COMMERCIAL RADIO

April
1935

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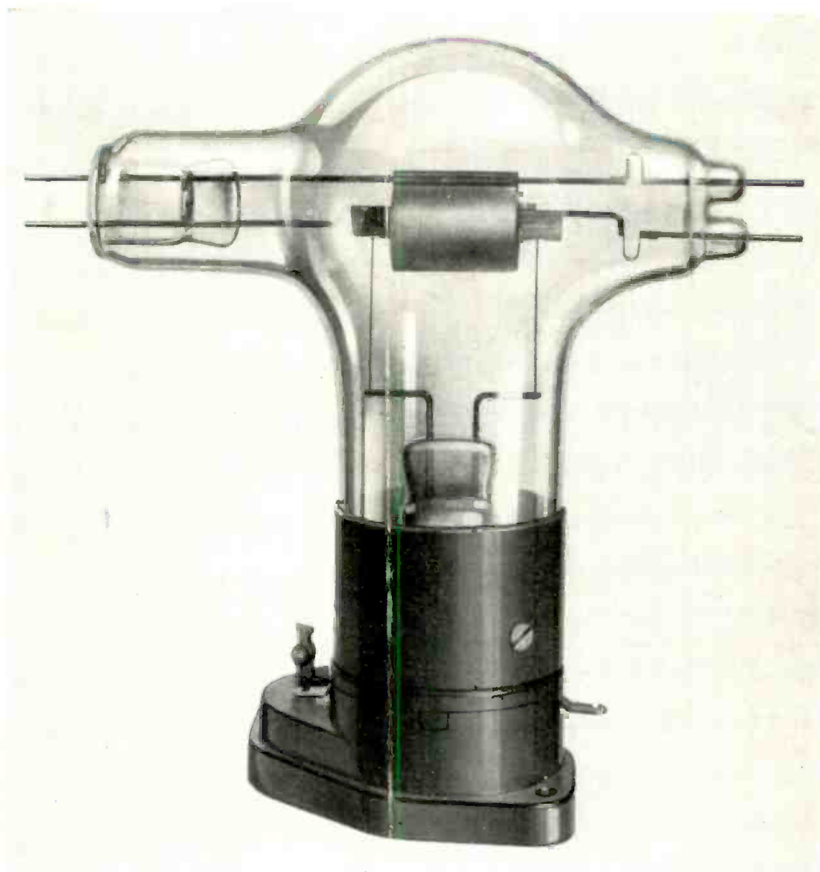

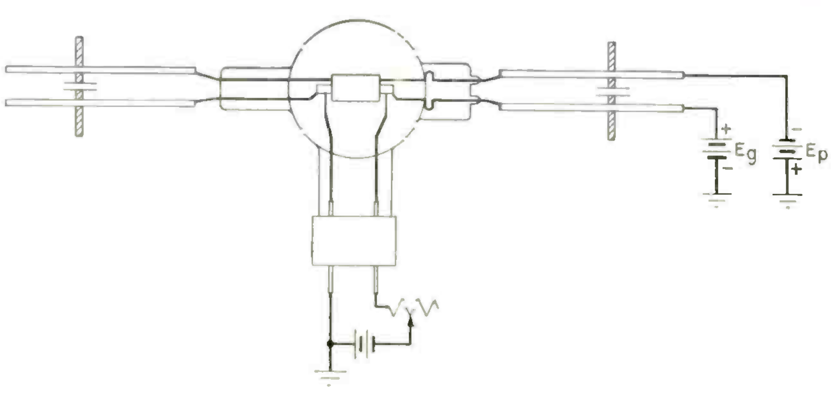

Vacuum Tube Oscillators

Precision Oscillator

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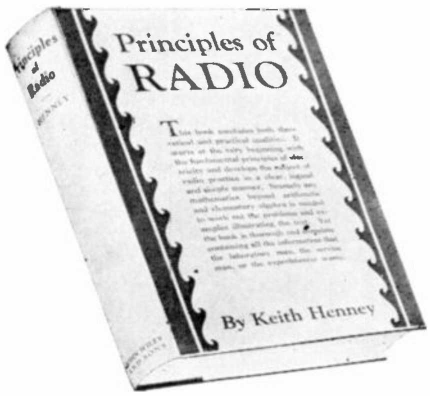

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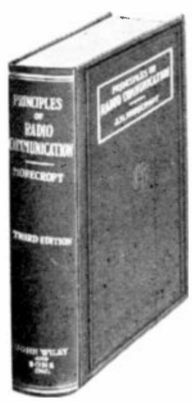

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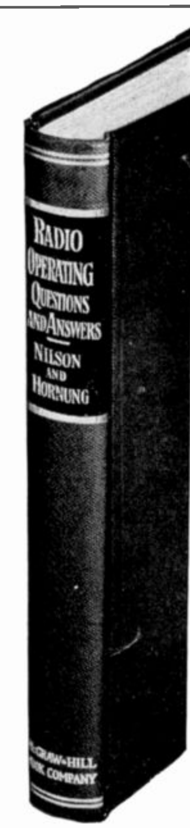

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WHILE Congress is wrestling with mighty problems it seems premature to think that a new member will be added to the President's official family in the form of a Communications Commissioner.

True, the seven men acting as The Communications Commission, divided in three divisions, the Broadcast Division, the Telegraph Division, and the Telephone Division, have their hands full.

Perhaps as some suggest local offices handling all district matters; only referring to Washington headquarters for general opinions, would simplify the task. Perhaps, this would also eliminate the necessity for the large commercial firms maintaining their Capitol contact offices. It would also eliminate the necessity of the smaller ones having to trip to Washington to get satisfactory hearings.

A great emergency would of course immediately solidify under one control this important communications problem, and it is not likely that the control would remain divided by seven.

But, the immediate future does not indicate any particular demand or necessity for a Commissioner of Communications. This is particularly true when viewed from the fact that the present Communications Commission is doing their job very nicely.

COMMERCIAL RADIO

(FORMERLY "C-Q")

The Only Magazine in America Devoted Entirely to the Commercial Radio Man

Contents for April, 1935

Page

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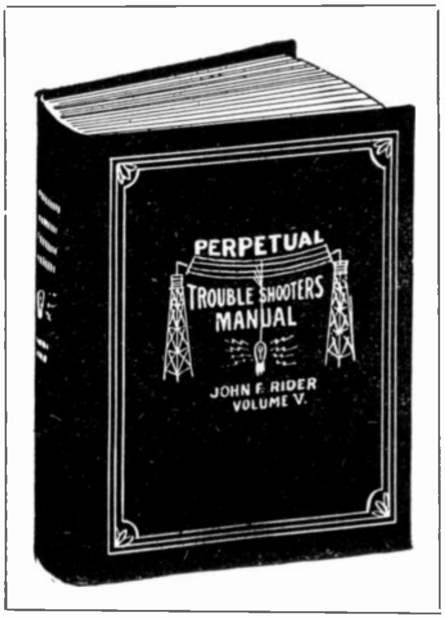

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Name	Quantity of Models
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Vacuum Tubes as High-Frequency Oscillators*

By M. J. KELLY and A. L. SAMUEL

Vacuum tubes as oscillators and amplifiers at frequencies greater than 100 megacycles (3 m.) are considered in this paper. The type of construction used in a large number of different tubes, and the characteristics of the tubes, are presented. Circuits for operating the tubes also are presented. Circuits for operating the tubes also are considered and the theory of operation and the factors limiting ultra-high frequencies are discussed. Principal attention is given to the tubes as oscillators, with brief consideration of the problem of amplification.

THE three types of oscillation generators which at present are the most efficient in the range from 100 megacycles to 3000 megacycles per second will be discussed in the following survey. These are: the negative grid tube which at lower frequencies is the conventional regenerative oscillator, the positive grid or Barkhausen oscillator, and the "magnetron" oscillator. The amplification problem will be briefly discussed. Because of the present unsettled state of the theory, only the most elementary and generally accepted part will be included. Much theoretical and experimental work remains to be done before knowledge of the mechanism of oscillation and amplification in this frequency range will be satisfactory. As is often the case, the empirical knowledge of some of these mechanisms has outdistanced the theoretical interpretation.

The Negative Grid Oscillator

The conventional thermionic vacuum triode, whether it be a large water cooled power tube or a small receiving tube, may be used as a generator of oscillations varying in frequency from a few cycles per second to some 20 or 30 megacycles with substantially undiminished efficiency and output. In this range the frequency at which a tube is to be employed is a factor of almost negligible importance in the determination of its characteristics and its form. Beyond this range, however, frequency plays an increasingly important part, and as one approaches 300 megacycles, it becomes the most important factor in the determination of tube design.

When an attempt is made to operate a standard triode at increasingly high frequencies it is found that the output and efficiency begin to decrease. The frequency at which this is first observed will depend upon the design of the tube but it will usually be in the 10- to 60-megacycle range. By successive modification of the circuit arrangement and size this decrease in power output and efficiency can be minimized. With optimum circuit arrangements, however, this decrease continues until finally a frequency is reached beyond which oscillations can no longer be produced.

In Fig. 1 are shown typical data for a standard 75-watt tube, the Western Electric type 242A, operated with reduced potentials over the frequency range from the point where oscillation frequency noticeably affects performance to the point where oscillations can no longer be produced. The plate potential was held constant at 750 volts throughout the entire frequency range. The oscillation circuit was modified at each point in order to obtain maximum output and efficiency, keeping the anode dissipation within the maximum rating of 100 watts and the anode circuit within the maximum rating of 0.150 amp. It can be seen from the curves that the output and efficiency are independent of the frequency until about 20 megacycles is reached, when they begin to decrease. At 100 megacycles the output power is only 2.5 watts and the efficiency only 2 per cent. The tube will not oscillate at 105 megacycles.

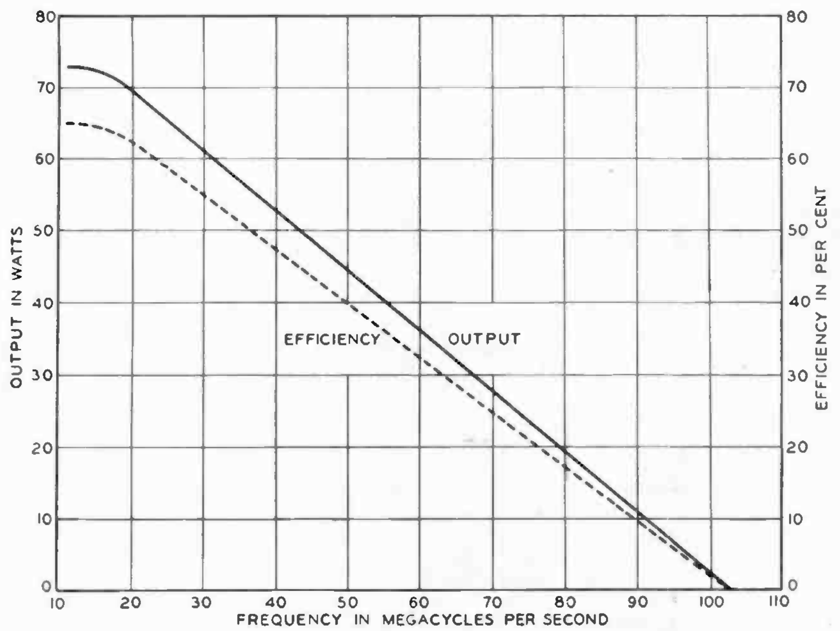
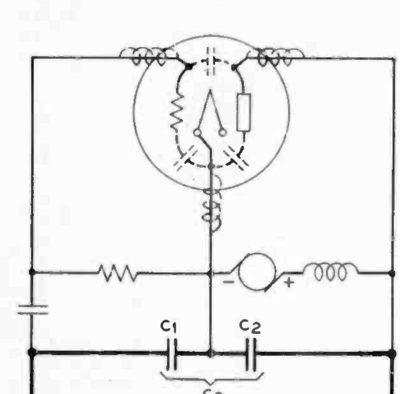


Fig. 1—Power output and anode efficiency as a function of frequency for a standard triode. These curves are typical of all tubes as they approach their upper limiting frequency



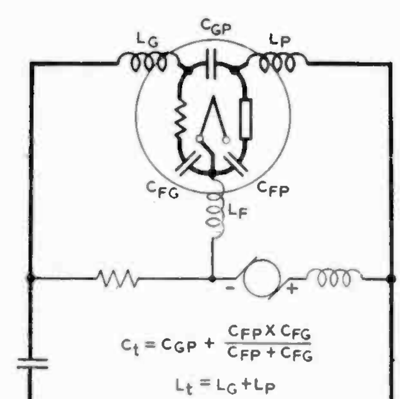


Fig. 2 (left)—A standard Colpitts oscillator circuit. The heavy lines indicate the main oscillating circuit. The dotted portions represent the inter-electrode capacitances and lead inductances which play a minor role at low frequencies

Fig. 3 (right)—The limiting circuit with the external tuning capacitance eliminated and the external inductance reduced to a short circuiting bar between the grid and plate leads. The main oscillating circuit, indicated by the heavy lines, is seen to include the inter-electrode capacitances and lead inductances

*Presented at Winter Convention A. I. E. E., January 22-25, 1935. Reproduced by courtesy of The Bell System Technical Journal, January, 1935.

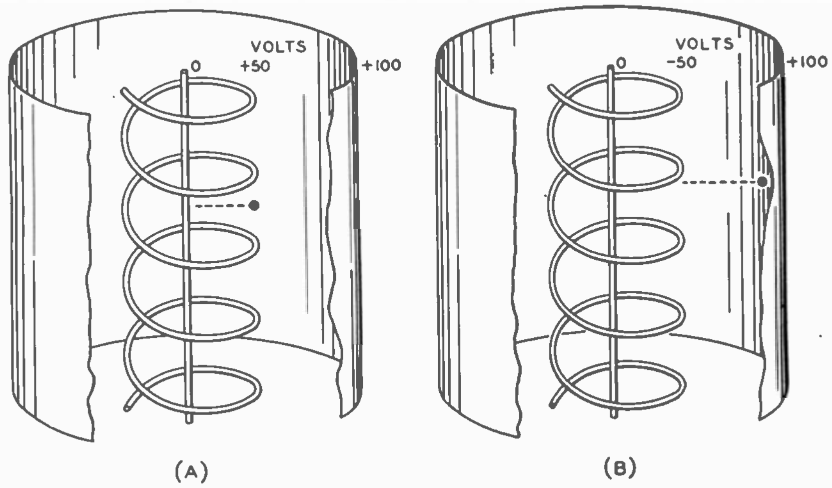


Fig. 4—Illustrating the mechanism which enables electrons to take energy from the oscillating circuit.

