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RADIO WORLD

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The First National Radio Weekly

667th Consecutive Issue—*Thirteenth Year*

SPECIAL USES OF STANDARD TUBES

SHORT-WAVE COIL-WINDING DATA

PRECISION RADIO-FREQUENCY MEASUREMENTS

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THIRTEENTH YEAR

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Methods of Using Standard-Frequency Radio Transmission

[Circular LC404, National Bureau of Standards.]

THIS pamphlet gives methods of frequency measurement for utilizing standard frequencies transmitted by radio by the National Bureau of Standards. It is in three parts.

Part 1 gives methods of using the 5000-kc/s transmissions for the calibration of standard oscillators in simple cases where the frequencies have such numerical values as to be readily checked directly in terms of the transmissions.

Part 2 gives specific information for the use of the transmissions to check with great accuracy the frequency standard used in any broadcasting station (e.g., the monitor required by F.R.C. Rule 145). The discussion is divided into three sections, A, B, and C, progressing in difficulty of measurement. Section A deals with two frequencies, 1000 and 1250 kc/s; very little apparatus is required for measurements at these frequencies. Section B gives the method of measurement, using an auxiliary generator, for frequencies which are multiples of 50 kilocycles per second. Section C gives the method of measurement for any broadcast frequency (multiples of ten).

Part 3 is a bibliography. [Omitted from this article.—Editor]

When to Listen In

The Standard Frequency Transmissions.—The National Bureau of Standards transmits standard frequencies from its station WWV, Beltsville, Md., near Washington, D. C., every Tuesday. The transmissions are on 5000 kilocycles per second, and are given continuously for two hours during the day and two hours at night. (At this date, the schedule is from 12 noon to 2 p. m., and from 10 p. m. to midnight, Eastern Standard Time). The transmissions can be heard and utilized by stations equipped for continuous-wave reception throughout the United States, although not with certainty in some places. The accuracy of the frequency is at all times better than one cycle per second (one in 5,000,000).

The transmissions consist mainly of continuous, unkeyed carrier frequency, giving a continuous whistle in the phones when received with an oscillatory receiving set. For the first five minutes the general call (CQ de WWV) and announcement of the frequency are transmitted. The frequency and the call letters of the station (WWV) are given every ten minutes thereafter.

PART 1. CHECKING STANDARD OSCILLATORS

While the standard frequency transmissions may be used for many standardization purposes, the most common use is to determine accurately the frequency of a piezo oscillator. The apparatus necessary is (1) the piezo oscillator, (2) a continuously variable radio-frequency generator which is approximately calibrated; (3) a variable audio-frequency generator; and (4) a radio receiving set. A frequency meter of resonance type is also useful but is not essential.

The fundamental frequency of a piezo oscillator is fixed by the dimensions of the quartz plate used. The vacuum-tube circuit arrangement in which the quartz plate is connected gives numerous harmonics for each fundamental frequency. The radio-frequency generator, which is continuously variable, can be adjusted to any frequency, and likewise gives a series of harmonics for each fundamental frequency to which it is adjusted. If the frequency of the radio-frequency generator is varied over a wide range, beat notes are produced at a number of settings of the generator by the interaction of various harmonics of the fundamental frequency of the piezo oscillator with a harmonic of the fundamental frequency of the generator. The beat notes may be heard in a pair of telephones suitably connected to the generator or to the piezo oscillator. Any frequency present in the piezo oscillator can beat with a corresponding frequency present in the radio-frequency generator, which makes it possible to set the generator at a number of frequencies which have a simple relation to the fundamental frequency of the piezo oscillator. Providing the harmonic relationship is known, measurements can be made at a great number of frequencies in terms of a single standard frequency.

If f is the fundamental frequency of the piezo oscillator which is being used and F the fundamental frequency of the auxiliary generator which gives zero beat, then

$$af = bF$$

where a and b are integers (1, 2, 3, 4, etc.).

The procedure is simplest when the ration of 5000 kc to the nominal frequency of the piezo oscillator to be standardized is a fairly small integer, less than 100. For instance, secondary standards whose fundamental frequencies are 50, 100, 200, 500, or 1000 kc can be measured very simply in terms of the 5000-kc transmissions, and these secondary standards may be advantageously used in turn to calibrate other apparatus. It is, however, possible to use the 5000-kc signals to establish accurately any desired frequency.

Suppose it is required to measure the frequency of a piezo oscillator, the approximate frequency of which is 700 kc, in terms of the 5000-kc standard frequency signals.

If the radio-frequency generator is set at 100 kc, the 50th harmonic (5000 kc) will beat with the 5000-kc transmission, and the 7th harmonic (700 kc) will beat with the fundamental of the piezo oscillator.

The 5000-kc standard frequency signal is received first and identified with the receiving set in the generating condition. The radio-frequency generator is then turned on and adjusted to near 100 kc. This should give a beat note with the frequency generated by the receiving set. The regeneration of the receiving set is then reduced until the set just stops generating. A beat note should then be heard which will in general be of less intensity than that previously heard. This is the beat between the 50th harmonic of the radio-frequency generator and the frequency of the incoming wave. This beat note should be reduced to zero frequency by adjusting the radio-frequency generator. For most precise work, this adjustment should be made by using a beat frequency indicator or other means of indicating exact zero beat. A simpler and equally accurate substitute is to bring in a tuning fork as described below. However, for a simple discussion of the steps involved in the measurement, it will be assumed that an accurate zero-beat setting is obtained.

The radio-frequency generator is therefore precisely adjusted so that it has a frequency of 100 kc. Without changing its adjustment, couple the piezo oscillator to it loosely. A beat note should be heard in the telephones in the output of the piezo oscillator unless the frequency given by the piezo oscillator is an exact

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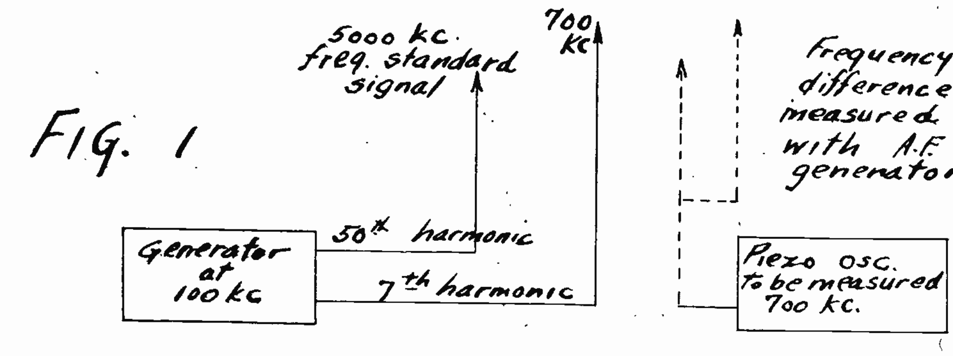

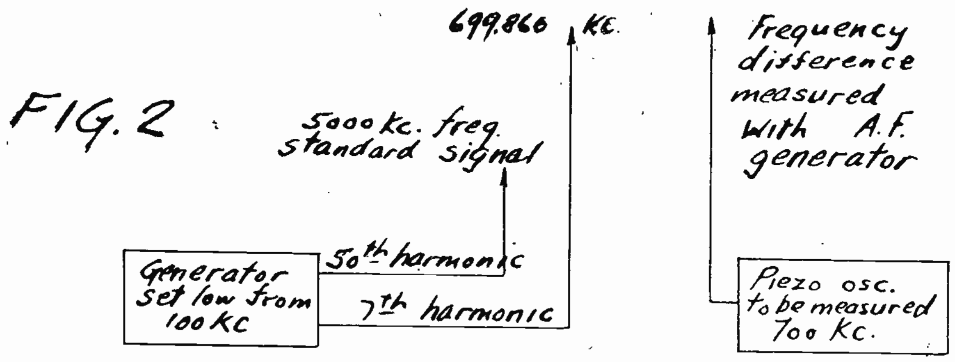

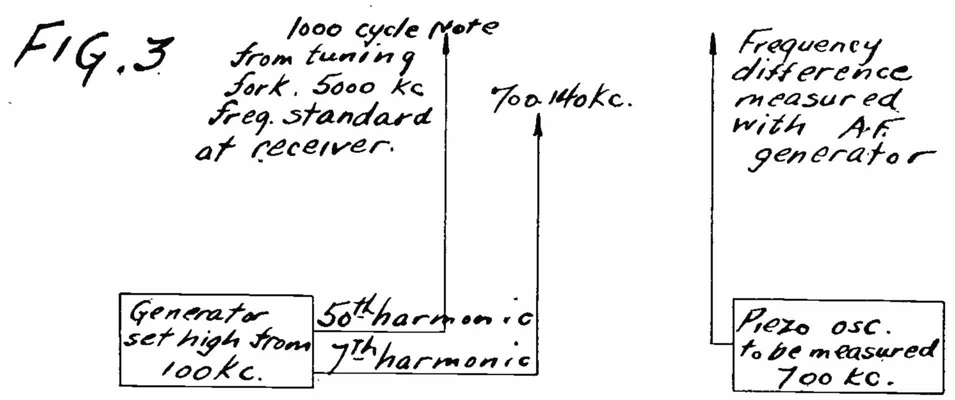

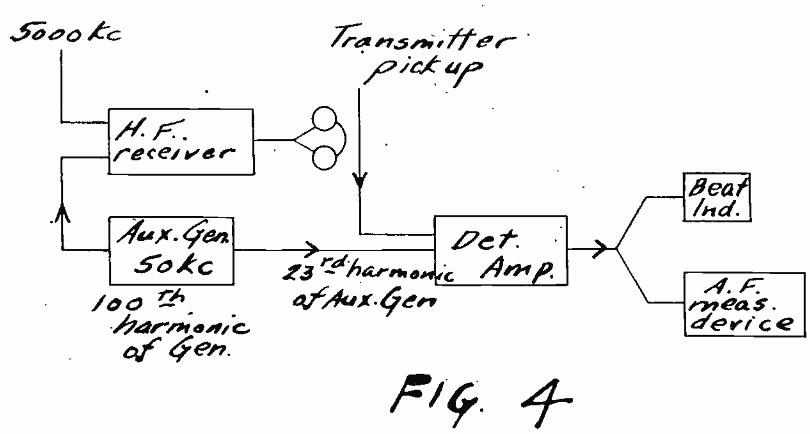

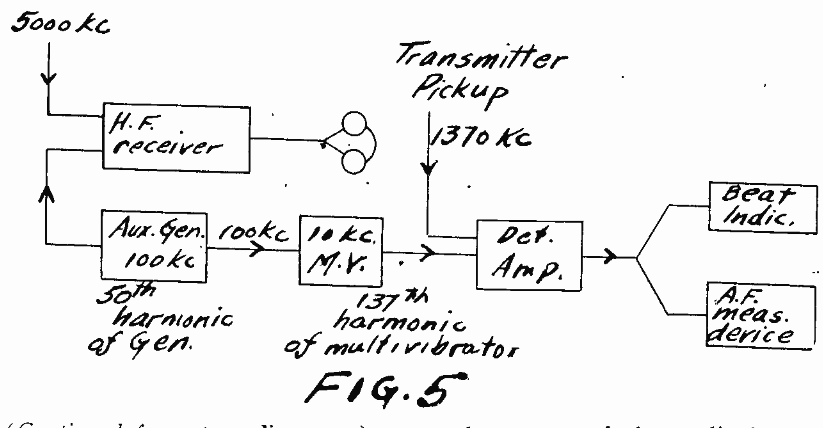

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multiple of 100 kc. Suppose, for example, it is 700.520 kc. In this case a beat of 520 cycles per second will be heard. To determine the value of this note, the audio-frequency generator must be used.

The frequency of the beat note and the frequency of the audio-frequency generator may be compared by using single phone units from each source and rapidly interchanging them at the ear. If sufficient intensity is available from the two sources then the two audio frequencies will combine and beats may be heard by the ear when the audio-frequency generator is closely adjusted. For exact zero beat the frequency of the adjustable audio-frequency generator gives the difference in frequency between the 7th harmonic (700 kc) of the generator adjusted to 100 kc and the fundamental of the piezo oscillator.

Fig. 1 gives a diagramatic representation of the frequencies used. It is necessary to determine whether the piezo oscillator is higher or lower than 700 kc. This can be done by varying the frequency of the radio-frequency generator. If increasing the frequency of this generator results in decreasing the beat note, then the piezo oscillator is higher than the reference frequency, that is, the audio frequency is to be added to 700 kc. If the reverse is true, then the audio frequency is to be subtracted.

Use of Audio-Frequency Note

A change in the method described above, which does not require a beat indicator, is to adjust the radio-frequency generator to have a known frequency difference with the incoming wave by means of matching with that of a tuning fork of known frequency such as 1000 cycles per second. This method is more complicated in calculation because a record must be made of four factors, (1) as to whether the radio-frequency generator was adjusted higher or lower than zero beat, (2) the frequency difference, (3) the harmonic relation between the standard signal and the radio-frequency generator, and (4) the harmonic relation between the radio-frequency generator and the piezo oscillator. The harmonic relations, however, come in to any method of measurement of this kind. The measurements involving the use of the tuning fork for adjusting the generator to give a beat note 1000 cycles per second below the 5000-kc signal would be made as follows, and are shown diagramatically in Fig. 2. Set generator from approximate zero beat at 100 kc to 99.98 kc. The 50th harmonic is 99.98 x 50 = 4999.0 kc (beats with 5000 kc in receiver which is not oscillating and gives a 1000-cycle note). The 7th harmonic of the generator (99.98 x 7 = 699.86 kc) may now be heard beating in the telephones of the piezo oscillator which is known to be approximately 700 kc/s. If this value were exactly 700 kc, a note of 700.000 — 699.860 kc or 140 cycles would be heard. However, the beat note produced is matched with a corresponding note from the audio-frequency generator. If the piezo oscillator had the frequency of 700.520 as assumed previously, the audio-frequency note measured would have been 700.520 — 699.860 = 0.660 kc or 660 cycles per second.

Whether to add or subtract the audio-frequency note of 660 cycles to the known frequency of 699.860 kc would be decided as follows when the radio-frequency generator was set lower than the standard frequency signal. If lowering the frequency of the radio-frequency generator increases the beat note (650 cycles in this case), add the beat note frequency, or if increasing the frequency of the radio-frequency generator decreases the beat note, add the beat note frequency.

The measurement could also be made by adjusting the generator to 100.020 kc using the thousand-cycle tuning fork, as in Fig. 3. The 50th harmonic is 100.020 x 50 = 5001 kc, which beats with the standard frequency signal of 5000 kc and produces a 1000-cycle note. A certain audio-frequency note is produced in the telephones of the piezo oscillator, which is matched with a similar note from the audio-frequency oscillator as before. If lowering the frequency of the radio-frequency generator reduces the audio-frequency note heard, subtract it from the known frequency of 700.140 kc,

(Continued on page 21)

The Electron Radiation Theory

Energy Released by Potential Causing Dislodgement

By M. K. Kunins

THE frequency and wavelength of radio waves constitute one of the fundamental concepts. Ask the most recently interested radio fan about his new hobby and he will hurl the terms kilocycles and meters at you, whether or not he has a vivid appreciation of what he speaks. Because of their fundamental nature these terms should not be slighted in the fan's efforts to understand radio.

The fan has become accustomed to realize that he may differentiate between radio stations by means of frequency discrimination. This is a habit that grew out of his first efforts to tune in a station. He therefore realizes that the frequency will broadly determine the type of signal he will receive. He has found that the frequencies between 550 and 1,500 kilocycles will bring him entertainment of various kinds. He has found that the frequencies just above 1,500 kc will allow him to listen in on the police calls, the amateurs and various experimental stations. He has also found that the frequencies below 550 kc will allow him to break in on the ships at sea. He accordingly has a most vivid appreciation of the importance of frequency as far as a radio signal is concerned.

Small Part of Spectrum

But frequency does not affect radio signals alone. It has been found that radio signals constitute just one small part of a spectrum of frequencies which constitute all electromagnetic radiations in the universe. These frequencies extend from a few kilocycles up to the quintillions and more of kilocycles.

It will be seen in the first sketch that the electromagnetic spectrum has been divided into a number of different types of radiation, each with its own special characteristics and functions. Thus, from a frequency of about 10 kilocycles up to about 30,000 kilocycles, there is the ordinary band that is used in radio communication—10 kc to 550 kc, the long waves; 550 kc to 1,500 kc, the broadcast waves; 1,500 kc to 30,000 kc, the short waves. From 30,000 kc to 1,250,000,000 kc, the new ultra short wave band has just been opened up to the minds of many experimenters and the many strange and useful characteristics of this portion of the spectrum have opened the eyes of many fans with interest. Due to the similarity in action between these frequencies and ordinary light waves this wave is often alluded to as the quasi-optical band. Above this band, from 1,250,000,000 kc to 375,000,000,000 kc, there exist the infra-red rays which constitute many of the waves that create the sensation of heat to the touch sense. We then strike the region that affects the visual apparatus of man, the frequencies from 375,000,000,000 kc to 750,000,000,000 kc. The narowness of this band is striking.

Still Higher Frequencies

Above the visual band of frequencies there lies the band of ultra-violet rays between 750,000,000,000 kc to 22,000,000,000,000 kc, then the X-Rays from this limit to 50,000,000,000,000,000 kc, then the cosmic rays from this point to 30,000,000,000,000,000,000 kc. At this point, the limit of human resourcefulness stops for the present, for it is not known whether waves above this limit exist. However, it is obvious that this gamut of frequencies is more than enough with which to play.

The fact that all these radiations are of the same nature, except in frequency, makes it interesting to investigate the manner in which all these rays are generated and avail themselves for the services of man. Let us therefore attempt a beginner's symposium.

An understanding of the manner in which radiation occurs will involve a knowledge of the structure of matter as evolved at the

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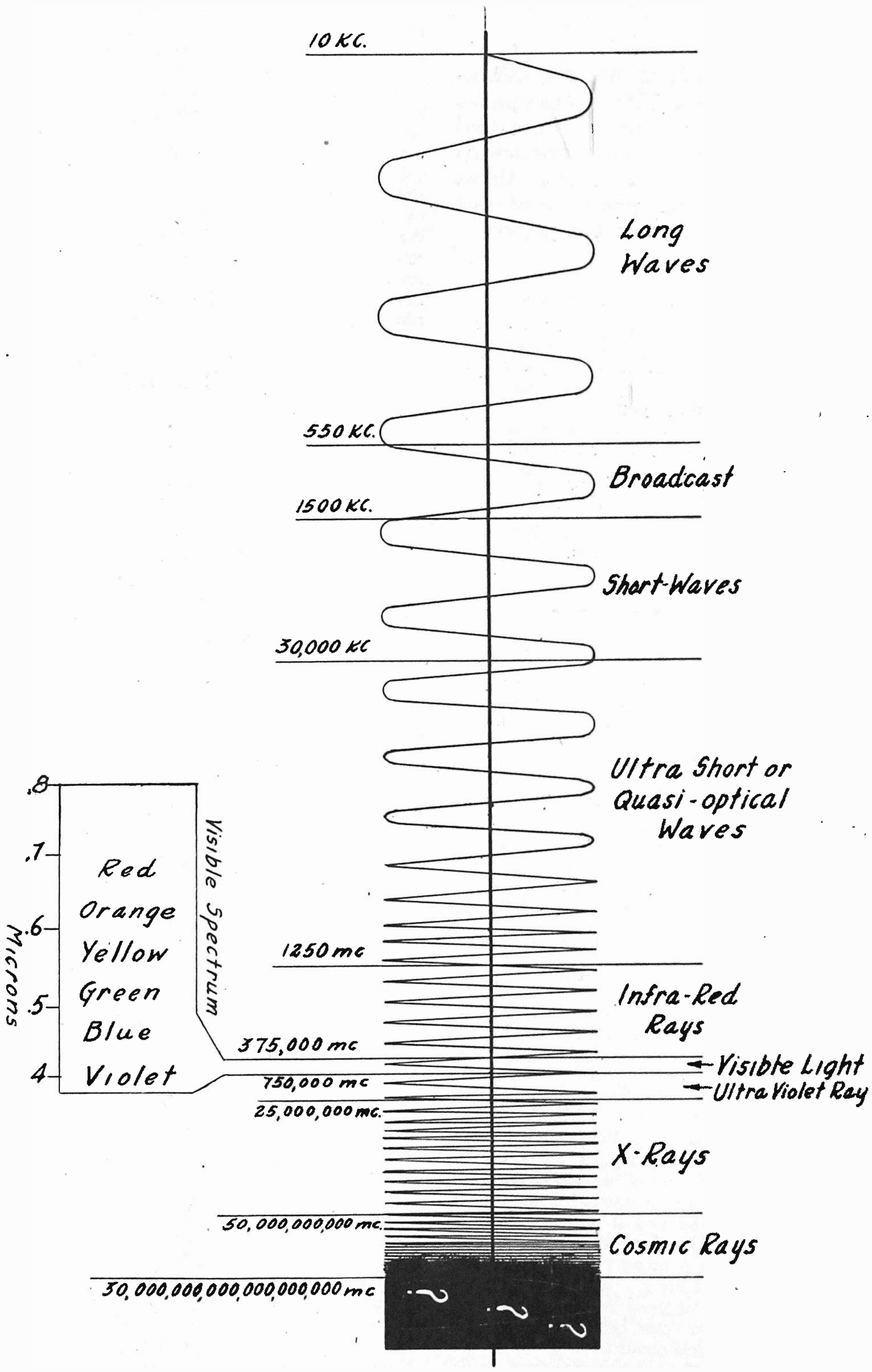
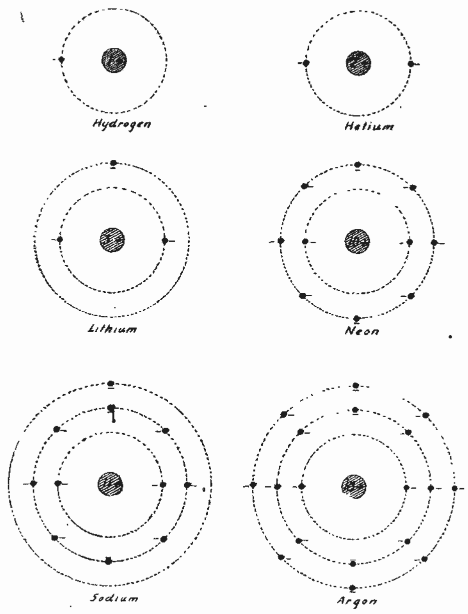


The electromagnetic radiation spectrum is now taken to extend from about 10 kilocycles of vibrations to more than 30,000,000,000,000,000,000,000 kilocycles and still we wonder whether the limit has been reached.



