledge, no satisfactory explanation has been forthcoming for a failure to adhere to this provision.

The wage classifications have been in dispute from the very outset. This section was so phrased as to be full of ambiguities and loopholes readily seized upon by the employers with the result that the purchasing power of technicians has remained practically unchanged.

It was the understanding of labor that the forty hour week would be reconsidered after a ninety day period of study by the Code Authority. Unemployment is still widespread. To remedy this the Code has accomplished practically nothing. During the peak of the broadcast season employers have enjoyed a forty eight hour week. Labor has been patient, believing that a forty hour week would be adopted when

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PERSONALS

Will F. Berens, of Washington, D. C., is interested in amateur, commercial, and service work, in radio, and that about covers all.

Phil Merryman, with NBC at Washington, sure keeps hopping on their Association Technical Employees. For those that don't know, this is the employees of NBC organization.

Eighteen days for mail to Alaska from New York is not bad time as Albert Harris, in Latouche, Alaska can verify if you feel like writing him.

F. J. Boseker is still making his headquarters in Ludington, Mich.

Louis Dehmlow is hanging his hat on shore at Galveston now, but may decide to go to sea again.

Eric O. Swordmaker is with the Tacoma Oriental SS Line, and knows a good deal about West Coasting.

W. E. Boring pulled up stakes and moved a little way down the street, but it is still good old Birmingham for him.

Walter Boraker, W9OYE to you, is waiting to hear from you boys who have lost contact. He is at Rocky Ford, Colo.

Summer time means shipping time on the lakes for C. R. Norstrom, and things are looking good for him now.

Eugene B. Bonnabel is operating on the SS Oakman of the Lykes-Ripley line down New Orleans way.

A. E. Goodgame is holding down the SS Dean Emery of Standard line and likes it plenty.

Carl A. Johnson is KGA'ing at Spokane, Washington.

W. D. Thomas who was down Washington way on the shipping code work calls North Quincy, Mass. his "real home".

E. J. Jones is on the U. S. S. Lexington, K Division, San Pedro, Cal.

E. K. Anstey is radio operating for the Imperial Oil people at Toronto, and can give you some light on Canadian shipping matters.

Jay Adams is at the transmitter of WFBC, down Greenville, S. Car. way.

R. G. Gloyd, Jr. still likes old station "C" at Vanderpool, Tex.

Keith Singer was still Transcontinental & Western Airing at Newark, N. J. the last we heard from him.

Another boy on the lakes is E. Wille, who calls Pt. Washington, Wisc., his port of embarkation.

Paul S. LeVan who really works at WHP, can usually be stirred up at W3MG on the amateur band.

You can never say for sure whether Bob Stauffer is at Hiram, Ohio, or on the good ship Joliet.

C. W. Bischoff who carries a telegraph second and phone first class ticket can be stirred up at Columbus, Ohio these days.

Peter Rice who is one of our old timers is in the windy city these days, Chicago, in case you don't know it.

Charlie Kemper made a big jump from San Pedro on the S. S. Gertrude Kellogg to Forty Fort, Pa. recently.

The Air "Racket"

"THE so-called 'Air Pirates' have little or no chance to get away with that racket," said George B. Porter, Acting General Counsel of the Federal Radio Commission, "as the air is being constantly monitored by our inspectors who quickly detect interlopers. It is a comparatively simple matter to get the necessary evidence to bring forth an indictment, and the Radio Act of 1927 as amended, has plenty of 'teeth' in it for violators of its provisions. The courts have uniformly held that all radio stations operating within the United States must be licensed by the Federal Radio Commission, and each station must be manned by an operator duly licensed by the Commission."

Radio Commission Warning

(Continued from Page 16)

perimental work in the shortwave field.

George B. Porter, acting general counsel says, that if any serious abuse is made by the general public of private radio messages vigorous steps will be taken to invoke the law.

In order that the public may be fully informed concerning the protection thrown around private radio messages, the Commission suggests that each purchaser of a combination broadcast and shortwave receiver be furnished by the salesman with the excerpts of the Radio Act concerning the secrecy of radio messages and the penalty for violations.

A Continuously Adjustable Band Pass Filter

By G. H. LOVELL

Member of Technical Staff, Bell Telephone Labs.

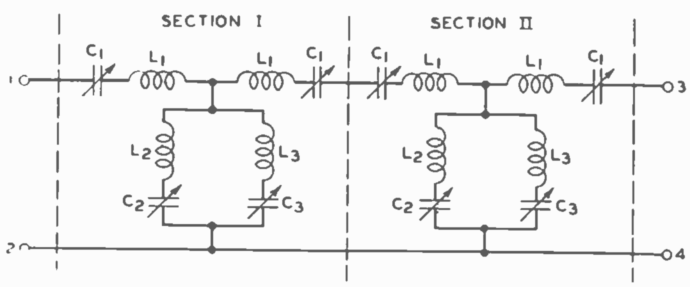

Fig. 1—This structure was chosen for the adjustable band pass filter. From an electrical standpoint the two adjacent capacitances C_1 could be combined in a single condenser, but the needed range in capacitance can be more readily obtained by two condensers

To select certain groups of high frequency currents and discriminate against others, it has been customary to employ tuned circuits on account of their simplicity and ease of construction. In some applications, however, tuned circuits have pronounced short-comings. Their transmission is decidedly non-uniform, on account of the sharp peak at the resonant frequency. For any given combination of coils and condensers, the peak is much sharper at the low-frequency end of the tuning range than at the high-frequency end so that the width of the passed band varies with the frequency setting. These drawbacks were very evident in preliminary consideration of a selective network which was required in connection with a new high-frequency generator. Happily recent advances in the filter art made it possible to design a filter-type network which satisfactorily met all the requirements.

The generator, which was to be used in the study of quartz crystals, was to deliver currents of precisely-known frequency anywhere in the range from 400 to 1200 kilocycles. Since the range required to investigate a single crystal is only a few hundred cycles, it was desirable to sweep over this range by turning a single control knob. The filter which is the subject of the present article was for use in the output circuit of the generator. The location of the band with respect to frequency was to be readily adjustable to any place in the 400-1200 kilocycle range, and it was not to require resetting during the sweep over a frequency range of 3000 cycles.

Design of this filter presented most of the difficulties inherent in any high frequency filter, such as those of controlling the effects of stray and distributed inductances and capacitances, and in addition other difficulties due to the requirement of readily adjustable band location. Any one of a number of different types of band-pass filter sections might have been used for the purpose if it were practicable to

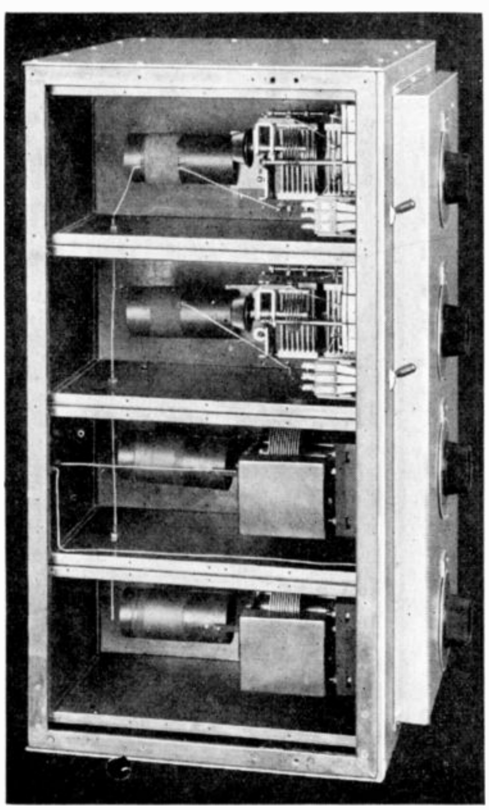

Fig. 2—A side view of the filter, with covers removed, shows one of the two sections. Each combination of associated coil and condenser is mounted in a separate compartment

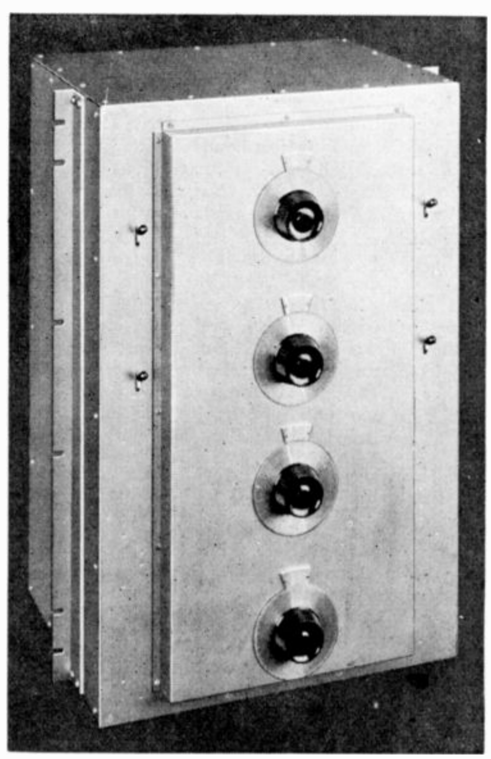

Fig. 3—The two upper knobs control the shunt condensers; and the two lower knobs, the series condensers

vary all of the elements, both coils and condensers, in the filter. The variation of so many elements, however, would have required a large number of controls in order to shift the pass band of the filter from one position to another.