Effect of Energy Losses on Performance

A tube operating in the range where frequency affects performance must withstand energy losses, and the resulting heating within its structure, which occur to only a negligible degree at the lower frequencies. Some of these losses are due to dielectric hysteresis in the insulating materials of the tube, particularly in the portions of the glass supporting stem or bulb which lies between the tube leads. The glass is sometimes so softened by the heat thus developed that it is punctured by the outside air pressure. Losses also occur in the auxiliary metallic parts of the tube structure due to the increased eddy currents that occur at high frequencies. Losses in the tube electrodes and their lead-in wires are also greatly increased due to skin effect which increases their resistance, and due to the increased charging current required by the inter-electrode capacitances. The increased lead temperature, depending upon its amount, will cause a more or less rapid deterioration of the lead-to-glass seals which may ultimately destroy the vacuum. In order to protect the tube from damage because of these new types of energy dissipation, the operating potentials and currents must be reduced to values less than those established for low-frequency operation. Some manufacturers are now giving special ratings on such of their standard tubes as may be used at ultra-high frequencies. These ratings should be adhered to when operating in this range.

Effect of Circuit on Performance

The decrease in output power and plate efficiency which sets in with the increase in frequency, while due in part to the losses described above, and to the rapid increase in radiation losses, is also due to two additional effects of fundamental importance. The first to become evident, with increasing frequencies, is circuital in nature. This can be explained by reference to the conventional oscillator shown in Fig. 2. The frequency of such an oscillator is given by

$$f = \frac{1}{2\pi\sqrt{LC}},$$

where L and C are the effective inductance and capacitance of the oscillating circuit. In the lower frequency range the LC product which determines the frequency is substantially equal to L_0C_0, that is, to the product of the inductance and capacitance of the external circuit. The inductance of the tube leads and the capacitance between its electrodes (indicated by the dotted lines in the figure) play a negligible role. In order to tune the circuit to higher and higher frequencies, the capacitance C_0 is first reduced and finally eliminated, leaving the inter-electrode capacitance as the only capacitance in the oscillating circuit. The tube leads then form a part of the main oscillating circuit, in which large circulating currents must exist for stable operation. For a further increase in frequency the external inductance L_0 must be reduced and, in the limit, it becomes the shortest possible connection between the grid and plate terminals. The oscillating frequency for this limiting circuit, shown in Fig. 3, is determined by the product of the lead inductance L_t and the inter-electrode capacitance C_t that is,

$$f_0 = \frac{1}{2\pi\sqrt{L_tC_t}},$$

where L_t is the sum of the grid and plate lead inductance and C_t is the total grid-plate capacitance. Even before this frequency limit is reached the output power and plate efficiency are seriously reduced by the lack of full control over the relative amplitude and phase of the alternating grid and plate potentials. Whereas the ratio of these amplitudes is controlled in the circuit shown in Fig. 2 by the condensers C_1 and C_2, it is determined in the limiting case primarily by the fixed ratio of the grid-filament to plate-filament inter-electrode capacitance. Most tubes made especially for ultra-high frequency use are constructed so as to minimize these circuit limitations by a reduction in the inter-electrode capacitance and lead inductance and by adjusting the capacitance ratio.

Effect of Transit Time on Performance

The second fundamental has to do with the time required for the electrons to

(Continued on Page 17)

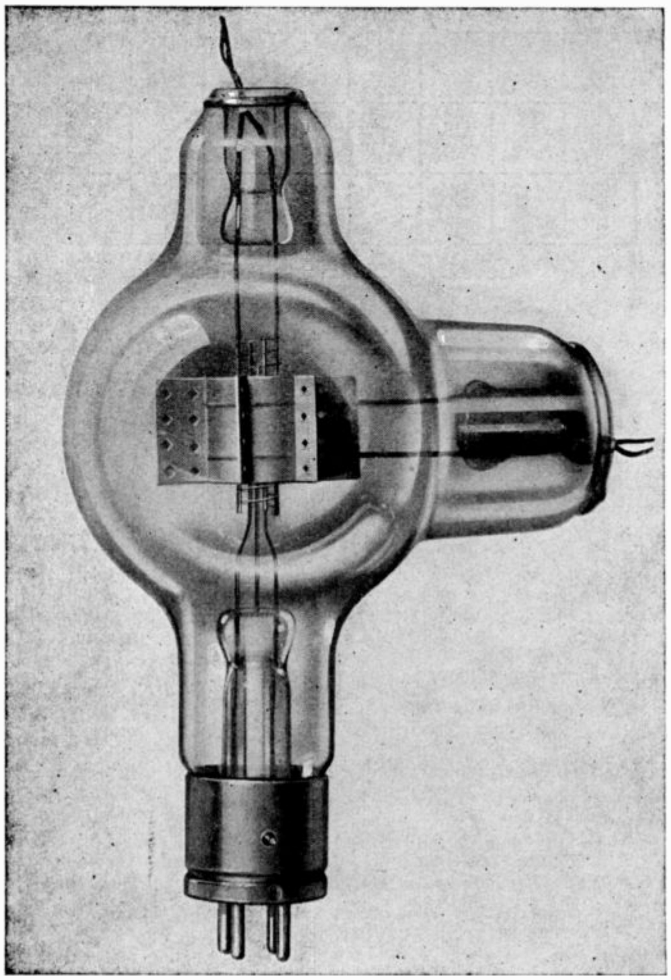


Fig. 5—A radiation cooled tube for use in the frequency range from 60 to 180 megacycles per second. Note the large ratio of the plate diameter to plate length and the special arrangement of the leads

New Survey Shows 21,455,799 U. S. Radios

There are 25,551,569 radio receiving sets in 21,455,799 homes in the United States—more than twice the number of residence telephones—and the total number of radio listeners over 10 years of age is placed at 70,804,137. These new figures are contained in what is believed to be the most comprehensive radio survey ever undertaken and just released by the Columbia Broadcasting System in cooperation with the statistical staffs of Dr. Daniel Starch, noted research expert, and of the McGraw-Hill Publishing Co.

The survey required a year of investigation by a nationwide field staff which made 125,000 house-to-house interviews in 321 communities, covering cities, small towns and farms in every state and studying every type of family in the various income brackets.

A breakdown by states of the number and percentage of radio-equipped homes in each, as given in the survey, follows:

State	No. of Families	Radio Homes	% Ownership
Alabama	602,200	216,979	36.0
Arizona	111,500	53,518	48.0
Arkansas	446,700	122,989	27.5
California	1,759,400	1,369,365	77.8
Colorado	270,800	186,598	68.9
Conn.	403,700	339,845	84.2
Delaware	60,500	45,898	75.9
Dist. of Col.	127,400	121,787	95.6
Florida	403,800	200,674	49.7
Georgia	661,600	260,011	39.3
Idaho	109,300	74,284	68.0
Illinois	2,019,500	1,647,283	81.6
Indiana	869,500	597,696	68.7
Iowa	637,200	459,988	72.2
Kansas	488,500	319,714	65.4
Kentucky	617,900	300,877	48.7
Louisiana	503,700	258,420	51.3
Maine	201,000	136,840	68.1
Maryland	397,900	318,877	80.1
Mass.	1,057,300	903,467	85.5
Michigan	1,242,200	919,946	74.1
Minnesota	619,500	441,164	71.2
Mississippi	478,400	113,989	23.8
Missouri	943,300	649,040	68.8
Montana	137,900	86,011	62.4
Nebraska	348,700	244,503	70.1
Nevada	26,900	16,370	60.9
New Hamp.	120,500	94,186	78.2
New Jersey	1,032,000	895,884	86.8
New Mexico	101,600	43,394	42.7
New York	3,264,700	2,928,870	89.7
No. Carolina	673,700	266,924	39.6
No. Dakota	146,400	84,138	57.5
Ohio	1,752,800	1,336,547	76.3
Oklahoma	589,300	291,595	49.5
Oregon	275,000	211,103	76.8
Penn.	2,285,100	1,913,349	83.7
Rhode Is.	171,900	148,961	86.7
So. Carolina	372,300	142,706	38.3
So. Dakota	164,000	103,342	63.0
Tennessee	622,300	312,491	50.2
Texas	1,445,900	733,128	50.7
Utah	118,200	84,293	71.3
Vermont	90,300	61,274	67.9
Virginia	531,700	301,894	56.8
Washington	434,600	333,236	76.7
West Va.	388,300	239,227	61.6
Wisconsin	732,900	489,602	66.8
Wyoming	59,500	33,522	56.3
U. S. Total	30,919,300	21,455,799	69.4

Shipping Items of Interest

Vessels under construction in U. S. yards March 1, 1935, were of estimated gross tons 34,990. The largest of these was two 9,000 ton tankers in the New York S. B. Co. All the others were under 1,000 tons. The total includes barges, tankers, towboats, fishing vessels, tugs and ferry boats.

At Boston a conference on the coordination of distress communications was held recently in the Commandant's office, Boston Navy Yard. Represented at the conference was Navy, Coast Guard, Lighthouse Service, Inspector of Steam Vessels, representatives of several steamship lines, as well as the commercial wireless firms.

The International Federation of Radiotelegraphists recently sent out the following notice: To all members of the affiliated associations. Automatic Alarm Device. In order to get an opinion of the working of the above instruments on board the ships, we would ask you to supply the Federation with information regarding your experience with this apparatus. It is therefore kindly requested that you will fill in the form and send it to your national association as soon as possible. It should be understood that we are only interested in strictly neutral information which can show the actual Working of the Automatic Alarm Device in the Safety Service at Sea. Yours faithfully, International Federation of Radiotelegraphists.

Commerce Men Have Hard Time

At the Mount Catherine beacon light on the Seattle-Spokane airway section commerce department men had to dig tunnels in snow to make their inspections. The snow was 24 feet deep, and four feet above the exhaust pipes from the gasoline engines in the shed. Heat from the exhaust pipes kept holes open in the snow so that the shed could be found. It took the men five hours digging snow to get in to make their inspection. That's work for radio men.

SONG OF THE SPARK SET

By HERMAN SWERDLOFF

I am just a bit of copper and black panel,
I'm beloved by the Komrades of the Key,
You've heard me call out in the English Channel,
My mellow voice was calling POZ.
My brass is always shining very brightly,
My gaps are ozone-filled and sparking right,
My motor smoothly runs like the whirling Cosmic Suns,
And my Leydon jars discharge their purple light.

They read the bold defiance in your sending
As I hurled your SOS across the sea,
And tho my dying note was rather feeble
They caught your message on the "Katydee";
For sixty-seven hours we were drifting,
Our decks were battered by that hellish sea,
And that lion roaring wind left our rigging far behind,
While the whiplashed ratlins shrieked their melody.

You pounded out: "There's water in the bilges,
The starb'd side is listing very fast."
With your fist upon the key you pounded CQD,
And I stuck with you, Shipmate, to the last;
And yet you thot that this would be your finish,
That your love at home would never see your bones,
But the gallant "Katydee" hove to in angry sea,
And snatched another prize from Davy Jones.

Do you recall that rough coast of Alaska?
The North winds and the icy roaring sea,
The night all lives were lost on the "Sophia"
You flashed the tragic story with your key;
You reckon how I raised that Limey Station?
You relayed twenty TR's on the air,
When the static was so bad that you swore till you were mad,
But the Limey said my spark rolled in quite fair.

You recollect those wild Straits of Magellan?
The engine crushed the Third Assistant's hand,
But I hurled his painful plea across a thousand miles of sea,
And the doctor gave advice from Lubber's land.
I've saved the sinful souls of shipwrecked sailors
Who prayed and prayed to God without avail,
But my kilowatt of spark saved them from the hungry shark
And brought them back alive to tell the tale.

I've made your lonely cruise a cheerful passage.
My waves of sparks have conquered waves of sea;
For I sentinel the air when the ships are in despair
And my shipmate is the pounder of the key.
We've sailed the seven lonely seas together,
We've felt that pride that only seamen know,
In our conquest of the sea with my spark gaps and your key,
Yet we've danced with death a dozen times or so.

They say ashore that you have been a failure.
It doesn't matter what you might have been,
But where sky and water meet you're the PRIDE of every fleet,
And they hail you as the savior of the sea!
Our silent deeds are written on time's pages
That the restess roving sons of men may see,
And with every storm that rages they will hear in distant ages
The saga of the SPARKS upon the sea.

How KGFW Got "a Beat"

Stratosphere Balloon Descent Was the Opportune Moment With Equipment on Hand

By ROY H. McCONNELL, Chief Eng. KGFW

IF some one had told staff members of radio station KGFW that they would broadcast the descent of the stratosphere balloon when preparations were being made for its flight into the high altitudes, I am very sure they would have done some tall laughing.

Yet that is just what happened. However, no one excepting those who live in central Nebraska have ever heard about it for the press avoided mentioning the fact. Perhaps you have heard that the newspapers don't care much for radio stations. This would seem to prove the assertion as no mention was made regarding the fact that KGFW broadcast the last two hours of the descent of the stratosphere balloon, giving data on the descent at frequent intervals.

The KGFW Shack. Verle Edminston, Announcer, and M. E. Thelen, Operator, Shown

Our first information regarding the flight of the balloon came from a listener who sent us a telegram from Gothenburg, Neb. He said, "The stratosphere balloon is right over my house, think it is about two miles up, seems to be in trouble, we can see something hanging loose on one side of the bag. It looks to be about three inches in diameter. Thought maybe you would like to tell your listeners about it." This we proceeded to do immediately. About thirty minutes later we received a telephone call from a farmer who said that he lived about ten miles north of Sumner, Neb., and that the balloon was at that moment passing over his house. He thought that it was about two miles high and that all was not well aboard. With the aid of a small telescope he could see that some of the rigging was misplaced and he believed that one of the passengers was partly out of the gondola. He said, "I thought maybe your listeners would like to know about the balloon." We thanked him for the information and relayed it on to our listeners.