The Bohr atom is in effect a miniature solar system. Though the paths of the electrons are really ellipsoidal rather than circular. They are drawn thus for simplicity. Also, these paths occur in all planes and not only in the plane of the paper.

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present time from the brilliant work of the many physicists who have been engaged in this endeavor. Past work has fairly definitely established the point that all matter (and that means anything you see and many things you don't see that have weight, volume or other physical characteristics) consists of individual arrangements of small entities. The term "molecule" has been given to that smallest amount of matter that still retains the characteristics of the mass of matter from which it derives.

The Atom Defined

Matter consists of elementary substances (which cannot be further divided) such as hydrogen, oxygen, sodium, etc., called "elements" and combinations of these elements are known as "compounds," such as ordinary table salt, which is a combination of the elements sodium and chlorine, or water which is the pairing of hydrogen and oxygen, etc. The term molecule has then been referred to the smallest piece of a compound and similarly the term "atom" has been ascribed to the smallest piece of an element that still retains the characteristics of the element.

Since compounds are divisible into elements, the term of molecule may be neglected for the somewhat similar term atom. This is our starting point for an understanding of electromagnetic radiation. In the finality of all this analysis, it will be understood that all matter is constructed from individual peculiarities of its atomic structure. An atom is so small that it is invisible to the smallest microscope, accordingly it has been necessary to theorize upon its make-up.

There have been many such theories advanced, but the one propounded by Bohr seems most plausible and it will accordingly be considered. The fact that this theory has been advanced a mere twenty years ago will indicate its recency. It states that the atom consists of a positive and negative charge, the positive one being concentrated in the nucleus which constitutes most of the atom's mass, and the negative charge being concentrated among a number of negative charges known as electrons. It is theorized here that these electrons travel at high speed in somewhat elliptical orbits around the centrally located nucleus, in similar fashion to the manner in which the planets of the solar system traverse the skies around the sun.

Concentration in Layers

These electrons do not necessarily all travel in the same plane but rather in all planes and in various layers. The diagrams roughly indicate this idea for six different atoms. (Note: The circular paths should be elliptical in reality.) An extension of this theory, known as Langmuir's Octet theory, explains that the concentration of electrons in these layers or shells will vary as 2/8/8/18/18/32/32. In other words, in the shell closest to the nucleus, there can exist only two electrons at a maximum. The next two shells can contain eight electrons each as a maximum; the next two, eighteen as a maximum, etc. Thus we see in the diagram that the helium, neon and argon atoms contain the maximum number of electrons in their shells. On the other hand, the hyrogen, lithium and sodium atoms are not completely filled. It will be noted that the outermost shell contains only one electron where eight might exist at a maximum. Since it is the everlasting function in Nature that forces equalize each other, there is an ever-present attraction for the neutralization of these incomplete outer shells, and it is because of this incomplete outer shell in some atoms that some chemicals display greater chemical activity than others. Thus, the well-known tendency of hydrogen, sodium and lithium, etc., to engage violently in chemical reactions is understandable. On the other hand, the lethargy of the rare gases, such as helium, neon, argon, etc., in the matter of chemical affinity is also vividly appreciated on this basis.

Table of Composition

The following table indicates the electron composition of all the different atoms:

Atom	Number of electrons	Arrangement of electrons into shells	Number of shells
Hydrogen	1	1	1
Helium	2	2	1
Lithium	3	2-1	2
Beryllium	4	2-2	2
Boron	5	2-3	2
Carbon	6	2-4	2
Nitrogen	7	2-5	2
Oxygen	8	2-6	2
Fluorine	9	2-7	2
Neon	10	2-8	2
Sodium	11	2-8-1	3
Magnesium	12	2-8-2	3
Aluminum	13	2-8-3	3
Silicon	14	2-8-4	3
Phosphorus	15	2-8-5	3
Sulphur	16	2-8-6	3
Chlorine	17	2-8-7	3
Argon	18	2-8-8	3
Potassium	19	2-8-8-1	4
Calcium	20	2-8-8-2	4
Scandium	21	2-8-8-3	4
Titanium	22	2-8-8-4	4
Vanadium	23	2-8-8-5	4
Chromium	24	2-8-8-6	4
Manganese	25	2-8-8-7	4
Iron	26	2-8-8-8	4
Cobalt	27	2-8-8-9	4
Nickel	28	2-8-8-10	4
Copper	29	2-8-8-11	4
Zinc	30	2-8-8-12	4
Gallium	31	2-8-8-13	4
Germanium	32	2-8-8-14	4
Arsenic	33	2-8-8-15	4
Selenium	34	2-8-8-16	4
Bromine	35	2-8-8-17	4
Krypton	36	2-8-8-18	4
Rubidium	37	2-8-8-18-1	5
Strontium	38	2-8-8-18-2	5
Yttrium	39	2-8-8-18-3	5
Zirconium	40	2-8-8-18-4	5
Columbium	41	2-8-8-18-5	5
Molybdenum	42	2-8-8-18-6	5
Masurium	43	2-8-8-18-7	5
Ruthenium	44	2-8-8-18-8	5
Rhodium	45	2-8-8-18-9	5
Palladium	46	2-8-8-18-10	5
Silver	47	2-8-8-18-11	5
Cadmium	48	2-8-8-18-12	5
Indium	49	2-8-8-18-13	5
Tin	50	2-8-8-18-14	5
Antimony	51	2-8-8-18-15	5
Tellurium	52	2-8-8-18-16	5
Iodine	53	2-8-8-18-17	5
Xenon	54	2-8-8-18-18	5
Caesium	55	2-8-8-18-18-1	6
Barium	56	2-8-8-18-18-2	6
Lanthanum	57	2-8-8-18-18-3	6
Cerium	58	2-8-8-18-18-4	6
Praseodymium	59	2-8-8-18-18-5	6
Neodymium	60	2-8-8-18-18-6	6
Illinium	61	2-8-8-18-18-7	6
Samarium	62	2-8-8-18-18-8	6
Europium	63	2-8-8-18-18-9	6
Gadolinium	64	2-8-8-18-18-10	6
Terbium	65	2-8-8-18-18-11	6
Dysprosium	66	2-8-8-18-18-12	6
Holmium	67	2-8-8-18-18-13	6
Erbium	68	2-8-8-18-18-14	6
Thulium	69	2-8-8-18-18-15	6
Ytterbium	70	2-8-8-18-18-16	6
Lutecium	71	2-8-8-18-18-17	6
Hafnium	72	2-8-8-18-18-18	6
Tantalum	73	2-8-8-18-18-19	6
Tungstein	74	2-8-8-18-18-20	6
Rhenium	75	2-8-8-18-18-21	6
Osmium	76	2-8-8-18-18-22	6
Iridium	77	2-8-8-18-18-23	6
Platinum	78	2-8-8-18-18-24	6
Gold	79	2-8-8-18-18-25	6
Mercury	80	2-8-8-18-18-26	6
Thallium	81	2-8-8-18-18-27	6
Lead	82	2-8-8-18-18-28	6
Bismuth	83	2-8-8-18-18-29	6
Polonium	84	2-8-8-18-18-30	6
Alabamine	85	2-8-8-18-18-31	6
Radon	86	2-8-8-18-18-32	6
Virginium	87	2-8-8-18-18-32-1	7
Radium	88	2-8-8-18-18-32-2	7
Actinium	89	2-8-8-18-18-32-3	7
Thorium	90	2-8-8-18-18-32-4	7
Protactinium	91	2-8-8-18-18-32-5	7
Uranium	92	2-8-8-18-18-32-6	7

Dislodgement by Potential

Normally, the planetary electrons are rotating around the nucleus of each atom in their proper orbits and no external manifestations of energy are indicated. Each electron possesses a certain amount of potential energy depending upon its distance from the nucleus. The greater this distance, the greater the potential energy. In order to move any electron from its normal path the application of a force is required which would then cause the existence of an unbalanced positive influence at the nucleus. Therefore, if a force causes such dislodgment of one or more of the electrons, an emission or absorption of energy occurs dependent upon whether the electron is dislodged toward or away from the center positive nucleus of the atom.

If the electron is dislocated toward the nucleus, the difference in energy represented by the change in potential level will be evidenced in the form of an external manifestation by the radiation of energy. This energy radiated from the atom as a result of the electron or electrons having been dislodged from normal, form electromagnetic radiations and for each electron that is moved, a certain amount of energy will be released.

The Quantum Theory

The amount of this energy is constant per electron per potential level and is known as a quantum. This energy then shoots out from the atom, according to latest measurements, at a velocity of 299,820,000 meters per second or somewhat more than 184,000 miles per second. A theory propounded by Prof. Albert Einstein sets forth that it is the scattering of these quanta of energy through space that constitutes the radiations that are emitted by any radiating matter. Our present knowledge does not indicate the exact nature of this energy nor does it ex-

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plain the manner in which it travels through space.

A knowledge of the theory involved in these radiations by itself is not very useful. It is of greater utility to know how these rays may be generated. Accordingly, the sketch showing some of the sources of these rays is of interest. It will be noted that electrical devices have in the main been illustrated. However, it should be understood that other agencies can also produce radiations. Illustrative of this fact is gas heat, coal heat, etc., for infra-red rays; and, any source of white light in which will usually be found some ultra-violet light rays.

New Tube Helps

In the radio communication range, we of course have the various types of vacuum tubes that can generate most capably any frequency within this range of this band. For the ultra-short waves the new acorn tube extends the possibilities of this region most completely. Formerly, the technique of this band utilied the Barkhausen-Kurz and Magnetron oscillators. In the inra-red or heat region, the electric coil heater within a parabolic bowl reflector furnishes the most easily handled form of this source of radiation. Other agencies make use of the gas flame, the heat from coal and other burning matter, etc.

Light waves, or those that affect the eye, are derived primarily from incandescent electric lamps. In the past, however, the sources constituted the candle, the kerosene lamp, the gas mantle and jet, etc. For ultra-violet light, we usually are dependent on any source of intense white light since the violet rays that make a light source more white. The best source of white light is the electric arc.

X-Rays and Cosmic Rays

The X-rays of Roentgen are universally generated by vacuum tubes of a design that is especially suited for the purpose. The theory in this connection is that when certain high-speed electrons strike a metal target, they are caused to rebound and form X-rays that have highly penetrative powers. If this target is inclined to the axis of the tube's electrodes, these rays may be made available outside the tube.

In the field of cosmic rays, we find that the scientists are still involved in hungry pursuit of the secrets of this region.

During the past year we have read in the daily press of many intrepid individuals who have ventured into the stratosphere where these rays exist in profusion, for the purpose of measuring the properties and thus acquiring a larger appreciation of the characteristics. This field is most exciting because of its celestial nature.

Some of the interesting properties of some of these waves have been tabulated by the Smithsonian Institution at bottom of this page.

Terms Used

In conclusion, it might be well to indicate the units that are used in the various branches of radiation study. In the foregoing, all these rays have been treated on the basis of frequency and of course when so treated the term kilocycles can be used. However, it is sometimes useful to describe these waves in terms of wave-length in which case, a number of different units are available, indicated below in tabulated form:

Waves	*unit*	*Symbol*	*Size with respect to meter*
radio communication	meter	m	1
Ultra-short waves	centimeter	cm.	10^{-2}
Infra-red rays	micron	μ	10^{-6}
Light waves	Angstrom unit	A	10^{-10}
Ultra-violet	Milli-Angstrom	mA	10^{-13}
X-rays	Micro-Angstrom	μA	10^{-16}

Tempting Field

The recent advent of the ultra-short waves has served to reawaken the pulses of dormant experimenters whose discoveries in the radio communication bands have served to advance the science and art of radio a great deal. However, the day will come when the ultra short waves will also hold no secrets for us and will be a commonplace utility. Then, the experimenters might again say there is nothing new to discover. BUT, THEY ARE WRONG! The gamut of frequencies above the ultra-high frequencies presents a field that is tremendous in its immensity of possible investigations. It, perhaps, even holds the secret to eternal life itself! Come on, you curious ones, try the infra-red rays, as a start. Get yourself one of these electrical heater coil units with the parabolic reflector behind it and see what you can find out. We are intensely interested and would be glad to hear of your results.

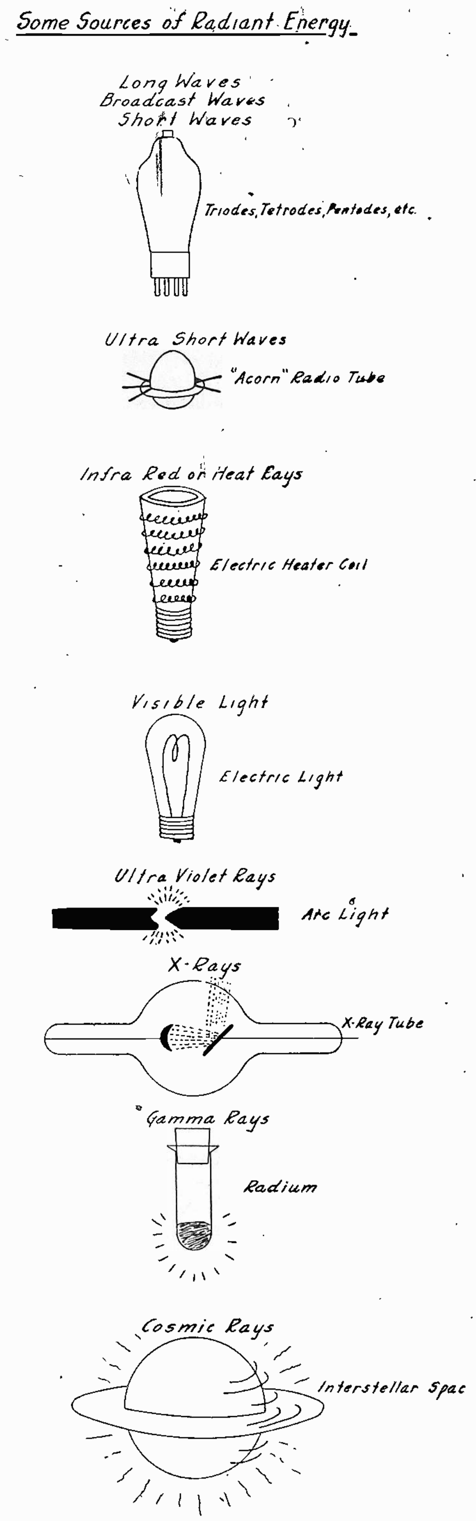
Wavelength (cm.)	*Nature of Radiation*	*Effect on Atom*	*Temperature Absolute*	*Where found*
7500×10^{-8} 3750×10^{-8}	visible light	disturbs outmost electrons	3880 to 7700	stellar atmosphere
250×10^{-8} 10^{-8}	X-rays	disturbs inner lectrons	115,000 to 2900000	stellar interiors
5×10^{-9} 10^{-9}	Soft gamma rays	strips off nearly all electrons	58000000 to 290000000	Central regions of dense stars
4×10^{-10}	Gamma rays of radium	Disturbs nucleus	720000000	....
5×10^{-11}	Hardest gamma rays	....	5800000000	
4.5×10^{-12}	....	Hydrogen atom becomes helium atom	64000000000	....
2×10^{-12}	Highly penetrating death rays	disintegrates nucleus	150000000000	...

Minimizing the Harmonics

There is one kind of static shield that is intended to lessen the crackling sounds one hears when trying to get distant stations. Another kind is designed to reduce the whistle often heard when the harmonics of a local station signal get mixed up with the fundamental signal of a weaker distant station. Distortion that is ever present in the generation and amplification of radio waves for broadcasting causes many unwanted harmonic frequencies to appear and a new simple device designed by Westinghouse engineers, to cure the harmonic trouble, do so by preventing the harmonics from getting into the ether. A static shield is used. A wire lattice-work is suspended between the coils that connect the transmitter to the antenna.

Legislation under the Federal Communications Commission has required strict observance of the percentage of harmonic radiation of all broadcast stations, so serious is the effect of these stray signals from super-power stations. When KYW started broadcasting, careful measurements and adjustments were made on harmonic radiation. With aid of the new static shield, it is estimated that the reduction of harmonics was hundreds of times better than the law requires.

The simplicity and effectiveness of the static shield and its coming popularity are evidenced by the fact that a miniature one is built into the new Westinghouse 50-watt police broadcast transmitter installed recently in Charleston, W. Va.



The various forms of electromagnetic radiation are manifested by the various examples shown here. Though some of them generate several different radiations, the indicated types preponderate.

Special Uses of Tubes

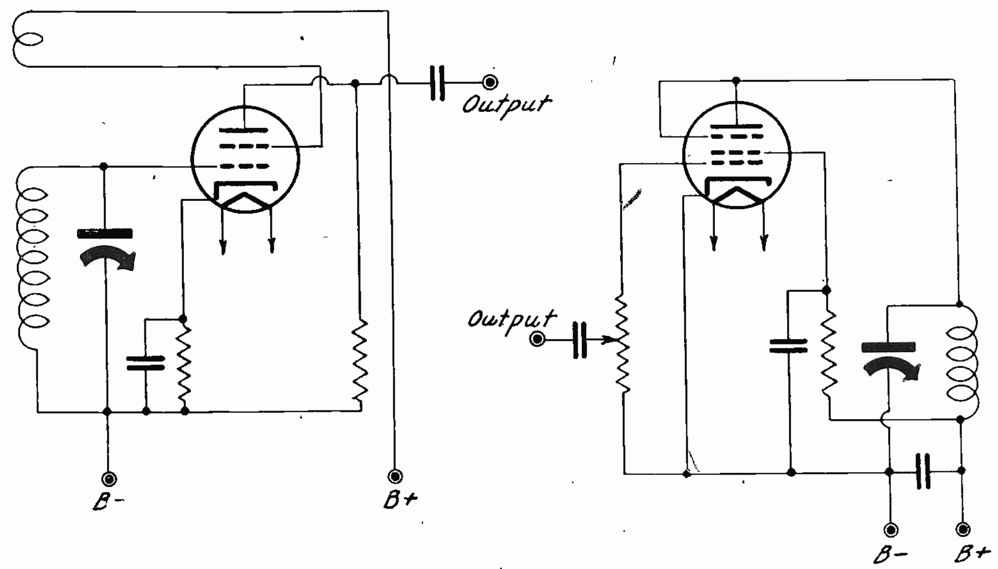
Two Oscillators, One Stable, Other Unstable

By Frederick L. Carter

TWO unusual tube uses are shown in the diagram. Both apply to oscillators. In the one instance a pentode is operated practically as a triode with suppressor. But as the suppressor action is nullified the triode appellation may be allowed to rest. Otherwise the tube as used would be called a tetrode.

This use was originated in these columns and the sole purpose is to provide electron coupling of the output. In that way the frequency of generation in the oscillator is not affected by the circuit into which the oscillation is put. The coupling is weak, besides. It is so weak that when the conventional plate circuit, here used as a pickup element, had a pair of phones in series with it, the generator hooked up for detection, practically nothing could be heard, despite good antenna input.

The freedom of influence of the work circuit on the generator circuit nevertheless has much to commend it, although other means, for stronger coupling, may be provided readily, and still the frequency influence of the work circuit on the tank circuit is small enough to disregard.



A pentode used effectively as a triode with conventional plate for pickup purposes, to provide electron-coupled output, so the work circuit will not influence the frequency of the generator. Another special use of a vacuum tube in a generator is that of a pentode converted into a tetrode, by tying the suppressor to plate or screen, so that dynatron characteristics may be maintained.

Feedback Through "Screen"

Not much is generally known about this special use of the tube. A few experimental facts are obvious. The effective plate to cathode resistance is higher this way than by the normal method. This would follow from the absence of the screening effect. The grounded screen of conventional practice, considering radio or audio frequencies, makes for a low output capacity. Still, low is a relative term. For the 24 tube it is indeed a small capacity, but for the suppressor type tubes the capacity at best runs to around 12 mmfd., and by the illustrated method is considerably higher.

Feedback being through the "screen," used as effective plate, the plate resistance is high, the relative change of plate current through the feedback circuit is small, hence stability is good, but difficulty may be experienced in maintaining oscillations at high frequencies, say, much above 10 mgc. Thus, within its limits, the method had excellent advantages, and for frequencies of 10 mgc and lower the smaller conductance is of little consequence.

An interesting consideration, this part being theoretical, applies to the current through the total resistance of the potentiometer. It is plain from the fact that there is output coupling that there is current through this resistance. Also it is true that the resistance must not be very high, otherwise the voltage across the resistance will be too much, or coupling too tight, and anything like a neon tube connected there for modulation purposes might not strike.

The Electron Effect

The current through the resistor has been measured and is of the order of a few microamperes. Now, why should current flow through a grounded resistor? In the first place, only one end of the resistor is grounded. The same is true of a grid leak in an audio circuit and in some radio-frequency circuits. We should not be surprised, then, to find current through the load resistance, for the element of the tube is itself not grounded, but at a positive potential.

The question is, how does the pickup element acquire its potential? This element is in the electron field. The electrons are moving. Whenever a conductor is placed in a field of moving electrons there is a potential acquired by the conductor. So there is a potential on the pickup element, because this element is surrounded by agitated electrons. If a resistor is connected between this element and ground, the electrons will be caused to flow through the resistance, to ground, through the B supply, and perhaps back to the cathode. So far as radio frequencies are concerned, the electrons of the generation frequency come to rest at ground and are not renewed. Very low frequency electrons, if present, might keep on going through. At radio frequencies renewal must come from the cathode, the source of all electrons in the vacuum tube, that is, the sole emitter.

The Dynatron

There is a condition known as secondary emission, but it is not emission in a strict sense, that is, one of origin. The cathode is the exclusive originator. Secondary emission consists of electrons that are emitted from the cathode only to strike some other element, say, the plate, to be bounced off, and some of them sent back in the direction of the cathode, thus to oppose the main flow of electrons. This opposition is a limiting factor on the performance of all tubes that possess the possibility of secondary emission. Suppressors intended to prevent such secondary emission therefore enable high plate efficiency, as much more can be gotten out of the tubes at relatively low voltages, a fact that domintes the performance of some power tubes.

The other circuit is that of a dynatron, where the tube used is not such as originally intended for dynatron purposes. A dynatron is an oscillator so circuited that the slope of the plate resistance, and also of the screen resistance, is negative. That is, when the voltage is increased for any reason, either a-c or d-c voltage, the current is less, instead of greater. Now, the suppressor is intended to render this practically impossible, except for certain occasional and scarcely controllable circumstances. If the presence of the suppressor is denied to the tube, as by combining the suppressor with the plate or screen, whereby the suppression no longer exists, the secondary emission has practically full sway, the dynatron conditions are satisfied, provided of course the d-c potentials are properly applied. This proper application consists of a certain critical apportionment of the d-c voltages, whereby the plate must be less positive than the screen. In general, the screen voltage may be around 60 per cent. of the total B voltage and the plate voltage around 40 per cent.