The first problem then, was to determine a type of filter section which could contain few adjustable elements and at the same time meet the transmission requirements. These were: that the filter transmit the same band width in cycles at any setting; that it provide the same amount of discrimination at any setting against frequencies outside the band; that it have small distortion within the band; and that the impedance of the filter remain approximately constant at various settings so as not to introduce reflection losses at some frequencies.

With all these requirements in mind, the characteristics of a number of available types of filter sections were studied. As a result of this study a filter section was found which seemed to meet the requirements best. In this section the band of the filter might be shifted up or down by adjusting the coils only, or the condensers only. Further consideration showed that if adjustable coils were used they must have a large range of inductance adjustment. Such coils have a small ratio of reactance to resistance as the inductance becomes smaller at the upper end of the frequency range. This would cause a much larger attenuation loss at the higher frequencies than at the lower. On the other hand adjustable condensers may be constructed which have negligible loss, and which consequently may be varied over the wide range without affecting the filter loss. For this reason the filter sections were made with fixed coils and adjustable condensers.

The filter consists of two such sections, shown schematically in Figure 1. The functions of the elements in determining the action of the filter may become evident, in a rough fashion, when it is remembered that the impedance of a path through an inductance and a capacitance, connected in series, is a minimum for the frequency at which these two elements are in resonance. Accordingly, frequencies close to that for which C_1 and L_1 are resonant will be readily transmitted through the filter from terminals 1 and 2 to terminals 3 and 4. At frequencies close to the resonant frequency of either C_2 and L_2 or C_3 and L_3, however, the filter tends to provide a short circuit through one or the other of the shunt paths provided by the combinations of these elements.

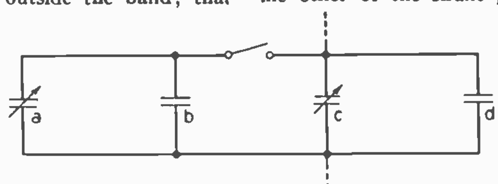

Fig. 4—C_2 and C_3 of Figure 1 are composed of fixed and variable condensers in parallel. c is the tuning condenser. b and d are used to place the capacitance within the desired range. a is adjusted when the filter is built so as to make the capacitance of a+b the same in the two sections of the filter.

In this filter the values of the elements are so proportioned that the resonant frequency of the series path is midway between the resonant frequencies of the two shunt paths. Thus the filter becomes a band-pass structure and has peaks of attenuation symmetrically located above and below the pass band. While the cut-off frequencies are dependent on all the elements in the section the mid-band frequency which is half-way between the two cut-off frequencies is determined by the resonance of L_1 and C_1; and the two peaks of attenuation are determined, one by the resonance of L_2 and C_2 and the other by the resonance of L_3 and C_3.

Mechanically the framework of the filter is a box-shaped brass cage fronted by a panel and covered on the remaining sides with aluminum sheets. On the inner surface of the panel the condensers are mounted and to the backs of the condensers their associated inductance coils are affixed. Each tuned crcuit is individually shielded by a copper can and the stators of the adjustable condensers are closely surrounded by shields to reduce the effects of stray capacities. The removal of the panel makes all the parts accessible.

The wiring of the filter is simple. Since the coils are mounted on the condensers, and wired as a unit, virtually the only wiring to be done after assembly is connecting two vertical wires to join the outer terminals of the coils. One of these vertical leads can be seen in Figure 2. The ground connections are made by the shunt condensers which are in contact with the panel.

By locating close to each other the corresponding arms of the two sections of the filter it is easy to gear together the condensers having identical functions. This cuts the number of independent controls in half. Of the four control knobs (Figure 3), the upper two are used for setting the shunt condensers, and the lower two for setting the series condensers. By the use of adjustable condensers in which the plates are so shaped that the resonant frequency, rather than the capacitance, is proportional to the angle through which the control dial is turned, the pass band of the filter can be set with equal accuracy throughout its range. Verniers, added to the condenser dials, increase the precision of the setting.

The shunt capacitances are composed of four condensers in parallel (Figure 4). By the use of keys located on either side of the panel, a portion of the total capacitance can be disconnected from the circuit. This arrangement is a simple means of increasing the range and the precision of adjustment of the condensers and is more economical than larger variable condensers. In this filter, for example, when the keys are thrown to the "in" position, the filter covers a frequency range from 400 to 535 kilocycles; and when they are thrown to the "out" position, it covers the range from 535 to 1200 kilocycles.

By the use of the verniers, the dials can be read to one-tenth of the smallest scale division, and the filter can be set to within ± 500 cycles, which is only about .06 per cent of the mid-band frequency when the filter is operating in the middle of its range. A calibration chart gives each setting in terms of the mid-band frequency. Using this chart, the pass band of the filter can be placed anywhere in the range which the filter covers. Such insertion-loss characteristics as those shown in Figure 5 for certain settings of the control dials are representative.

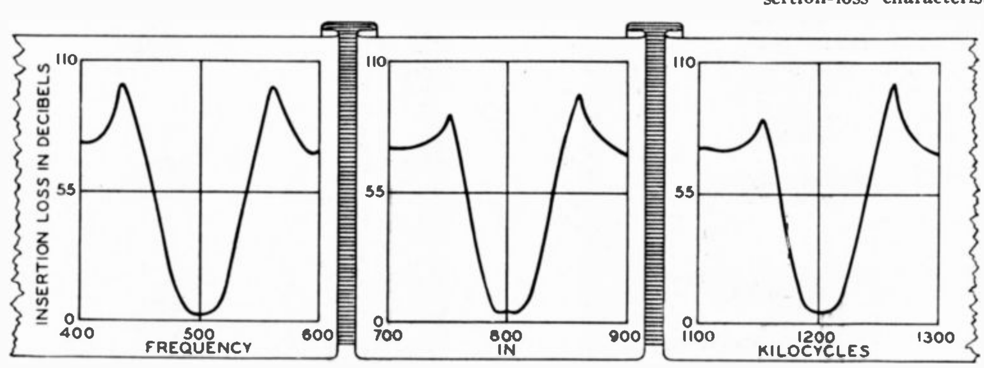

Fig. 5—A constant band width of 3000 cycles is secured throughout the range from 400 to 1200 kilocycles

This style of filter is not restricted to the high-frequency range of the filter described. In addition to this filter, which has a range from 400 to 1200 kilocycles per second and a band width of 3000 cycles, a filter has been built, similar in appearance and construction, with a range from 22 to 52 kilocycles and a band width of 500 cycles.

The Pitt-Westinghouse Graduate Program

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"5. Credits earned through the Westinghouse courses are recorded as resident credits.

"6. A minimum of 30 resident credits is required for any degree from the University, of which, in this particular arrangement, a minimum of 16, if the thesis is worked out on the campus, must be earned in campus courses.

"7. The research work leading to a thesis may be conducted with the consent of the head of the department, under the direction of any of the Westinghouse lecturers."

As indicated in these regulations, there are at present 30 Westinghouse lecturers actively identified with this program. As such, they are recognized members of the graduate faculty of the University, meeting from time to time as a group with the resident faculty.

The 30 credits required for the master's degree normally would take at least 5 or 6 years of evening work even under the most ideal conditions, assuming that suitable evening courses were available during such an extended period of time. Such sustained effort and continued financial sacrifices for tuition and the like, particularly during early life, makes the obtaining of a master's degree impracticable, if not impossible, in the majority of cases. With the plan described, it is quite possible with reasonable effort outside of business hours and under moderate financial obligations to obtain this degree in about 3 years. At the same time, the total requirements in the way of university credits have not been lessened in the least and the thesis requirements have been increased.

With reference to the thesis, it must be considered that the laboratory facilities now existing in the larger industries will permit the carrying on of work of a character often impossible with the facilities available in the colleges; consequently, the thesis results accomplished are likely to be, but not necessarily, of a higher order and of greater usefulness. The fact that the work carried on in industry is to serve as the basis for a thesis will prove an incentive for the use of a higher order of analytical work and originality. Consequently, the results will be of greater value to the industry, and the engineer himself will profit because of the necessity for greater accomplishment and for carrying such additional studies as are required for his thesis. Appendix II gives a list of these subjects so far completed as a part of this program. As a rule, the thesis work is carried on under available research or development appropriations of the company, although at times small special appropriations are made for the purpose; therefore, no expense to either the student or the university is involved. Where appropriations for experimental work cannot be made available a purely analytical study often is chosen for the thesis. The work usually is supervised by one of the University of Pittsburgh—Westinghouse lecturers after formal approval has been granted by the department of electrical engineering of the university.

Dr. E. A. Holbrook, dean of the schools of engineering and mines of the University of Pittsburgh, says:

"During the past 4 years I have reviewed a number of the theses presented by candidates for the master's degree under our Westinghouse co-operative graduate program. Uniformly, these theses show more professional maturity and higher research technique than the usual postgraduate master's theses in engineering. I make this comparison, having in mind not the University of Pittsburgh alone, but also the graduate theses I have read in the several colleges with which I have been connected."