By this time we were getting numerous phone calls from persons asking about the sphere and also calls bearing news of its whereabouts. Probably fifteen minutes later we sighted the balloon west of the station. It was coming out of a cloud, looked about as large as a common marble and appeared to be white in color. The stratosphere seemed to remain almost stationary, as to height, for several minutes and then started to settle. It was drifting rapidly southeast and began to sink speedily towards the earth.

Perhaps twenty minutes after it began to settle, the balloon collapsed and dived towards the earth. We had placed a microphone outside the studio and were watching the balloon through a pair of field glasses, giving our listeners a play by play description of the flight. We could see that something was hanging on the right side of the balloon. It looked like a parachute. The gondola was a tiny speck of silver hanging below the balloon the bottom of which seemed to be missing. We learned later that what appeared to be a parachute was part of the balloon which had torn loose and was hanging down.

Apparently the whole top tore out of the balloon and it dropped like a plummet. Naturally we assumed that the men were in the gondola and it was with sad hearts that we told our listeners that the balloon had fallen. We made no predictions concerning the passengers as we were too far away to see them jump.

A few minutes after the balloon fell we received a telephone call informing us that the members of the balloon crew escaped via the parachute route. This good news was passed on to the hundreds of listeners who were anxiously waiting to learn what had happened to the daring airmen.

Shortly before the balloon landed, we

(Continued on Page 11)

Verle Edminston, Announcer, watching stratosphere balloon descent and giving the news to KGFW listeners.

THE IONOSPHERE

By W. M. GOODALL

Member of the Technical Staff, Bell Telephone Laboratories

WHEN you pick up your telephone and talk with a friend in Europe, South America, or Hawaii, the radio waves commonly employed to carry your voice do not cling to the earth in their journey, but reach their destination after being reflected from some point high in the atmosphere. For short-wave transmission, it has been known for some time that as the receiver is moved away from the transmitter, the received signal becomes weaker and at a comparatively short distance—from 50 to 100 miles—disappears entirely into the background of noise. As the distance is further increased, however, the signal will reappear, and become strong. This phenomenon is known as the "skip" effect. Its observation led to the inference that short-wave signals are returned to the transmitter by being reflected from some of the upper layers of the atmosphere. Without such a reflecting region, long-distance radio communication by short waves would be impossible. It is obviously desirable to have as sound a knowledge as possible, both of the physical nature of this region and of the method by which radio waves are propagated through it. With this in view, experiments have been carried on for some time by J. P. Schafer and the writer at the Deal Laboratory.

Early in 1882, Balfour Stewart had suggested the existence of a conducting layer high in the atmosphere to explain variations in the magnetic field of the earth. In 1902, Kennelly and Heaviside had independently also used the assumption of a conducting layer to provide a mechanism capable of reflecting radio waves. In spite of these early suggestions, however, it was not until the last decade that experiments had been carried out which were sufficiently direct to the bitter end that a conducting layer is an unnecessary assumption. Today, however, no one questions its existence. The evidence admits of no other interpretation.

Present-day knowledge of conductivity in gases suggests that this conducting layer is an ionized region of the atmosphere. Ultra-violet light from the sun is, under favorable conditions, a powerful ionizing agency, and might well produce these ionized regions. From measurements made by the Laboratories during a recent solar eclipse, moreover, it appears that the sun is largely responsible for ionization in at least two of the reflecting regions of the upper atmosphere.

The atmosphere surrounding the earth may be divided into two or more layers. The lower of these, extending upward to about eleven kilometers above the earth, is known as the troposphere. In this region clouds form and temperature decreases in proportion to altitude. In the region above this level, called the stratosphere, the temperature does not vary with the altitude and cloud formations of the type found in the troposphere never appear. It is in a still higher region that radio waves are reflected, and it has been suggested that this latter region be called the ionosphere, a name that was derived from its most important attribute—ionization.

A convenient method of studying the ionosphere is to measure the time required for a radio signal to travel to the reflecting layer and back to the earth. Knowing the velocity of the waves, one can easily compute the distance to the point of reflection from the total elapsed time, much as the distance to a mountain could be calculated by timing the return of a sound echo. With radio waves, however, an uncertainty enters because the reflection does not occur sharply at a plane. The wave penetrates the ionized region for some distance and in this region its velocity is reduced.

Because of this, two heights are referred to—the virtual height and the actual height. Virtual height is that calculated on the assumption that the radio wave travels with the velocity of light to the reflecting plane where it is sharply reflected and returns at the same velocity. Actual height is that of the highest point the wave reaches. The situation is suggested diagrammatically in Figure 1. When the virtual height is independent of frequency for a considerable range of frequencies, the virtual height is probably not greatly different from the actual height. When virtual height changes with frequency, it may be several times the actual height. Only the virtual height can be measured directly, but from plots of virtual height against frequency together with certain reasonable assumptions, it is possible to estimate ionic density of the different reflecting regions and to make approximate estimates of the actual heights.

For measuring virtual heights a radio transmitter and receiver are mounted side by side so as to be controlled by a single operator. Transmitting and receiving antennas are located above the small building housing the testing apparatus. Short pulses are sent out from the transmitter at the rate of sixty per second, which travel up to the reflecting layer and back to the ground. The receiver picks up both the direct and the reflected signal, and the time displacement of the two is a measure of the virtual height of the reflecting layer.

The output of the receiver is connected to one pair of deflecting plates of a cathode ray tube, while the other pair of deflecting plates is connected to the sixty-cycle source that controls the rate of emission of the transmitted pulses. When no signals are being sent out, the pattern on the cathode ray tube is a horizontal straight line caused by the electron stream sweeping back and forth across the tube sixty times a second. When pulses are being transmitted, the motion of the electron stream across the tube will be deflected vertically twice or more each trip—once for the direct pulse picked up and once or more for the reflected pulses. The time of sending the pulse relative to the sixty cycle current can be adjusted, and is usually chosen to bring the first or direct-received pulse near the left edge of the tube and at the zero of the small scale fastened on the front of the tube.

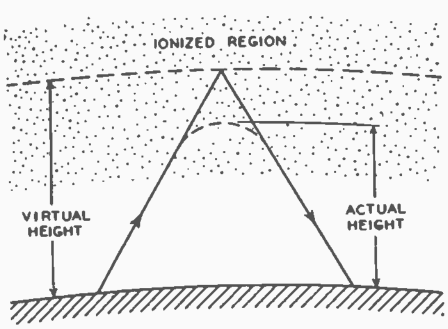


Fig. 1—Radio waves are not reflected as light from the surface of a mirror, but in effect curve around at a decreased velocity.

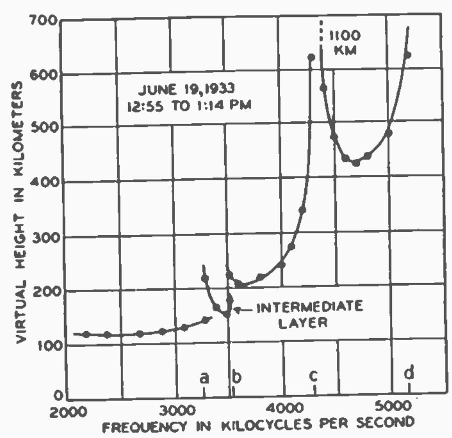


Fig. 2—A plot of virtual height against frequency showing at least three critical frequencies

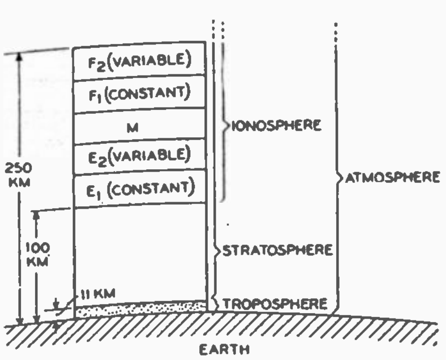


Fig. 3—Positions of various ionized regions in the upper atmosphere

The position of the second or reflected pulse can then be read directly from this scale. Since the receiving antenna is immediately adjacent to the transmitter, the direct signals are much stronger than the reflected ones. If the gain of the receiver is increased until the reflected signal produces a satisfactory deflection, however, the overloading effect limits the amplitude of the direct pulse to a satisfactory value.

An extremely useful method of studying the structure of the ionosphere is to measure the virtual height as a function of frequency. To secure such data, the frequency is changed so rapidly that the condition of ionization remains essentially constant during the experiment. A plot of one such set of measurements is shown in Figure 2. The significant feature of the relationship shown is that the virtual height remains essentially constant for a range of frequencies and then suddenly increases. Beyond these critical frequencies the virtual height rapidly decreases, but always to a value higher than found below the critical frequency. The critical frequency is that at which the lower reflecting layer is completely penetrated, and the virtual height beyond the critical frequency is that of the next

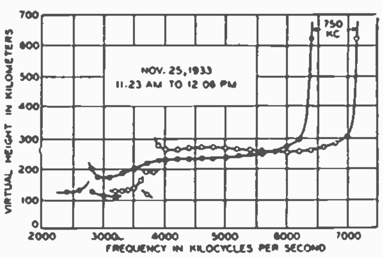


Fig. 4—Virtual height and frequency plot for two components of reflected wave

higher layer. The large virtual height obtained at the critical frequency is not due to a greater penetration but to a decrease in velocity of travel through the penetrated layer at the critical frequency. From such sets of measurements it becomes evident that there is more than one reflecting layer in the ionosphere.

At one time it was thought that there were two general ionized regions, an upper and a lower, designated the F and the E respectively. As a result of studies made by the Laboratories, however, it is now known that the ionosphere is composed of at least five, and possibly more, reflecting regions. Their heights are not constant and may even shift relative to each other but a typical indication of their arrangement is shown in Figure 3. The various regions differ not only in their heights but in the manner in which their ionization varies.

In regions E_1 and F_1, the ionization throughout the day varies uniformly with time in a manner that would be expected if the ionizing agent were the sun. The same cycle of ionic density repeats itself day after day, attaining a maximum shortly after noon. Tests made during the solar eclipse a few years ago indicate strongly that ultra-violet light from the sun is the ionizing agency. In the other regions, the ionization varies in an erratic manner from day to day and even from hour to hour. During winter the ionic density in the F_2 region may change as much as 50 per cent. in from 15 to 30 minutes. The maximum for this region usually occurs about noon in winter and about sunset in summer. The ionization of the M region sometimes varies in a constant manner, as does that of the E_1 and F_1 regions, and sometimes varies erratically from hour to hour.

Because of this variation in ionic density, it is not always possible to find all the regions at the same time. If, for example, the ionic density of the E_2 region should be greater than that of any higher regions, signals that completely penetrated the E_2 layer would not be returned to the earth, giving no indication of the existence of higher levels. In general a signal that completely penetrates one layer will be reflected only by a layer of higher density.

Besides this complexity of reflecting regions, there is an additional complication caused by the effect of the earth's magnetic field. In such a field the signal is split into two components, each of which in general is reflected at a different virtual height and has a different critical frequency. This is indicated in Figure 4, where one component is indicated by black dots and the other by circles.

The effects described so far are detected when the transmitter and receiver are side by side, and the signal is transmitted up and back vertically. When the receiver is at a considerable distance from the transmitter, however, the reflection phenomena are further complicated by there being a number of paths which use different parts of the ionosphere for reflection as shown in Figure 5. When it is remembered that the reflection along all of these paths encounters the diversity of reflecting regions and the splitting effect of the magnetic field already described, it becomes apparent that the transmission of short waves must be a very complicated process. Fundamental studies of the elements of this type of propagation should contribute materially to the improvements in long-distance radio transmission which the next few years should bring forth.

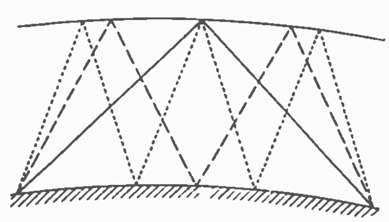


Fig. 5—Possible multiple paths for radio transmission

"IN BALTIMORE"

By WM. D. KELLY

The Institute of Radio Confrees in Baltimore held their first annual dance February first. A very good time was had by all. There were eats, good orchestra and a good crowd. Messrs. Sterling, Ellert, Cohen and Chapin of the R. I. staff in Baltimore were all there as well as Jack Lynch from WCAU, W. Wilson of Delaware Radio Sales. The A. T. and T. was well represented as well as Western Electric. All of the broadcast stations were well represented as well as the local police radio station. There

(Continued on Page 12)

LINE EQUALIZATION

By ROBERT C. MOODY
Chief Engineer, KDB

While the trend in broadcasting is without a doubt for higher fidelity and quality of transmission there are still in use a great number of Grade C lines for wire transmission. Most of these of course are used in minor networks and hauls where high quality high speed lines or even Grade A lines are not economically practical. Such lines call for transmission at a given power level at 1000 cycles and no attention is paid to transmission at other frequencies. In one such line a frequency run showed 2.9 mills at 1000 cycles, 0.9 mill at 100 cycles and 1.1 mill at 4500 cycles. This represents an amplitude distortion of somewhat more than 10 db. Naturally one could not expect to equalize such an error especially since there are repeaters in the line whose amplitude distortion may not follow the inverse response of any simple equalizer. It is possible to alleviate the condition very noticeably with two equalizers; one a 5000-cycle and the other tuned to about 80 or 100 cycles. For the 5000 cycle equalizer one can use a 5 millihenry coil in parallel with a .17 condenser. A 1000 ohm rheostat is put in series with the parallel circuit and the line. In case the equalizer tunes too sharply some resistance should be put in series with the coil. A 50-ohm rheostat should work well. Usually about 15 to 25 ohms is necessary. For the low frequency equalizer a 2 henry coil and a 2 microfarad condenser can be used, connected the same as the high frequency equalizer. Use a 1000 ohm rheostat in series as already described and some resistance in series with the coil if necessary. If the coil is an iron core choke in the case of the low frequency equalizer care should be taken that the resistance is not too high. The d. c. resistance should be quite low, say under 25 ohms or 50 at the most. Otherwise the equalizer will tune too broadly. I have used an old type 71-H choke to good advantage from a Western Electric 8-A amplifier. It is best of course to equalize with some sort of an audio frequency oscillator but good results can be had by adjusting the 1000 ohm rheostats by ear. Such equalizers can often be used to good advantage in other cases and may be made to show up on the jack panel. It must be remembered that equalizers of this type work on the principle of attenuating all frequencies except those in the neighborhood of the resonant frequency. The overall level may drop anywhere from a few to 15 or 20 db when the equalizer is bridged across the line and adjusted and hence additional amplification may be necessary. The writer has always held that if everything is as it should be equalization is hardly necessary especially for low frequencies but having such equalizers handy will often make a poor remote control or network program sound much better.