Dynatron Unstable

No doubt the dynatron makes the simplest oscillator. The plate circuit alone has to be tuned. There is no grid circuit affected by radio frequencies in any sense related to the tube performance. The grid may be left open-circuited, and still there will be oscillation. But the grid circuit alone may not be tuned, for then there would be no oscillation. All that can be said of the grid circuit is that a negative bias may be introduced to limit the plate and screen currents, with the precaution noted that if the bias is too high there will be no oscillation no matter what the proportion of the B voltage to screen and plate, assuming no potential increase of the total B voltage supply commensurate with the negative bias increase.

Technique of the New KYW

Philadelphia Transmitter Introduces Important Improvements

By Charles P. Worcester

EXEMPLIFYING the technical perfection of modern radio engineering, the new transmitting facilities of KYW went on the air from Philadelphia.

The original KYW, Chicago, transmitted its first program in 1921. It was the pioneer broadcasting station in the Middle-West. In moving the station to Philadelphia, Westinghouse engineers provided it with completely new transmitting equipment, which in its technical perfection more forcibly brings to mind the pioneering beginning and long years of operation that are behind the call letters KYW.

Directional Antenna Used

The style of architecture is Pennsylvania Colonial. This is the first time in broadcasting history that a transmitter of 50 kilowatt maximum rating has been so designed that its size is suitable for a building of this style. Two innovations that resulted in saving much space were the use of extremely compact nitrogen-filled radio condensers and a new design of high-voltage rectifier.

This new station will use four 245 foot vertical antennas each connected separately to the transmitter. The power of the transmitter will be divided into these four units. By controlling the phase relationship of the current delivered to the four vertical masts, it will be possible to accurately adjust the direction of the radio beam so that maximum signal will be delivered into Philadelphia. At the same time a minimum signal will be delivered in other directions where, if a signal were present, interference would result with other radio stations.

The control over this phase relationship is accomplished from the control room of the station.

Power Capacity 50 kw

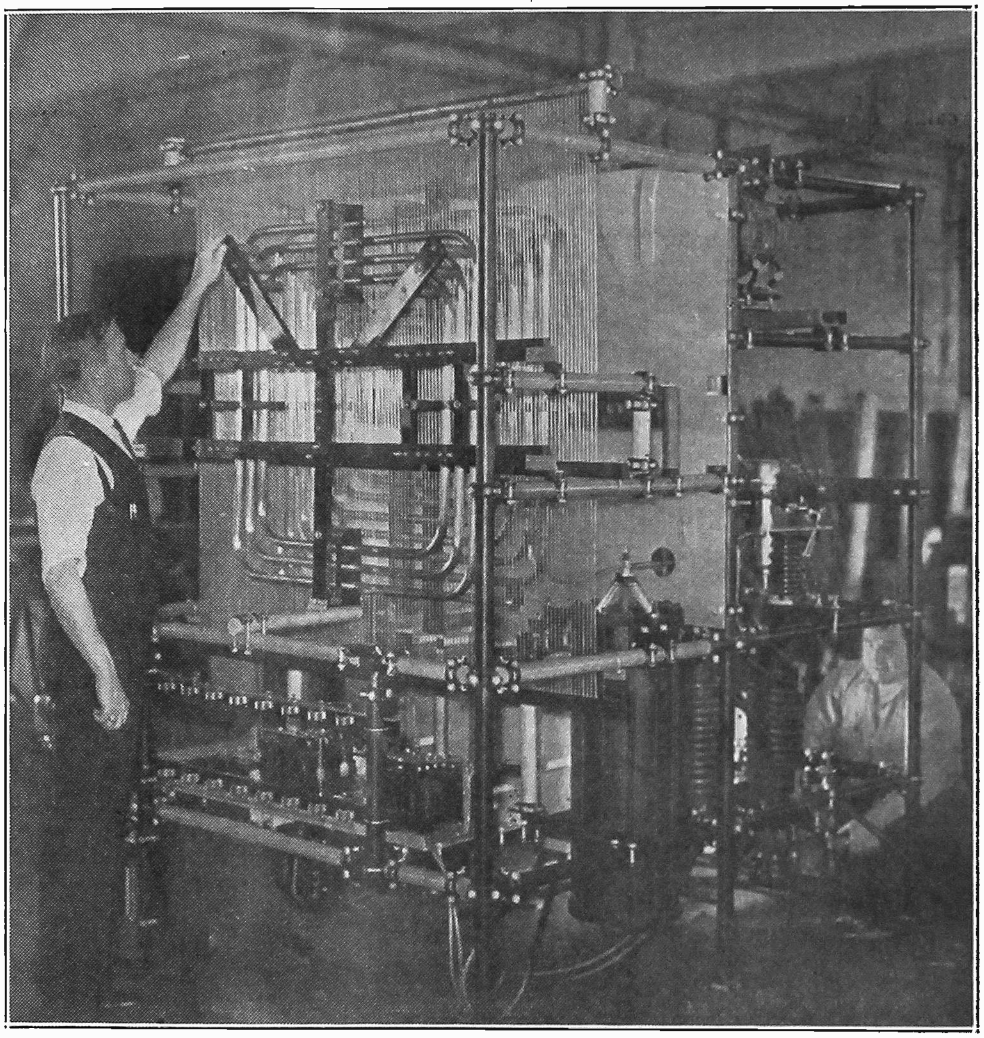
The KYW transmitter is designed as a 50 kilowatt transmitter but modified for operation at 10 kilowatts. The power supply to the station is 4150 volts, 3 phase, 60 cycles.

Like other broadcasting stations, KYW is required to maintain its frequency (1020 kc) within plus or minus 50 cycles. To accomplish this, quartz crystal plate measuring about 1 inch square is used to generate the radio-frequency oscillations. The feeble oscillations of this crystal are amplified in the transmitter and connected to the antenna system. Up to this point, this system is not different than most modern broadcast stations.

However, the oscillation unit in which the quartz plate is held is a new development by Westinghouse containing many refinements after years of experimental work. Actual tests in which one of these crystal oscillator units was used to generate the frequency at WBZ, the variation of the assigned frequency was not more than 5 cycles. The quartz plate is held at a constant temperature through the use of mercury thermostats and the complete oven is contained in an aluminum casting making the circuit free of all interference from external circuits.

As a matter of precaution and to assure continuity of program service, a duplicate quartz crystal oscillator unit will be maintained in operation at all times.

STATIC SHIELD STAYS HARMONICS



The static shield used at new KYW, Philadelphia, for preventing the transmission of harmonics.

Distortion Checked Visually

Another device, also containing a quartz crystal plate held at constant temperature, will be used as a means of checking the stability of frequency of the station. This frequency checking or monitoring device contains a meter, the pointer of which remains at the center position when the station is on its correct frequency. Any deviation above or below the assigned frequency is accompanied by a movement of this meter pointer to the right or left of center. The unit is kept in operation at all times as a guard against any accidental shifting of the station frequency.

The control room of the station will contain an oscilloscope, using a cathode-ray tube similar to that used in the latest television developments. By connecting various circuits to this tube, the operator can observe distortion and percentage of modulation in the program and in various parts of the transmitter.

High-level Class B modulation is used at this station using equipment similar to that designed by Westinghouse engineers for the 500 kw transmitter at WLW. One hundred percent modulation will be possible over the musical scale, including frequencies between 30 and 10,000 cycles.

Enormous Audio Transformers

The ability to achieve this perfection is the result of the development by Westinghouse engineers of enormous audio transformers, free of the usual distortion.

When modulation exceeds 100 per cent, serious distortion results. As a safeguard against this occurence, engineers have devised an over-modulation indicator which operates in connection with the radio power amplifier at the transmitter. On the panel in the station control room, a

(Continued on next page)

Rectifiers for D-C Meters

Several Ways of Establishing Instrument as "Universal"

By William Akerron

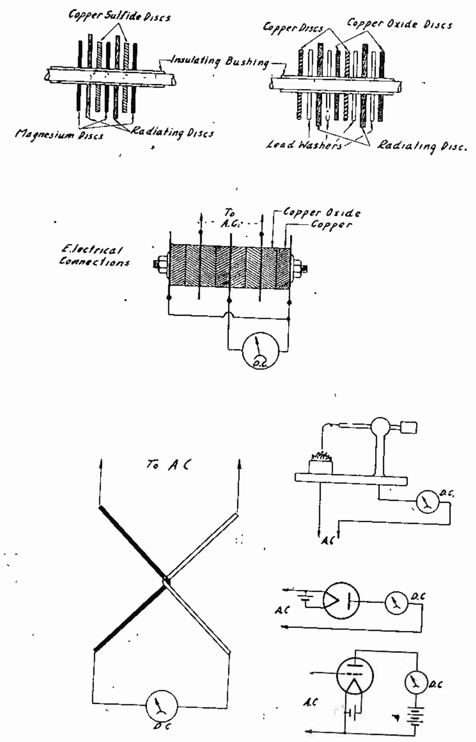
THE less fortunate ham who hasn't wads of money with which to purchase the many luxuries of a more nearly ideal existence finds himself spending a great deal of time (if not money) thinking up economical ways of doing things that his more fortunate confrere finds of no moment at all. In this process, many new uses for old devices have been discovered and this difficulty becomes in reality a blessing. You've heard the old adage, "Necessity is the mother of invention."

One of the most common luxuries for the thus disposed ham are meters and other instruments. We call them luxuries since radio equipment can work without them (though usually out of adjustment) and because of the comparatively large cost. Though one meter may cost $5, several meters are necessary. It is accordingly economic to take steps that will reduce the number of instruments required to perform the necessary measurements in a radio circuit.

Rectifier for D-C Instrument

Thus, through economic pressure, meters have become associated with sets of shunts and multipliers whereby one instrument could perform the function of many meters through a variety of ranges thus furnished. In this way, one meter many times performs the functions of ten or twenty meters. However, a restriction is usually involved. The meter may be a d-c instrument which can only be used for such currents. If it is desired to measure an alternating current, this combination is not applicable in its form as mentioned. However, this instrument may be rendered capable of furnishing this service by the expedient of a rectifier which will change the alternating current into direct current that is measurable by the meter.

There are several ways of accomplishing this end with the various types of rectifiers that are available. It is proposed to treat a few of these possibilities: (1) the thermopile; (2) the thermocouple; (3) the crystal rectifier; (4) the diode rectifier, and (5) the triode rectifier.



The construction of two types of dry disc copper rectifiers. The thermocouple, consisting of two dissimilar metals joined at a "point," a very simple type of rectifier, is shown at left. The old crystal detector with its "cat's whisker" can be returned from oblivion for rectifying purposes. Also the diode and triode vacuum tubes are useful.

The work of various physicists of the past evolved the fact that a series arrangement of two dissimilar metals in contact with each other had the useful property of conducting an electric current in only one direction. This is of course the process of rectification, whereby an alternating current that reverses its polarity or direction periodically in an input circuit to the thermopile may be made to function in only one direction in the output circuit to constitute a direct current.

The first two sketches illustrate two types of such a rectifier. In the first one, the active elements are two alternate discs of copper sulfide and magnesium. In the second one, the active discs are made of copper in the pure state and copper oxide. In both of these thermopiles the discs are mounted in alternating sequence upon an insulated threaded rod between successive radiating discs for the dissipation of the heat that is generated within the units.

Danger of Nullification

The purpose of the threaded rod is to furnish a convenient means for clamping the units tightly together. This latter requirement is especially important in the copper oxide type since this type of rectifier will quickly lose its value if the air can get at the copper disc to oxidize it to copper oxide. If this should happen, there would be two copper oxide discs in juncture which would nullify this action. Therefore when the copper oxide disc is very tightly squeezed against the copper disc so that no air may enter in between, the life of this unit is materially increased.

The copper oxide rectifier is quite the more universal type of dry disc rectifier and is readily obtainable in the open market.

In the third sketch, the manner of connecting it up electrically is readily seen. It is apparent therefrom that the alternating current under consideration is connected between the two middle sections of a four-section rectifier while the rectified direct current is taken off the middle point and the outsides.

In this manner, the multiple purpose meter may be made to measure alternating current in addition to direct current. for the measurement of alternating current makes use of the thermocouple. This Another way of utilizing a d-c meter

(*Continued on page* 20)

KYW Minimizes Harmonic Radiation

(*Continued from preceding page*)

red light flashes each time the modulation exceeds a predetermined value and warns the operator so that the volume will be reduced.

The main rectifier is of new design and considerably smaller than previous rectifier designs for 50 kw stations. It is capable of delivering 12,000 volts, 17 amperes d.c. This voltage is adjustable and will be used at considerably lower rating at KYW.

An intermediate and bias rectifier are contained on the same unit as the main rectifier.

All high voltages are shielded behind doors in the transmitting room. When it becomes necessary for the operator to enter the transmitting room, the high voltages are automatically turned off and grounded through the operation of interlocks. Similar methods are employed by nearly all high power broadcasting stations.

A.C. on Sending Tubes

The filaments of all of the transmitting tubes operate directly from alternating current. All other high-power broadcasting stations thus far have required the use of large motor generators to convert the alternating current into direct current for the transmitting tube filaments. The use of alternating current on filaments of tubes introduces noise on the carrier wave radiated by the station. To neutralize this, Westinghouse engineers have developed a "magnetron suppressor" which introduces a current of the right phase and amplititude into the power amplifier circuit to neutralize the noise current produced by the use of a.c. on the filaments. All of the power tubes of the station are cooled with distilled water which is circulated through the tubes and through cooling radiators. Large blowers force the cool air through the radiators extracting the heat from the distilled water.

Thermostats and water flow meters are used as a guard against failure of the water system to cool the radio tubes properly. Automatic regulators are used to maintain the filament voltages at their correct operating value. Short circuits or flash overs in the radio equipment which might overload and ruin the expensive tubes cause other automatic devices to operate which reduce the high voltage direet current from the rectifier to half value. If the trouble which occurred was only momentarily and clears itself up, the

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type of rectifier has the advantage of extreme economy since all that is required are two short lengths (about 2 or 3 inches long) of dissimilar wire—one might be iron and the other advance resistance wire.

The procedure involved in this type of rectifier constitutes joining these two wires together in the form of an "X" so that they have a common junction point. The efficiency of this couple is directly affected by the size of this juncture. For best results it is essential that this point be as small as possible and it is for that reason that soldering the two wires together is not good procedure, since the layer of solder shorts the joint into a large area.

Method of Connection

As will be seen in the sketch, the alternating current under consideration in this case is fed to two dissimilar ends of this couple while the output side to the d-c meter is taken from the two remaining ends. Thus, the correct hook-up involves two dissimilar wires in the input side and two dissimilar wires in the output side to the meter.

The thermoelectric effect that allows this couple to act as a rectifier depends upon the fact that two dissimilar metals in contact have the reciprocal property of generating an electric current from heat. The alternating current flowing in the input side of the couple thus generates heat at the junction which heat generates a direct current in the output side.

The good old crystal detector was the standby in the days of yore as far as radio is concerned. It performed its function of detection against great odds until the advent of the vacuum tube caused its abandonment. The infinitely greater capabilities of the vacuum tube dropped the crystal detector from the radio scene for reception but the crystal still is useful as a rectifier for relative measurement purposes in a pinch when no other rectifier is available.

The Crystal Rectifier

Certain minerals, such as galena, magnetite, pyrites, carborundum, etc., have the natural property of allowing an electric current to flow through them in only one direction. This ability of certain crystals has never been satisfactorily explained but nevertheless that does not prevent us from utilizing this curious phenomenon. Therefore, to avail ourselves of this property all that is necessary is that we find that "sensitive spot" with a cat's whisker when the crystal is connected in series with the meter for the measurement purposes outlined heretofore.

Of course, the use of a cat's whisker, with its annoying ability of jumping, is quite a nuisance. Because of this fact, the sensitive spot often is lost, and the circuit's effectiveness jeopardized. Therefore, in mitigation of this failing, the less sensitive carborundum crystal in series with an energizing battery may be substituted for the crystal with the cat's whisker. With the carborundum crystal, it is possible to make a permanent contact with pressure which is not easily jarred.

Though Edison noticed the Edison effect many years ago, he did not appreciate the utility of two electrodes in a vacuum tube being able to rectify an alternating current. It was not until Fleming envisioned this use that the diode vacuum tube became applicable to the purpose of rectifying alternating current into direct current. An extension of this application may be adopted for our purpose and according to the connections shown in the sketch, our d-c meter may be used in the measurement of alternating current voltages. No worry about sensitive spot troubles, which most certainly is a decided advantage.

The Triode Rectifier

The triode vacuum tube is seen so often in the guise of an amplifier that its rectification possibilities are not fully realized. However, the triode is an even better rectifier than the diode—since it also amplifies in addition to its rectification action, and may be made to rectify without itself drawing current from the measured source, which is never true of a diode. It is this function of rectification that is applied in the vacuum tube voltmeter. A fundamental connection for this purpose is shown in the final sketch. It will be noted here that the alternating current is fed into the grid-filament circuit of the tube while the meter in the plate-filament circuit measures the direct current increments or decrements that flow as a result of the a. c. in the grid circuit. Through the amplifying action of the triode tube, the a. c. after rectification is amplified to d. c. of a greater comparative magnitude.

It should be obvious to the experimenter that there are many ways of "skinning a cat" and it is to the everlasting credit of the ham with the limited pocketbook that he has been able to function under adversity incurred by a capital of practically no dimensions.

Resistance of Rectifier

Rectification is commonly regarded as changing alternating current to direct current. In connection with d-c meters, to constitute them of the rectifier type, the definition holds strictly, because something is done to produce a direct current where the input was an alternating current, and this direct current the d-c meter of course will read. By suitable shunts the current range may be extended. By suitable series resistors the voltage range may be extended, a voltmeter simply being a current meter where the equivalent voltage values to produce definite currents are calibrated in volts.

A fact to consider in connection with the rectifier is the resistance thereof. Likely this will run high in some instances. The thermopile type may be included in this group. Special rectifiers, consisting of plates, as used in rectifier type "universal" instruments, have a relatively high resistance. In one instance this resistance is 4,950 ohms. The rectifier evidently was specially made to have this resistance, for the meter resistance itself is 50 ohms, and the sum of the two resistances is 5,000 ohms, or just right for the 0-5 scale of voltage on the meter, which is of the 1-milliampere full-scale deflection type.

Avoiding Multiplicity

Since the rectifier may have appreciable resistance, it is well to measure this resistance, and to treat the other series resistances accordingly. Therefore for a 50-volt scale, the limiting resistance would have to be 49,950 ohms, since the meter has the other 50 ohms resistance, but the rectifier has 4,950 ohms, so the resistor to use would be 45,000 ohms. Meter and rectifier make up the difference.

This would be true for use of the a-c scale. For the d-c purpose, then, a resistance would have to be cut in, equal to the rectifier resistance, or 4,950 ohms, and when this is done, the resistors used for higher voltage ranges on a.c. also would be applicable to the same ranges on d.c. That is, two sets of resistors would not be needed.

However, the two scales do not track. That is, there must be an a.c. scale, or calibration, and a d-c scale, or calibration. The difference is rather pronounced over a portion of the scales, but there is practically always some difference. This is principally due to the impedance factor, that is, the capacity and inductance effects of the resistor or rectifier at the frequencies considered. The capacity may be rather high.

Also, the frequencies themselves are not unlimited. In general, frequencies for the types of rectifier units used in conjunction with meters, using the dissimilar plates closely held together, are not serviceable above 30 kc. It isn't that current fails to flow, but that it fails to flow according to the calibration of the scale. The absolute values becomes worthless, practically, at higher frequencies, although a meter manufacturer might supply data wherefrom the true voltage could be calculated, in respect to frequencies higher than 30 kc. In general, of course, measurements are made of low frequencies, say, not above 10 kc. These frequencies are in the audio realm.

Other Rectification Aspects

Aside from the use of rectifiers with d-c meters, it is interesting to note that real rectification exists whenever there is a substantial change of frequency. In the more familiar instances to which the word rectification is applied the change is from a-c values to d-c values. There may be a ripple of a.c. present, but a filter would be used to wipe that out. In a superheterodyne, the mixer tube, or modulator, is a rectifier in a very real sense. Are not two frequencies put into it, and is not one lower frequency taken out? Hence has there not been a change of frequency? There has. Rectification has taken place.

In the same sense the cathode-ray oscilloscope may be regarded as a rectifier, because a.c. may be put in, of a very high frequency, a timing circuit used to cause reduction in the number of pulses, while maintaining their relative amplitudes and other proportions, hence there has been a change of frequency for visual purposes, or rectification.

KYW

(*Continued from preceding page*)

transmitter will return at once to full power. If the trouble is not cleared up, the station automatically shuts down and requires attention of the operator.

Air Envelope for Condensers

The tuning condensers for most transmitters are large plates carefully insulated and spaced from each other and suspended in the transmitting frame with free circulation of air around. In the new station, the tuning condensers are mounted in cylindrical tanks measuring not over a foot in diameter and 3 feet high. These tanks are sealed and nitrogen is introduced under high pressure. Although greatly reduced in size from former types of condensers, these nitrogen filled condensers are able to withstand even higher operating voltages. Even though the parts of the condenser are sealed inside, it is possible to tune them from the front panel of the transmitter control board just as one would turn a dial on an ordinary radio receiver.

To minimize the generation of harmonic frequencies in the radio equipment, special attention is given to the balancing of all circuits. Furthermore in the power amplifier, where the generation of harmonic frequencies is of serious consequence, the use of shielded nitrogen filled condensers is used. Other parts of the power amplifier are carefully shielded and balanced.

The Static Shield

Also, there is a static shield consisting of a sheet of vertical wires suspended between the two coils which connect the output of the radio amplifier to the antenna system. This static shield is grounded, thereby, preventing the transmission of harmonic frequencies by capacity reaction between these two coils.

THE RCA COMMUN

Model ACR-136 Suitable Especially for A

By Ler

A NEWLY announced radio receiver is the RCA Amateur Communications receiver Model ACR-136. This receiver utilizes the super-heterodyne circuit with an i.f. of 460 kc and an additional oscillator for beating against c-w signals. It also contains automatic volume control and a pentode output stage. Its tuning range occurs in three bands as follows:

A 540— 1720 kc—Broadcast, police
B 1720— 5400 kc — Amateur, police, aviation
C 5400—18000 kc — Amateur, S. W. broadcast, aviation.

Integral with the equipment are the power supply and a dynamic loudspeaker operating from the pentode output stage which delivers 1.9 watts of undistorted power. In other words, the whole works is in one box.