A general idea of the character of the courses of study can be obtained from Appendix 1. Many of these consist of lecture courses and problem work, although in several the problem work predominates. In general the courses are conducted in a manner quite similar to the regular university courses, except that most of them are given during working hours and some of them at night. The course E.E. 151-152W on electrical theory and engineering practice, which is an outcome of the so-called engineering school of the Westinghouse company, is somewhat different from the ordinary course. It consists of weekly assignments of a relatively large number of questions which the students are called upon to answer during an extended quiz at the end of the week. The questions represent broadly a survey of the present state of the electrical art and accumulated experience in the application of fundamental principles to engineering problems. They involve the study of designs, materials, methods of construction, testing, application, and maintenance of a wide variety of electrical appliances and equipment as well as significant excursions into the history of the development of the art. This part of the graduate program, as well as many other features, has grown out of the pioneering work in advanced engineering education by Mr. B. G. Lamme; some of Mr. Lamme's fundamental ideas along this line are set forth in his publications. (See "Technical Training for Engineers," *Electric Journal*, September 1916, p. 404.)

Among the courses instituted during the more recent years, special attention might be called to E.E. 193W by Doctor Slepian on conduction of electricity in gases, E.E. 181-182W by Doctor Lewis on symmetrical components, and M.E. 161-162W by Doctor Nadai on applied elasticity. Complying with an urgent demand, these courses and also the one on electrical theory and engineering practice have been made available to students outside of the Westinghouse company and an appreciable number of engineers connected with the utilities and also instructors and postgraduate students of the university have availed themselves of this opportunity.

Special attention is called to the fact that credits can be obtained only by successful completion of these various courses. No credits whatsoever are obtained for any of the shop, testing, drafting, or engineering work done by the students during working hours. The experimental work for the theses is conducted, of course, in the laboratories of the company during working hours, and frequently the engineering work of the company benefits from the solution of the problems in connection with the theses.

The entire work of the students is done under the broad guidance of the school of engineering of the university, and the university assumes the responsibility for the adequacy of the program. However, since a great many of the engineering subjects required for the master's degree are given by the Westinghouse staff, the evening courses covered by the university staff relate essentially to such subjects as advanced physics, mathematics, economics, and the like, so that a properly balanced curriculum will be maintained. The degree conferred is that of Master of Science, usually with the major in electrical or mechanical engineering.

In 1930 the plan was extended to include the doctor's degree, the requirements for which, although in the first stages similar to those for the master's degree, are more extensive both in quantity and quality of work to be covered. For the doctor's degree great care is exerted to select candidates who have much more than the capacity to pursue courses and to conduct simple, straightforward research. It is felt that, for the most part, the investigations and courses should be carried on in the fundamental fields of physics, mathematics, or chemistry. Although for the master's degree certain credits can be obtained through Westinghouse courses and research work, the majority of the credits for the doctor's degree have to be obtained through the university courses.

Tables I, II and III give some statistical data relating to the graduate program and the results obtained. Table I gives the number of degrees granted during successive years. Table II indicates that a total of 354 students have participated in this work and 59 or only about one-sixth of that number have obtained degrees. Some pertinent conclusions may be drawn on the basis of these figures:

1. Requirements for the degrees are high, which means that, in addition to the necessary analytical ability, a great amount of energy and perseverance is needed

2. Distracting influences are encountered due to increasing professional and family responsibilities.

3. Depression readjustments and low financial sources have prevented some from completing the work.

4. Under normal conditions, many students are transferred to distant branches of the company, and although the university has arranged reciprocal relations with other graduate schools, the resultant progress is slower.

Table III shows that in addition to the fact that approximately 50 per cent of the graduates remain with the company, about 25 per cent are called into teaching or some phase of educational work.

Table I—Degrees Awarded

Year	M.S.	Ph.D.
1927	1	
1928	1	
1929	8	1
1930	9	
1931	14	
1932	12	1
1933	11	1
Total	56	3

From the standpoint of the industry, the results of this postgraduate work have been most gratifying. Although the average engineering graduate is inclined to settle down to routine work after entering industry an entirely different spirit can be noted among those taking part in this postgraduate work. During the various courses their interest in analytical work

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PIONEER WIRELESS OPERATORS

By DR. LEE De FOREST

HERE'S a bit of ancient wireless history interesting to your readers who man the ships sailing to the Gulf ports.

It's taken from a Mobile paper, of Dec. 22, 1905.

"First Aerograms have been exchanged between Steam-ship St. George" enroute to Mobile and the Mobile office of the De Forest Wireless Telegraph Co. in the City Bank Bldg., when the new Mobile-Havana liner was located 152 miles off Ft. Morgan. Mr. Pillichody of the Tugboat Association, who is said not to have any faith in the Wireless System, had the operator of the Tugboat Association up all night at Fort Morgan, for the purpose of being the first if possible to report the approach of the Steamer. But while the Prince George was 35 miles off from the light, which is just off Fort Morgan, at 6:45 A. M. and still out of sight of the fort, the De Forest office here received the following wireless message: 'Steamship St. George at Sea. Dec. 22, 1905.

"'To Mobile, Ala.

"'Just stay there five minutes, will have business. Will dock about noon. We are 35 miles from light. Where are you located? Do you know how the Fitzsimmons—O'Brien fight came out? Captain says will be there 10 A. M. thinks.

(Signed) Heilig. Operator'"

Then this, from the Mallory Liner, San Jacinto:

Kniskern, Mobile:

Yes, hear you, but faint, change your tune. Nothing of S. S. St. George. Don't know her call.

(Signed) Conklin, Operator.

75 miles off Southwest Pass. L. A.

Then this one from New York (either 42 Broadway or D. F.)

Kniskern, Mobile:

Prince George left New York. Dec. 16th. Arrives Mobile sometime Friday or Saturday morning. His call is Cu.

(Signed) Herndon.

"The Prince George has been expected in Mobile since early yesterday but has not been sighted from this city yet. The De Forest operator remained at his instrument through the night in order to locate and get a report from the vessel, and the Fort Morgan operator of the private line between Mobile and the fort also remained on duty all night."

(As was to be expected, and despite the regrettable skepticism of Mr. Pillichody. the wireless beat the Wig-wag and telescope.) "Although the De Forest office here kept track of the Prince George from the time she left New York on the 16th. inst. it did not locate and get word from her until early this morning. Each vessel equipped with wireless apparatus has a schedule and a call. The Prince George will arrange a schedule upon her arrival here. In view of the fact that a wireless operator receives messages from the ticker like a telephone girl receives calls for numbers a reporter asked Mr. Kniskern if he did not have to keep the instrument over his ears all the time on duty, and was consequently put to more trouble than the ordinary telegraph operator? He replied in the negative, giving his reason that the wireless offices on land have schedules with vessels having wireless apparatus and knew where they ought to be at certain times. When a wireless message is sent there is a noisy flash from the instrument." Nevertheless, and notwithstanding operator Kniskern's optimism, the enthusiastic operators of those days grew callouses and became flat-eared from uninterrupted application of "the cans", (thereby frequently benefitting in appearance.)

At Christmas, 1905, dear old Admiral Manney of the Navy, who personally had taken an extraordinary interest in the early progress of Wireless, had resolved on a grandiose experiment, and it was splendidly carried out. His idea was to get in touch with all stations south and north from Washington as the radiating point, (Arlington was not yet built)—to broadcast Christmas greetings from the Navy and to receive responses from all stations possible, in the shortest possible time.

Portsmouth, N. H. was first heard from, then came Boston, then Newport, next New Orleans, then St. Augustine, Beaufort, N. C., then Jupitor Inlet.

"Nearby stations, such as New York, Atlantic City, Hampton Rhodes, etc. were easy, and the messages came back all right about midnight." The record on that occasion was with Guantanamo: "Manney, Washington, Christmas Greetings—Rodgers."

This message gladdened my heart at least as much as Admiral Manney's for I knew something of the awful Hell those brave operators, both civilian and navy, had undergone for twelve months down there in the stifling, stinking mangoe swamps, not at all aided or cheered by "Limpy Rodgers", to enable him from his comfortable old cheesebox, "Amphritite," to flash his Xmas greetings to the Capital.

The newspaper clipping finishes:

"Admiral Manney thinks getting messages across the Atlantic not impossible in the future."

And just to fortify him in this prophecy, on Jan. 3, 1906 "D. F." at Manhattan Beach sent the first 2150 mile message to Curtis, or Dorchester, Civilian Operators at the newly completed Navy Station of Colon; almost the distance to the west coast of Ireland.

But not alone with the Navy did the idea of those fond Christmas greetings broadcast by Wireless originate. The St. Louis "Post-Dispatch" arranged with our 25 KW. East St. Louis station to send out to all these listening early Christmas morning: "Peace on Earth, Good will towards Men." The Archbishop of St. Louis, Most Rev. John J. Glennon, and the Rt. Rev. Daniel S. Tuttle, Bishop Episcopal Church Diocese of Missouri, were among its notable sponsors. The poetically-minded reporter of the Post-Dispatch waxed most eloquent over a full page of the Sunday Edition, richly and imaginatively illustrated.