Forced Air Recommended

By S. S. DAVIS, Chief Engineer, KFJB

In low power transmitters, using air cooled tubes, such as the '49 and the '04A, I have found that greater efficiency may be obtained if the temperature of the operating room is kept between 65 and 70 degrees, and a forced circulation of air (room temperature) is played upon tubes and resistances.

Another point of advantage this forced circulation gives is the life of the tubes is generally increased.

Applications for New Broadcasting Stations

Morton S. Zaller, Lakewood, O., requesting 1310 kc, 100 watts.

H. K. Glass-M. C. Kirkland, Eustis, Fla., requesting 1310 kc., 100 watts.

Florida Capitol Broadcasters, Inc., Tallahassee, Fla., request 1310 kc, 100 watts

Palm Beach Broad. Service, West Palm Beach, Fla., requests 1370 kc., 100 watts.

Hearst Radio, Inc., Albany, N. Y., requests 970 kc., 1 kw.

Pampa Daily News, Inc., Pampa, Tex., requests 630 kc., 100 watts.

G. D. Goff, Tampa, Fla., requests 1500 kc., 100 watts.

Evansville on the Air, Inc., Evansville, Ind., requests 1370 kc., 100 watts.

Amon G. Carter, Ft. Worth, Tex., requests 790 kc., 5 kw.

Lawrence B. Holman, Atlanta, Ga., requests 590 kc., 250 watts.

Roy L. Albertson, Buffalo, N. Y., requests 1370 kc., 100 watts.

Harold H. Hanseth, Fresno, Cal., requests 1410 kc, 1 kw.

D. A. Wark and H. H. Hedstrom, Twin Falls, Ida., requests 1500 kc., 100 watts.

George Bissell and Herbert Littlefield, Watertown, N. Y., requests 1420 kc., 100 watts.

Wyoming Radio Ed. Asso., Cheyenne, Wyo., requests 780 kc., 100 watts.

Ward Walker, Seattle, Wash., requests 760 kc., 250 watts.

Clark Standiford, Porterville, Cal., requests 1420 kc., 100 watts.

Duluth Broad. Co., Duluth, Minn., requests 1200 kc., 100 watts.

Paul Sullivan Andrews, Lewiston, Me., requests 560 kc., 250 watts.

Dallas Broad. Co., Dallas, Tex., requests 1500 kc., 100 watts.

Hammond-Calumet Broad. Corp., Hammond, Ind., requests 1480 kc., 5 kw.

Times Herald Pub. Co., Vallejo, Cal., requests 850 kc., 250 watts.

Hauser Radio Co., Ventura, Cal., requests 1810 kc., 100 watts.

Monocacy Broad. Co., Frederick, Md., requests 900 kc., 500 watts.

Springfield Newspapers, Inc., Springfield, Mo., requests 1120 kc., 250 watts.

Pittsburg Pub. Co., Pittsburg, Kans., requests 1500 kc., 100 watts.

Commercial Broadcasters, Inc., Moorhead, Minn., requests 1310 kc., 100 watts.

Robert L. Sanders, San Pedro, Cal., requests 1180 kc., 250 watts.

Harry Prezant, Los Angeles, Cal., requests 1120 kc., 1 kw.

Radio Chapel of the Air, Minneapolis, Minn., requests 1370 kc., 100 watts.

Southern Oregon Pub. Co., Roseburg, Ore., requests 1500 kc., 100 watts.

Big Spring Herald, Inc., Big Spring, Tex., requests 1500 kc., 100 watts.

Guilford Broad. Co., Abilene, Tex., requests 1420 kc., 100 watts.

Clark Standiford, Visalia, Cal., requests 850 kc., 100 watts.

Clark Standiford, Chico, Cal., requests 1210 kc, 100 watts.

Robert E. Cole, Washington, Pa., requests 1200 kc., 100 watts.

Reporter Pub. Co., Abiline, Tex., requests 1420 kc., 100 watts.

North Texas Pub. Co., Paris, Tex., requests 1500 kc., 100 watts.

J. W. Birdwell and S. R. Jennings, Johnson City, Tenn., requests 1200 kc., 100 watts.

Big Spring Herald, Inc., Big Spring, Tex., requests 1500 kc., 100 watts.

W. H. Kindig, Hollywood, Cal., requests 1160 kc., 1 kw.

Ray J. Arend, Rochester, Minn., requests 1200 kc., 100 watts.

Plainview Broad. Co., Plainview, Tex., requests 1500 kc., 100 watts.

Milton Kaufman and Jonas Weiland, Kinston, N. C., requests 620 kc., 1 kw.

A. Corenson, Ventura, Cal., requests 1210 kc., 100 watts.

A. B. C. Broad. Co., Big Spring, Tex., requests 1500 kc., 100 watts.

Fountain of Youth Properties, St. Augustine, Fla., requests 1210 kc., 100 watts

Clark Standiford, San Jose, Cal., requests 1490 kc., 100 watts.

A. Corenson, Pasadena, Cal., requests 1480 kc., 100 watts.

How KGFW Got "a Beat"

(Continued from Page 8)

received a communication from Mr. H. H. Neilsen of the A. T. & T. Co. who was at the Bell Telephone headquarters in Grand Island, Neb. He wanted to know whether we would lend him a remote control amplifier to take to Loomis, Neb., in order that Major Kentner might broadcast his experiences over a chain net work.

We informed Mr. Nielsen that he was welcome to use our equipment for such a purpose and he replied that he and his assistants would be up as soon as possible, pick up the equipment and proceed to Loomis, Neb., for the broadcast. They arrived in about 50 minutes. Mr. Neilsen learned from officials and phone company employees at Loomis that Major Kentner had already broadcast using a regular country telephone. We did not get to hear his talk as the net used does not have a station that can be heard here.

Some time later we received the following letter from the National Broadcasting Company, thanking us for our cooperation. It follows:

"Engineer in Charge,
"Radio Station KGFW,
"Kearney, Nebraska.
"Dear Sir:

"It has been brought to my attention that on July 29th Mr. H. H. Nielsen of the A. T. & T. Company and Mr. Cartwright of the Northwestern Bell Company, both stationed at Grand Island on the day of the National Geographic Society-Army Air Corps Stratosphere flight, acting in an emergency, borrowed audio pick up equipment from your radio station and proceeded to the home of Ruben Johnson to place Major Kepner on our network after he had landed safely at the end of the balloon flight.

"Although these two men arrived at Mr. Johnson's home after Major Kepner had concluded his talk to the net work, we wish to thank you for your cooperation in lending equipment to the telephone company personal. This is a fine example of the spirit of helpfulness which exists among radio broadcasters in this country. It is the kind of cooperation that helps us keep the public fully advised at all times during the broadcast of current major events.

"Please accept this as an expression of our appreciation.

"Yours sincerely,
"GEORGE McELRATH,
"Operating Engineer"

It was a unique experience to have been able to make this broadcast, one of those things that happen once in a life time and one that makes radio broadcasting an interesting game.

Station KROW

Final Installation Completed

HAVING operated since the early part of January of this year with high fidelity equipment of a temporary nature, the permanent equipment in the San Francisco studios of the Educational Broadcasting Corporation, owners and operators of station KROW, Oakland-San Francisco, Calif., has just been completely installed, is reported by Ted Bindner, chief technician for the company.

The equipment was manufactured by the Remler Company to the specifications of Mr. Bindner and C. E. Downey, radio engineer. It incudes the latest developments and refinements in speech in-put equipment, is entirely AC operated, and provides amplification and mixer facilities in duplicate. This forestalls any delay to a program due to a breakdown in any unit, as a switch to the other unit can be made in the fraction of a second.

These San Francisco studios provide KROW with facilities for servicing their sponsored programs emanating from that side of the Bay. Two studios are in use, with more space available as it is needed.

Equipment Converted

During the past two months, technicians of station KROW, of Oakland, Calif., have converted all speech in-put equipment to High Fidelity standards, with complete conversion to AC operation, and further refinements in the transmitter proper. The work has been done under the supervision of Ted Bindner, chief technician, and C. E Downey, radio engineer for the company.

Limited Equipment Tests Ingenuity of Radio Technician

A few years ago, Ted Bindner, chief radio technician for the Educational Broadcasting Corporation—owners and operators of station KROW, of Oakland-San Francisco, Calif., was confronted with the task of properly handling remote control broadcasts with equipment somewhat antiquated and extremely limited.

He needed a means of simplifying a method of "cuing" on remote pickups, and he was limited to one broadcast line, or loop, with no co-ordination circuit. So, he evolved the idea —new to him— of providing output of the monitor amplifier to the broadcast line running to the remote pickup point, and of automatically disconnecting the monitor output (or feedback as it has been termed) from the line when switching to the remote at the actual time of the program originating there.

This means that the operator at the remote pickup point may, by means of a headset across the line, hear the preceding program for a line test, and also hear the "swinging" announcement for a "cue"—which enables him to ascertain the exact moment the remote program is to begin.

It is obvious that the above eliminates the necessity of a radio set, or a separate telephone circuit from the main studios, and provides a satisfactory means of testing the lines prior to the remote program. "Ted" does not claim this as necessarily a new wrinkle, but at least it was new to him.

Studio Items

Ted Bindner, chief technician for the

Educational Broadcasting Corporation—KROW of Oakland and San Francisco—claims that his greatest thrill was in 1922 when as wireless operator on an ocean-going vessel he was obliged to send an SOS call. They were off Balboa and a heavy sea was running. Fortunately the call was later cancelled and the boat limped into port.

Scott Weakley, production manager for station KROW—Oakland and San Francisco, Calif.—went through the 1921 typhoon in Florida as a member of the Naval Reserve Radio station at St. Petersburg. For a time that station was the only means of outside contact with the rest of the world. Was he thrilled?

C. E. Downey, radio engineer for station KROW, of Oakland and San Francisco, Calif., commenced his radio career in 1920 as operator on a boat plying the Great Lakes. His greatest radio thrill to date, he claims, was when he constructed a 150 kw job—and it worked right off.

Bill Meyer and Ted Bindner, sports announcer and chief technician respectively of station KROW at Oakland, Calif., recently completed their 300th remote control broadcast together. And this in a period of 15 months, and without a hitch of any kind. The events included prizefights, ice hockey matches, motorcycle races, and leading current events.

An Adjustable Oscillator of High Frequency

(Continued from Page 21)

calibration chart at approximately 92,500 cycles. When these two frequencies are combined in modulation C', the difference frequency is 9,167 which is sufficiently spaced from the other products to make it a simple matter to allow the output circuit of the modulator to make the necessary discrimination.

The frequency selected from the G' oscillator is 92,105—83,333, or 8,772 cycles. This in turn is combined with the 9,167 modulation product, and results in a difference frequency of 395, which again is low enough compared to other products to make discrimination easy without filters. This 395-cycle current is applied to the synchronous motor but is too high in frequency to operate it. The vernier on the output oscillator is thus manually operated to reduce this frequency. When the output frequency gets as low as about 92,125 cycles the synchronous motor will operate, and will then reduce the frequency to the desired 92,105 and hold it there.

The precision of setting of the overlapping oscillator unit of Section 1 is very high. There are on the average forty-five marked divisions on a precision air condenser of this unit per cycle. This is equivalent to approximately two and one-half linear inches per cycle. For the entire range of the oscillator, from ten to one thousand kc, the equivalent length of the scale is thus approximately forty miles. A heterodyne oscillator of this range, allowing an average of only one-thirty-second inch per cycle, would require a dial eight hundred feet in diameter. If placed horizontally such a dial would require about fifteen acres of ground, while twelve square feet of floor space is all that is needed for this new oscillator.

"In Baltimore"

(Continued from Page 10)

were several hams from the Eastern Shore of Maryland there, too.

—

Mr. L. C. Herndon, well-known R. I. of Baltimore, has been transferred to Seattle, Wash. The story goes that he drove out there from Baltimore and got into a sandstorm on the way, and now he has a new paint job on his car.

—

Also there is a rumor that the local R. I. Labs will be moved to Washington, D. C.

—

Station News

Sammy Houston of WCBM gets a new Ford (new to him). Only three years old this time. His last one was five years old.

Snyder (WCBM) is going into the heavyweight operators' class. He is on the way to the 200 pound class.

Kries is going to Johns Hopkins and is taking up electrical engineering—he also winds transformers at home and still tries to make 'em work in his ham station.

A good one on George Porter Houston III—one day he came down town and found a swell parking place seven blocks away from the studios of WCBM and then walked the seven blocks to work and was blowing about what a good place he found to park this morning. The story goes that it was a holiday and he could have parked right in front of the studios.

Here is one for the math hounds but it should be easy—

A commuter arrives at his local station at 5 p.m. usually, but today he got off earlier and arrived at the station at 4 p.m. His chauffeur was not there to meet him so he started to walk and meet the automobile. He meets the chauffeur on the way and drives the rest of the way home, and arrives home 20 minutes earlier than usual. HOW LONG DID THE MAN WALK?

Ed Laker of WCBM has gone in for P. A. work and is using the new RCA P. A. equipment. His first job was the Baltimore Automobile show and he did a good job on it.

Lynch of WCAO has gone and swapped his new Chevvy ('34) for one of the new Fords ('35). Out of the fire into the frying pan—so to speak.

Bassford of WCAO is on the sick list. Here is hoping that he gets into high again soon.

Jones of WCAO claims that he freezes in the control room and yet 'tis said that he goes swimming in February.

Jimmy Schultz, WCAO's chief, has taken his 500 watt phone off the air for two good reasons. He loaned his RK 20 to someone and the filter cond. blew up on him. He said that he is going to spend about a thousand dollars on it—when he wins on his Irish S. S. ticket.