A.V.C. May Be Cut Out

The tuner part has one tuned r-f stage, for low image-frequency response and high signal-to-noise ratio. The set has sufficient sensitivity to go well below the noise level in almost any location. The selectivity is such that stations can be copied through the QRM. The audio system of this receiver is equal in quality with that of a good broadcast receiver, bringing a new pleasure to phone work.

The controls have been arranged for maximum convenience and ease of operation. No plug-in coils are required, the desired band being selected by a switch next to the main tuning control. The use of both a sensitivity control and an audio-gain control permit the operator unusual flexibility in controlling background noise. A jack, which mutes the speaker when phones are plugged in, is provided on the front panel. An easily operated toggle "stand-by" switch removes the plate voltage from the tubes during periods of transmission, but leaves the heaters lighted and ready for instant operation. A switch to cut out the a.v.c. permits the clarification of slow-speed telegraph signals. An adjustment of the beat oscillator control allows the selection of the desired beat frequency for c-w reception. A tone control is provided and is particularly useful in reducing background noises.

Ease of tuning is provided mechanically by a two-speed reduction drive. The low ratio (10 to 1) permits any band to be covered rapidly, while pulling out the main tuning knob increases the ratio to 50 to 1 for fine tuning.

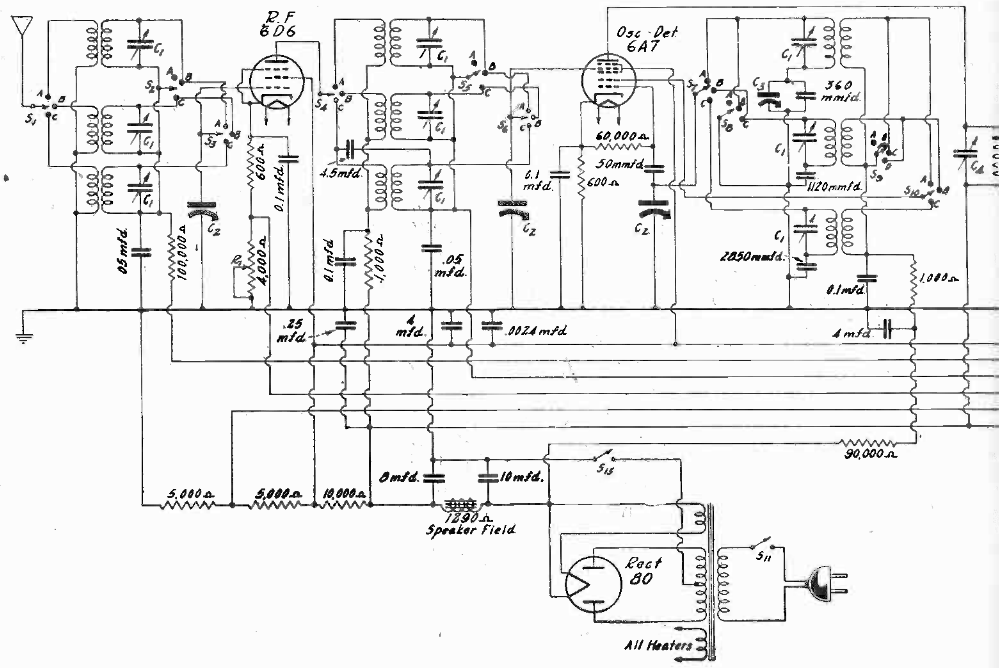
A unique dial permits the positive logging of stations of any frequency without re-setting to a reference point. Band spreading is provided by the vernier pointer which travels approximately nineteen times as fast as the main pointer. The main dial, accurately calibrated in megacycles, facilitates the location of stations.

Operation Detailed

By the agency of this dial, tuning is of course accomplished. This controls by means of a single knob the tuning of the r-f amplifier, oscillator and first detector circuits through a three-gang variable capacitor. The procedure in tuning this set for broadcast or amateur phone stations involves the following steps:

1. Turn the power switch on and advance the sensitivity control for maximum sensitivity.
2. Select the position of the band switch at which the band letter that is visible through the small opening in the dial corresponds to the frequency scale that includes the station desired.
3. Set standby and a-v controls on and the beat frequency oscillator control off.
4. Advance volume control until background noise is heard.
5. Push in tuning knob on dial and rotate short pointer to approximate setting of desired station then pull knob out and adjust to exact center of carrier.
6. Decrease volume as necessary and adjust tone control for preferred quality of reproduction.

If several moderately strong stations are available, silent tuning between station settings may be obtained by turning sensitivity control counterlockwise until background noise (at any point on the dial where no signal is heard) just disappears. Obviously, weak or distant stations below the noise level will not be received after this adjustment.



The circuit of the ACR

Use of Beat Oscillator

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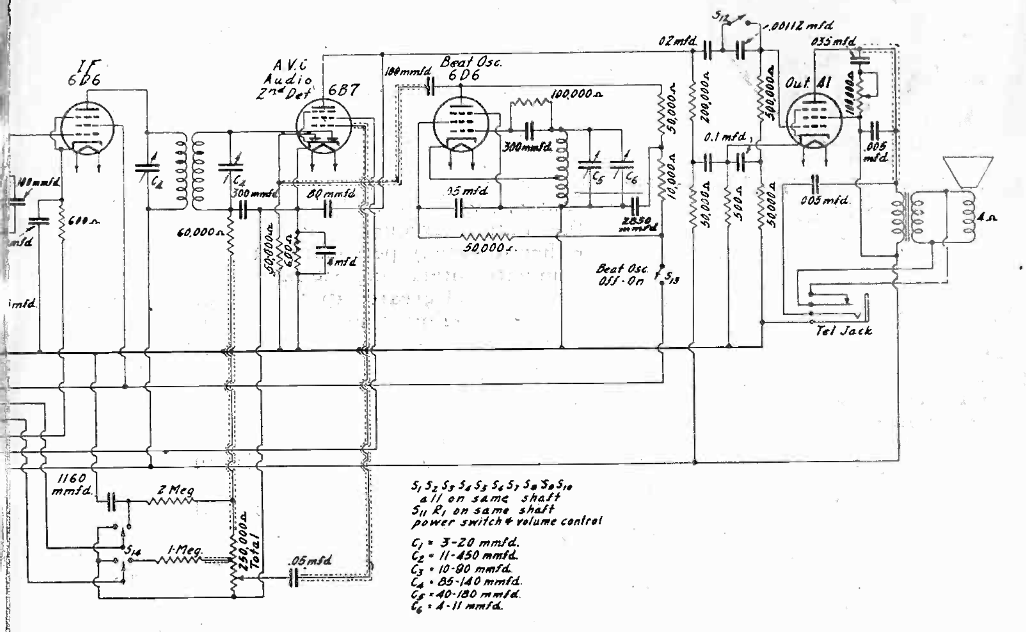

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It should be noted at this point that the three tuning ranges are obtained through a coil-selector system in conjunction with the one three-gang variable capacitor. Three sets of coils, each set consisting of three coils, are employed and with each shift of the range switch, a different and complete coil set is substituted. In addition to selecting the desired coil set, other contacts are provided on the range switch to short-circuit the coil set for band A when operating in band B and the coil set for band B together with the oscillator coil for band A when operating in band C. This practice prevents the occurence of "dead spots" in bands B and C because of absorption effects in coil sets A and B which (when untuned) have natural periods within the range of the next higher-frequency band.

The beat frequency that is set up in the first detector carries the same modulation as the original r-f signal and is commonly termed the *intermediate* frequency. Since this intermediate frequency is constant for all r-f carriers, the next (i-f amplifier) stage utilizes fixed tuning. Its grid circuit is coupled to the first detector through a transformer, both windings of which are tuned to the intermediate frequency (460 kilocycles) by means of independent adjustable capacitors. A similarly-tuned transformer is used to couple the output of this amplifier to the second detector, making a total of four capacitors for adjustment during alignment.

The i-f signal generated by the beat oscillator for c-w reception also is applied to the input of the second detector. As mentioned, the variable capacitor operated by the horizontal rod inside the case is actually a *vernier* control which permits adjustment of the oscillator output frequency over a very limited range on either side of the receiver intermediate frequency. The little condenser is connected in parallel with the main tuning capacitor for the oscillator stage—also a variable air-dielectric unit accessible for adjustment by means of a screw-driver through an opening in bottom of case. Both capacitors together with the oscillator tuning coil are contained inside a single shield.

A.V.C. in This Stages

In addition to detection, the succeeding stage also performs functions of automatic volume control and audio-frequency amplification. Diode detection is employed to avoid distortion and provide automatic volume control. The i-f signal is applied between the cathode and diode plate elements of the tube and the volume control, which is in series with this circut, assumes a negative d-c potential of an amplitude that varies directly in accordance with the strength of the original r-f carrier. By returning this potential or portions thereof to the grids of the r-f amplifier, first detector and i-f amplifier, these tubes are biased in varying degree to compensate for fluctuations in field strength (fading) and for extreme changes of r-f input when tuning. The switch in this circuit permits elimination of the automatic volume control feature by removing all variable bias from the afore-mentioned tubes.

The audio-frequency component of the rectified signal is capacitance-coupled from the arm of the volume control to the pentode section wherein amplification occurs. Resistance coupling is used between this amplifier section and the power output stage which also is connected as a pentode for high-power sensitivity. The plate circuit of the output stage is matched to the cone coil of the electro-dynamic loudspeaker through a step-down (output) transformer.

A tone control circuit consisting of a variable resistor and a fixed capacitor in series is connected across the primary of the output transformer. The sensitivity control is a variable resistor common to the cathode circuits of the r-f and i-f amplifiers for alteration of self-bias produced by the combined plate currents for those tubes.

All power voltages are obtained from a full-wave rectifier and filter system connected to the a-c line. The loudspeaker field coil is excited from this system and serves therein as a filter reactor.

Controls

All controls except the beat oscillator frequency adjustment are located upon the front panel and identified insofar as necessary by adjacent markings.

Power Switch and Sensitivity Control—The POWER switch is combined with a SENSITIVITY control and operates at the counter-clockwise end of rotation. When the knob is turned clockwise from latter extremity, the switch closes initially to supply power to receiver and continued rotation increases the sensitivity of receiver gradually to a maximum. Sensitivity is controlled by variation of the grid-bias voltage applied to the r-f and i-f amplifiers. In operation, this control may be employed to provide "silent tuning" between station settings. It is particularly advantageous, however, as an auxiliary volume control when the automatic volume control action of the receiver is removed.

Tone Control—Next in order to the right is a TONE control for attenuation of the higher frequencies, *full-range* reproduction being obtained with the knob turned fully clockwise. Under adverse weather conditions, static interference generally will be reduced to an appreciable extent by restricting the audio-response range. The control circuit consists of a variable resistor in series with a fixed capacitor and is connected across the primary of the output transformer.

Beat Oscillator Switch—The C. W. OSC. switch, located immediately to the right of the tone control, serves to interrupt plate and screen grid supply voltages to the beat-frequency oscillator stage. Thus, that stage can be rendered inoperative at any time, but, since the filament remains

(Continued on next page)

THE RCA COMMUN

Model ACR-136 Suitable Especially for A

By Ler

A NEWLY announced radio receiver is the RCA Amateur Communications receiver Model ACR-136. This receiver utilizes the super-heterodyne circuit with an i.f. of 460 kc and an additional oscillator for beating against c-w signals. It also contains automatic volume control and a pentode output stage. Its tuning range occurs in three bands as follows:

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The controls have been arranged for maximum convenience and ease of operation. No plug-in coils are required, the desired band being selected by a switch next to the main tuning control. The use of both a sensitivity control and an audio-gain control permit the operator unusual flexibility in controlling background noise. A jack, which mutes the speaker when phones are plugged in, is provided on the front panel. An easily operated toggle "stand-by" switch removes the plate voltage from the tubes during periods of transmission, but leaves the heaters lighted and ready for instant operation. A switch to cut out the a.v.c. permits the clarification of slow-speed telegraph signals. An adjustment of the beat oscillator control allows the selection of the desired beat frequency for c-w reception. A tone control is provided and is particularly useful in reducing background noises.

Ease of tuning is provided mechanically by a two-speed reduction drive. The low ratio (10 to 1) permits any band to be covered rapidly, while pulling out the main tuning knob increases the ratio to 50 to 1 for fine tuning.

A unique dial permits the positive logging of stations of any frequency without re-setting to a reference point. Band spreading is provided by the vernier pointer which travels approximately nineteen times as fast as the main pointer. The main dial, accurately calibrated in megacycles, facilitates the location of stations.

Operation Detailed

By the agency of this dial, tuning is of course accomplished. This controls by means of a single knob the tuning of the r-f amplifier, oscillator and first detector circuits through a three-gang variable capacitor. The procedure in tuning this set for broadcast or amateur phone stations involves the following steps:

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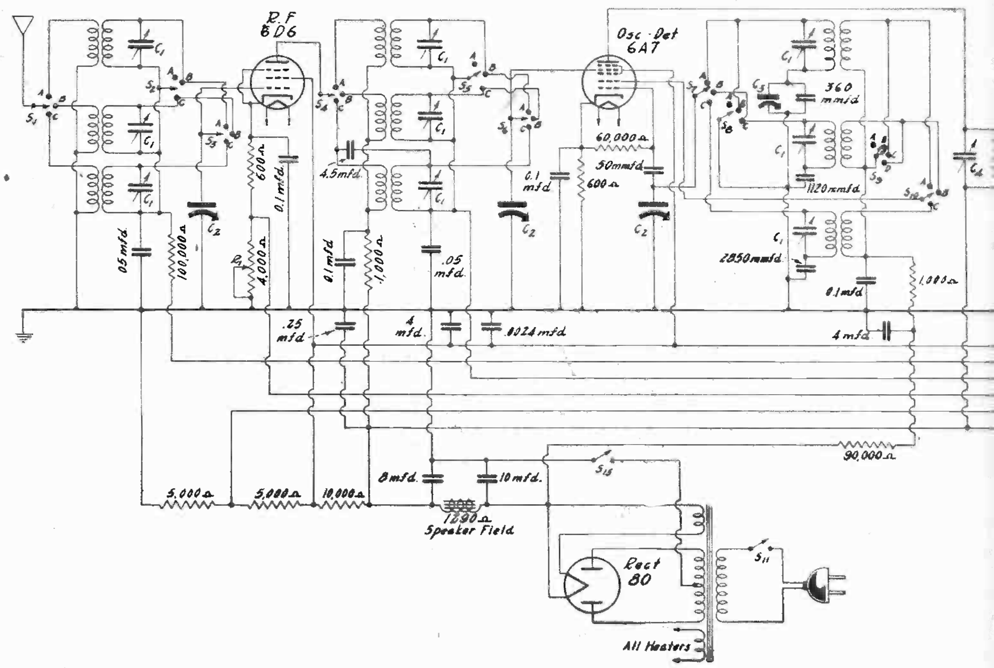

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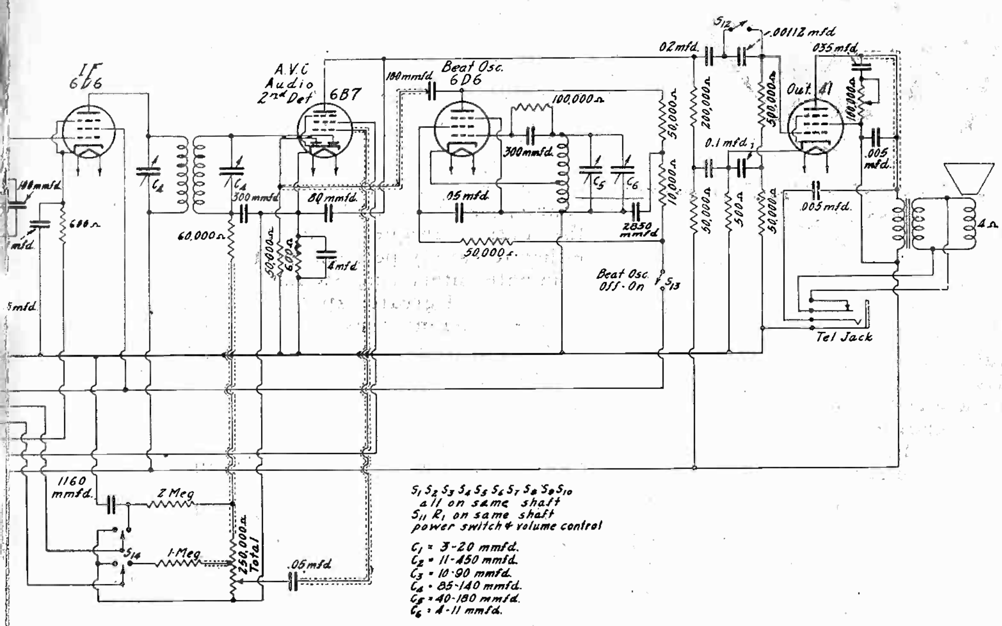

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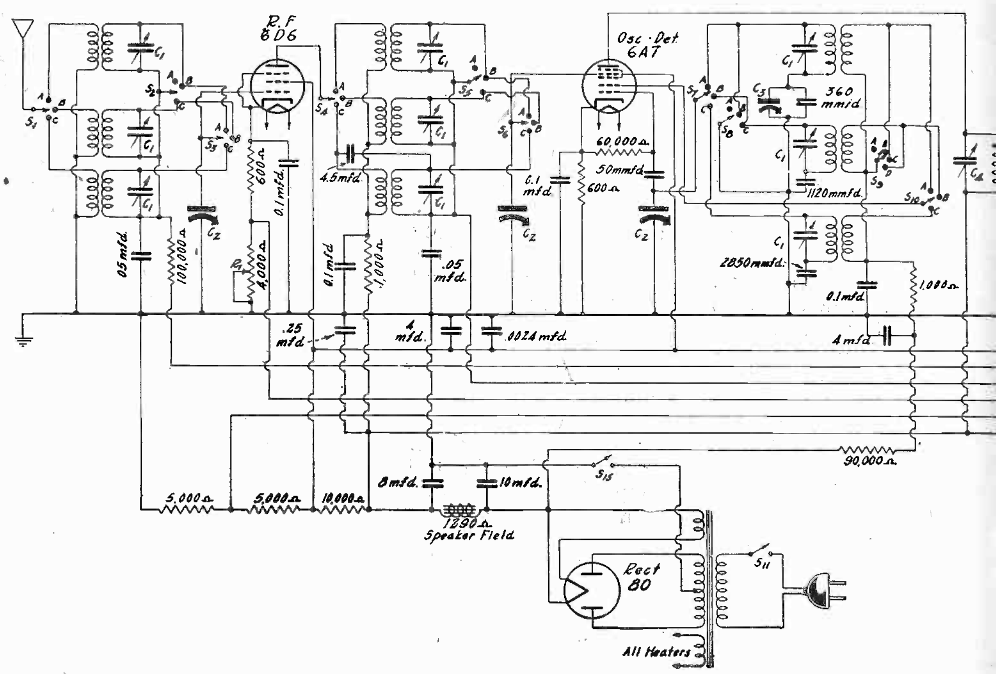

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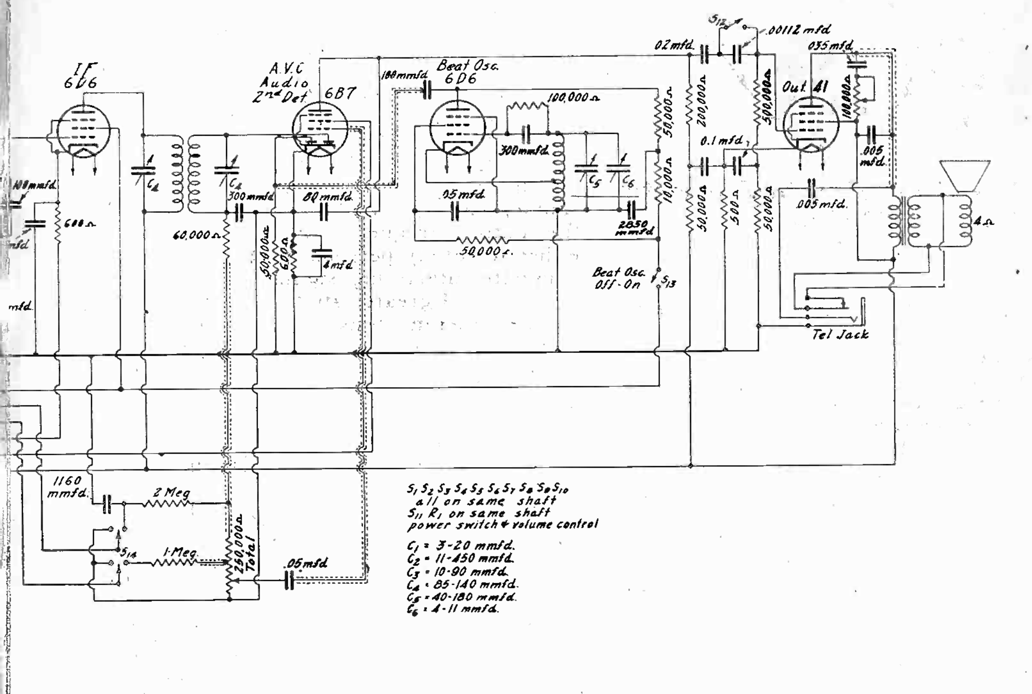

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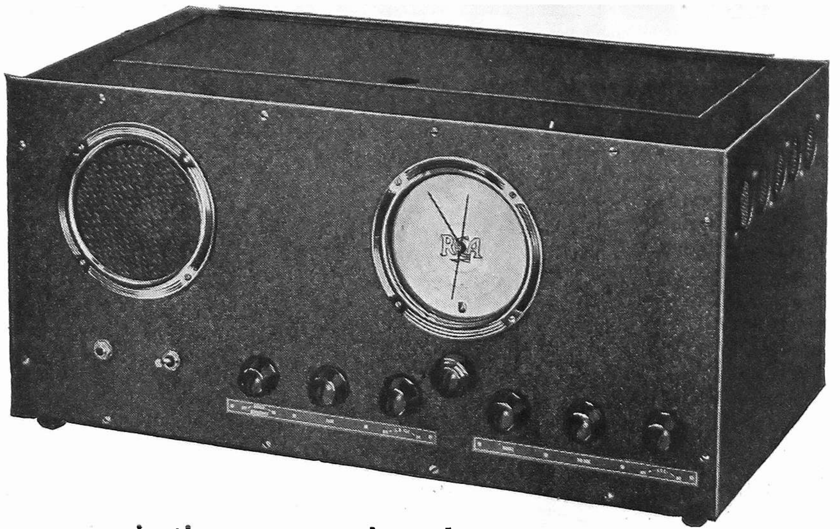

A new communication type receiver that is self-contained and operates between the frequencies of 540 kc. to 18000 kc.