"A World-Wide Christmas Greeting." "It is a message that will be sent forth in song from thousand of temples throughout the world. But from nowhere else over all the broad earth will it spring forth to be gathered in other lands from the very air even as it was in the starlit watches of the morning in Judea, 1900 years ago. It is to be sent out on the suggestion of the Sunday Post Dispatch from the De Forest Wireless telegraphy station in East St. Louis at sunrise Christmas morning.

"Peace on Earth, Good Will towards Men."

A feeling almost of awe may well encompass the operator who puts on the wings of the ether on the birthday of the Christ that message which was given forth by the angel host. With no irreverent hand will he touch the key that sets that message in motion. He will be performing a miracle of modern science, doing a thing never done before, actually, intelligibly filling the air with the song of Christmastide.

"From his hands it will spread filling all the terrestrial atmosphere and will find its way almost instantaneously to the uttermost corners of the earth, to the islands of the sea, to and through the ships on the sea, over mountains, valleys, plains into the frozen north, through the tropics and across the equator, out on the western ocean, back over to the Judean land from whence it sprang at the dawn of Christendom." And so on and on! Unlimited faith in the potency and coverage of our East St. Louis station this imaginative writer possessed verily. And yet it is to me, looking back over all the busy years of radio progress since this was written, noteworthy to find here, so feelingly expressed, the wondering and poetic appreciation of what has, long since he wrote, been actually accomplished by the Radio Broadcast. there foreshadowed.

"The message that goes out from his little isolated temple of Science, by the East St. Louis tower, will itself spread and radiate and permeate the whole atmosphere, a paean of peace and praise and good-will sung by an invisible aerial mast. It will absolutely and actually be a greeting to the furthest corners of the Earth."

It is a pity that now-a-days, because this "miracle of science" has become so trite and commonplace, scarcely a thought is given to the mystery and to the spiritual significance of the marvelous medium with which we toil and earn our daily bread.

And that is the sad feature of science; that its wonder and its philosophical meanings are so quickly submerged in the dire tangles of an intricate technique, lost to our dulled perception.

The last of the five big Navy Wireless Stations which I had designed, that at San Juan, Porto Rico, was now also in commission. From his long siege at Pensacola, quarantined by the yellow fever scare, G. S. Iredell had been transferred, as a fitting reward, to complete and open that larger station.

On Nov. 18th, 1905 he copied the first complete wireless message ever received in Porto Rico from the mainland, altho during the three weeks following his transfer fragmentary messages had been heard from Brooklyn, Savannah, Pensacola, and Guantanamo. This one was addressed to the "The Eagle"—leading newspaper at Ponce.

"Key West, via San Juan. There were no new cases of yellow fever in Habana yesterday. There now remain under treatment five cases of yellow fever altogether. There are many suspects however, because physicians are reporting their *dengue* patients as suspicious."

"WE ARE CERTAINLY PROGRESSING." "FIRST WIRELESS FROM MAINLAND"—are the startling headlines with which "The Eagle" plumed itself, on that momentous occasion. Shortly after the New Year Iredell had the P. R. transmitter in successful operation with her four big sister stations of the Navy chain, and ready for the long-delayed Official Acceptance tests.

Popular interest not only in Wireless but in electrical matters generally had now risen to such a level that for the first time in history Electrical Expositions were to be held, the first one at the old Madison Square Garden in New York. Our first "Wireless Booth", primitive precursor of all the gigantic Radio Expositions or World Fairs of today, seemed to attract more interest there than any other exhibit.

An electric automobile equipped for wireless transmitting and receiving was displayed. A "wireless Bulletin Service", posting news items and happenings aboard the various steamships equipped with De Forest wireless were continuously posted. As a "historic exhibit" even at that early date, we displayed one of the weather-beaten sets which had earned such honors for wireless by its record-making press-work for the London-New York Times in reporting the Russo—Japanese war off Port Arthur, and brought home at last by Operators Brown and Athearn.

A complete new 1 kw spark transmitter, gap unmuffled, drew mobs of gapers with its deafening staccato rattle. Rapidly New Yorkers became wireless-minded.

And then during the month following, on January 15th, 1906 to be exact, Chicago opened her first Electrical Exposition, at the Coliseum.

"THOUSANDS HEAR PRESIDENT'S WIRELESS MESSAGE OPENING BIG ELECTRICAL SHOW: 'To the Chicago Electrical Show: Congratulations and best wishes. Theodore Roosevelt.'

"Thousands of persons breathlessly silent on the floor of the Coliseum last night heard this message from President Theodore Roosevelt read from a balcony.

"Instantly the electric currents were turned on. Thousands of incandescent lights flashed, electric bells rang, electric whistles blew, and the band played the Star Spangled Banner, all marking the formal opening of the first Electrical show to be held in Chicago.

"The message was received by De Forest wireless telegraph. Every click of the big receiving machine made a marked impression upon the hundreds of persons crowded around the booth. (Evidently our operator "relayed" it through his spark-gap, as received by 'phone from the West Chicago wireless station.)

Looked Upon As Miracle

"The silence awaiting the coming of the aerogram was such as would attend the performance of a miracle.

"The aerogram reached the receiving station in the Coliseum at four minutes past 8 o'clock. It was copied on a typewriter and handed to Earnest Rietz, a messenger boy. True to tradition the little fellow was rather late in reaching his destination, although the crowded aisles were sufficient excuse. He reached the band balcony at 8:16. A bugle announced his arrival(!)

"Then followed the opening of the Show."

And now, nearly thirty years afterwards, another President Roosevelt in Washington speaks into a *microphone;* and not his telegram but his voice is heard, not by a few thousands in the Chicago Coliseum, but by as many millions in their homes scattered over the broad face of the North American continent.

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is maintained, and the necessity for taking the initiative in their thesis work develops

Table II—Total Earned Credits

	No. of Individuals
Less than 6 credits	106
6-10 credits	53
11-14 credits	38
15-23 credits	80
Less than 24 credits	277
Exactly 24 credits	23
More than 24 credits	54
Number with sufficient credit for degree	77
Total participants	354
Degrees granted	59
Credit requirements complete for master's degree	18

a definite self-confidence in their ability to do original and advanced analytical work. As a consequence all of their later engineering work is influenced along similar lines. It is noted also that of the various papers presented by the company engineers before the different professional societies, a large percentage is supplied by engineers who either are on the Westinghouse teaching staff or who have completed successfully their work for the master's or doctor's degree in this co-operative course.

Table III—Present Location of Those Who Have Received Degrees

Westinghouse Elec. and Mfg. Co.	30
Teaching and educational work	15
Other work	14
Total	59

With reference to the university, this co-operative program is found to be of benefit in so far as it has a highly stimulating influence upon the faculty members connected with the work. It has made possible courses that would not have been possible without such a plan; in some cases this co-operation has led to certain mathematical courses prepared jointly by a member of the university staff and one of the industrial staff, with the result that the application of mathematics to practical engineering problems has been presented more effectively to the students.

APPENDIX I—Descriptions of Courses

The following course descriptions have been taken from the last edition of the "Graduate School Bulletin" of the University of Pittsburgh; they illustrate the advanced nature of the technical content of the various Westinghouse courses and the credits allowed.

EE 151W. Electrical Theory and Engineering Practice, I; 2 credits: A study of theory of operation and standards of practice in design, manufacture, and application of electrical equipment, generators, motors and their control, thermionic tubes, oscillographs, voltage regulators, relays, and transformers. *Hellmund and Dudley*

EE 152W. Electrical Theory and Engineering Practices, II; 2 credits: A second course similar in character to EE 151W, but embracing synchronous converters, materials and processes, refrigeration, railway motors, circuit breakers, switches and fuses, lightning arresters, heating appliances, capacitors, switchboards, and rectifiers. *Hellmund and Dudley*

EE 161W. Electrical Machine Design, I; 2 credits: Fundamental equations for the generated emf. The distribution of the magnetizing flux is determined by rigid graphical solutions. The mmf's of distributed windings by mathematical and graphical methods. The effect of pulsations and harmonics of the mmf's. Flux analysis for 2-dimensional fields. Calculation of saturation curves. *Laffoon and Calvert*

EE 162W. Electrical Machine Design, II; 2 credits: A quantitative analysis of the theory of commutation for both direct and alternating current machines. Detailed treatment of commutation as a switching problem, secondary phenomena affecting commutation, etc. *Hellmund, Baker, and Labberton*

EE 163W. Electrical Machine Design, III; 2 credits: A study of the constants of alternating current machines which determine the transient and continuous operating characteristics. Development of formulas for calculating constants. The special problems of synchronous machine design. *Dudley, Shutt, and Kilgore*

EE 164W. Electrical Machine Design, IV; 2 credits: Consideration of the fundamental laws of magnetism and of the magnetic and electrical properties of core materials, with their adaptations to electrical apparatus. *Spooner*

EE 165W. Electrical Apparatus Design; 2 credits: The fundamentals of design of magnets and transformers. Initial magnetizing transients. Methods of determining reactance, regulation, and short-circuit forces. Three-winding transformers. Mercury arc rectifiers. *Peters*

EE 166W. Circuit Interruption; 2 credits: Fundamental studies in circuit interruption by an arc. Effects of resistances,

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CORRESPONDENCE

Dear Editor:

Let's tell the boys the truth. Better still, let me.