There has been no change in the engineering force at WBAL. You know WBAL is the latest addition to Hearst Radio, Inc.

Clem Holloway of WFBR has gone in to brushing up on his continental. Soz that he needs it.

Carlton Nopper is still DXing with his Scott and no one else gets a word in edgewise when he is around.

Bill Kelly, the Control Room supervisor, is a philatelist—? (stamp collector to you). He has a few of them things.

Bill Ranft still swears by his Ford and the Plymouth and Ford owners can't talk him out of it.

Paul Ruckert is planning already for his vacation to Canada this summer.

Eddis Stover is still WFBR's shortest rider to work—the distance of one-eighth mile.

Ted Crozier is still pounding brass on the SS Clairton.

Do you remember Edward Bennett of old Independent Wireless Telegraph Co.? Well he is the government's R. I. in Norfok.

—

The March meeting of the I. R. C. was held in Roland Hall, Johns Hopkins University, at 8 p.m., March 15. The speaker of the evening was Dr. J. C. Hubbard, Prof. of Physics, J. H. U., who spoke on "Piezo Electric Applications to Radio."

News From Radio Manufacturers

Westinghouse announces that a three week radio training school for a special field force of police signal system was started at the Chicopee Falls, Mass., works, by J. G. Beard, Commercial Radio Engineer. The school is intended to give each attendant a comprehensive knowlege of radio as applicable to police work in connection with the Westinghouse organization. Sales of apparatus is announced to the police of Idaho Falls, Ida., and Police Department of Macon, Ga.

Seven stations have ordered apparatus of the 5 kilowatt broadcast transmitter type from Western Electric Company, KFRC, San Francisco; KHJ, Los Angeles; WSPD, Toledo; WJAS, Pittsburgh; KLZ, Denver; WOW, Omaha, and WTCN, Minneapolis. The general circuit of the transmitter is a quartz controlled oscillator operating into a buffer amplifier, followed by a parallel stage which drives a modulating amplifier consisting of two tubes in push-pull, followed by two amplifiers in cascade, each a push-pull combination. The grid and plate voltages are obtained from mercury-filled rectifiers.

A new aircraft transmitter is announced by Westinghouse. Class B modulation is used. Output is 50 watts, frequency range 3,000 to 6,000 kc, eight tubes including two rectifiers. Designation is Type CL, total weight about 50 lbs., with additional 40 lbs. for General-Dynamotor.

A two band, superheterodyne radio receiver for aircraft for weather beacon and broadcast reception is announced by Western Electric, intended for private fliers, under the designation of No. 17A. Frequency range is 200 to 400 and 550 to 1500 kc. Operates from either 6 or 12 volt battery, with plate supply furnished by a dynamotor operating from battery. Unequipped weight is 9½ lbs. Front dimensions of the receiver are less than 8 inches, and side dimensions less than 14 inches. It is intended to cover the private flying demands for both necessary information as well as radio entertainment while in the air.

A new dynamic microphone is announced by Universal Microphone Co., Inglewood, Calif. Response from 50 to 10,000 cycles is claimed. One stage of pre-amplification is needed for ordinary use. No D. C. exciting voltage is needed.

TRS - The Radio Social

HERE is your big chance. Commercial men everywhere have been wanting a local club where they can meet other commercial men. THE RADIO SOCIAL is the answer.

Local clubs will be formed of men holding commercial radio operator's licenses from the Federal Communications Commission. This is the one requirement. The other is the spirit of good fellowship. The field is broad, men engaged in broadcast station work, airway radio work, police transmitting work, ship men, point-to-point men, ship-to-shore station men; in fact everywhere a commercial radio operator's license is required. Every man holding a commercial radio operator's license is eligible.

The Annual Dues are practically nothing, Two Dollars a year. This includes a one year subscription to *"Commercial Radio."* Just enough to cover the expense of postage requirements, office expenses which will be held down to a minimum, and actual working expenses of carrying out the purpose of THE RADIO SOCIAL. Local clubs already organized are asked to cooperate, under the standard of sociability.

Charter memberships are open now. Annual banquets in your territory will be arranged wherever the number warrants it. These will be as near as possible the same date all over the country. THE RADIO SOCIAL will attempt to bring together in every locality men holding a commercial radio operator's license.

Many requests have been received asking where men socially inclined would be able to meet with other men holding commercial radio licenses. Where are these units?

Local units will have to guide their own affairs to a great extent. They will have to arrange their own meeting places, and time of their meetings. They will agree to the annual meeting and banquet as set by the national grouping which will be set long in advance.

Memberships are now open. Two things are essential in the application for membership: One the class of commercial operating license held by the applicant, the other the date and place that the license was issued.

Membership identifications will be issued. In the case of group memberships this information together with mailing address of each member must be furnished.

Membership activities will be published regularly in *"Commercial Radio."* Men are wanted to work up local units, and build up membership. All assistance along this line is furnished voluntarily, and no other motive than the social cause outlined herein shall be offered.

THE RADIO SOCIAL shall not conflict with any present organization, either local or national. It is as its name indicates, purely a national organization of commercially licensed radio men wishing to meet other men in the same field for purely social purposes. A wider acquaintance with men in the same endeavor.

Much good can and will come out of this contact. It is a move which covers a gap not at present covered. It offers a basis of comradeship locally and nationally which has been a missing unit up to this time.

Applications for membership will be published in these columns, as long as it is physically possible to do so. Memberships will be acted upon in the order of receipt.

No one applying for membership assumes responsibility other than that outlined herein, and may at his own discretion withdraw from membership at any time.

The spirit of comradeship, the wish to meet other men, in other fields, holding similar requirements as your own, the commercial license issued by the Government. The wish to at least once a year, where it can be arranged, attend a local banquet, dinner, or get together is the purpose of the organization. Those wishing to join with this intention will be heartily welcomed to membership.

APPLICATION FOR MEMBERSHIP

THE RADIO SOCIAL,
7 West 44th St.,
New York City

Gentlemen:

I wish to make formal application for membership in THE RADIO SOCIAL. Enclosed herewith is Two Dollars for my Entrance Fee, and First Year's Dues. If for any reason my Membership is rejected, this is to be returned to me. Inform me of activities.

At the present time I hold ....License.

This was issued to me at ....

Signature ....

St. and No. ....

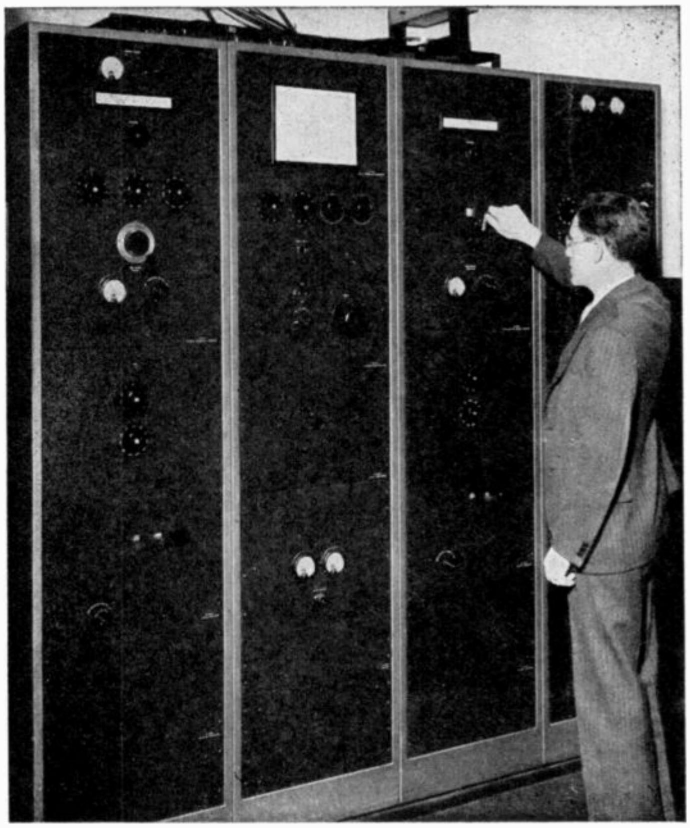
City ....

Print name here for proper spelling -- Employed by ---------------------

An Adjustable Oscillator of High Precision

By L. ARMITAGE

Member of the Technical Staff, Bell Telephone Laboratories



In determining the characteristics of high precision filter elements, recently developed for carrier-on-cable and other projects, the frequencies at which measurements are made must be very precisely known. Moreover, in regions where the properties of the apparatus vary rapidly with frequency, measurements must be made at very small frequency intervals over a band twenty to thirty cycles wide, which may be located anywhere in the range of ten to a thousand kilocycles. To make such measurements an oscillator was required having an accuracy of about three cycles. At the high end of the frequency range this accuracy corresponds to three parts in a million which is about the same as one inch in five miles.

The difficulty in measuring within a given absolute error depends on how great this error is in relation to the quantity being measured. Thus an accuracy of three cycles in three thousand, or 0.1 per cent, is fairly easy of attainment, while an accuracy of three cycles in a million, or 0.0003 per cent, is exceedingly difficult. There is one exception to this rule. If a constant frequency is available, such as the Laboratories' frequency standard, any exact multiple or sub-multiple of that frequency may be obtained to a precision equalling that of the standard. Advantage is taken of these facts in the design of the new oscillator by employing a series of discrete frequencies of high precision derived from the primary standard, and a low range adjustable oscillator to overlap the gaps between them.

The method employed can be illustrated by an analogy. Suppose it were desired to strike off a line having a length within the range of ten thousand to a million units, and that the required accuracy in establishing the length of this line is two or three units regardless of its total length. To measure this line there is available a standard a million units long, which is marked, starting at 10,000, at certain discrete points along its length. These markings are relatively few but the distance between any two is never greater than 3,400 units. Suppose that besides this basic standard there is available an accurately calibrated scale, 3,400 units long. This shorter scale is employed by placing one end on one of the marked points of the long scale and marking the correct distance beyond this point by the short scale. From its method of use this shorter scale may be called the overlapping scale.

In the design of the new oscillator the complete range of 10 to 1,000 kc is divided into two sub-ranges: one from 10 to 100 kc, and the other from 100 to 1,000 kc, and except for the control oscillator, separate apparatus is employed for obtaining frequencies in these two ranges. The two sections are essentially alike except for the frequency values. In the photograph of the complete oscillator at the head of this article, the two panels at the left comprise the lower range section, and those at the right, the higher range. A schematic of the separate pieces of apparatus comprising the oscillator

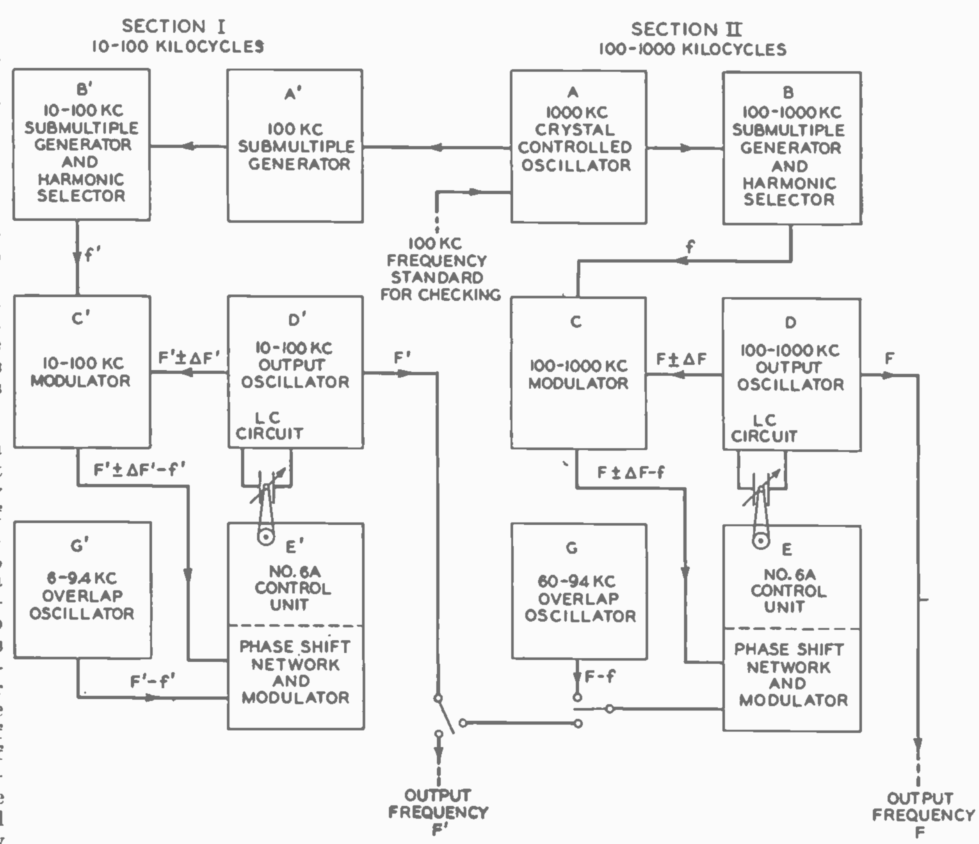


Fig. 1—Block schematic of new oscillator showing division into two sections—one with a frequency range from 10 to 100 kc and one from 100 to 1000 kc

Frequencies of 10-100 kc Sub-multiple Generator			
f	*m/n*	*f*	*m/n*
8333	1/12	50000	3/6
10000	1/10	53333	8/15
11111	1/9	55556	5/9
14286	1/7	58333	7/12
16667	1/6	60000	6/10
20000	3/15	61539	8/13
23077	3/13	63636	7/11
25000	2/8	66667	4/6
27273	3/11	70000	7/10
30000	3/10	73333	11/15
33333	2/6	75000	6/8
36364	4/11	77778	7/9
38462	5/13	80000	8/10
40000	4/10	83333	5/6
41667	5/12	86667	13/15
44444	4/9	90000	9/10
46667	7/15	93333	14/15

Table 1—Series of fixed and precise frequencies that may be obtained from the harmonic selector of Section 1

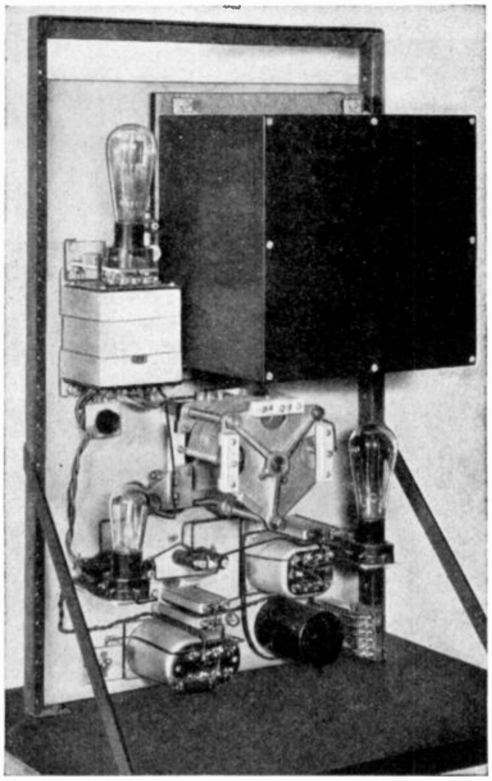
monic selector any harmonic (m) of this sub-multiple frequency up to the fourteenth may be selected. Since the frequency obtained from the harmonic selector unit has a definite relationship to the control frequency, its accuracy is essentially that of the control frequency itself—or about one-half cycle.