(*Continued from preceding page*)
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Beat Oscillator Frequency Control—To provide manual control of the output frequency over a limited range on each side of the "zero-beat" position, a midget variable air capacitor is connected across the main tuning capacitor for the beat oscillator stage. Such adjustment is made inside the case upon lifting the lid, the small capacitor being located inside a shield at the rear left-hand corner of the chassis and operated by means of a horizontal rod pivoted from the top of that shield.

Tuning Control—The knob directly beneath the dial is the main tuning control. This knob when set inward affords a drive ratio of 10:1 for rapid adjustment and, when pulled out, engages a secondary drive with a ratio of 50:1 for precise tuning—a valuable feature for short-wave work.

Range Switch—The following knob to the right is a RANGE switch for selecting any of the three bands whose frequency limits are tabulated under "Electrical Specifications." A visual band indicator operates in conjunction with this knob, the band letters corresponding to the various switch positions appearing in sequence through a small opening in the lower half of the dial.

Volume-Control—The VOLUME control is connected in the audio-frequency circuit and increases the output level with clockwise rotation.

Automatic Volume Control Switch—On the extreme right-hand end of the front panel is the a.v.c. control—a switch for eliminating automatic volume control action to obtain best reception of slow-speed code transmission.

Stand-by Switch—The toggle switch located on the front panel is connected in the plate circuit of the rectifier stage. When thrown to the left, all plate and screen grid voltages are removed, but the filament supply is unaffected, leaving the receiver "warmed-up" so that operation can be resumed instantaneously. Amateurs will find this switch highly advantageous for silencing the receiver during "sending" periods.

Phone Jack—The phone jack on the panel at the extreme left-hand end permits quick substitution of headphones for reception of extremely weak signals. When a phone plug is inserted in this jack, it simultaneously short-circuits the voice coil of the electrodynamic loudspeaker and connects the phones through a small capacitor across the plate circuit of the power output stage. Since the loudspeaker field is employed as a filter for the rectifier stage, that unit still forms an active part of the circuit when using headphones.

Dial

The dial of this instrument incorporates a mechanical band-spread system particularly suited to amateur or other work where a fine degree of resetability is required. In addition to the three main scales calibrated directly in frequency (kilocycles or megacycles), two arbitrary scales are available for precision logging. These are known as the *vernier* and *vernier index* scales, the former being fully circular at the outside of the dial and the latter semi-circular at the center of the dial.

It will be observed that the *vernier* scale is graduated from "0" to "100" and traversed by the long single-ended pointer. On the other hand, the *vernier index* scale is graduated from "0" to "9" and traversed by the short double-ended pointer used for the main frequency scales. The longer pointer makes one complete revolution for each unit of travel of the shorter pointer on the *vernier index* scale. Thus, any station may be logged accurately with three digits; for example, if the *vernier index* reading is between "3" and "4" and the *vernier* reading is "72," then the log number is "372." The index number is always the lower of the two numbers between which the pointer is located.

In logging stations by this method, the band *letter* also must be named. For the above example, therefore, the full log number would be "A-372," "B-372," or "C-372," depending upon the setting of the range switch. As mentioned under "Controls," the band letter is visible through a small opening near the bottom of the dial.

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Beat Oscillator

The beat-frequency oscillator embodied in this receiver is of the electron-coupled type, known to afford excellent frequency stability. Its primary purpose, of course, is to enable the reception of c-w (continuous-wave) telegraph signals, but it also may be used to advantage in locating regular broadcast or other modulated forms of transmission by the "birdie" method. Although the latter practice usually will be unnecessary because of the high sensitivity of this receiver, it may be found expedient in cases where the signal strength is very low or the carrier is not modulated continuously.

For c-w reception, it is customary to adjust the oscillator frequency to a value 1 or 2 kc above or below the intermediate frequency of the receiver. Thus, all carriers to which the receiver can be tuned will be heard at ***exact*** resonance as notes of the same pitch since the beat or separation frequency will be constant throughout the entire tuning range. The pitch, of course, may be varied at will by changing the output frequency of the oscillator, either to satisfy personal preference or to eliminate interfering signals. Best intelligibility and greater apparent volume due to the inherent sensitivity characteristic of the human ear will result using a moderately low-pitch or beat frequency in the order of 500 to 1,000 cycles, but *audio-image* interference will decrease with ascending pitch.

Audio-image interference is an effect entirely distinct from that commonly referred to in superheterodynes by the term "image-frequency response." By the latter is meant interference set up by an incoming carrier on the same side of the desired carrier as the *radio-frequency* oscillator but removed by *exactly* twice the receiver intermediate frequency. Such interference in this receiver is rendered negligible through the use of a pre-selector or radio-frequency amplifier stage.

Data on Beats

When using the beat oscillator, interference of the same pitch as the desired signal can be produced by any continuous-wave signal which upon passing through the receiver is converted to an intermediate frequency on the same side of the receiver intermediate frequency as the beat oscillator but removed by *exactly* twice the separation of the beat oscillator. In this case, the interfering signal would be a *true* audio image. If one merely visualizes the sharp selectivity curve of the superheterodyne, he will observe at once that the attenuation offered by the tuned circuits of the receiver to such *image* responses will increase very rapidly as the oscillator separation is widened.

It should be appreciated in relation to the preceding paragraph that interference signals can be encountered not only at the *audio-image* frequency but at any frequency above or below the beat oscillator frequency at a separation within the audio range. Such beat notes ordinarily will be distinguishable from the pitch of the desired signal because of the dissimilarity of pitch. In cases where both sound almost alike, confusion between the desired and undesired signals can be practically always eliminated by shifting the setting of the beat oscillator.

If a beat note of approximately the same pitch as the desired signal is heard, the interfering signal must be either near the frequency of resonance or near the *audio-image* frequency. For the first condition, best discrimination will be obtained using a fairly low pitch frequency on the opposite side of zero beat from the interfering frequency. Use of a relatively low pitch is recommended since for a given small frequency separation, say 100 cycles, two notes will be much more discernible in the region of 500 cycles than at 1,500 cycles. When the interfering signal is at or near the audio-image frequency, however, two alternatives are possible. The

(*Continued on next page*)

Radio Demolishes Frontiers for Farmers

By Powel Crosley, Jr.

(*Continued from preceding page*)
oscillator frequency either can be adjusted to zero beat with the frequency of interferences or swung through zero beat with the desired signal to some value on the opposite side of i-f resonance.

Difference Frequency

As an example, to illustrate the latter alternatives, suppose that with the receiver tuned to a station, the beat oscillator is adjusted to one kilocycle above the intermediate frequency and that an interfering signal is present at 1,900 cycles above i-f resonance (100 cycles below the audio-image frequency). Thus, the desired frequency will produce a 1 kilocycle note and the interfering signal a note of 900 cycles, these tones being sufficiently close that the former probably would not be discernible readily. By increasing the oscillator frequency by 900 cycles, however, the desired signal would be as a 1,900 cycle note and the undesired signal heterodyned to zero frequency. On the other hand, the oscillator frequency could be changed to a point on the opposite side of the i-f resonance so that the desired signal would again be heard as a one kilocycle note. The interfering signal then would produce a note of 2,900 cycles and so should cause no confusion.

Quite a great percentage of the kick derived from the ham game involves the reception of distant stations and to improve this phase of the game, a good receiver is a big asset. Also, a transmitter will reach no further than the distance which can be reliably heard on the receiver. Thus, we are enabled to say that with the use of such a sensitive receiver as described herein, the range of a ham station transmission is increased without touching the adjustments of the transmitter.

EDDY IS NEW WBZA OPERATOR

J. C. Eddy, former ship to shore operator for the United Fruit Line, has become station operator at WBZA in Springfield, Massachusetts. Mr. Eddy was associated with WEAF in 1926 and 1927 and since that time has been with the United Fruit Line.

AT one time it was thought that each farmer lived in a world by himself, independent of all other forces. That never was true, but many farmers and others thought it was. In recent years farmers have awakened to the fact that perhaps more than any other group of people they are most vitally affected not only by local, state and national conditions, but by the affairs of the world, especially those that have a bearing on world markets. No, none of us, not even the farmer, lives by himself.

Four factors have played an outstanding part in bringing farmers in closer contact with the world, much to their advantage. First came rural free delivery that made possible daily newspapers on the farm. About the same time came the telephone, making communication quick between farmers and their neighbors, as well as their local markets. Next came the automobile, which gave farmers the personal transportation advantage. Then came radio, and the farmer's range of contacts was extended over a state or several states. Now with radios for American and foreign reception, his sphere has extended beyond the boundaries of a single country to all the world.

Barriers Broken Down

What has all this meant to farmers? For one thing, it has broken down the last barriers of isolation. It has put farmers in close, first-hand touch with the world, with markets and all the things that govern farm prices, with state, national and even international events and developments. It has made it possible for them to be informed about everything that has a bearing on their economic, social and political welfare. It has brought about a better knowledge of conditions and therefore greater opportunity for farmers to act with as much information and foresight about their business as business men and other groups. By hearing discussions of business, economic and political questions farmers are in a better position to formulate their own plans and policies and take better advised action in their own interest. No longer is it necessary for them to grope uninformed about vital issues and conditions that in the past have been unseen and unknown forces that controlled their destiny, and seemingly were insurmountable and uncontrollable.

Aside from these practical advantages, there is brought to farmers a whole world of entertainment. Programs in distant cities that would be unavailable and that would be exceedingly costly were it possible to attend them, are brought right into the home on the farm.

Sphere Is Widened

The farm family can sit by the fireside on cold wintry nights and in unfavorable weather and have the best enjoyment that the wide world affords, for with American and foreign radio receiving sets, all one has to do is to turn the dial to get programs from any part of the country or the world. Through radio, news is available to farmers as well as to others right while it is happening. Every educational and cultural advantage is theirs for they can listen to plays, musicals and lectures on all kinds of subjects, which but for radio would be impossible. The work of the womenfolk on the farm is made lighter and brighter by programs that bring music, plays and other entertainment, as well as helpful suggestions about homework, cooking and the many things women have to do. During the noon hour as well as in the evening recreation is brought to the men, also.

Battery sets, as well as sets operated by home power plants, are available at low cost so that if the farm is away from power lines, a radio may be enjoyed regardless of location. Radios have been so perfected that it is easy to instal any type.

Location Is Best

Moreover, farmers get the best reception because they are away from the sources of man-made interference or the disturbances of industrial centers. There are no steel structures, electric lines, street railways, nor power plants to cause interference in reception. They not only have greater range, but much better quality of reception.

A radio will pay for itself many times over on the farm by bringing up-to-the-minute market quotations and weather reports that let farmers know when to plant crops or harvest them, and when to sell grain, stock, poultry and produce. It warns them of frosts and other factors that have a bearing on farmers' profits. With a radio the farmer knows what to expect and what to do. And good radios are to be had from twenty dollars up!

PERSONAL NOTES

E. H. Gager has been appointed plant manager of KYW. For several months he was in charge of the construction of the Philadelphia station. Mr. Gager for nineteen years was assistant superintendent of the Commonwealth Edison Company, Chicago. From 1922 to 1925 he was associated with KYW, Chicago. For four years he was chief engineer of WEMR, Chicago, later becoming staff engineer with the National Broadcasting Company. Mr. Gager's duties will include technical supervision of the studio and station of KYW.

A. C. Goodnow, formerly studio supervisor at KDKA, holds the same position at KYW. The control operators include F. M. Sloan, from KDKA; I. N. Eney and C. E. Donaldson, from WBZ.

J. J. Michaels, formerly chief operator of KYW, chicago, is chief operator at the Philadelphia transmitter. His operating staff includes Bryan Cole, Bernard Clark and W. C. Ellsworth. Mr. Clark was formerly of the Radio Broadcasting Headquarters staff and Mr. Ellsworth of the Radio Engineering Department of the Radio Division of Westinghouse in Chicopee Falls, Mass.

NEW SOLAR CATALOGUE

The Solar Manufacturing Corporation, 599-601 Broadway, New York City, manufacturer of Fixed Capacitors for radio use, announces the issuance of the latest Special Service Catalog No. 6-S.

Features of interest to the service trade include ultra-compact dry electrolytics in various voltage ratings, special self-healing type wet electrolytic condensers, auto vibrator and suppressor condensers, together with a wide assortment of paper, mica, trimmer and padding condensers.

These catalogs may be obtained direct from the Solar Manufacturing Corporation.

FASTER HOMCHARGER

Originally introduced in 1920 by the Automatic Electrical Devices Co., of 324 East Third Street, Cincinnati, Ohio, the Homcharger for recharging automobile batteries in your own garage proved so successful that nearly a million were sold within a few years. Now the same company announces a new and improved model known as the Hi-Rate Homcharger.

The use of larger and higher compression engines, dual electric horns, more powerful lights, auto radios, etc. has imposed such a drain upon the car battery that a much faster charging rate was deemed necessary.

A THOUGHT FOR THE WEEK

TO BE OR NOT TO BE—POPULAR OR CLASSIC? The wiseacres of the music world are racking their brains in an effort to discover whether the public as a whole prefers popular music or the music of the masters. Of course, when the ransacking of brains and the balancing of percentages is all over they still won't know very much more than they do now. There are so many people in the world and so little standardization, how can guessers settle a question which has been debated for centuries? And whose decision will be accepted as final? And who has figures that are convincing—and what the dickens is it all about, anyhow?

THE RCA COMMUN

Model ACR-136 Suitable Especially for A

By Ler

A NEWLY announced radio receiver is the RCA Amateur Communications receiver Model ACR-136. This receiver utilizes the super-heterodyne circuit with an i.f. of 460 kc and an additional oscillator for beating against c-w signals. It also contains automatic volume control and a pentode output stage. Its tuning range occurs in three bands as follows:

A 540— 1720 kc—Broadcast, police
B 1720— 5400 kc — Amateur, police, aviation
C 5400—18000 kc — Amateur, S. W. broadcast, aviation.

Integral with the equipment are the power supply and a dynamic loudspeaker operating from the pentode output stage which delivers 1.9 watts of undistorted power. In other words, the whole works is in one box.

A.V.C. May Be Cut Out

The tuner part has one tuned r-f stage, for low image-frequency response and high signal-to-noise ratio. The set has sufficient sensitivity to go well below the noise level in almost any location. The selectivity is such that stations can be copied through the QRM. The audio system of this receiver is equal in quality with that of a good broadcast receiver, bringing a new pleasure to phone work.

The controls have been arranged for maximum convenience and ease of operation. No plug-in coils are required, the desired band being selected by a switch next to the main tuning control. The use of both a sensitivity control and an audio-gain control permit the operator unusual flexibility in controlling background noise. A jack, which mutes the speaker when phones are plugged in, is provided on the front panel. An easily operated toggle "stand-by" switch removes the plate voltage from the tubes during periods of transmission, but leaves the heaters lighted and ready for instant operation. A switch to cut out the a.v.c. permits the clarification of slow-speed telegraph signals. An adjustment of the beat oscillator control allows the selection of the desired beat frequency for c-w reception. A tone control is provided and is particularly useful in reducing background noises.

Ease of tuning is provided mechanically by a two-speed reduction drive. The low ratio (10 to 1) permits any band to be covered rapidly, while pulling out the main tuning knob increases the ratio to 50 to 1 for fine tuning.

A unique dial permits the positive logging of stations of any frequency without re-setting to a reference point. Band spreading is provided by the vernier pointer which travels approximately nineteen times as fast as the main pointer. The main dial, accurately calibrated in megacycles, facilitates the location of stations.

Operation Detailed

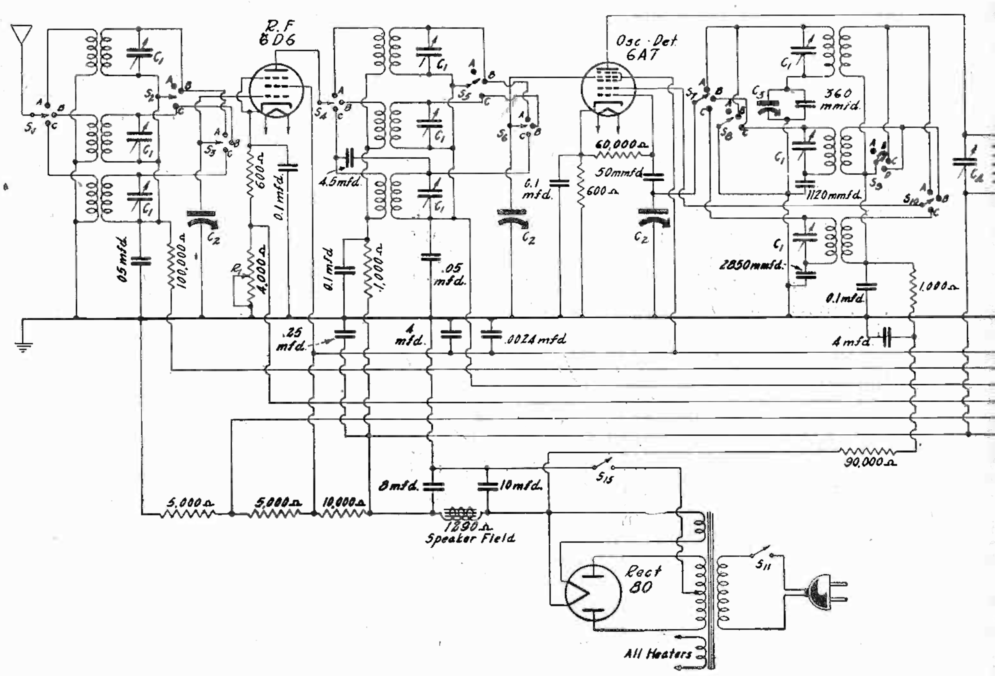
By the agency of this dial, tuning is of course accomplished. This controls by means of a single knob the tuning of the r-f amplifier, oscillator and first detector circuits through a three-gang variable capacitor. The procedure in tuning this set for broadcast or amateur phone stations involves the following steps:

1. Turn the power switch on and advance the sensitivity control for maximum sensitivity.
2. Select the position of the band switch at which the band letter that is visible through the small opening in the dial corresponds to the frequency scale that includes the station desired.
3. Set standby and a-v controls on and the beat frequency oscillator control off.
4. Advance volume control until background noise is heard.
5. Push in tuning knob on dial and rotate short pointer to approximate setting of desired station then pull knob out and adjust to exact center of carrier.
6. Decrease volume as necessary and adjust tone control for preferred quality of reproduction.

If several moderately strong stations are available, silent tuning between station settings may be obtained by turning sensitivity control counterlockwise until background noise (at any point on the dial where no signal is heard) just disappears. Obviously, weak or distant stations below the noise level will not be received after this adjustment.

Use of Beat Oscillator

In the efforts to locat eweak, odulated signals, the beat oscillator may be used to advantage. It should be tuned for this purpose exactly to the intermediate frequency of the receiver so that an audio frequency note of ascending pitch will be obtained on each side of every incoming carrier. To adjust the beat oscillator in this manner, simply tune the receiver accurately to any carrier of suitable



The circuit of the ACI

strength, then turn the beat oscillat switch on and swing the small horizont rod inside the case in either direction ur zero beat is obtained. It follows then th any carrier will be tuned to exact res nance when the tuning capacities are a justed to zero beat and that the presen of weak signals will be heard almost well as that of signals of greater streng because of the heterodyne whistle pr duced while passing through resonance.

For c-w code reception, the tuning pr cedure is the same as for modulated s nals except that the beat oscillator pe forms a definite rather than inciden function. It is set not at the intermedia frequency but slightly above or below as to provide an audio frequency be note when the receiver is tuned to res nance with any carrier. The tuning c pacities then should be adjusted to t center of the carrier by listening to t switch or key clicks before turning the beat oscilla or switch. Always adj the pitch with the horizontal rod never means of the tuning control knob.

Data on Circuit

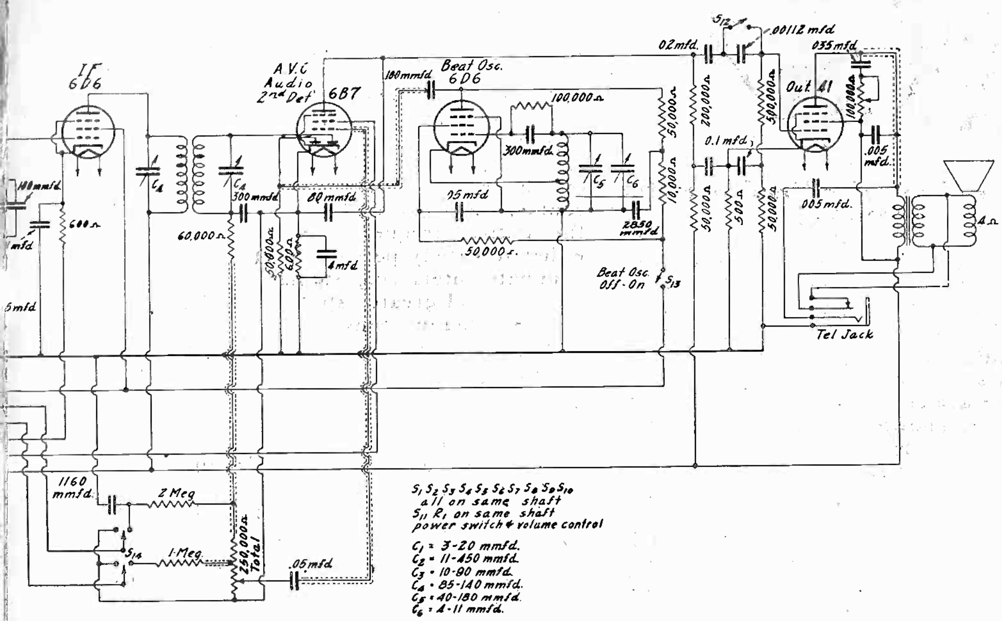
Upon entering the receiver a sign passes through a shielded lead to the a tenna coupling transformer, the seconda of which is tuned by one section of t three-gang variable capacitor, and thence impressed upon the grid of the amplifier—a stage of pre-selection us primarily for reducing image-frequen interference to a negligible value. T output of this stage is transformer coupl to the grid circuit of the first detect which also is tuned to the signal frequen by the second unit of the gang capacit

As in all superheterodynes, the first c tector is actually a mixer stage, combini

ICATION RECEIVER

ıateurs, Though for General All-Wave Use

Mastick



communication receiver.

the incoming r-f carrier with an unmodulated sinusoidal voltage produced by a local oscillator. The oscillator plate circuit, being tuned by the third section of the gang capacitor, maintains a constant frequency difference from the transmitted signal throughout the entire tuning range. Thus, a difference or *beat* frequency is developed when any signal is received which is the same at each position of exact resonance. In this receiver, the functions of the first detector and oscillator are performed by a single tube.

