electronics

radio, sound, industrial applications of electron tubes + + + design, engineering, manufacture

Radio production begins autumn spurt

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Electronic control of traffic

✦

Economics of tone quality

✦

Microphone calibration

✦

Synchronous broadcasting interference

✦

Radio spectrum characteristics

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O. H. CALDWELL
Editor
FRANKLIN S. IRBY, Ph. D.
Associate Editor
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Some startling fruits of Research

THE ultimate chapter of electronic discovery is apparently yet a long way off.

We are probably still far from having all the fundamental inventions on which the electronic art of the future will be based.

Research can yet unlock many secrets which will afford new ways of doing things with electrons. Nature, in her electronic aspects, is full of surprises for us,—all just around the corner, if we will but experiment relentlessly. No single group or laboratory can expect to capture or hold all the secrets of any art.

WITHIN the past month, for example, the editors have witnessed several radical new inventions in operation, that bear out this view.

A new electronic light source exhibited in New York produces a flood of brilliant illumination from gas energized by cold electrodes operated on 110 volts. It is half a dozen times as efficient as tungsten lighting, and the device in other forms has possibilities for large-scale rectification and current control.

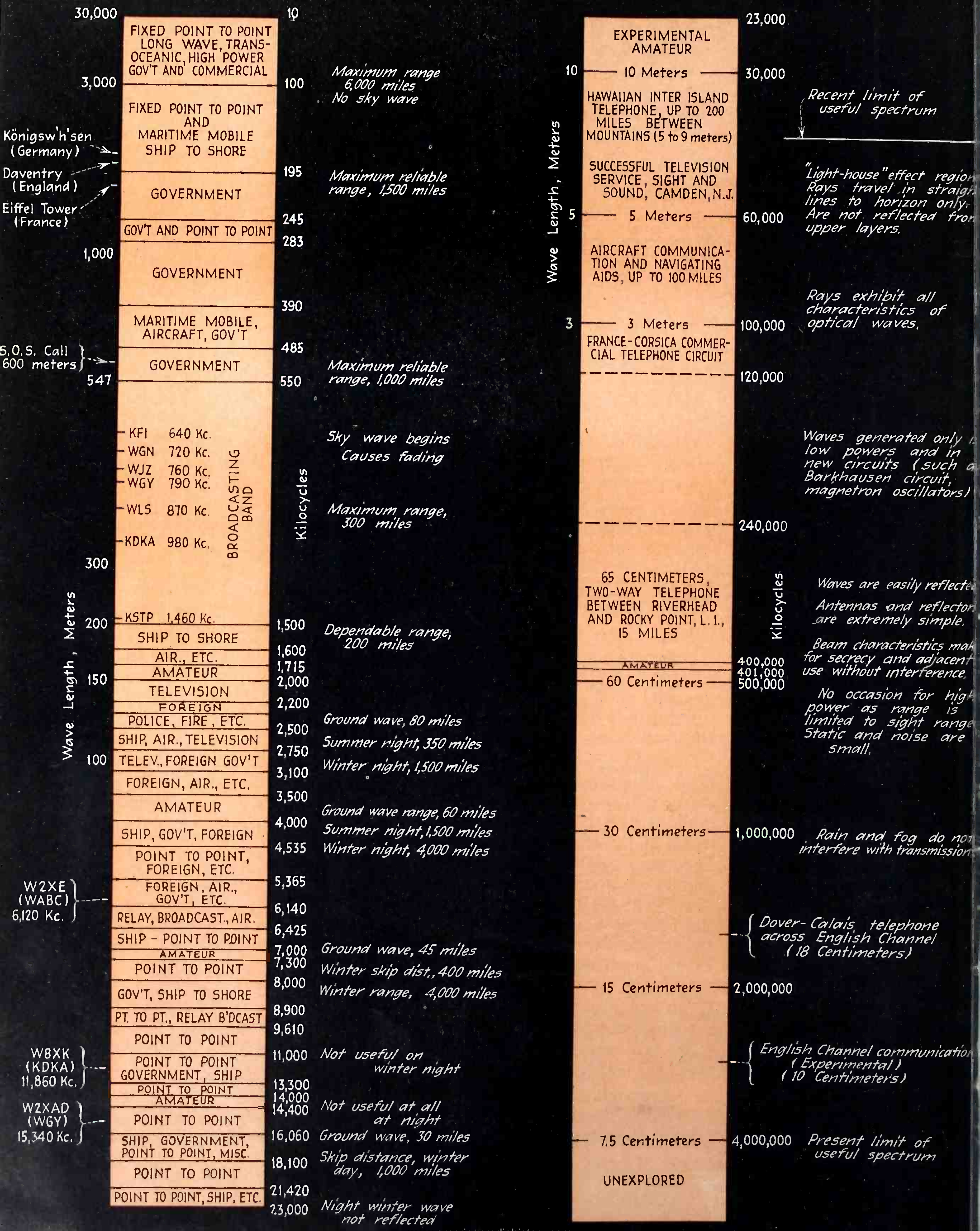
Again, a new filamentless radio tube now being developed by large independent interests, will apparently do everything the three-electrode vacuum tube can do—as amplifier, rectifier and oscillator. Such tubes have a high amplification factor, are simple and easy to make, and can be manufactured for a few cents each. Already they have been applied exclusively in a three-tube radio set with satisfactory results. They have also been employed in test transmitters. Having negligible internal capacity, they can be worked directly on short waves even below one meter. Fortunately this invention is in strong independent hands, where it can be administered for the benefit of all concerned.