COMMERCIAL wireless operators on American vessels have always been booted around like a lot of tramps. Looked upon as hermaphrodite officers, men of all work, a bunch of horses' necks. Even a half-donkey wireless operator has to have about 500 per cent more special training than the best licensed deck officer. Yet the operator is paid half as much and is regarded as highly as a louse.

I was an operator once—

I was an operator once: shifted out of the game and for some years now have been skippering a pretty difficult type of craft. Hence I feel competent to judge between the comparative qualifications necessary for brasspounding and deck-officering. But to look at his salary figures on American shipping articles you'd think he was something below a winchman.

In foreign vessels, greatly to the contrary, the radio operator is paid and classed on a par with deck officers. On Jap ships the bug artist's salary is never less than that of the chief mate. And said bug artist rates an exceptional amount of personal service from the steward's department.

Of course all wages are low on some foreign ships. Therefore in certain cases American operators may be getting as much actual money as some foreign brasspounders. But the foreign op is shoulder to shoulder with his fellow ship's officers, and the American key wrassler is not. Why?

The answer is exceedingly simple. America has an enormous and enjoyable free training school for radio operators, and foreign nations do not. What training school? Amateur radio, of course. Ham radio, that's the hotbed of this iniquity.

Hold on, hams! Don't start ripping this sheet up and go to gnashing your teeth with rage. Read on, and swear not to be always such asinine chumps as some of us old timers, your ex-buddies, have been. I still itch between thumb and forefinger, so gather closer and listen to a grim and dour brother ham.

Fully ninety-five percent of all American marine operators have originally been owners of amateur sending rigs. Lots of 'em still are. Nobody can question that ham radio was and is the rich recruiting ground of maritime interests, whence are hooked forty suckers for every crummy brasspounder's berth.

Hellsbells—you might say—foreign countries are also afflicted with ham ops. How come they haven't also run the commercial game down to a beggarly level of wages?

As a matter of fact, amateurs are few and far between, outside of the United States; and they mostly belong to privileged classes of society. In foreign countries, with the qualified exception of Canada, practically the only boys with dough enough and drag enough to put up a ham rig and get a license for it are the more or less blueblooded sons of the bourgeois rich. They are not the class of infants who go forth to be rocked in the cradle of the deep at fifty a month on some rusty hooker. In Japan, nobody of less degree than at least the illegitimate third son of a fourth grade Samari count can even hope to get a ham station permit from Nippon's militaristic rulers. In Italy amateur transmitters are totally illegal. To get caught with one means nothing less than the rock-pile or the Pontine marshes for Guiseppe Hammo. Even Big I Mussolini would have to ask himself permission to put one on the air, and the ugly bambino would probably turn himself down. Mr. G'mo Marconi is just about Italy's only legal ham.

Furthermore, even in those countries where ham stations are permitted—under rigid restrictions—sending gear costs big kale. You can't swap a spare tire or a basket of brussels sprouts for a 5-watt ham rig in CzechoSlovakia. No obsolete AC broadcast receiver to build a low-powered transmitter with is available for a gummy dollar bill in Estonia.

There is one immense country where most of the foregoing does not apply. That is the U. S. S. R., or the Soviet Union—often incorrectly referred to as "Russia". (The name "Russia" has been deleted from Soviet maps since 1917.)

In the U. S. S. R. hams are aided and encouraged. There will eventually be tens of thousands of amateurs here. However, this is not likely to have any effect on the wages of Soviet commercial operators. In this land wages and working conditions are controlled by labor itself. Good radio men in the Soviet Union are classed as specialists and engineers. They probably always will be; for the starving U. S. S. R. already operating broadcast transmitters with 500 and 1000 KW in the last power stage, is developing the world's greatest short-wave networks.

Incidentally, a good many good-looking gals are wireless ops on Soviet ships. In the U. S. S. R. a woman is as good as two or three males any time. Women may be engineers or deck officers, or even skippers. The wireless op may be married to the captain, and the fingers that mend the sox may be the fingers that flip the bug.

Yep, world's changing. But in the United States, so far as commercial brass-pounding is concerned, it's changing for the worse. Wages have not been lower in twenty years. More and more extra duties are being shoved onto sucker ops. One transatlantic line will not hire an operator unless he has a mate's ticket; then he is required to stand a deck officer's watch at a greatly slashed salary, and do the brasspounding for nothing. What to do?

Get together boys.

Nothing magic, nothing inspiring about that proposal, you'll say. And the beach crowded by enough stranded brass-pounders to start a soup line with. True enough. But there's absolutely no prospect of improvement except through collective action. Unionization is no final cure-all. Yet a militant, fighting organization can land a jolt to the jaw that will make some improperly sired gentleman see stars.

The most persistent and bitter criticism of united strike action is that there are always some hungry pups ready to rush in and grab the jobs for less money.

That positively can be stopped. Don't organize an old hens' sewing circle of the sort that's been out of date since the gay nineties. Organize a union with fight in it. Railroaders, butchers, plumbers, printers and some other classes of workers have showed long ago that they can accomplish a great deal through unionization.

Many people think that America is already embarked on revolutionary changes. Peaceful changes. Looks like workers may have to fight like the devil to put over this peaceful revolution. Some say it requires peaceful strikes, peaceful picketing, peaceful riots, peaceful gunning.

Nevertheless even the most critical seem to see unprecedented opportunities under the Rooseveltian deal for thorough and effective unionization. Privately among themselves, the powerful cliques that own America are savagely critical of what they consider unparalleled and unwarranted encouragement of unionization by the present administration. A lot of the big shots don't like the looks of things.

Right today, in the face of vast unemployment, live fighting unions are getting somewhere. For instance, grimy coal-diggers are forcing even the mighty steel trust to back down. How? By means of a hard-boiled union that refuses to eat dirt, even when begged to do so by its own slushy, soft-soaping bought-out leaders.

It's already pretty evident that the author of the "New Deal" is not going to hand anything out to workers on a silver platter, nor even on a dime store crumb-tray. At the same time workers have never before been offered such an opportunity to get together collectively and fight for themselves.

Comrades, fellow-workers, sooty gentlemen of the mills, and even white-handed wireless ops—you are virtually being told to get together. Now is the time for all good men to come to the aid of their own class and do a little good peaceful fighting.

What are you doing about it? Shrugging your shoulders. Saying that unions are no good—never accomplished anything. That you're looking out for Jack, to heck with everybody else. Well, that sort of yellow dog stuff is entirely out of date. It's ancient hsitory. If you won't work together now, Jack will get chuck-all, and so will everybody else. The looker-out for Jack alone is a traitor to himself and to every man, woman, child and house-dog dependent for daily bread on the line of work Jack's engaged in.

Surely unions have pulled off unsuccessful strikes. Surely unions have been sold out time and again by crooked double-crossing officials and leaders. It's repeatedly alleged that beyond a shadow of a doubt the largest of unions has never been in the hands of a smugger bunch of marionette-show officials than the present pack.

Sad, but possibly true. Unionize just the same. If the union is run by greasy hypocrites, by crooks and glib tongued misleaders, throw them out. Raise the roof, call a showdown, demand a vote. Get new officials, and if they slip, kick them out. Put some good peaceful fighting into the picture. Don't whimper like a wet cur and pound brass on some dirty old scow for fifty a month, curry and rice, and a sneer. What in the devil have you got to lose?

There's the old persistent response. No matter how bad a ship is, or how low the wages, a dozen punks with the ink wet on their tickets are itching to grab the berth.

That's partly true today. But it's true only because there is not yet a sufficiently strong, militant and business-like operators' union that is in a position to command respect. One is trying to build itself up now. The thing to do is to join it, help it; dish out at least enough dues to make it hum. Printing bills and rent can't be paid for with love and kisses. Not a union's bills, at any rate.

Operators have got to build up an organization aggressive enough and active enough not only to request consideration, but to demand it. Also it should carry on some unionization work, or at least maintain contacts, in every radio school in the country. It would be a mistake to build up a commercial operators' association that failed to reach out persistently for the newcomers in the schools. Most hams intending to become commercial ops do usually go to some school or other for a short while to bone up for a license. These newcomers ought to be drawn into the organization early.

The brilliant success of American hams in creating and maintaining one organization is certainly proof enough that the boys *can* get together.

There may be a few wealthy members in the A. R. R. L., but the organization functions primarily on funds and through the activities of average hams who have very little cash to throw away. We have shown long ago that we can get together as amateurs. Amateurs can also stick together when they become commercial ops. No doubt about it.

It just requires some guts, some determination, a little peaceful battling. Here's an interesting straw. A rotten one-horse outfit on the Gulf chiselled wages for operators down to forty a month. One of their tubs sailed four voyages operatorless before some poor hungry bum was found who would take the job. This before the present operators' union was hardly functioning at all, and with dozens of brasspounders on the beach. It goes to show what might be accomplished with a good live, well-supported organization.