Alignment Coils Shorted

It should be noted at this point that the three tuning ranges are obtained through a coil-selector system in conjunction with the one three-gang variable capacitor. Three sets of coils, each set consisting of three coils, are employed and with each shift of the range switch, a different and complete coil set is substituted. In addition to selecting the desired coil set, other contacts are provided on the range switch to short-circuit the coil set for band A when operating in band B and the coil set for band B together with the oscillator coil for band A when operating in band C. This practice prevents the occurence of "dead spots" in bands B and C because of absorption effects in coil sets A and B which (when untuned) have natural periods within the range of the next higher-frequency band.

The beat frequency that is set up in the first detector carries the same modulation as the original r-f signal and is commonly termed the *intermediate* frequency. Since this intermediate frequency is constant for all r-f carriers, the next (i-f amplifier) stage utilizes fixed tuning. Its grid circuit is coupled to the first detector through a transformer, both windings of which are tuned to the intermediate frequency (460 kilocycles) by means of independent adjustable capacitors. A similarly-tuned transformer is used to couple the output of this amplifier to the second detector, making a total of four capacitors for adjustment during alignment.

The i-f signal generated by the beat oscillator for c-w reception also is applied to the input of the second detector. As mentioned, the variable capacitor operated by the horizontal rod inside the case is actually a *vernier* control which permits adjustment of the oscillator output frequency over a very limited range on either side of the receiver intermediate frequency. The little condenser is connected in parallel with the main tuning capacitor for the oscillator stage—also a variable air-dielectric unit accessible for adjustment by means of a screw-driver through an opening in bottom of case. Both capacitors together with the oscillator tuning coil are contained inside a single shield.

A.V.C. in This Stages

In addition to detection, the succeeding stage also performs functions of automatic volume control and audio-frequency amplification. Diode detection is employed to avoid distortion and provide automatic volume control. The i-f signal is applied between the cathode and diode plate elements of the tube and the volume control, which is in series with this circut, assumes a negative d-c potential of an amplitude that varies directly in accordance with the strength of the original r-f carrier. By returning this potential or portions thereof to the grids of the r-f amplifier, first detector and i-f amplifier, these tubes are biased in varying degree to compensate for fluctuations in field strength (fading) and for extreme changes of r-f input when tuning. The switch in this circuit permits elimination of the automatic volume control feature by removing all variable bias from the afore-mentioned tubes.

The audio-frequency component of the rectified signal is capacitance-coupled from the arm of the volume control to the pentode section wherein amplification occurs. Resistance coupling is used between this amplifier section and the power output stage which also is connected as a pentode for high-power sensitivity. The plate circuit of the output stage is matched to the cone coil of the electro-dynamic loudspeaker through a step-down (output) transformer.

A tone control circuit consisting of a variable resistor and a fixed capacitor in series is connected across the primary of the output transformer. The sensitivity control is a variable resistor common to the cathode circuits of the r-f and i-f amplifiers for alteration of self-bias produced by the combined plate currents for those tubes.

All power voltages are obtained from a full-wave rectifier and filter system connected to the a-c line. The loudspeaker field coil is excited from this system and serves therein as a filter reactor.

Controls

All controls except the beat oscillator frequency adjustment are located upon the front panel and identified insofar as necessary by adjacent markings.

Power Switch and Sensitivity Control—The POWER switch is combined with a SENSITIVITY control and operates at the counter-clockwise end of rotation. When the knob is turned clockwise from latter extremity, the switch closes initially to supply power to receiver and continued rotation increases the sensitivity of receiver gradually to a maximum. Sensitivity is controlled by variation of the grid-bias voltage applied to the r-f and i-f amplifiers. In operation, this control may be employed to provide "silent tuning" between station settings. It is particularly advantageous, however, as an auxiliary volume control when the automatic volume control action of the receiver is removed.

Tone Control—Next in order to the right is a TONE control for attenuation of the higher frequencies, *full-range* reproduction being obtained with the knob turned fully clockwise. Under adverse weather conditions, static interference generally will be reduced to an appreciable extent by restricting the audio-response range. The control circuit consists of a variable resistor in series with a fixed capacitor and is connected across the primary of the output transformer.

Beat Oscillator Switch—The C. W. OSC. switch, located immediately to the right of the tone control, serves to interrupt plate and screen grid supply voltages to the beat-frequency oscillator stage. Thus, that stage can be rendered inoperative at any time, but, since the filament remains

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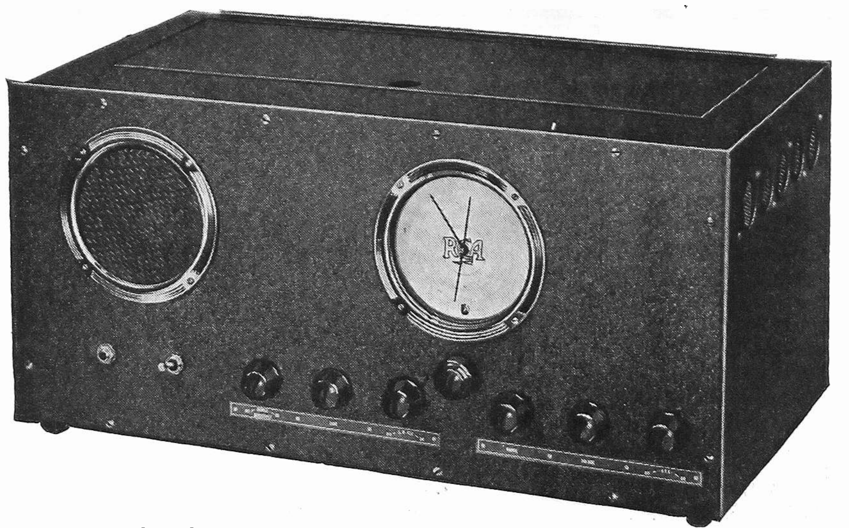

A new communication type receiver that is self-contained and operates between the frequencies of 540 kc. to 18000 kc.

(*Continued from preceding page*)

heated continuously, is ready for instantaneous operation.

Beat Oscillator Frequency Control—To provide manual control of the output frequency over a limited range on each side of the "zero-beat" position, a midget variable air capacitor is connected across the main tuning capacitor for the beat oscillator stage. Such adjustment is made inside the case upon lifting the lid, the small capacitor being located inside a shield at the rear left-hand corner of the chassis and operated by means of a horizontal rod pivoted from the top of that shield.

Tuning Control—The knob directly beneath the dial is the main tuning control. This knob when set inward affords a drive ratio of 10:1 for rapid adjustment and, when pulled out, engages a secondary drive with a ratio of 50:1 for precise tuning—a valuable feature for short-wave work.

Range Switch—The following knob to the right is a RANGE switch for selecting any of the three bands whose frequency limits are tabulated under "Electrical Specifications." A visual band indicator operates in conjunction with this knob, the band letters corresponding to the various switch positions appearing in sequence through a small opening in the lower half of the dial.

Volume-Control—The VOLUME control is connected in the audio-frequency circuit and increases the output level with clockwise rotation.

Automatic Volume Control Switch—On the extreme right-hand end of the front panel is the a.v.c. control—a switch for eliminating automatic volume control action to obtain best reception of slow-speed code transmission.

Stand-by Switch—The toggle switch located on the front panel is connected in the plate circuit of the rectifier stage. When thrown to the left, all plate and screen grid voltages are removed, but the filament supply is unaffected, leaving the receiver "warmed-up" so that operation can be resumed instantaneously. Amateurs will find this switch highly advantageous for silencing the receiver during "sending" periods.

Phone Jack—The phone jack on the panel at the extreme left-hand end permits quick substitution of headphones for reception of extremely weak signals. When a phone plug is inserted in this jack, it simultaneously short-circuits the voice coil of the electrodynamic loudspeaker and connects the phones through a small capacitor across the plate circuit of the power output stage. Since the loudspeaker field is employed as a filter for the rectifier stage, that unit still forms an active part of the circuit when using headphones.

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The dial of this instrument incorporates a mechanical band-spread system particularly suited to amateur or other work where a fine degree of resetability is required. In addition to the three main scales calibrated directly in frequency (kilocycles or megacycles), two arbitrary scales are available for precision logging. These are known as the *vernier* and *vernier index* scales, the former being fully circular at the outside of the dial and the latter semi-circular at the center of the dial.

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When using the beat oscillator, interference of the same pitch as the desired signal can be produced by any continuous-wave signal which upon passing through the receiver is converted to an intermediate frequency on the same side of the receiver intermediate frequency as the beat oscillator but removed by *exactly* twice the separation of the beat oscillator. In this case, the interfering signal would be a *true* audio image. If one merely visualizes the sharp selectivity curve of the superheterodyne, he will observe at once that the attenuation offered by the tuned circuits of the receiver to such *image* responses will increase very rapidly as the oscillator separation is widened.

It should be appreciated in relation to the preceding paragraph that interference signals can be encountered not only at the *audio-image* frequency but at any frequency above or below the beat oscillator frequency at a separation within the audio range. Such beat notes ordinarily will be distinguishable from the pitch of the desired signal because of the dissimilarity of pitch. In cases where both sound almost alike, confusion between the desired and undesired signals can be practically always eliminated by shifting the setting of the beat oscillator.

If a beat note of approximately the same pitch as the desired signal is heard, the interfering signal must be either near the frequency of resonance or near the *audio-image* frequency. For the first condition, best discrimination will be obtained using a fairly low pitch frequency on the opposite side of zero beat from the interfering frequency. Use of a relatively low pitch is recommended since for a given small frequency separation, say 100 cycles, two notes will be much more discernible in the region of 500 cycles than at 1,500 cycles. When the interfering signal is at or near the audio-image frequency, however, two alternatives are possible. The

(*Continued on next page*)

Radio Demolishes Frontiers for Farmers

By Powel Crosley, Jr.

(*Continued from preceding page*)
oscillator frequency either can be adjusted to zero beat with the frequency of interferences or swung through zero beat with the desired signal to some value on the opposite side of i-f resonance.

Difference Frequency

As an example, to illustrate the latter alternatives, suppose that with the receiver tuned to a station, the beat oscillator is adjusted to one kilocycle above the intermediate frequency and that an interfering signal is present at 1,900 cycles above i-f resonance (100 cycles below the audio-image frequency). Thus, the desired frequency will produce a 1 kilocycle note and the interfering signal a note of 900 cycles, these tones being sufficiently close that the former probably would not be discernible readily. By increasing the oscillator frequency by 900 cycles, however, the desired signal would be as a 1,900 cycle note and the undesired signal heterodyned to zero frequency. On the other hand, the oscillator frequency could be changed to a point on the opposite side of the i-f resonance so that the desired signal would again be heard as a one kilocycle note. The interfering signal then would produce a note of 2,900 cycles and so should cause no confusion.

Quite a great percentage of the kick derived from the ham game involves the reception of distant stations and to improve this phase of the game, a good receiver is a big asset. Also, a transmitter will reach no further than the distance which can be reliably heard on the receiver. Thus, we are enabled to say that with the use of such a sensitive receiver as described herein, the range of a ham station transmission is increased without touching the adjustments of the transmitter.

AT one time it was thought that each farmer lived in a world by himself, independent of all other forces. That never was true, but many farmers and others thought it was. In recent years farmers have awakened to the fact that perhaps more than any other group of people they are most vitally affected not only by local, state and national conditions, but by the affairs of the world, especially those that have a bearing on world markets. No, none of us, not even the farmer, lives by himself.

Four factors have played an outstanding part in bringing farmers in closer contact with the world, much to their advantage. First came rural free delivery that made possible daily newspapers on the farm. About the same time came the telephone, making communication quick between farmers and their neighbors, as well as their local markets. Next came the automobile, which gave farmers the personal transportation advantage. Then came radio, and the farmer's range of contacts was extended over a state or several states. Now with radios for American and foreign reception, his sphere has extended beyond the boundaries of a single country to all the world.

Barriers Broken Down

What has all this meant to farmers? For one thing, it has broken down the last barriers of isolation. It has put farmers in close, first-hand touch with the world, with markets and all the things that govern farm prices, with state, national and even international events and developments. It has made it possible for them to be informed about everything that has a bearing on their economic, social and political welfare. It has brought about a better knowledge of conditions and therefore greater opportunity for farmers to act with as much information and foresight about their business as business men and other groups. By hearing discussions of business, economic and political questions farmers are in a better position to formulate their own plans and policies and take better advised action in their own interest. No longer is it necessary for them to grope uninformed about vital issues and conditions that in the past have been unseen and unknown forces that controlled their destiny, and seemingly were insurmountable and uncontrollable.

Aside from these practical advantages, there is brought to farmers a whole world of entertainment. Programs in distant cities that would be unavailable and that would be exceedingly costly were it possible to attend them, are brought right into the home on the farm.

Sphere Is Widened

The farm family can sit by the fireside on cold wintry nights and in unfavorable weather and have the best enjoyment that the wide world affords, for with American and foreign radio receiving sets, all one has to do is to turn the dial to get programs from any part of the country or the world. Through radio, news is available to farmers as well as to others right while it is happening. Every educational and cultural advantage is theirs for they can listen to plays, musicals and lectures on all kinds of subjects, which but for radio would be impossible. The work of the womenfolk on the farm is made lighter and brighter by programs that bring music, plays and other entertainment, as well as helpful suggestions about homework, cooking and the many things women have to do. During the noon hour as well as in the evening recreation is brought to the men, also.

Battery sets, as well as sets operated by home power plants, are available at low cost so that if the farm is away from power lines, a radio may be enjoyed regardless of location. Radios have been so perfected that it is easy to instal any type.

Location Is Best

Moreover, farmers get the best reception because they are away from the sources of man-made interference or the disturbances of industrial centers. There are no steel structures, electric lines, street railways, nor power plants to cause interference in reception. They not only have greater range, but much better quality of reception.

A radio will pay for itself many times over on the farm by bringing up-to-the-minute market quotations and weather reports that let farmers know when to plant crops or harvest them, and when to sell grain, stock, poultry and produce. It warns them of frosts and other factors that have a bearing on farmers' profits. With a radio the farmer knows what to expect and what to do. And good radios are to be had from twenty dollars up!

EDDY IS NEW WBZA OPERATOR

J. C. Eddy, former ship to shore operator for the United Fruit Line, has become station operator at WBZA in Springfield, Massachusetts. Mr. Eddy was associated with WEAF in 1926 and 1927 and since that time has been with the United Fruit Line.

PERSONAL NOTES

E. H. Gager has been appointed plant manager of KYW. For several months he was in charge of the construction of the Philadelphia station. Mr. Gager for nineteen years was assistant superintendent of the Commonwealth Edison Company, Chicago. From 1922 to 1925 he was associated with KYW, Chicago. For four years he was chief engineer of WEMR, Chicago, later becoming staff engineer with the National Broadcasting Company. Mr. Gager's duties will include technical supervision of the studio and station of KYW.

A. C. Goodnow, formerly studio supervisor at KDKA, holds the same position at KYW. The control operators include F. M. Sloan, from KDKA; I. N. Eney and C. E. Donaldson, from WBZ.

J. J. Michaels, formerly chief operator of KYW, chicago, is chief operator at the Philadelphia transmitter. His operating staff includes Bryan Cole, Bernard Clark and W. C. Ellsworth. Mr. Clark was formerly of the Radio Broadcasting Headquarters staff and Mr. Ellsworth of the Radio Engineering Department of the Radio Division of Westinghouse in Chicopee Falls, Mass.

NEW SOLAR CATALOGUE

The Solar Manufacturing Corporation, 599-601 Broadway, New York City, manufacturer of Fixed Capacitors for radio use, announces the issuance of the latest Special Service Catalog No. 6-S.

Features of interest to the service trade include ultra-compact dry electrolytics in various voltage ratings, special self-healing type wet electrolytic condensers, auto vibrator and suppressor condensers, together with a wide assortment of paper, mica, trimmer and padding condensers.

These catalogs may be obtained direct from the Solar Manufacturing Corporation.

FASTER HOMCHARGER

Originally introduced in 1920 by the Automatic Electrical Devices Co., of 324 East Third Street, Cincinnati, Ohio, the Homcharger for recharging automobile batteries in your own garage proved so successful that nearly a million were sold within a few years. Now the same company announces a new and improved model known as the Hi-Rate Homcharger.

The use of larger and higher compression engines, dual electric horns, more powerful lights, auto radios, etc. has imposed such a drain upon the car battery that a much faster charging rate was deemed necessary.

A THOUGHT FOR THE WEEK

TO BE OR NOT TO BE—POPULAR OR CLASSIC? The wiseacres of the music world are racking their brains in an effort to discover whether the public as a whole prefers popular music or the music of the masters. Of course, when the ransacking of brains and the balancing of percentages is all over they still won't know very much more than they do now. There are so many people in the world and so little standardization, how can guessers settle a question which has been debated for centuries? And whose decision will be accepted as final? And who has figures that are convincing—and what the dickens is it all about, anyhow?

Photo Cell Terminology

Standard Definitions Covering Fascinating Field

By Samuel Wein

IN the previous issue, December 29th, we discussed the underlying principles dealing with light. In the present issue we discuss those facts that deal with the phototube. An intelligent understanding of light and the photo cell is necessary in order properly to design devices associated with both.

The phototube has been the subject of considerable investigation by careful scientists as well as electrical engineers with a view of refining the apparatus used in connection with the cell, in the hope of getting the best and most consistent results. After all, like all phases of scientific endeavor, it is based upon an intelligent understanding of the elements used in a "set up."

The definitions given herewith were taken from the report of the Standards Committee of the Institute of Radio Engineers.

Terminology

The Standards Committee of the Institute of Radio Engineers have accepted the expression "phototube" which is more or less extensively used.

High Vacuum Phototube

A high vacuum phototube is one which is evacuated to a degree that its electrical characteristics are essentially unaffected by gaseous ionization.

Gas Phototube

A gas phototube is one into which a quantity of gas has been introduced, usually for the purpose of increasing sensitivity.

Sensitivity of a Phototube

The sensitivity of a phototube is the ratio of the short-circuit current through the tube to the incident radiant flux. It is usually expressed in terms of current per unit radiant or luminous flux. In general, the sensitivity depends upon the voltage applied to the tube and upon the intensity and the spectral distribution of the flux.

In the special case of a simple vacuum phototube, the relation between the current and radiant flux is linear. Also, in this case the specified voltage may be taken as any voltage sufficient for saturation current.

Static Sensitivity

Static sensitivity is the ratio of the direct current through a phototube operated at a specified voltage to the incident radiant flux of specified value.

Dynamic Sensitivity

Dynamic sensitivity is the ratio of the alternating component of current through a phototube operated at a specified voltage to the incident pulsating radiant flux of specified mean intensity, frequency of pulsation, and degree of modulation.

Monochromatic Sensitivity

Monochromatic sensitivity is the ratio of the short-circuit current through the phototube to the incident radiant flux of a given frequency or very narrow frequency range.

Total Sensitivity

Total sensitivity is the ratio of the current which flows through a phototube at a specified steady voltage to the total radiant flu- (in watts) of specified spectral energy distribution entering the tube. The total sensitivity depends on the spectral distribution of energy of the radiation and is related to the monochromatic sensitivity.

In the special case of a simple vacuum phototube, this sensitivity is independent of the radiant flux and equals the variational sensitivity. Also in this case the specified voltage may be taken to be a voltage sufficient for saturation current.

Total Luminous Sensitivity

Total luminous sensitivity is the ratio of the direct current through a phototube operated at a specified voltage to the total luminous flux in lumens.

Luminous Tungsten Sensitivity

Luminous tungsten sensitivity is the ratio of the current which flows through the tube at a specified steady voltage to the total luminous flux in lumens entering the tube from a tungsten filament lamp at a specified temperature.

2870 Tungsten Sensitivity

This is the ratio of the current which flows through the tube at a specified steady voltage to the total lumens entering the tube from a tungsten filament lamp at a color temperature 2,870 degrees Absolute.

Variational Sensitivity

Variational sensitivity is the ratio of the change in current which flows through the tube at a specified voltage to the change in the total flux entering the tube. As most precisely used, the term refers to infinitesimal changes.

Variational Sensitivity Amplitude Relation

The variational sensitivity amplitude relation is the relation between variational sensitivity of a phototube and the amplitude of the total steady radiant flux entering the tube.

Current-Wavelength Characteristic

Current-wavelength characteristic is a relation usually shown by a graph, between the direct current through a phototube and the wavelength of a steady radiant flux.

Conductance of a Phototube

The conductance of a phototube is the ratio of the current through a phototube at a specified radiant flux to the voltage at its terminals.

Variational Conductance of a Phototube

The variational conductance of a photo tube is the ratio of the change in current through a phototube at a specified radiant flux to the change of voltage at its terminals.

Resistance of a Phototube

Resistance of a phototube is the reciprocal of the conductance.

Variational Resistance of a Phototube

Variational resistance of a phototube is the reciprocal of the variational conductance.

Photo-Voltage Coefficient

The photo-voltage coefficient is an expression of the open circuit voltage generated by a phototube in response to a unit variation in radiant flux when the tube is regarded as a constant voltage generator. It is the ratio of the variational sensitivity to the variational tube conductance at specified values of operating direct voltages at the terminals of the tube, and of radiant flux.

For a simple phototube and with voltage sufficient to draw saturation current, this quantity becomes infinite. In this case the tube is more conveniently regarded as a constant current generator. The tube is likewise more conveniently regarded as a constant current generator when the impedance is very high.

Photo Current Coefficient

This is an expression of the short circuit current generated by a phototube in response to a unit variation in radiant flux when the tube is regarded as a constant current generator. It is numerically equal to the variational sensitivity.

Gas Amplification

This is the ratio of the sensitivity of a phototube, measured at a voltage greater than the ionization potential of the gas, to the sensitivity measured at a voltage less than the ionization potential of the gas.

Antenna Called Key to 5-Meter Range

The successful operation of the ultra shortwave transmitter located in the heart of New York City on the roof of the Hotel New Yorker has interested metropolitan amateur radio circles. The transmitter itself is of comparatively low power but it is supplying a signal which covers the entire metropolitan area, with an intensity which is at least equal to any other New York Sstation, although several are operating on from 5 to 10 times the amount of power.

Members of the Club attribute most of their success to the height of the antenna itself, the efficiency of the transmission line, which is used to connect the transmitter to the antenna and the extremely high efficiency of the "long lines oscillator" which is employed.