The sub-multiple generator unit B′ is calibrated to furnish frequencies which in no case are more than 3,400 cycles apart. These frequencies and the m/n ratios used in producing them are shown in Table 1.

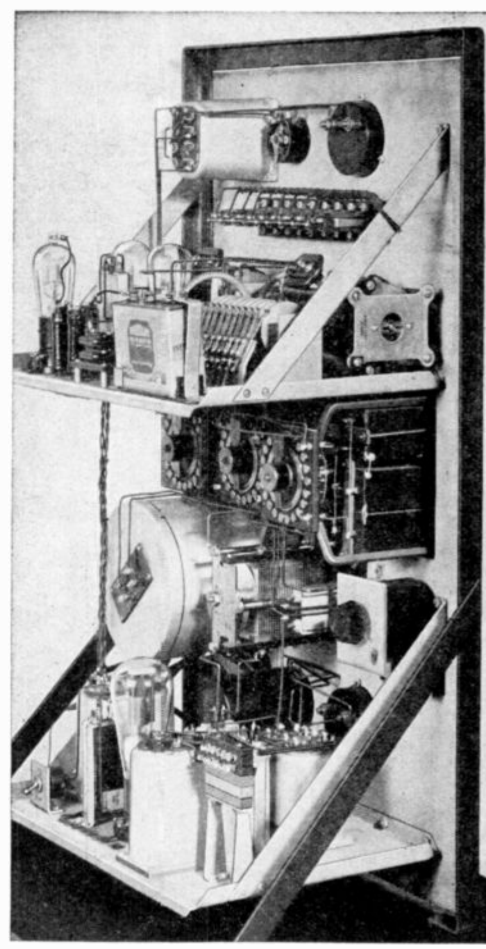
To serve as the short, or over-lapping scale, a second oscillator unit G′ is provided. This is adjustable, to within one cycle or better, between 6 and 9.4 kc—a range of 3,400 cycles. By "adding" the numerical value of a definite frequency from this over-lapping oscillator to one of the fixed frequencies obtained from the sub-multiple generator, any desired frequency may be obtained to the required overall precision.

quency depending on the difference between the frequency of D′ and the desired frequency of F′. When these are the same, the frequency of the control current becomes zero and the motor stops. Any tendency of the frequency D′ to vary from its correct value at once starts the motor to turn the condenser in a direction to bring the output frequency back to its correct value.

The control current that operates the synchronous motor is obtained by a double modulation. A frequency f′ is selected from the sub-multiple generator B′, that is between 6 and 9.4 kc below the desired output frequency F′. This is modulated with the frequency from D′ in modulator C′. The overlap oscillator G′ is then set by its calibration chart at a frequency equal to F′-f′, the difference between the desired output frequency and the frequency selected from B′. This frequency is modulated with the output from modulator C′, and the resulting difference frequency, after pass-



Rear view of 6-9.4 kc overlap oscillator



Rear view of 10-100 kc sub-multiple generator unit

is shown in Figure 1, where again the low section is at the left and the high section at the right. The primary frequency control is a 700A Oscillator indicated as A in Figure 1. This is a 1000-kc crystal-controlled oscillator, and corresponds to the 1,000,000-unit scale in the analogy. A 100-kc sub-multiple frequency of this oscillator, obtained from the sub-multiple generator A′, is checked at intervals against the Laboratories' standard by a beat-frequency circuit. This 100-kc frequency also serves as the standardizing frequency for the lower section, and the 1000-kc from the oscillator, for the higher section.

The equivalents of the marked points on the long scale in the analogy are obtained from a sub-multiple generator and harmonic selector, B′.

With the former, any sub-multiple (n), from the sixth to the fifteenth inclusive, of the standardizing frequency A′ of Figure 1 may be obtained, and by the har-

Considering Section 1 only, there is an output oscillator D′ variable over the entire range of the section, from ten to one hundred kc. This oscillator may be set approximately to any of a large number of frequencies by a calibration chart. It is provided with two output circuits; one serves as the main output, and the other is utilized, in conjunction with other apparatus, to bring this oscillator accurately to the required frequency.

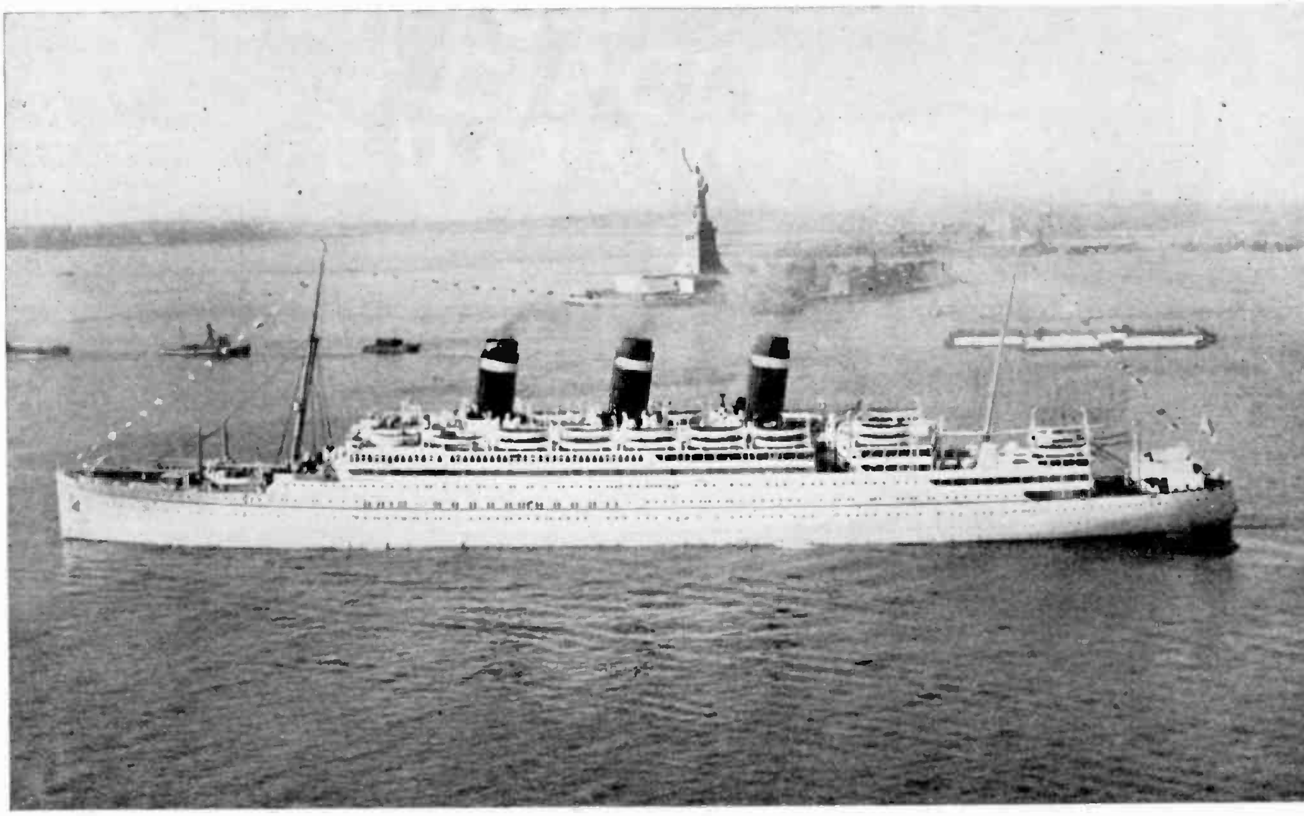
In the tuned circuit of oscillator D′ is an air condenser which is rotated by a synchronous motor of the two-phase type. This motor is self-starting in either direction at frequencies from zero up to about twenty cycles. It is operated by a control current which varies in fre-

ing through a phase shifting network to secure two components 90 degrees out of phase, is the control frequency which operates the synchronous motor.

The difference product of this second modulation will become zero only when the frequency of oscillator D′ is at the desired value. At any other output frequency it will operate the motor in a direction such as to bring the output frequency to the correct value. When first set up, this difference frequency may be greater than 20 cycles, and in this case a manually controlled vernier on the output oscillator is operated to adjust the frequency until it is within 20 cycles of the desired value. From there on the

(Continued on Page 21)

COLUMBIA GOES INTO SERVICE



The Columbia passing the Statue of Liberty in New York Harbor

The American flag was raised over the SS Columbia, on January 26th. Miss Eleanor Roosevelt was sponsor for the boat, which is a 39,935-ton liner, and is now in the Panama-Pacific Line service, doing cruise service to Nassau, Miami, and Havana.

ASSIGNMENTS

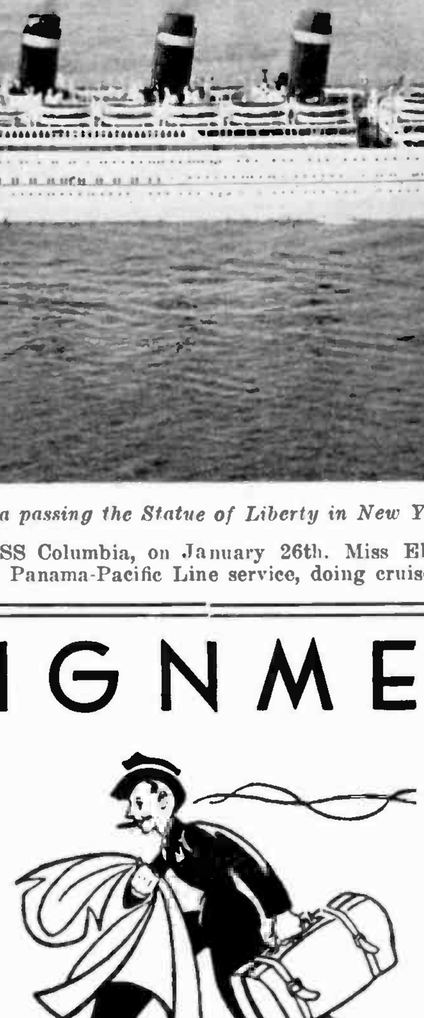
Mackay Radio—New York

Vessel — Radio Officer

SS Ario—L. Mason
SS Cherokee—J. Bamberg (Junior)
SS Shawnee—S. Rosenberg (Junior)
SS Cities Svc Empire—T. Burns
Y. Doromar—Chas. Thoman
SS W. R. Keever—E. Tabakman
SS Manhattan—H. Burns (Third officer)
SS Shawnee—P. Kimball (Junior)
SS City of Dalhart—A. Gyorfi
SS Seminole—W. Weber (Junior)

Radiomarine Corp.—New York

Oriente—C. D. Short
Pan Bolivar—A. L. Bergom
Santa Elisa—W. P. Paschal
Nosa Queen—A. H. Rowe
Mariana—M. DeValez
Oriente—S. Sanchez
Caracas—T. D. Cary
City of New York—L. R. Shaw
American Shipper—J. H. Swallow
Beaconstar—K. C. Peterson
Santa Clara—C. J. Melville
Madison—K. R. Williams
Daylight—H. E. Anderson
Walter Luckenbach—L. H. Brennan
E. M. Clark—E. M. Fuller
Maine—H. G. Wright
Exilona—M. Kamke
Acme—J. Gately
American Banker—V. Madsen
Oriente—T. L. Siglin
Paul H. Harwood—H. Sudborough



Santa Cecilia—E. G. Washington
Santa Cecilia—V. E. Penta
Columbia—D. L. Shaw
Columbia—W. K. Koch
Columbia—I. Margolis
Gatun—H. Sheerin
Walter Jennings—J. Gorbig
Cerro Azul—Ed. Roeger
Allan Jackson—H. C. Wagar
American Farmer—A. Finch
Santa Maria—Everett Perry
Nosa Prince—J. R. Horton
Santa Monica—Van Orstrand

RMCA—Boston

Trawler Maine—J. Fish
Cities Svc Oklahoma—M. Wakefield (relief)
Cities Svc Oklahoma—A. Iodice (returned)

Mackay—Boston

Trawler Plymouth—H. MacCalmon
Trawler Dorchester—A. Southerland
Trawler T. J. Whalen—C. Kelleher
Shawmut—W. D. Thomas

States Steamship Company

General Pershing—Roy Welbon
General Pershing—Harry Schoolaeld
General Sherman—Karl Steiner
General Sherman—Ted Toppi
General Lee—Everett Henry
General Lee—James Crouse
California—Ben Cohen
Texas—Roy Whittington
Michigan—Dallas L. Hughes
Illinois—W. T. Shultrich
New York—Gordon Burnett
Wisconsin—Walter F. Mee
Washington—John Robinson
Pennsylvania—Kenneth Harris
Kentucky—A. A. Marsh
Oregon—Howard McMahon
Iowa—Rupert S. Bean
San Angelo—Frank Caldwell
San Anselmo—Earl Garrick
San Bernardino—Herbert Oliver
San Clemente—David Youngberg
San Diego—Claude Wareham
San Domingo—Dewayne Duncan
San Felipe—M. R. Derby

Vacuum Tubes as High-Frequency Oscillators

(Continued from Page 6)

travel from the cathode to the anode within the tube structure. This time, the so-called transit time, is very small in present day commercial types of power tubes, usually much less than one microsecond. Obviously at low frequencies it can be neglected and, in fact, for many tubes it still plays a minor role either in determining the output and efficiency in the high-frequency range or in establishing the limiting frequency for oscillations. When the frequency range of oscillation of a tube is extended by an adequate decrease in energy losses and by improvements in electrical design, transit time becomes a dominating factor in the reduction of output power and efficiency and in establishing the limiting frequency of oscillation.