Oh yes, but in the end some insignificant runt took the job, you'll say. Look here. Nobody has a better chance to spread news around the ocean than a wireless op. With a strong aggressive union functioning, every operator at sea could and should be notified of any ship carrying a scab at non-union wages. First put on a little gentle pressure in the way of suggestions over the air to join the gang. If ND, ostracize the dear fool. Smear his name on the air. No op would stand that very long, and every brasspounder who reads this knows it. Just a little nice, peaceful maneuvering.

So far as the working classes of America are concerned, opportunity's tangly forelock bears a big tag marked "Collective *action!*" Are you going to grab it? If you don't, you've all got mud up your neck. Ought to be shoveling sand in a fascisti concentration camp. And first thing you know, you will be.

Got to get in and do a little peaceful scrapping for yourselves. It absolutely can be done. The time for militant organizing is here, right now. Never was more to be gained, less to be lost. Join—pay your dues—read your union mag—and write up your grievances for it. Come on, get wise, sucker.

Old rules, old bets are off. This is a new day, a new deal. If the cards are crooked, take the dealer to task. Time flies, things change. Workers are not half so scabby today as they were twenty years ago. Growing rebellious, reckless. Big business senses this; hence it dreads militant collective action more now than ever before.

Yours and 73,

Signed (D.V.)

An interesting little booklet of 32 pages is issued under the title of "The Electric Eye", by Accousto-Lite Corp., Ltd. 2908 S. Vermont Ave., Los Angeles, Cal. The price is 25c. and anyone interested in Selenium Cell work will find much of interest in the booklet.

Open-Wire Program Circuits

(Continued from Page 8)

additional outlets should not affect the through transmission.

Such taps are obtained by a distributing network inserted in the circuit. The insertion of this network in the line, however, produces a loss, which is made up by a single-stage amplifier inserted in the line immediately ahead of the distributing network. The arrangement of amplifier and network, which form a single unit called the 11-F amplifier, is shown in Figure 3. One of the six outlets will be used for the through circuit and will be connected directly to the input of a 14-B amplifier, while the other five may be employed for connections to branch circuits or local stations.

Although program circuits differ from telephone circuits in requiring transmission in only one direction, a reversal in the direction of transmission is often required. A circuit employed normally to transmit programs originating in New York, may frequently be used to transmit entertainments arising in San Francisco or some other western point. To make the fullest and most economical use of repeater facilities, therefore, it is necessary to be able to reverse the direction of their transmission in a minimum of time. This is accomplished by a simple key operation, which interchanges the connections between the lines entering an office and the input and output of the amplifier. The arrangement is shown in Figure 4, where the keys are represented by the switches A, B, C, and D. With the switches down, as in the illustration, the direction of transmission is from left to right, passing through a low-pass filter, switch A, a low-frequency equalizer suitable for the line on the left, switch B, the common high frequency equalizer, an attenuator, a 14-B amplifier, switches C and D, a low-pass filter, and on to the line to the right.

When transmission is to be reversed all switches are thrown to the up position. This removes from the circuit the low-frequency equalizer suited to the left-hand line and substitutes one suitable to the right-hand line, and carries the right-hand line around to the input side of the repeater circuit. With left to right transmission the program passes through the four switches in alphabetical order, A, B, C, and D, while with transmission from right to left, the order is D, B, C, A. When the lines on both sides of the repeater are of the same gauge only one low-frequency equalizer need be provided. Under these conditions the single low-frequency equalizer would be placed between B and the high-frequency equalizer, where it would be properly located in the circuit with the switches either up or down, and the two low-frequency equalizers shown in the illustration would be replaced by continuous conductors.

The new open-wire program transmission system provides transmission performances comparable to those of the B-22 cable program system. It constitutes an important step in the development of a nation-wide program network, and will permit a uniform high-grade transmission between any pick-up point and any group of broadcasting stations in the country.

LINE FILTERS FOR OPEN-WIRE PROGRAM CIRCUITS

By A. W. CLEMENT

Member of Technical Staff, Bell Telephone Labs.

OPEN-WIRE circuits over which wide-band broadcast programs can be transmitted with greater naturalness and over greater distances than heretofore have recently been developed by the Bell System. Whereas former open-wire program ciriuits have in general transmitted only up to 5000 cycles, the new circuits can transmit frequencies up to 8000 cycles. The new circuits are operated simultaneously with carrier telephone message circuits on the same wires, just as are the 5000 cycle circuits.

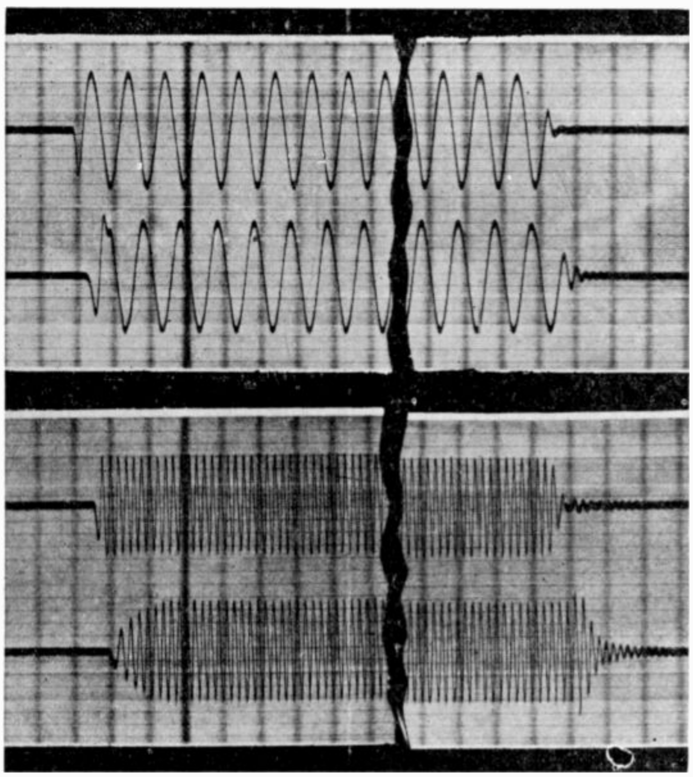

Fig. 1—Pulses as sent and received through a typical low pass filter —1000 cycles above, and 4700 cycles below

Wherever it is necessary to separate the carrier and program currents, filters are employed. At each side of repeater stations and at the line side of terminals for example, a high-pass and a low-pass filter, called line filters, are connected in parallel; the high-pass filter readily passes the carrier currents but suppresses the program currents while the low-pass filter passes the program and suppresses the carrier currents. These low-pass filters are thus a part of the program circuit and must meet the severe requirements for this class of service.

The primary purpose of these low-pass line filters is to attenuate highly all frequencies above the program band while readily passing all those within it. They must be so designed, however, that in performing this primary function, they introduce no objectionable distortion in the program circuits themselves. In general, when currents of a wide band of frequencies pass over any circuit not specially equalized for such a band, they suffer distortion. This distortion is principally of two forms: amplitude distortion, occurring when the loss is not the same at all frequencies in the band, and delay distortion, occurring when the currents of various frequencies require different intervals to build up and die out. The distortion due to a single filter would ordinarily be inappreciable but since very long program circuits may have as many as fifty filters as well as much other apparatus, the overall distortion, if not corrected, would be readily perceptible.

Amplitude distortion in low-pass filters and lines usually decreases the strength of the higher frequency currents more than the lower, and thus has the effect of somewhat narrowing the transmitted band. When present in small amounts, its effects are not readily noticeable except to a practiced ear, and its correction is relatively easy of accomplishment.

The result of delay distortion is distinctly different and in general is both more noticeable and more difficult to correct. Its effect on a transmitted signal is to prolong the interval of time required for the signal to build up to its full amplitude, and what is generally more noticeable, to prolong the time required for it to die down. In a low-pass filter, this prolongation is most marked at the higher frequencies. The effect is illustrated in Figure 1, which shows oscillograms of pulses of both 1000 cycles (upper) and 4700 cycles (lower) as sent and as received through a low pass filter. After an initial delay, the received 1000 cycle pulse builds up almost immediately to full amplitude, showing practically none of the prolongation effect described above. On the other hand, it will be noticed that, after the same initial delay, the received 4700 cycle pulse is considerably prolonged, both in building up to full amplitude and in dying out at the end. In transmitted speech, which is composed of a large number of frequencies embracing the entire program band, this action of delay distortion causes a slurring over of the beginning and a dragging out of the ends of the speech sounds, which impart an unnatural character to speech variously described as "blurred," "fuzzy" and "hissing."

To obtain the desired filter action without objectionable distortion, it has been customary in the past to design three separate transmission networks. A filter is first designed to produce the desired attenuation-frequency characteristics. Then a separate delay equalizer is designed to correct the delay distortion of the filter. After this, a loss equalizer is designed as a third piece of apparatus to correct the attenuation distortion of both filter and delay equalizer. The loss equalizer introduces only a small amount of delay distortion which can be anticipated and allowed for in the design of the delay equalizer.

In developing the filter for the new wide-band open-wire program circuits, a distinctly different method has been followed. By employing a recently developed lattice type filter section, it has been possible to incorporate all three functions in a unified filter structure. The total amount of apparatus necessary, and thus the total cost as well, are thereby considerably reduced.