Tuned to Antenna Wave

Very definite proof has been established, indicating that the transmitter is most efficient when it is tuned to the exact wavelength of the antenna itself. Special telescopic antennas, made of aircraft duralumin, enable the operators to change the length of the antenna at will. Tests conducted between this station and a portable station located in an airplane have shown that this same type of antenna and a National Portable transceiver, operated with dry cells, can be utilized satisfactorily for two-way radio telephone conversation up to a distance of 40 miles.

Smilar tests conducted with transceivers in automobiles have shown that it was possible for two-way communication to be established between the Hotel and cars as far distant as Eagle Rock, N. J., a distance of approximately 25 miles.

Transmission Line Used

The advantage of the telescopic type of antenna and a newly developed high frequency transmission line cable, has greatly simplified the work of installing the transceiver in the aeroplanes and automobiles.

Characteristics of Resistors

Some Change Value Considerably Under Load

By Morris N. Beitman

Supreme Resistor Company

FIXED resistors find extensive application in modern radio design. Their uses are numerous, with their resistances varying anywhere between a few ohms to grid leaks of several megohms. One has only to look under a radio chasis to realize that resistors are the most extensively used radio parts.

Usually carbon composition resistors are employed where little current is concerned and when cost is an important factor. Wire-wound resistors must be used when power dissipated is more than about one watt or when a fair degree of precision is needed.

Methods of Manufacture

In the composition type resistor the conductor is mixed with a binder of insulated material in a proportion to produce resistors of the desired size. Carbon and graphite are usually used for the conductor. Clay, rubber, and various chemical plastics are used for the filler and binder. The solid body type of resistors are either extruded or molded similarly to other ceramic products. Sometimes this mixture instead of being made in rods with connecting leads is coated on ceramic forms, baked, and covered over with another ceramic material.

Nickel-chromium alloys are usually employed for wire-wound resistors. But nickel-iron and nickelcopper have also found application. This wire is used bare, enameled, or oxidized. The latter form is used when the units are close wound and the voltage difference between turns is very small. Sizes range all the way down to .001 of an inch in diameter. It is interesting to note that an average wire (.00175) used for this purpose has the resistance of 220 ohms per running foot.

Wire Wound Units

Wire-wound resistors are wound on porcelain or other ceramic forms. Terminals are attached at the ends. The entire assembly, except the extreme ends of the terminals or the pigtails, if used, is coated with vitreous enamel or refractory cement. This coating serves as a protective covering for the fine wire and also keeps out the moisture. The characteristics of wire-wound resistors are slight or negligible positive temperature coefficient and no voltage coefficient.

On the other hand, the resistance of a composition resistor is closely correlated to the applied voltage. In other words, the resistance of a composition resistor varies with the applied voltage. The increase in voltage has a tendency to reduce the resistance; and this drop, in poor resistors, may be as high as 25% of the total resistance. This variation, of course, is not a desirable effect and compels the use of the wire-wound type where a greater degree of accuracy is required.

Composition type resistors further shows considerable variation of resistance with applied load. The resistance here changes positively or negatively, depending on constituents of the resistor. Under a slight overload in extreme cases the change may be as high as 30%. The poorest wire-wound resistor, in comparison, when overloaded 100% will not show a greater variation than about eight percent.

With the advent of high-fidelity receivers, noises that arise in the parts must be reduced to an absolute minimum. Wire-wound resistors create almost no noise. Composition resistors do show the presence of microphonic noise which is somewhat dependent on the load.

The rating of wire-wound resistors is based on the wattage they will dissipate continuously for an unlimited time in free air without passing° C. temperature in an ambient temperature of 40° C. Of course when these units are mounted inside of radio sets the condition existing is very far away from the open air requirement.

Also the heat from adjacent parts, such as power transformers and tubes, makes the ambient temperature of higher value than specified. Because of these limitations wire-wound resistors should be used at a fraction of their nominal rating when mounted inside of a chasis. However, many wire-wound resistors may be greatly overloaded if mounted in free air or away from any parts that may be harmed by extreme temperatures of about 450° C.

In rating composition resistors greater difficulties are encountered. Since the resistance of this type of resistors is directly dependent on the temperature and applied voltage, it may change its resistance to a degree because of these variable factors where it will no longer be of suitable size. No standard has as yet been worked out to rate composition type resistors, but as a maximum one square inch of radiating surface is considered capable of dissipating one watt.

The Accuracy

Due to the changing nature of composition resistors it would be hardly worth while to manufacture to more exact resistance than the present plus or minus 10%. Many do not realize what a great variation of resistance this figure represents. As an example, when you purchase a 1,000 ohm resistor you may be getting any size between 900 and 1,100 ohms. When further changes mentioned before occur, no one really knows what resistance you have. For this reason wire-wound resistors also prove their superiority.

Wire-wound resistors may be wound to the exactness of plus or minus 2%, but 5% is the usual figure. Possessing negligible temperature coefficient and no other variable factors, they are suitable to more exact work.

The Color Code

Composition resistors are color coded according to the R.M.A. specifications. The color of the body of the resistor represents the first figure. One end is colored to represent the second figure. The band or dot in the middle is colored to represent the number of ciphers that follow the first two figures. The figure-color table is below:

0 Black
1 Brown
2 Red
3 Orange
4 Yellow
5 Green
6 Blue
7 Violet
8 Gray
9 White.

Wire-wound resistors are not usually color coded, but are marked with metal or paper tags. The wattage of wire-wound resistors is of great many sizes of which the following are commonly manufactured: 1, 5, 10, 20, 30, 50, 100 and higher.

A Surprising Difficulty Met

In Coinciding Calibrated Scale with Signal Generator's Frequencies

By Herman Bernard

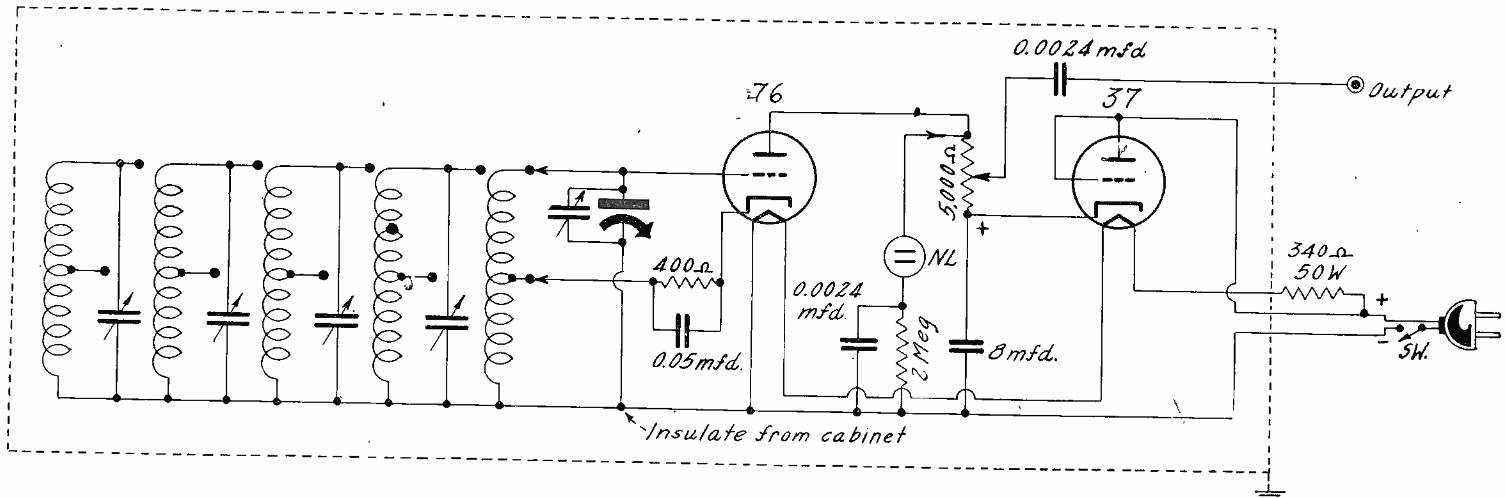

Diagram of the 339 signal generator, in the adjustment of which a controlling factor in such a Hartley circuit was discovered.

THE diagram represents a five-band signal generator, 54 to 17,000 kc, for which coils were originally wound, and an airplane dial calibrated, with some capacity added to the condenser's tuning capacity when the calibration was established. Without resort to the original constants an attempt was made to duplicate the circuit and tracking. It proved rather difficult.

What happened was that the frequency range for the band under test, 54 to 170 kc, was not fully covered, in fact, missed out seriously. There seemed to be no good reason for this. There had been no mistake made in the original calibration. A 76 tube had been used in self-bias fashion. The circuit was a Hartley Oscillator. The voltages applied to the plate and to the heater were the same as before. The condenser across the biasing resistor was the same capacity.' In fact, it was the indentical condenser, taken out of the original model.

What do you suppose cause the failure of coincidence between dial scale and generated frequency?

Mystery Solved

A new coil was made, other one ignored, and the inductance selected was that which caused the generation of 54 kc when the dial reading was 54. But when attempt was made to reach 170 kc there was no success. Not much more than 130 kc could be registered. Surely something was wrong.

The original coil was put in. This was the coil used when the scale was calibrated. Surely there could be nothing wrong with the coil. There wasn't. Still, bad missout.

No, the only possible source of trouble was the bias on the tube. And when that was duplicated, compared to the original setup, the tracking prevailed nicely. In fact, the accuracy happened to be ¼ per cent., which is rather remarkable. Only precision laboratory instruments of high cost achieve such accuracy, as a rule.

The biasing resistor for the generating tube is shown as 400 ohms, just as an indication that it should be a rather low value, but in point of fact will be selected on the basis of enabling one to carry to the high-frequency extreme of any band with fair exactitude, leaving perhaps a little leeway, so that a trimming capacity may be introduced.

This solution of unexpected trouble may prove valuable to many experimenters, not only in building this generator, but any circuit, like it or different from it, generating or non-generating. The point is that the bias changes the resistance of the tube, hence there is a dual effect: first, the effect resistance itself has on frequency; second, that change in resistance has an auxiliary capacity effect.

Avoid This Modulation

The situation that obtains when the resistor and the capacity related to it are considered becomes rather complex. If the case of a grid leak and condenser is considered it will be found that the larger the resistance the smaller the equivalent parallel capacity effect of the series condenser, considering the tuned circuit. That is, the grid condenser is across the tuned circuit in fact, because the parallel capacity effect would be complete if all resistance were removed, leak and tube alike, but d-c potential source retained.

In the Hartley, as shown, the biasing resistor and condenser across it work in the direction of larger capacity across the tuned circuit, the higher the resistance and the higher the bypass capacity. Also, since the biasing circuit is so closely allied with the tuned circuit, being tied in with the grid circuit from tap to cathode, and with the plate circuit, from cathode to ground, the time constant of the resistor-capacity combination may be high enough to produce low-frequency modulation. This is essentially not desired. Either capacity or resistance or both may be reduced to avoid this retrouble, but there is no danger of it, if the biasing resistor is less than 2,000 ohms, as it must be, and if the bypass condenser is 0.05 mfd. or less.

The Filtration

The signal generator shown in the diagram, known as the 339, is perhaps the simplest one that can be built for serious all-wave coverage. It has a 76 oscillator, a 37 rectifier, and a neon tube modulator or audio-frequency generator. Wave bands are changed by front-panel switching. There is an attenuator. The modulation may be removed or introduced by switching, and this is true whether the service is a.c. (any commercial frequency) or d.c., 90-125 volts.

The rectifier tube resistance, in conjunction with the 8 mfd. 175-volt electrolytic condenser, constitute a sufficient filter, as the current is low. How the degree of current influences the effect of such filtration may be demonstrated by the fact that there is a slight trace of hum at the higher frequencies of tuning in any band, due to the greater current drawn by the tube, arising from the increased amplitude of oscillation, of course. This may be corrected, if desired, by using a bypassed limiting resistor in the plate leg, between end of volume control and B plus, although the general lowering of the amplitude will result.

At maximum, under conditions shown, the plate current is around 6 milliamperes. At minimum it may be around 3 milliamperes. If a limiting plate resistance of 1 meg. is introduced, bypassed by 0.05 mfd., the current will drop to 250 microamperes (one-quarter of 1 milliampere) and will not change more than 15 microamperes over the tuning range. The only trouble with introducing this limiting device is that its presence must be consistent with oscillations in those regions where oscillations are not so easy to maintain, around 10 to 16 mgc. The limiting resistor, then, should be no higher in value than permits the retention of oscillation.

76 a Good Oscillator

The 76 tube, the 6.3-volt equivalent of the 56, though a bit sturdier in construction than the 2.5-volt equivalent, was selected because it is such a good oscillator. Also it is inherently more stable than the 6C6 which was tried out originally, and the substitution was made for that reason. In

(*Continued on page 20*)

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De-Jur Amsco dual 0.00014 mfd. Order P-1418. Offer C.
Three 100 mmfd. compression type trimmer condensers. Order P-1419. Offer A.
Eight tubular condensers, 600 volts. Capacities, .002, .006, .01, .02. State quantity and capacities, your selection. Order P-1420. Offer A.
Three tubular condensers, 600 volts, .01, 0.25 mfd. Your selection. State quantities and capacities. Order P-1421. Offer B.
8 mfd. electrolytic. 500v. d.c. Order P-1422. Offer B.
16 mfd. electrolytic. 500v. d.c. Order P-1423. Offer C.
Two 8 mfd. eletrolytic in one case. Order P-1424. Offer C.
Three-gang 0.00035 mfd. ⅜-inch shaft diam. Order P-1425. Offer B.

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Kit of 12 assorted volume controls (our selection). Order P-1401. Offer A.
Kit of 25 fixed assorted resistors (our selection). Order P-1404. Offer A.
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Crosley Has Gadgets Logging Short-Wave Stations

Cincinnati

Applying the principle of the circular slide rule, a Crosley radio engineer has worked out a novel circular short-wave dial log of all the principal short-wave stations in thirty-four countries. The outstanding feature of this dial log is the fact that with a single setting of the rotating arm, the days of the week, hours of broadcasting, call letters, kilocycles, city and country in which each station is located, all appear in a straight line through a cutout in the arm and can be read at a glance.

In the outer circle are listed the kilocycles of the different stations. Inside is another circle in which are given the station call letters, and in the center are listed the cities and countries in which they are located. On the rotating arm are two tables which give the days of the week and the hours of broadcasting. On the reverse side of the dial log the thirty-four countries are listed and the kilocycles for each given, so that all it is necessary to do is to turn the arm to the number of kilocycles listed in the outer circle of the log and all information regarding time of broadcasts, etc., is immediately available. These dials are published by the Crosley Radio Corporation and stocked by Crosley dealers.

Pick-up and Recorder Announced by Universal

The newest item in the production schedule of the Universal Microphone Co. factory at Inglewood, Cal., is a combination pick-up and recorder, impedance 400 ohms.

The equipment is full annular ball bearing mounted, and thus eliminates side wear of grooves.

The spring adjustment is a special feature. It is so assembled that pressure can be easily and quickly adjusted down to a featherweight on the needle groove, thereby eliminating groove and needle wear.

It matches the input of standard microphone transformers. As a recording cutting head, it matches standard line-to-line mixers, tube-to-line and line-to-line transformers.

Men cut your shaving cost
with this big razor deal.
1 Genuine Auto Strop razor.
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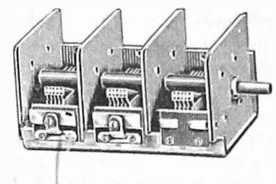
RELIABLE RADIO CO.
145 W. 45th St., New York City

RCA CREATES INFORMATION DEPARTMENT

The creation of a new department of the Radio Corporation of America, to be known as the Department of Information, was announced by David Sarnoff, president. The department will be headed by Frank E. Mullen, who has been promoted from his previous post as Director of Agriculture of the National Broadcasting Company at its Chicago office. Among the duties of the department will be those which have been handled by the Department of Public Relations, and Mr. Mullen will take over the work of Glenn I. Tucker, formerly manager of that department, who resigned recently.

Short-Wave Condenser



Three-gang 0.00014 mfd. tuning condenser, with high shields between sections. Trimmers built in on two of the sections. Section with trimmer off is to be used for antenna-stage tuning. As a series variable antenna condenser, of 50 mmfd. or somewhat less, is recommended, and changes the tuning of this stage, no fixed trimmer is necessary here. The condenser has brass plates, such as the most expensive condensers have, and has ⅜" shaft. Shipping weight 4 lbs. Send $3.00 for 26-week subscription for RADIO WORLD (26 issues, one each week), and ask for P-1031. We pay transportation on these condensers.

Radio World, 145 W. 45th St., New York, N. Y.

Quick-Action Classified Advertisements

5 cents a word. 50 cents minimum.

"ELECTRON TUBES IN INDUSTRY," by Keith Henney. A thorough, authoritative presentation of the practical aspects of electronics. Describes in detail amplifier, rectifier, and other tubes and photocells, and shows how they are being used now in industry. 490 pages, 6 x 9, illustrated. $5.00. Book Dept., Radio World, 145 W. 45th St., New York City.

LITERARY

AUTHORS: £50 CASH PRIZES FOR POEMS: full particulars free. MSS all kinds (especially fiction) invited for publication. Stockwell Ltd., 29, Ludgate Hill, London, England.

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THE AMATEUR ORACLE

Address Questions Concerning Amateur Regulations and Technique to M. K. Kunins (W2DPS), Technical Editor, Radio World, 145 West 45th Street, New York, N. Y.

Infra-red Rays

CAN YOU GIVE me any information concerning infra-red rays, the so-called black light? Can it be produced at home? And, if so, what kind of glass is used in this connection, since ordinary glass does not transmit ultra-violet light and I assume the same holds true for the infra-red?—J. G.

Infra-red rays are very high frequency electromagnetic radiations that are immediately next to the quasi-optical or ultra short radio waves of the radiation spectrum. The frequency range is approximately between 1250 megacycles and 375,000 megacycles. They are heat waves, approximately and may be most conveniently generated in the home by means of the regular electric heater that utilizes a copper reflector. An automotive product firm makes a small edition for defrosting windshields of automobiles, that can be operated from a 6-volt storage battery. It is advisable not to use any sort of glass with such a unit because of the possibility of its fracture from the heat.

* * *

Speaker Field Choke

In the October 27th issue there appeared a diagram of an 8-tube super. I fail to note any data regarding the filter choke and would like to ask what is its size.—M. H. R.

This filter choke may be the field coil of a standard dynamic loudspeaker. The d-c resistance may be about 1,500 ohms.

* * *

Error Corrected

IN YOUR ISSUE of May 5th, I notice in a diagram of a universal short-wave set that there is no return for the a.c. voltage. Please advise whether this is so or not.—W. A. S., Jr.

You are right. To correct this situation, it is recommended that the upper end of the 210-ohm resistor be disconnected and attached to the negative side of the line. The other loose lead is already connected to the other side of the line.

Filter Design

WHAT ARE the fundamental points involved in filter design? I am interested especially in band-pass filters.—R. L. C.

Filters are merely combinations of condensers, inductances and sometimes resistances. Advantage is taken of the fact that capacity attenuates the low frequencies, that inductance attenuates the high frequencies and that resistances attenuate all frequencies. Therefore to construct a filter that will kill the low frequencies, we shunt the line with capacities; to kill the high frequencies, we shunt the line with inductances; and to kill all frequencies except a certain band, we shunt the line with a shunt arrangement of L and C; and to kill one band of frequencies and pass all others, we shunt the line with a series arrangement of L and C. The sharpness of the points of cut-off is determined by the number of such elementary sections that are used.

* * *

Field Office Relocations

Several of the district field offices of the Federal Communications Commission have moved to new locations. They are given below with their new addresses:

Sixth district.
411 New Post Office Building, Atlanta, Georgia.

Seventh district.
P. O. Box 150, Miami, Florida.

Thirteenth district.
207 New U. S. Court House Building, Portland, Oregon.

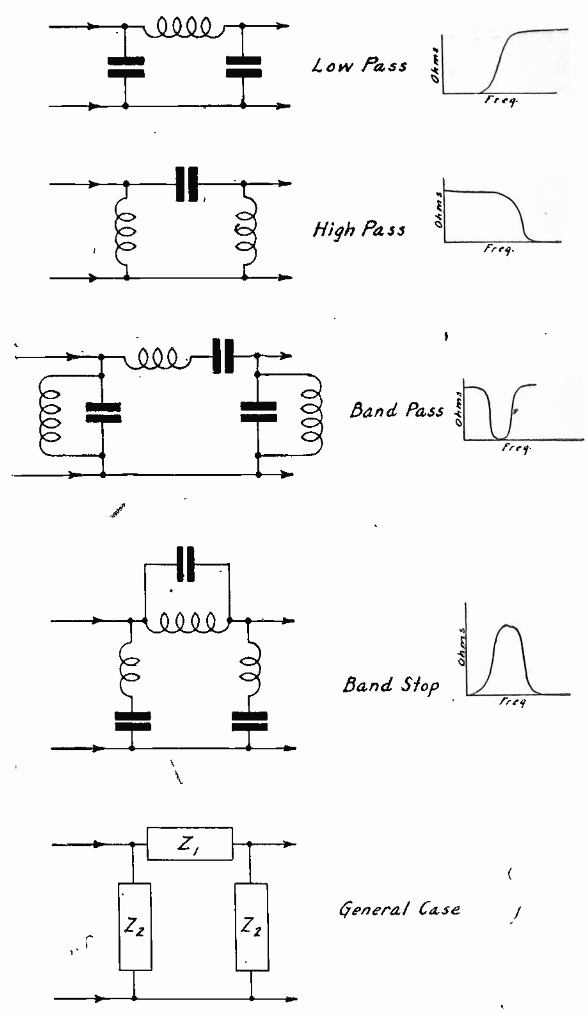
Sixteenth district.
927 New Post Office Building, St. Paul, Minnesota.

Seventeenth district.
410 Federal Building, Kansas City, Missouri.

* * *

New Rectifier Tube

APROPOS the question of D. N. appearing in this column, December 15th, 1934, issue, Harry D. Dudichum, Jr. of Pitman, N. J., states that Sylvania has a new rectifier tube known as the 25Y5 for 220 volts.



Filters are selected for the purposes to be served and are designated accordingly. A low-pass filter lets lows go through but stops highs. A high-pass filter lets highs go through but stops lows. A band-pass filter allows a small band through and cuts off, more or less, outside that band.

(Continued from page 18)

theory the 6C6 should be quite stable, because it is a suppressor type tube of the r-f pentode variety, and the plate current remains practically constant, regardless of the plate voltage. However, the screen has to be tied somewhere, and in small devices (also in some large ones) a series resistor is used. Hence the change in the amplitude of oscillation will considerably change the voltage drop in the limiting screen resistor, hence alter the effective screen voltage. And since the screen voltage, rather than the plate voltage, determines the plate current, it can be seen that the plate characteristic becomes unstable for indirect reasons.