This comes about in two ways. In the first place, the relative phase of the alternating grid and plate potentials for best operation must be altered to compensate for the time required for the electrons to travel from the region in which the grid has its greatest effect upon their motion to the region in which their motion has the greatest effect upon the plate current. The available control over these phases is usually insufficient to permit a realization of the optimum adjustment. In terms of the measured characteristics of the tube, the transconductance has become complex. But even with the optimum phase adjustment the efficiency is reduced by losses which occur because of the variations in grid and plate potentials during the transit time. Electrons arriving at the plate will in general have velocities greater than the velocity corresponding to the potential of the anode at the instant of their arrival. The excess energy corresponding to the greater veloci-

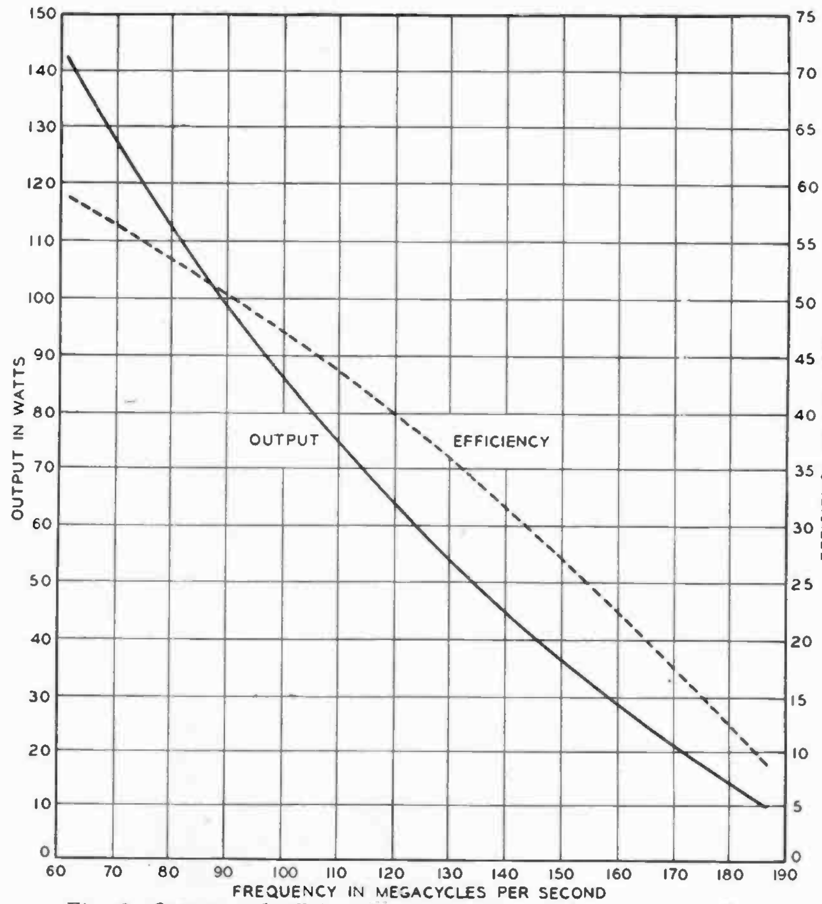


Fig. 6—Output and efficiency as a function of frequency for the tube shown in Fig. 5. A comparison of these curves with those shown in Fig. 1 illustrates the improvement obtained by taking account of those factors which become important at high frequencies.

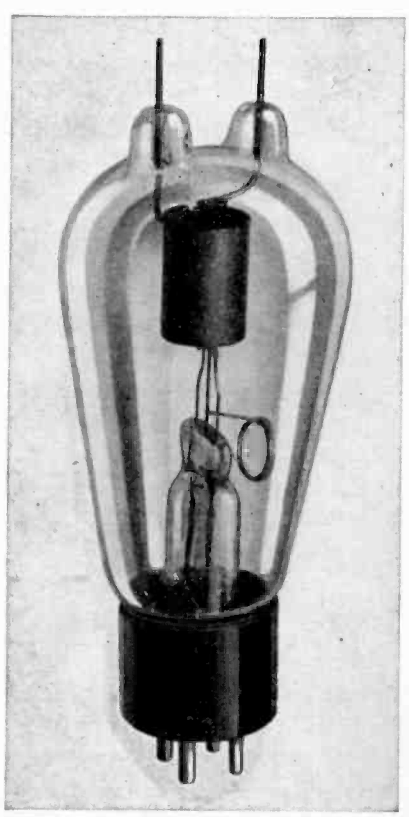


Fig. 7—A tube for use at frequencies up to 350 megacycles

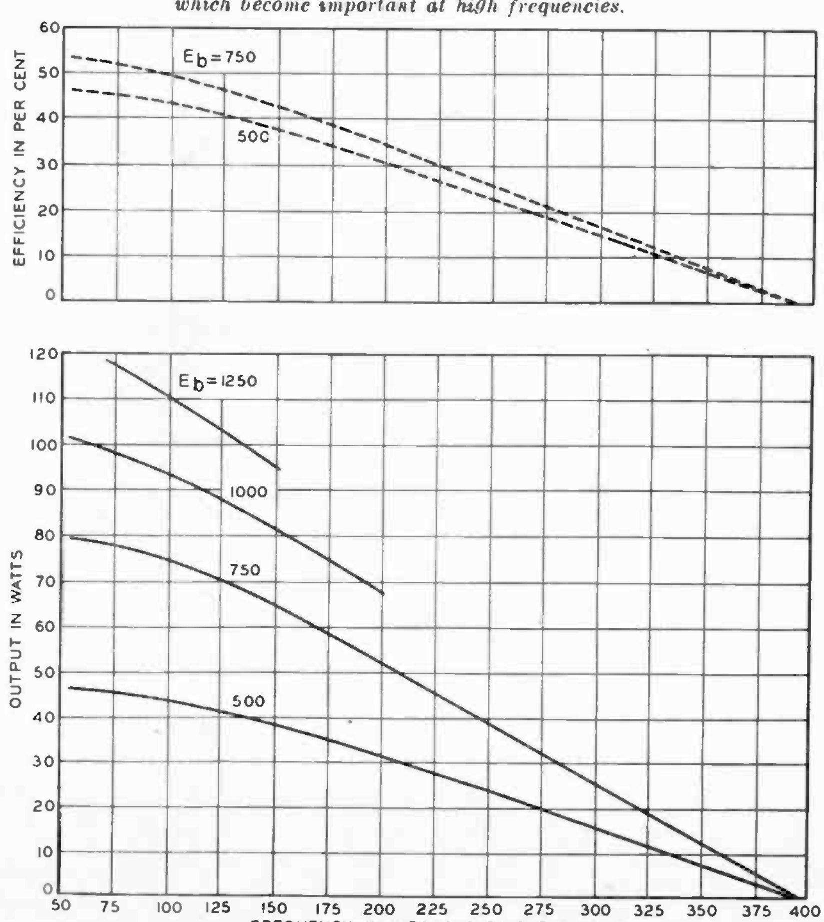


Fig. 8—Output and efficiency curves for 2 tubes of the type shown in Fig. 7.

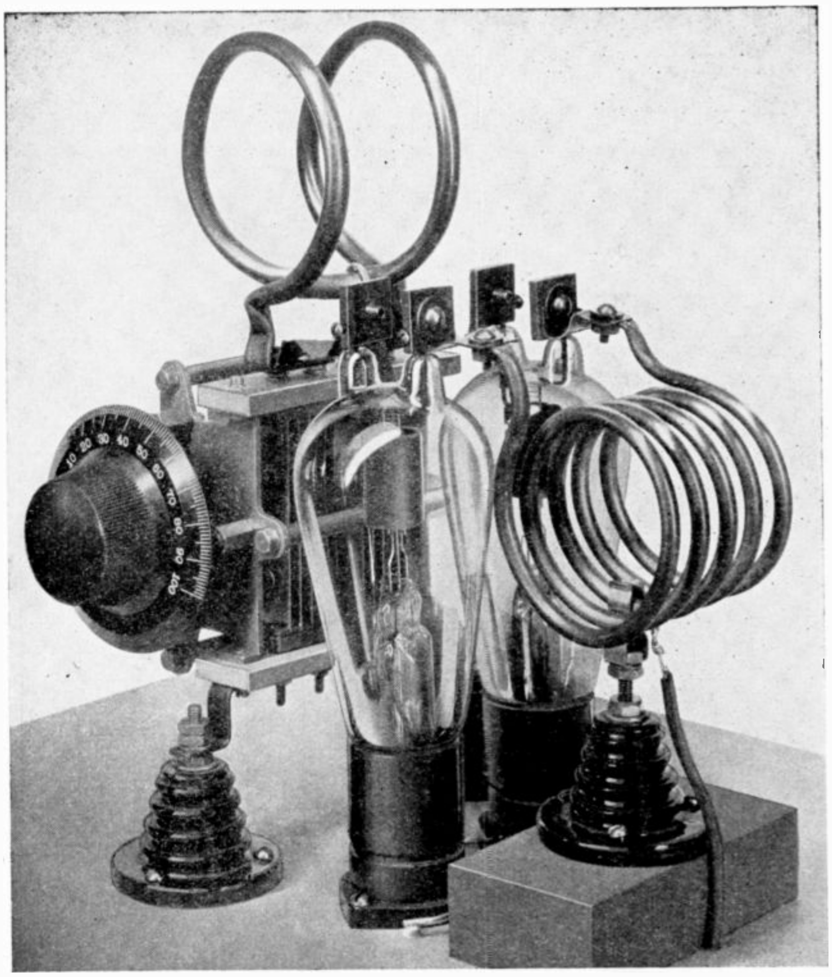


Fig. 9—A typical push-pull circuit for use at ultra-high frequencies. A circuit of this type was used to obtain the data shown in Figs. 8 and 11

ty is obtained from the oscillating circuit and is dissipated at the plate in the form of heat. Again in terms of the measured characteristics, the input conductance has been increased above its low-frequency value.

The mechanism which enables electrons to take energy from the oscillatory circuit in their passage across the tube is evident from a consideration of a somewhat simplified case as shown in Fig. 4. Assume that the anode is held at a constant potential of 100 volts, and that the grid is held at 50 volts positive just long enough to allow an electron to come from the cathode to the grid plane (very near one of the wires), where its velocity will correspond to a fall of 50 volts. The potential of the grid is then suddenly changed to 50 volts negative. The electron will then fall through an additional potential difference of 150 volts, arriving at the anode with a velocity corresponding to 200 volts, producing just twice as much heat as it would have done had the grid potential not been changed during the transit time. This added energy must come from the source which produced the change in the grid potential. In the actual case the change in grid potential is not abrupt but a similar loss occurs. This limits the useful frequency range of a tube to values for which the oscillation period is long compared to the electron transit time.

Special Designs Required for Different Ranges of High Frequencies

Most standard power tubes reach their upper frequency limit of oscillation somewhere in the 10- to 100-megacycle frequency range. For frequencies above this, specially designed tubes are required. The frequency range in which a given design is near the optimum is limited. Therefore, there is a succession of tubes, each rated for a band of frequencies. Characteristics such as a high mutual conductance and a sharp cut-off which make a tube a good oscillator at low frequencies, while still of importance at ultra-high frequencies, are apt to be secondary to the special frequency requirements. Although some progress has been made in the modification of conventionally designed water-cooled tubes for use above 100 megacycles, more attention has so far been given to the development of radiation-cooled tubes for this frequency range.

A departure from conventional design with increasing frequency is illustrated by a radiation-cooled tube described by McArthur and Spitzer in which the ratio of the plate diameter to

Fig. 10—This tube will oscillate at frequencies up to 740 megacycles. Note the absence of the usual press and the extremely small size of the elements

the plate length is much larger than for the conventional tube. Radiating fins are employed to compensate for the decrease in heat radiating ability of the plate which would otherwise occur because of its short length. In Fig. 5 is shown a photograph of this tube. It will be noted that the tube electrodes are supported directly from their leads. The complete absence of auxiliary supporting members either of metal or of insulating material and the large size of leads reduce radiation, eddy current, and conduction current losses. That portion of the inter-electrode capacitances due to the supporting structure is also made small by this method of support.

The inter-electrode capacitances are given below, together with the corresponding values for the type 242A tube, which has the same plate dissipation

(Continued on Page 20)

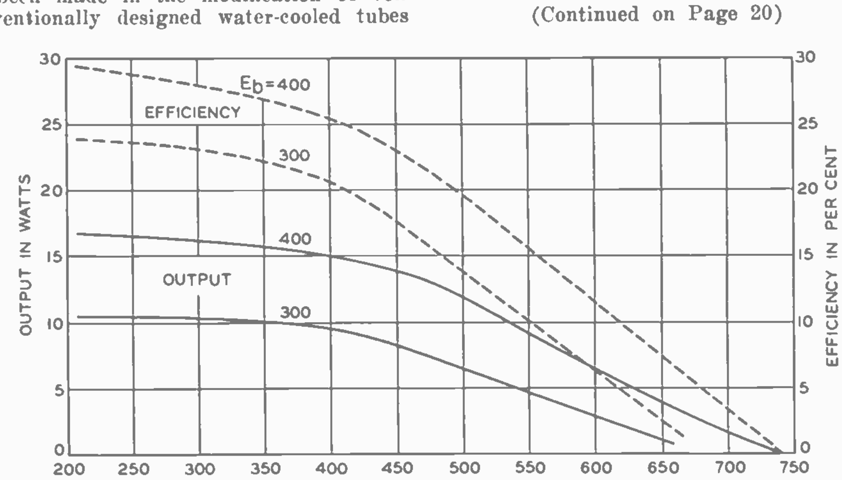


Fig. 11—Output and efficency curves for 2 tubes of the type shown in Fig. 10

Vacuum Tubes as High-Frequency Oscillators

(Continued from Page 18)

rating but is designed for use at lower frequencies:

	High Frequency Tube	242A
Plate to grid	3 μμf	13.0 μμf
Grid to filament	2 μμf	6.5 μμf
Plate to filament	1 μμf	4.0 μμf

The decrease in capacitance by a factor of approximately 4 makes possible a much greater improvement in performance in the 60- to 150-megacycle per-second frequency range than the corresponding degradation in performance due to the lower mutual conductance and the increased electron transit time resulting from the increased spacing. The material increase in plate impedance makes it necessary to employ an anode potential approximately twice as great with the high-frequency tube.