This new filter, shown schematically in Figure 2, has four parts. All four perform the primary filter function of attenuating the carrier frequencies, but the sharp rise in attenuation just above the upper edge of the program band is chiefly secured in the end section at the right and in the second section from the left end, which—because its attenuation rises to a high value or "peak" in a small frequency interval above the transmitting band and falls off again at still higher frequencies—is called a peak section. The two end sections and the peak section produce appreciable delay and amplitude distortion, for which it is the function of the new lattice section to compensate.

The lattice section, in addition to providing part of the attenuation to carrier frequencies, furnishes delay and loss which are complementary to those of the rest of the filter throughout the program band. Consequently the delay and loss of the complete filter are practically constant in this range.

If the lattice section is to furnish the proper delay correction, there must be no reflection between sections of the filter or between the filter and the line and office apparatus. To make the filter meet the varied requirements placed upon it the lattice section has an impedance that does not match the line. One of the major functions of the two end sections is to build out the lattice impedance to this desired value. That auto-transformer at the office end of the filter is employed to modify this impedance to match that of the office apparatus.

Over substantially all of the program band, the loss of the filter does not vary more than .05db, while the attenuation to the carrier frequencies varies from 48 to 80 db. Thus a program circuit long enough to require 50 filters would not have a loss variation due to the filters of more than 2.5 db, which is less than the smallest level difference ordinarily noticeable between component tones of a program. The delay over the lower 93 per cent of the program band does not vary more than .00004 second, or .002 second for fifty filters. Delay distortion of this magnitude is not noticeable to the average listener.

This new filter, in its methods of controlling distortion, represents a distinct advance over former practice. The functions of a filter, a delay corrector, and of an attenuation corrector have all been obtained in a single filter structure. By the use of the new lattice section, a consolidation has been possible which results in a more compact design and in an over-all cost that represents a considerable economy over former methods.

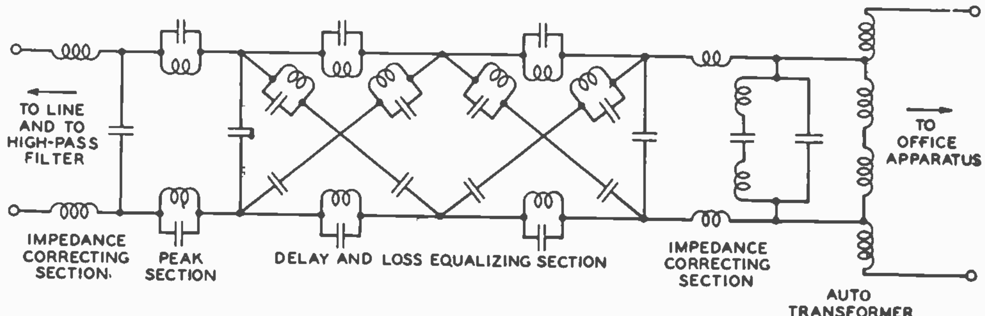

Fig. 2—Schematic of new 8000 cycle low pass line filter for open-wire program circuits

The Martian Marvel

(Continued from Page 14)

bansky. "A Venus flyer did land several hundred years ago, but he was burnt for a devil by some religious people, and since then the Earth has been boycotted by all interstellar explorers."

Getting out of the rocket a little later, I find Baron Koubansky's pressure suits are sort of armour outfits made of some light transparent stuff like pyralin and fitted with flexible air-tight joints, while on the back is a cylinder of compressed oxygen connected through a reducing valve to the helmet. As we help each other get these rigs on, I discover that we can talk and hear through the transparent stuff almost as easily as if it wasn't there at all.

When we are dressed we pass through a door into another chamber where the air is blown off around us; then we go out into a big room in which we find about half-a-dozen Martians waitin' for us.

These here Martian gazooneys are about four feet high, heavy set, and yellow skinned. They look like small Japs, only their heads are about twelve inches in diameter, bald, an' round as cannonballs. I decides right off I ain't got no use for them.

"We are glad to see you again, Baron Koubansky," they says, bowin' to the old goof. "You have brought a friend with you this time."

"Yes," replies the Baron. "Meet Mr. —er—"

"Jones," I tells 'em. "Samuel Jones —a hard-boiled brasspounder from Frisco!"

"We are glad to make your acquaintance, Mr. Jones," they say, all makin' a fancy bow.

"Same to you," I says, diplomatic like. "By the way, would you mind tellin' me what kind of language you speak? I seem to get it all right, but it ain't English."

"It is a universal tongue," replies one of the roundheads. "It can be understood by anybody, even though they have never heard it before. Here on Mars we have one people, one language, and one state. Every one belongs to the state, and every one serves the state in whatever way he is most useful."

"I guess it's a fine system," I replies. "Say, how's chances to get a nip of that famous old Martian rye you got up here?"

"Rye," repeats the roundhead, puzzled like. "What—perhaps you mean liquor!"

"I didn't ask fer soda-water, did I!" I retorts.

"But liquor was abolished on Mars almost eighteen thousand years ago!" exclaims the roundhead, astonished like. "Except for a hundred-gallon cask of rye whiskey which has been preserved for thousands of years in a cask in the great museum at Zo-Zonne the capital city, there isn't a single drop anywhere on the planet."

"Holy cross-eyed angels!" I groans; —then I turns on Baron Koubansky. "So you put it over on me, huh—you lousy old skunk—"

"Wait," he interrupts me, troubled like. "I admit and regret having deceived you, but I was anxious for you to see the wonderful Martian radio system; and this appeared to be the only way whereby I could persuade you to come."

I feel like taking a slam at him, but I realizes I ain't in no position to start anything.

"Well, all right then," I growls. "Let's be going."

"Good," says old Koubansky, relieved like. "I shall leave you with one of these gentlemen, who will take you around. I have some private business to attend to, and I will wait for you here at the landing station this evening."

One of the Martians takes me out onto the white noiseless street, which is full of hundreds of busy roundheads passin' back and forth. The first thing I notices is something that looks like a Oklahoma cyclone—a kind of dark cone-shaped cloud—floating high up over the city with a long stem reaching down among the buildings.

"Looks like a friendly little tornado breezin' along," I remarks. "Are they common here?"

"That is not a tornado," answers the Martian. "If you watch a moment, you will see that it is quite stationary. It is the antenna of the great radio transmitter with which we are trying to signal the Earth."

We get into a thing that looks like a cross beween a taxicab an' a telephone booth, the Martian shuts the door, turns a numbered dial, sticks a nickel in a slot, pushes a button, opens the door again, and we are in another place.

"That is nice fast work," I remarks, steppin' out. "Where are we now?"

"If you will look up, you will see overhead the gigantic antenna you observed a moment ago," he answers. "This group of buildings before us is the Martian interstellar calling and listening radio station."

The roundhead takes me inside and introduces me to another roundhead, who seems to be the chief engineer of the joint.

"So this is the friend Baron Koubansky brought," says the chief; and I sees a queer kind of look pass between the two roundheads. "First I will show you our receiving section, Mr. Jones. It may surprise you to be told that we have been listening to your Earth stations for years."

With this he shows me into a big windowless laboratory made entirely of copper and fitted with copper doors, where the first thing I hear is concert music that sounds like it might be comin' from the Frisco *Examiner's* broadcastin' station.

"Shut that off!" snaps the chief, clappin' his hands to his ears and glarin' at his gang of assistant roundheads. "How many times have I told you not to listen to those frightful discords. They will eventually give you audiophobia!"

I observes that the laboratory contains three big tables about thirty-five feet long, all of which are loaded down with receiving gear and masses of silk-cord connections. Here and there on each table are rows and clusters of vacuum tubes, about ninety altogether—and all burning.

"This is only a part of our receiving

(Continued on Page 33)

"The Control Grid vs. Plate Current"

(Continued from Page 9)

by the same amount it had increased. Hence on the negative alternation we find that the voltage drop across the resistance equals 40 volts while the plate voltage actually now equals 110 volts.

These variations across R take place during each cycle of the impressed excitation voltage. This ten volt increase and decrease may be said to take place between the actual plate and filament circuit of the tube since they are connected to a common ground. These variations although they are not strictly alternating, are of great enough pulsations to have alternating effects. The pulsations taking place across R, are induced across G, which in turn impresses them across the grid and filament of tube 2. Hence we have an excitation voltage by means of a resistance drop. These plate current variations are a direct result of the grid excitation voltage impressed upon the control grid; and these variations are in turn amplified into acoustical outputs, varying in accordance with the grid excitation voltage.

Throughout this entire article it has been the desire of the writer, to describe the various functions in ordinary fundamental words without going into the many intense technical terms.