The 56 and 76 are coming into wider and wider use as oscillators, because of the high mutual conductance. While this high conductance in a sense works against stability, because small changes in oscillation amplitude on the grid side produce relatively large changes in plate voltage drop, the stability may be enhanced by the use of a series limiting resistor in the plate circuit that is large compared to the d-c resistance of that circuit. Besides, the main consideration is that there be oscillation, so a tube that affords oscillation with no difficulty whatever is a wise choice. Refinements may be introduced at any time, consistent with the maintenance of oscillation.

Currents Given

The stability is improved by the limiting resistor method because a pure resistance is a very large part of the total resistance. The impure resistance is the tube plate circuit. How stable the frequency will be with proper limitation of the plate current by the series resistor method is shown by the comparison of maximum and minimum currents. When the change is only 15 parts out of 250, or roughly 5 per cent., the frequency stability will be as good as 1 part in 10,000, without any special treatment of inductance, temperature, etc. It should be remembered, however, that the usual period of operational use is considered. Over long periods—months or years—changes may take place that would impair the scale-to-generation accuracy, but scarcely the frequency stability. What would be required would be capacity readjustments in the trimmer circuits.

For the first band, 54 to 170 kc, the adjustment may be made for a frequency of 140 to 160 kc, by using stations 1,400 to 1,600 kc in the broadcast band, and beating the tenth harmonics of the generator with the station fundamentals. As a check, use some station near the low end of the broadcast band. Say it is WEAF, 660 kc. The tenth harmonic is of 66 is 660, so at 66 there should be coincidence. But the eleventh harmonic of 60 also is 660, so there should be coincidence at 60. And the twelfth harmonic of 55 is 660, which enables comparison of 55 on the scale, zero beat with the station being used. So one station may be used, if preferred, to traverse the dial for several spot frequencies. Take the broadcasting station frequency, one near the low end, and divide it by 13, 12, 11, 10, 9, 8, etc., and note what these frequencies are. If the case is that of 660 kc, we can tie down the circuit inductively when the dial reads 55, check at 60, 65, 73.3, 82.5, nearly 95, 110, 132 and 165. Thus the high-frequency tie-down point of 165 on the dial may be used for capacity adjustment. Actually, the coils are made commercially, so no inductive tie-down is necessary, only the capacity adjustment, which should include the bias resistor reduction if the spot frequencies are not as numerous or as coincidental as required.

(*Continued from page 4*)

or if increasing the frequency of the radio-frequency generator increases the audio note, subtract it. The audio-frequency note heard with a piezo oscillator having the assumed frequency would be 380 cycles, hence 700.140 + 0.380 = 700.520 kc.

PART 2. CHECKING BROADCAST FREQUENCY STANDARDS

A. Integral Sub-multiples of 5000 kc.

The frequencies which are integral submultiples of 5000 kc are most easily measured. There are only two broadcast frequencies, 1000 and 1250 kc/s, which bear tnis relation. The fifth harmonic of 1000 kc is 5000 kc. If a 1000-kc oscillator, whether a transmitting set or frequency standard, is coupled to a radio receiver tuned to 5000 kc at a time when the standard signal is being received, a heterodyne note will be produced which is equal to the frequency difference between the 5th harmonic of the 10400-kc oscillator and the standard signal.

Assuming that the nominal value of the 1000-kc oscillator is known, all that remains in order to measure the frequency accurately, is to determine the frequency of the beat note and whether the frequency is higher or lower than the standard signal. This is done when the radio receiver is not in the generating condition. The most convenient method, if the beat note is in the audible range, is to match it with a known audio frequency produced by a calibrated audio-frequency oscillator.

The direction of the deviation is most easily determined by making a slight change of known direction in the unknown frequency. If an increase in the unknown frequency increases the audio-frequency beat note the frequency is high. If an increase in the unknown frequency decreases the audio-frequency beat note, the frequency is low. Conversely, if a decrease in the unknown frequency increases the audio-frequency beat note the frequency is low, and if a decrease in the unknown frequency decreases the audio-frequency beat note, the frequency is high. If the audio-frequency to be measured is between 5 and 200 cycles per second, the audio-frequency arrangement described in a previous Bureau publication by N. P. Case can be used with a very high degree of accuracy. If the audio frequency is still lower and goes below the range of the audio-frequency amplifier, it is necessarv to provide a carrier for this audio-frequency note. This is done by making the radio receiver generate and adjusting the resulting beat note so that it is approximately 1000 cycles per second. A fluctuation in the amplitude of this 1000-cycle note, which has a frequency equal to the frequency difference between the two radio frequencies, will then be heard. If it is only desired to readjust the unknown frequency to agreement with the standard signal, it is a simple matter to adjust to zero beat. The same method can be used for a frequency of 1250 kc. Precaution must be taken to make it possible to combine the signals with approximately equal intensity. Some difficulty in this respect may be expected if measurements are made when the transmitter is operating unless the harmonics are very completely suppressed.

Case of 1000 or 1250 kc.

A station frequency monitor which utilizes a piezo oscillator having a frequency of 1,000 or 1,250 kc can be measured or adjusted to frequency in a similar manner. If the radio transmitter is operating, the measurement can be made indirectly in terms of the transmitter in the following manner. Measure the frequency of the radio transmitter in terms of the 5,000 kc signal and simultaneously read the frequency as indicated by the frequency deviation meter on the monitor. The two frequencies should agree. If they do not, adjust the frequency monitor until the deviation meter indicates the correct frequency deviation. It may be desirable to measure the frequency monitor directly against the standard signal at a time when the radio transmitter is not operating.

If the frequency monitor is of the type which is adjusted to exactly 1,000 or 1,250 kc, the measurement can be made the same as in the case of the radio transmitter. However, if the monitor is set high or low by 500 or 1,000 cycles, it will be necessary to make use of an audio-frequency oscillator to determine the value of the audio beat frequency. In the case of a monitor which has a frequency of 999.500 or 1,000.500 kc, the beat note to be measured would be 2,500 cycles per second. As five cycles variation in the beat note is only 1 part in 10^6, any audio-frequency oscillator which would be constant to 5 or 10 cycles per second would be adequate. In the case of a monitor which has a frequency of 999.000 or 1,001.000 kc a 5,000-cycle note would be produced. Similarly for 1,250 kc, audio-frequency beat notes of 2,000 and 4,000 cycles per second would have to be measured. The general relation is that the audio-frequency note produced by heterodyning the monitor frequency and the 5,000-kc standard signal is equal to the product of the number of cycles the monitor is set high or low and the ratio of 5,000 to the nominal value of the monitor.

B. Measurements With Auxiliary Generator for Frequency Multiples of 50.

Measurements of any of these frequencies require the use of an auxiliary generator in addition to the high-frequency receiver. The auxiliary generator may be a piezo oscillator or it may be a manually controlled oscillator. If a piezo oscillator of the desired frequency is available, it is desirable to use one. In this case a distorting amplifier is necessary in order to bring out the harmonics so that the beat against the 5,000-kc standard signal can be easily heard. This piezo oscillator should be provided with a vernier frequency adjustment so that it can be readily adjusted to agreement with the 5,000-kc standard in the manner previously described. After this is done the monitor or radio transmitter can be measured in terms of harmonics of the auxiliary generator. If a manually controlled generator is used, the L/C ratio must be low so that the frequency can be easily adjusted to zero beat with the standard frequency, and readily held on that frequency.

There are two main factors which determine the frequency to which the auxiliary generator should be adjusted. The first is that its frequency must have an integral relationship with the standard frequency and the frequency to be measured. The second is that the harmonic which is heterodyned with the standard frequency must be of sufficient intensity to produce a beat note which is easily recognized.

Taking both factors into account the best result is attained if the frequency of the auxiliary generator is the highest common factor of the standard frequency and the frequency to be measured. There is one other consideration in the case of a manually controlled auxiliary generator and that is, the lower its frequency, the less trouble is experienced in holding it at zero beat against the standard frequency. The following table indicates the broadcast frequencies which can be measured in terms of the 5,000-kc standard frequency transmission by means of a high-frequency radio receiver and an auxiliary generator. It will be understood that the table gives all broadcast frequencies which are multiples of 50, but does not indicate more than one generator frequency for these frequencies except for 1,000 and 1,500 kc.

500 kc	200 kc	100 kc	50 kc
1,000	600	700	550
1,500	800	900	650
	1,000	1,100	750
	1,200	1,300	850
	1,400	1,500	950
			1,050
			1,150
			1,250
			1,350
			1,450

Example of Auxiliary Method

As an example of this method of measurement, assume the frequency of the radio transmitter to be 1,150 kc. The radio receiver, in the generating condition, is tuned until the 5,000-kc standard frequency signal is heard. The auxiliary generator, set on approximately 50 kc, is then turned on and the frequency varied until a second audio frequency is heard on the output of the high-frequency receiver. If the radio receiver is then adjusted so that it does not generate, the auxiliary generator can be set to zero beat with the standard frequency signal. If the radio receiver is again made to generate, the auxiliary generator can be easily set to agreement with the standard frequency signal as previously explained. The rough adjustment to zero beat must be made when the radio receiver is in the non-generating condition, otherwise there is danger of setting to zero beat between the two audio frequencies of harmonics of the audio frequencies. If a piezo oscillator is used, this precaution is unnecessary. A detector-amplifier is set up so as to receive portions of the outputs of the auxiliary generator and the 1,150-kc radio transmitter, Fig. 4. The output of the amplifier will give the audio beat frequency between the 23d harmonic of the auxiliary generator and the 1,150 kc of the radio transmitter. If this audio-frequency is reduced to zero as indicated on a visual beat indicator the transmitter frequency will be in exact agreement with the standard frequency signal. One person can make this adjustment, as an aural indication may be used for the auxiliary generator and a visual one for the transmitter adjustment.

If a piezo oscillator is used as the auxiliary generator, it need only be checked against the standard frequency signal at intervals.

C. Measurement of Any Broadcast Frequency

The methods of measurement given in the preceding paragraphs are applicable to twenty of the frequencies in the broadcast band. The highest common factor of 5,000 kc and the remaining broadcast frequencies is 10 kc. The frequency of the auxiliary generator must therefore be 10 kc if the other broadcast frequencies are to be checked readily in terms of the 5,000-kc transmissions. The beat note between the 500th harmonic of the 10-kc generator and the 5,000-kc transmission would not be loud enough to be heard distinctly. The simplest solution, therefore, is to set the auxiliary generator on 100 kc and let it control a 10-kc multivibrator. The beat against the standard frequency signal could then be heard easily and the harmonics of the 10 kc would heterodyne equally well with fre-

(*Continued on next page*)

Station Sparks

By Alice Remsen

NEW ONES FOR 1935

THIS 1935 brings quite a few new programs to the air. Little Jackie Heller, the 61-inch tenor, will inaugurate his first sponsored evening program on Monday, January 14th, over an NBC-WJZ network at 10:00 p. m. EST. Jackie will be heard at that time each Monday under the sponsorship of Chappel Brothers, makers of Ken-L-Ration. . . . Igor Gorin, young Russian baritone, who was "discovered" by Rudy Vallee, began a new series of programs recently over an NBC-WEAF network. Each Monday at noon. He sings in all languages, especially Russian and Spanish. . . . Morton Downey is back on the air at his old stamping ground, the NBC. Under the sponsorship of the makers of Carlsbad Sprudel Salts, Downey is heard twice weekly. Each Sunday for a half hour at 4:30 p. m.; and each Tuesday for fifteen minutes at 7:15 p. m. over an NBC-WJZ network. His contract is an ambitious one, calling for a salary of six thousand dollars weekly. Downey began his radio career about ten years ago via the NBC networks. He has been successful ever since. . . . Anne Jamison, petite lyric soprano from Canada, has signed an exclusive contract with the NBC Artists Service. Miss Jamison was born in Belfast, Ireland. At the age of four she went to India with her family, lived there four years, then returned to Ireland. Her next move was to the little town of Guelph, Ontario; and now—New York, and a nice contract. . . . "The O'Neills," new dramatic serial of American home life, now heard over the CBS-WABC network under the sponsorship of the Gold Dust Corporation, have over two thousand American housewives to thank for their contract. These housewives listened to eight programs and picked the O'Neills as the best. Now you may hear them, Monday, Wednesday and Friday evenings at 7:30 p. m. over WABC and network. . . .

ORMANDY IN EARLY THIRTIES

The Minneapolis Symphony Orchestra, under the direction of the eminent young Hungarian conductor, Eugene Ormandy, inaugurated a series of weekly concerts over the nationwide WABC-Columbia network on Friday, December 28, from 3:15 to 5:00 p. m., EST. Originating in Minneapolis, the broadcasts are relayed to the Columbia network through the facilities of WCCO. The concerts will be heard on Fridays, January 4, 11, and 18, March 1, 8, 15, 22 and 29, and April 5, 12, 19 and 26.

Numbering 85 members, the Minneapolis Symphony ranks among the leading orchestras of the world. In its 31 seasons in Minneapolis the orchestra has become a northwestern institution and its extensive annual tours and frequent broadcasts have won for it an enviable place in America's musical world. Ormandy plans to offer primarily works which the public knows and loves. He has had wide experience in the theatre, concert hall and radio, and his popular programs will also feature less familiar masterpieces famous for their melodic beauty.

The young conductor, still in his early thirties, was a child prodigy at the Budapest Academy of Music when he gave his first public recital at the age of seven. When only seventeen he was awarded a Professorship of Music. In 1921 Ormandy came to America and immediately embarked upon the versatile career which ultimately carried him to guest conductorship with the New York Philharmonic-Symphony, the Philadelphia Orchestra, and with the Columbia Broadcasting System prior to his Minneapolis engagement.

THE GUMPS GOING STRONG

The Big Show is continuing the Ex-Lax series with the same stars, Block and Sully, Gertrude Niesen, and Lud Gladkin's Continental Orchestra. David Freeman is still writing the comedy material for the show. Mondays, 9:30 p. m. WABC-Columbia network. . . . Owing to the enthusiastic reception given to "The Gumps," famous cartoon family, as characters of a radio series, the WABC-Columbia network over which they are heard has been increased from twenty stations to forty-eight. They may be heard daily except Saturday and Sunday at 12:15 p. m. The Gumps are sponsored by the Corn Products Refining Company. . . . Kate Smith is sponsored again, this time by the Hudson Motor Car Company, each Monday night at 8:30 p. m. over the nation-wide WABC-Columbia network. But Kate is not relying upon herself alone—she is auditioning ambitious semi-amateur artists, and will use weekly guest entertainers from among those auditioned; Jack Miller's Orchestra, and the Three Ambassadors, male trio, complete the program. Kate is journeying to a different city each Friday night to conduct the hunt for new talent. . . . Lavender and Old Lace won a contract renewal for 1935. The program remains the same, with Frank Munn, tenor; Hazel Glenn, soprano, and Gus Haenschen's Orchestra. Each Tuesday, at 8:00 p. m. Sponsored by Bayer's Aspirin. . . . "Melodiana," which is sponsored by the makers of Phillips Dental Magnesia, also won a new contract, and also keeps its program intact. Featured are Vivienne Segal, prima donnar soprano; Oliver Smith, tenor, and Abe Lyman's Orchestra. Each Tuesday, 8:30 p. m. . . .

STUFF AND SOME NONSENSE

Taxicab drivers who line up outside the Columbia Radio Playhouse waiting for possible fares at the end of the Caravan program all tune their cab radio in on the show while they wait. . . . Babs Ryan has her luxurious blonde hair done up differently for just about every broadcast. . . . All those cheers heard in the vicinity of West 44th Street the other night were made of the real college stuff. About fifty alumni of Pittsburgh University attended Fred Waring's program at the CBS Playhouse and when it was off the air Fred and the orchestra and all fifty faithfuls yelled themselves hoarse for every college they could think of. Norman Brokenshire, announced on the CBS Headliners program, reports he's spending a lot of spare time now working out the details of his inventions, an all-consuming hobby of Norman's. . . . David Ross claims to have antedated the piano-sitting Helen Morgan by several years. He was quite a tiny lad at school but had a good, big reciting voice so the principal sat him on top of the piano at assemblies and bade him perform. . . . Colonel Lemuel Q. Stoopnagle reports a weird fan letter. It encloses a clipping showing that a husband and wife who were on the verge of parting listened to "Stoopnagle and Bud's" gloom-chasing antics and were made to laugh together so uproariously that they resolved to "live happily ever after." . . . Ray Henricks is the newest star from the Pacific Coast to join the staff of the American Broadcasting System. He is now featured over the ABS-WMCA network on Tuesdays at 7:00 p. m. . . . Station WJW, popular Akron, Ohio, station on 1210 kilocycles, has joined the ABS. "The Voice of Romance" has been moved to an earlier position on the ABS-WMCA schedule. He may be heard, Monday through to Friday, at 8:30 p. m. . . .

STUDIO NOTES

Jack Denny is always getting letters meant for Jack Benny and vice versa. . . . Phil Hanna, Three Cheers top tenor, has a top tennis rating in California, and won the Canadian Doubles Junior Championship when he was just out of high school. . . . Ben Bernie has grown a mustache since he has been in Hollywood. He's also carrying a cane. What next? . . . Muriel Pollock is busy writing some smart new tunes. . . . George Givot, the "Grik" Ambassador of Good Will, is really a Russian, but was raised in Omaha, Nebraska. . . . Glen Gray's nickname is "Spike." . . . Mario Braggiotti, CBS partner of Jacques Fray, is a sort of walking League of Nations. Born in Florence, Mario was brought up in Boston and is an American citizen. His four grandparents were English, French, German and Italian. . . . And there's Victor Kolar, Ford Symphony conductor, also an American citizen. He was born in Budapest, Hungary—his father a Slovakian and his mother a German. He was educated in Prague, then German, now Czechoslovakian, and populated mainly by Bohemians, and he is equally at home speaking English, German, Bohemian, Hungarian and Slovakian.

(Continued from preceding page)

quencies in the broadcast band. It is evident that with this equipment all assigned frequencies in the broadcast band can be checked against the 5,000-kc standard frequency signal, Figure 5.

There are some cases in which a frequency can be measured by more than one of the methods indicated. The question arises as to the advantages and disadvantages of the various possibilities or as to how existing equipment might be brought into use. The first method is applicable to only two frequencies. It provides the most accurate check for frequencies which are very near the harmonic value. For monitors, however, which are set high or low by 500 or 1,000 cycles per second, the audio frequency which must be measured is so high that it is very difficult to determine its value. This method is further handicapped by the fact that if the measurements are made in the transmitting station when the power amplifiei is operating, the harreceiver. If that is the case it would be may be so strong that it will block the monic which is picked up on the receiver necessary to locate the receiver at some distance from the transmitter and use a line between transmitter and receiver.

The second method requires an auxiliary generator and detector-amplifier in addition to the equipment used in the first method. A small error may be introduced in this method in the adjustment of the auxiliary generator. If a piezo oscillator is used this error is negligible. The error is much greater if a manually-controlled oscillator is used. In either case, however, it should not be more than a few parts in a million. This method is applicable to 20 of the broadcast frequencies, and is much more satisfactory for checking monitors which are set off-frequency because the audio frequency to be measured equals the amount the monitor is set high or low. If a harmonic amplifier is coupled to the auxiliary generator so that sufficient voltage is procan be read directly on the visual indicator vided, the measurement of the monitor provided with that unit.

It is necessary to use the third method in checking the remaining 76 broadcast frequencies. This method requires a high-frequency receiving set, auxiliary generator, 10-kc multivibrator; detector-amplifier; and audio-frequency measuring equipment.

Generator with Amplifier Stage

In several services low frequencies are commonly given only their wavelength equivalents, and for very high frequencies this is true likewise. So a Signal Generator, that enables determinations in both wavelengths and frequencies is the thing. That service is what the new Bernard Signal Generator Model 333-A renders.

Besides the more general purpose of lining up superheterodynes at intermediate, broadcast and short-wave levels, and peaking tuned-radio-frequency sets, it may be used as an all-wave Station-Finder, constantly modulated. Dual Measurement and Combination Use make this Signal Generator most valuable.

The fundamental frequencies and wavelengths are direct-reading. There are no charts to strain the eyes. The dial is accurately calibrated and the Signal Generator accurately adjusted. These fundamentals are: 83 to 99.9 kc. (1 kc. separation); 140 to 500 kc. (5 kc. separation); 540 to 1,600 kc. (10 kc. separation); 1,400 to 5,000 kc. (20 to 50 kc. separation); 3,010 to 3,600 meters (25 and 50 meter separation).

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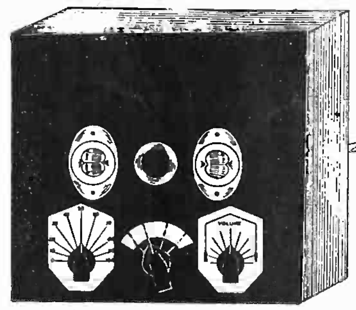

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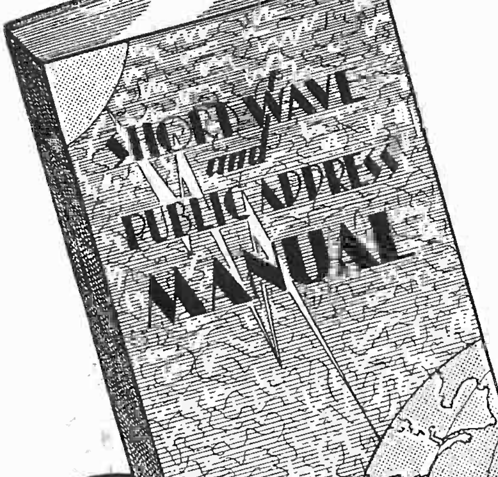

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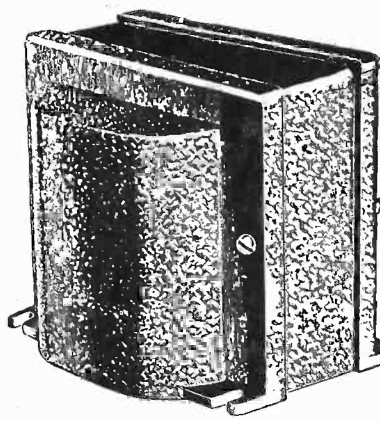

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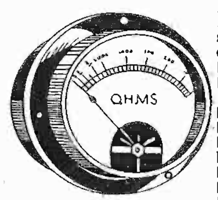

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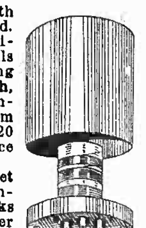

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