Output and efficiency curves are shown in Fig. 6. (For the sake of uniformity, curves taken from published papers have, in most cases, been redrawn.) The particular shape of the output curve is due to the manner in which the applied anode potential was reduced with increasing frequency to minimize the danger of tube failure from the increased energy losses which occur at high frequencies. The limiting frequency as set by the inter-electrode capacitances and lead inductances is given by the authors as 230 megacycles. An extension of the efficiency curve to higher values indicates that the tube will probably fail to oscillate before this limit is reached. From this it can be inferred that the decrease in efficiency in the range from 150 to 200 megacycles is due largely to the effect of the relatively large transit time, since the authors' method of arriving at the output by taking the difference between the measured input and the measured plate losses includes circuit and lead losses as a part of the output. A comparison of the data of Fig. 1 and Fig. 6 shows that at 100 megacycles the output of the type 242A tube is 2 watts and the corresponding output of the high-frequency tube is approximately 86 watts with substantially the same plate loss. This strikingly illustrates the improvement obtained by taking into account the factors which become important in the high-frequency range.

Transit Time Becomes More Important

In extending the frequency range to 300 megacycles the importance of electron transit time becomes relatively greater. It must be kept as low as possible even at the expense of relatively higher interelectrode capacitances. In the tube just described for the frequency range around 100 megacycles the reverse procedure is followed in order to make the inter-electrode capacitances as small as possible, transit times are increased. Fay and Samuel in a recent paper presented before the International Scientific Radio Union (U. R. S. I.) describe a tube designed for use at 300 megacycles which well illustrates this point. The tube is shown in Fig. 7. It differs from the one previously discussed in the close spacings between elements, particularly between the grid and filament. The lead length is further decreased and lead diameter made considerably larger in order to increase lead inductance and resistance. The inter-electrode capacitances are:

Plate to grid	2.5 μμf
Grid to filament	2.0 μμf
Plate to filament	0.67 μμf

While these capacitances are substantially the same as for the tube shown in Fig. 5, the limiting frequency, as set by circuit resonance is somewhat beyond 400 megacycles as contrasted with 230 megacycles for the other tube. This is due, primarily, to the material decrease in lead inductance. The decreased losses resulting from the minimized transit time more than compensate for the increased circuit loss resulting from the required

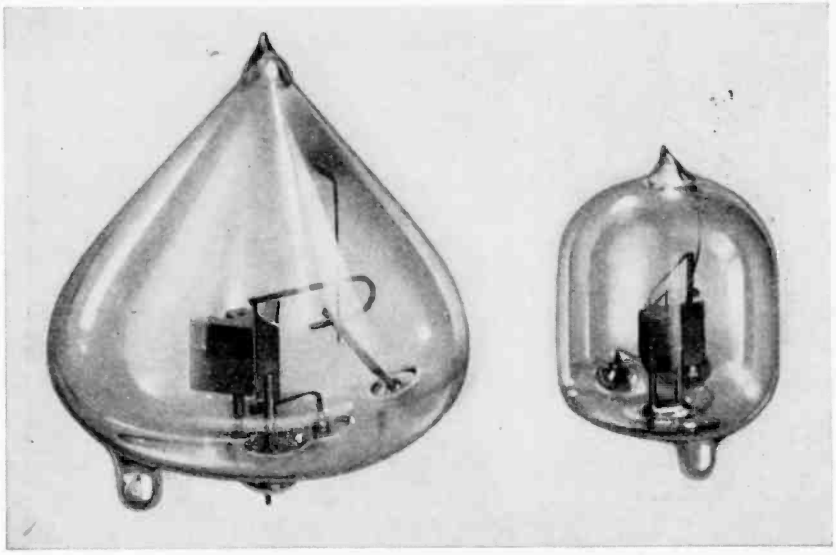


Fig. 12—These tubes represent a further extension in design according to the principles under discussion. The smaller one will oscillate at 1200 megacycles per second

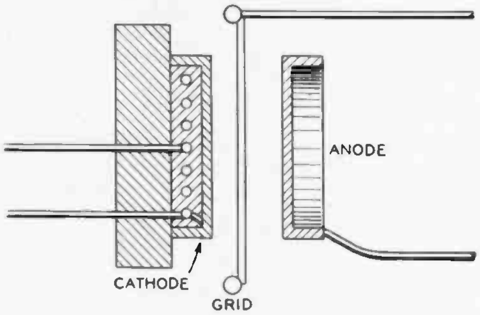


Fig. 14—A sectional view of the triode developed by Thompson and Rose

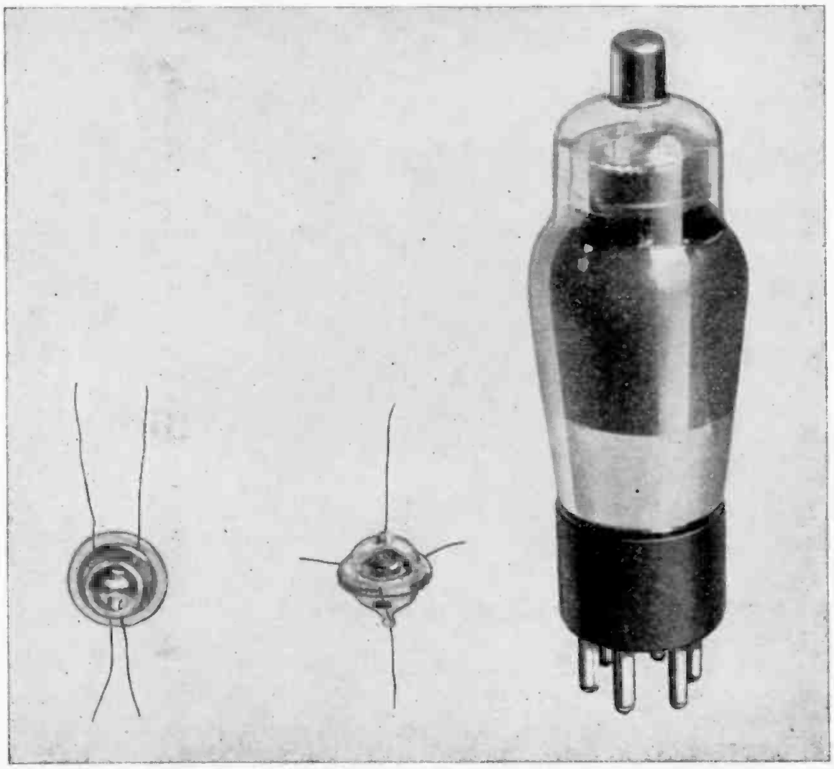


Fig. 13—Receiving tubes of extremely small dimensions. A conventional receiving type tube is shown at the right for comparison.

higher charging currents to the interelectrode capacitances. Its mutual conductance of 2200 micro-ohms and the sharp cut-off shown by the static characteristics indicate that those electrical characteristics which are important for efficient oscillators in the low-frequency range have not been sacrified in meeting the requirements of 300-megacycle operation.

Output and efficiency curves for this tube are shown in Fig. 8. These data are for two tubes operated in the push-pull circuit shown in Fig. 9. The output shown represents only useful power, since it is the photometrically measured power consumed in a lamp load. It will be noted that, whereas the maximum output at 100 megacycles is 55 watts per tube and the efficiency 50 per cent., corresponding roughly to the 86 watts output at 47 per cent. efficiency for the tube of Fig. 5, the output at 200 megacycles is 34 watts at 33 per cent. efficiency as compared to less than 10 watts at an efficiency of only a few per cent. for the other tube. At 300 megacycles the higher frequency tube gives an output of 13 watts, while the tube of Fig. 5 no longer oscillates. This difference in behavior is due primarily to the decreases in transit time and in circuit losses, and to the more nearly optimum ratio existing between the interelectrode capacitances. It is due to a considerably less extent to the increase in the frequency limit set by circuit resonance.

(To be Continued in Next Issue)

An Adjustable Oscillator of High Precision

(Continued from Page 15)

motor will automatically hold it at that value.

The apparatus of Section 2 is identical in function to Section 1. Because of the higher range, however—running from 100 to 1000 kc—the overlap oscillator has a range of 34,000 cycles, or from 60 to 94 kc. It can be set by its calibration chart to anywhere within ten or fifteen cycles of the desired value. A frequency between sixty and ninety-four kc, however, is within the range of Section 1, and so where greater precision than ten or fifteen cycles is required, Section 1 is substituted for the overlap oscillator of Section 2. The switching by which this is done is indicated in Figure 1. Since the output of Section 1 is accurate to within one or one and one-half cycles, the output of Section 2 will be held to practically a like accuracy.

The principle of operation adopted for this oscillator has quite appreciably reduced its cost by making it unnecessary to employ filters, which are generally required to eliminate the unwanted products of modulation. With this oscillator the two frequencies modulated are in every case quite close in value, and of at least moderately high frequency. As a result, there is a wide spread between the difference frequency and the other modulation products. The spread is so great that the necessary discrimination is obtained in the modulator output circuit without tuning. An example will illustrate this feature and, in addition, will show the general method of operation.

Assume a frequency of 92,105 cycles is desired. From Figure 2 it is quickly seen that the frequency obtainable from B' which will be less than 92,105 by 6 to 9.4 kc is 83,333 cycles. The output oscillator, on the other hand, can be set from its

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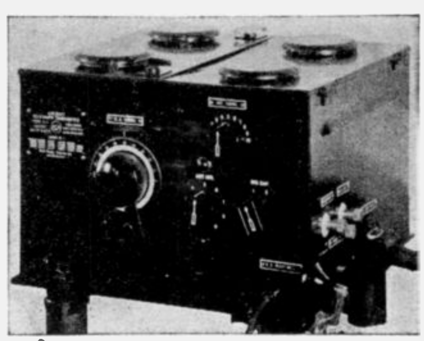
NEW APPARATUS

New 75-Watt Aircraft Transmitter Weighs 75 Pounds

A NEW long distance telegraph transmitter weighing only 15 pounds and delivering a nominal 75 watts of continuous wave radio frequency power to the antenna, is announced by the radio division of Westinghouse Electric & Manufacturing Company, Chicopee Falls, Mass. The new CH transmitter represents 5 watts for each pound of transmitter unit, and operates on frequencies ranging from 333 kilocycles up to 10000 kilocycles by means of plug-in coil assemblies. This provides for operation with marine stations including ships at sea as well as operation on the aviation communication bands.

The set operates from the 12 volt battery system of the plane through dynamotor. The relatively low plate supply voltage of 500 utilized for a transmitter of this power, as compared with 1000 volts usually employed, is a decided advantage for reliable operation under various climatic conditions.

The dynamotor is purposely designed for aircraft service. It is unusually light in weight although ruggedness has not been sacrificed. The use of magnesium alloy castings combined with careful design has resulted in a machine of 13½ pounds weight capable of delivering 150 watts of 500 volt power to the



transmitter. This represents a factor of 11 watts per pound of dynamotor.

In brief, specifications of the new transmitter are:

Power Output—75 watts nominal
Type of Signals—Continuous Wave Telegraph
Coil Systems:
- 2700-3450 kilocycles
- 3450-4420 kilocycles
- 4420-5890 kilocycles
- 5890-7410 kilocycles
- 7410-8620 kilocycles
- 8620-9700 kilocycles
- 500 kilocycles with external antenna coil
- 333 kilocycles with external antenna coil

Power Supply: 12 to 14 volts D.C. through a 500 volt dynamotor
Tube Complement:
- 1-UX-210 as Master Oscillator
- 4-UX-210's as Power Amplifier

Weights:	lbs.
Transmitter Unit with one set of coils and shock absorbing base	15
Operator's Control Unit	1
Dynamotor	13½
Flameproof Telegraph Key	1

FOR SERVICING

A new test oscillator specifically designed to meet the servicing requirements of modern all-wave radio receivers has been announced by the Weston Electrical Instrument Corporation, Newark, N. J. It has a frequency range from 100 kilocycles to 22 megacycles, and a special attenuator system which makes possible an approximate output of one microvolt. This low minimum signal is a factor of increasing importance in servicing operations, as it permits alignment of receivers equipped with automatic volume control below the a.v.c. level.

Constant output over the wide frequency range is provided by means of six individual coils, which are plugged into a doubly shielded compartment for operation on each of six frequency bands. The use of plug-in coils eliminates switching leads, thus reducing electromagnetic and electro-static fields within the oscillator. Complete shielding of the coil in use, in addition to over-all shielding, prevents interaction and resonance effects with coils not in use on other parts of the circuit.

Output of the Model 692 oscillator may be attenuated from a 0.2-volt maximum to approximately one microvolt, a constant impedance of 200 ohms being maintained at the output jack pins thruout this attenuator range. Thus the attenuator setting does not affect input impedance at the antenna and ground posts of the receiver and alignment may be carried without upsetting the first tuned circuit of the receiver by subsequent changes in attenuator adjustment. All attenuation is done ahead of the constant output resistance, so that inaccuracies resulting from the common practice of short-circuiting the output posts to obtain a signal of low value are eliminated.

The unit is equipped with two Type 30 tubes, one of which operates in a separate modulator circuit to provide constant internal modulation of 50% at all frequencies. Tests have shown that only an independent modulator circuit will provide this constant modulation on high frequency bands. A switch cutting out internal modulation permits the unit to be used as a pure r.f. oscillator for tuning receivers by the Hiss or Tuning Meter method. In addition, two pin jacks are provided on the panel for introducing external modulation when desired. This feature is particularly useful for making fidelity measurements on receivers by means of constant phonograph records now available.

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