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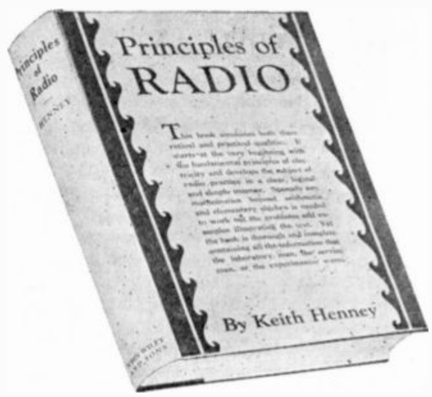

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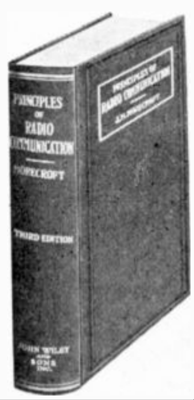

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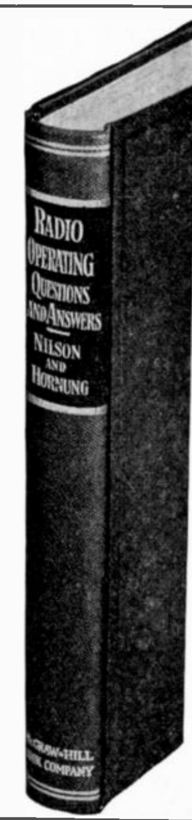

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The Martian Marvel

(Continued from Page 26)

equipment," says the chief-engineer roundhead. "About thirty miles from here we have a building containing an elaborate apparatus with which we project a powerful radio-sensitive, non-diverging beam, or, as we call it Zero ray. We can adjust this ray to strike on any desired part of the Earth or other planet, and radio waves impinging upon the ray are registered throughout its length."

"I wonder if I get you right," I says. "The wireless waves hop onto this here ray and slide up to Mars like a kid on a bannister?"

"That is not precisely the action," replies the roundhead, "but the result is about the same. At this end the Zero ray re-radiates very feeble waves corresponding to those striking its farther end; and these re-radiated waves are detected and amplified by the apparatus you see before you—a multi-degenerator and a forty-eight step radio-frequency amplifier."

"Forty-eight step!" I repeats, kind of dazed like. "Your vacuum tubes ain't much like ours, I guess."

"They are pretty good," admits the chief. "Even so, it took us eight years to get all the circuits balanced, and five of our best radio engineers committed suicide doing it, while nine others are still in the mental sanatorium at Zo-Zonne having their brains readjusted."

From the receiving laboratory, the chief takes me out into a kind of central court to look at the transmitting aerial. This seems to consist of a hundred or more cables, each over a foot in diameter, coming down from out of the sky and shackled into four porcelain insulators, which are about eighty feet across. From the insulators the cables are led off in a bunch to a great building of solid brown porcelain.

"This antenna has a circular-shaped flat top," says the chief pointing upward to where it spreads out like a giant mushroom. "It is about eighteen miles in diameter, and is supported at an elevation of thirty thousand feet by means of a set of twelve Zit-ray generators, similar to those you have seen on Baron Koubansky's rocket. This cone-shaped system of cables coming down to the insulators keeps the aerial from flying away, and at the same time serves as a lead-in."

We pass into the porcelain building; and I find myself in a vast high-ceilinged hall, perhaps twelve-hundred feet long and half as wide, with big steel-latticed windows in the walls, except at one end, where there are twenty vertical inductance coils about fifty feet in diameter and ninety feet high. Most of the remaining floor space is taken up by eighty gray metal cylinders, maybe a foot in diameter, five feet high, and shaped like the shells of a twelve-inch gun. These are mounted in an upright position on heavy brown porcelain beds spaced about ten feet apart, and are arranged in four rows of twenty.

From each porcelain base two large pipes and three ten-inch cables go down into the floor, and a fourth cable runs up overhead into a system of enormous braided copper buses suspended from huge insulators. I notices that each of the metal shells has a small mica window in one side, through which emanates a hot red glow.

"Burnin' Jerusalem!" I gasps. "Vacuum tubes!"

"Yes, these are our power tubes," says the chief, complacent like. "The water-cooled alloy-metal shell serves as the plate element, upon which is impressed a direct current of approximately fifteen hundred thousand volts. The tubes are each of three hundred and fifty kilowatt input, giving us a total power of twenty-eight thousand kilowatts. This is radiated on a wave-length of five hundred kilometers, or five hundred thousand meters. Yet all this enormous energy is controlled in the final master circuit by one little four-watt tube. Magnificent station, is it not?"

"Yes, it's a real neat little layout," I replies, dizzy like. "You must get several amperes radiation."

"The man who designed and built the station had his license suspended five years and was permanently reduced to a third-grade engineer because he could not bring the radiation up to the required minimum of forty-six thousand amperes," replies the roundhead. "Just at present I am holding the antenna current at fifty-two thousand, but it varies two or three thousand according to the weather."

"Of course, that would be expected," I says. "A couple of thousand amps more or less don't amount to nothin,' anyway."

Just about this time my guide, who has been away some place, joins us again.

"I am sorry to interrupt your inspection of the station, Mr. Jones," he says regretful like, "but the professors of the First National Academy of Anthropology at Zo-Zone wish to see you."

"Well, I s'pose I have to go," I says to the chief-engineer roundhead. "I'll be back in a little while an' get all th' dope on this joint—if it's all right with you."

"Certainly," replies the chief. "Any time you wish." But he glances at the other roundhead with a kind of phony smile which I don't like.

The guide takes me out into another telephone booth taxi; and a couple of seconds later we arrive at Zo-Zonne. Here we go into a building that looks like the palace of the King of England, and before long I find myself standin' up on a stage in a sort of big auditorium, in which about a thousand roundheads are sittin', lookin' at me. I can see that these are real old birds, because their round domes are glistenin' like billiard balls, an' they all have fancy snow white goatees.

Pretty soon one old gazooney, who looks like he is the great-grand father of all the roundheads, comes out alongside me on the stage.

"Fellow scientists and investigators," he begins, addressin' his gang out in front of us. "I take great pleasure in presenting to you this afternoon the first living specimen of the Earth genera homo saphead that it has ever been our good fortune to get possession of. Now, at last, we shall be able definitely to settle the long continued and bitter dispute between our good Doctors Zeeno and Zo-Zit regarding the brain and nervous structure of our prehistoric people; for this specimen fairly represents our own imperfect development of eighteen thousand years ago. We are going to remove his cerebellum, medulla oblongata, and spinal cord, to investigate—

"Hey, look here, you old gooney," I breaks in. "Are you talkin' about me!"

"Why, of course," he answers. "It is a perfectly harmless procedure. Your vital spark will be safely preserved in a jar of chemically pure radium, to be afterwards replaced—"

"Well, all I got to say is that it's nothin' doin!" I informs him and his crew. "I ain't goin' to allow no gang of basket ball headed old freaks to go draggin' my cerebellum an' medullum obligata around like that. You can put that in your pipe an' smoke it!"

"But you have nothing to say in the matter, sir," replies the roundhead. "It is your duty to the state—"

"It is not!" I barks. "I don't owe this state nothin'! I don't belong to it!"

"Oh yes, you do," insists the old brain butcher. "You have been leased to the Martian State for a period of twenty years by Baron Koubansky."

Now wouldn't that boil you!

"Oh, he did, huh!" I says, grim like. "How much was his cumshaw?"

"Five gallons of the ancient rye whiskey preserved in the cask in the national museum," replies the old round head. "He has already taken it and returned to the Earth."

By this time I can see that I am in a hell of a fix.

"Well, I refuse," I declares, ugly like. "I'll bust th' jaw of th' first cerebellum grabber that comes near me! Do you get that!"

"I advise you to submit peaceably," replies the old round head. "If you resist, we shall be forced to apply the Zing ray, which will instantly paralyze you."

I begins to realize then that I'm done for.

"All right," I says, "but look here—give me a quart of that old rye in the cask in the museum an' let me drink it first."

After some deliberation, the gang of old medullum slitters agree to this. They send out a young attendant roundhead, who soon returns with the quart. Then they put me in a big glass box and pump up the air inside so I can open up my pyralin helmet.

"Well, here goes," I says. "If your Martian wireless ever reaches th' earth, tell 'em I died happy."

With this I takes a big swig out of the bottle.

That eighteen thousand-year-old rye seems to go right down an' bounce against my toes—and then I thought I was a rocket myself. I see explodin' meteors, flamin' helium suns, fallin' stars, spinnin' moons, blazin' comets, an' collidin' planets. The next thing I know, I am lyin' on the bench in Golden Gate Park, while a big cop has me by the shoulders an' is pretty near shakin' th' teeth out of me.

"Holy purple-eyed wildcats!" I gasps, sittin' up. "Some kick to that stuff!"

Gettin' to my feet, I feels a sharp pain in the seat of my pants whereupon I suddenly remember I still have that big sliver I run onto while I was sittin' on the bench. I reaches around behind to pull it out, an' what does my fingers close over but a big hypodermic needle—a regular hop-gun! Old Baron Koubansky must have dropped it out of his pocket when he came and sat alongside me.

"Some kick to that stuff!" I repeats, yankin' out the needle an' throwin' it away into th' bushes, cautious like.

"Gwan!" barks th' copper. "Git out!"

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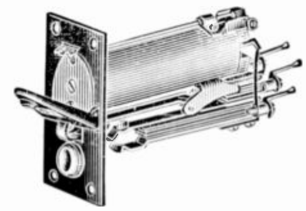

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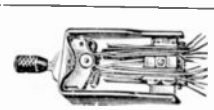

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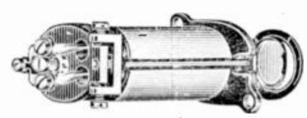

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