SHORT-WAVE developments, new modulation methods, new light-sensitive cells, photocell control, new vacuum-switch contacts, etc., are other directions in which research has produced fruitful results.

Research along electronic pathways still promises much.

Research will pay dividends, build new industries, create new wealth, restore employment.

Radio Frequencies - Their Characteristics



THE EXPANDING SHORT-WAVE SPECTRUM

FOR a long period the useful part of the radio spectrum was thought to end at about 200 meters; then suddenly it began to expand; amateurs and experimenters had disproved existing theory and practice which led one to believe that on the shorter waves absorption would prevent the desired communication.

Unless all signs fail, the radio spectrum is due for another widening, again downward into a region now unused, virtually unexplored. The very reason why experimenters thought these very low waves useless, and why so few amateurs continued their experiments in the 5-meter region and below, may be the reason why they will come into wide use. They are not long-distance waves; they are short-length waves, short-distance waves, easily reflected and guided into narrow beams. And so vast is the region that all the transmitters that desire may find room.

Once useless very short waves become most valuable

Waves below 200 meters were thought useless because no one dreamed that a new phenomenon would be found —the reflected sky-wave. At these frequencies the ground-wave *is* soon absorbed, but shooting upward from the transmitter is another wave which is turned downward to earth again, delivering its message perhaps 100 miles from the transmitter, perhaps a thousand, beneficently skipping over the intervening territory.

This sky-wave phenomenon however is a not unalloyed virtue; fading and interference effects are multiplied. But as the wavelength is shortened to the region below 10 meters, the sky-wave is no longer reflected, and only the highly absorbed ground-wave remains. Thus the interference due to the sky-wave is eliminated, and the fact that the distance between transmitter and receiver must be limited to the range of the ground-wave—40 to 50 miles—will be an advantage, for a multiplicity of transmitters can be operated on the same frequency without trouble.

These ultra-short waves possess the following characteristics:

1. They are efficiently handled and directed by means of simple reflectors and mirrors of different shapes.
2. Apparently their propagation will be limited to cases where transmission and reception points have actually, or very nearly, reciprocal optical visibility.
3. Fog and rain will probably not interfere with such transmissions.
4. Secrecy of communication will be aided by the ability to sharply focus the waves; the same characteristic will enable intensive duplication of the same frequency in a given geographical locality.
5. Waves of one meter and above can be generated by present methods; shorter waves will probably be generated in oscillators where the electron time of transit will govern the frequency.

Research on the very short waves has gone on in Europe for a considerable time, much of it being done in Germany where experimental broadcasting has taken place on seven meters. A half-kilowatt station on this wavelength is situated about three miles from the center of Berlin, the crystal controlled transmitter installed in a tower about 100 feet high. Waves lower than seven meters were tried but were found to be influenced too much by large buildings. Longer waves radiated too great a distance and skywaves began to cause fading. Good receiving results have been attained at a distance of five miles from this transmitter.

Double modulation scheme suggested by von Ardenne

Much work has been done by engineers of the International Telephone and Telegraph Company; it was this work which led to the startling announcement of telephone transmission across the English Channel on waves as low as 18 centimeters. In this country considerable work has been done by the Radio Corporation, much of it at Riverhead, Long Island.

An interesting system of broadcasting on these frequencies has been suggested by von Ardenne in Germany. By a system of multiple modulation a 7-meter wave would be modulated with 300, 400, 500 and 600 meter waves which in turn would carry programs. At the receiving end, a simple frequency changer would enable a standard broadcast tuner to pick out any one of the four programs. Such a system does not save space in the ether, but it is a method of transmitting four programs from one carrier station.

Because of the vast number of standard 10-kilocycle channels into which the waves below 10 meters can be divided, it is certain television when finally developed will find a place in the ether of this region. Channels for many 200-kilocycle wide transmitters can be provided in many localities, all working without interfering with each other. Similarly a vast number of point-to-point stations can be accommodated.

▼

A COMPILATION OF KNOWN DATA ON PRESENT AND FUTURE RADIO CHANNELS

STRIKINGLY shown on the chart opposite is the vastness of the ultra-short-wave region, compared with the present spectrum.

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Patents relating to

Electronic devices in industry

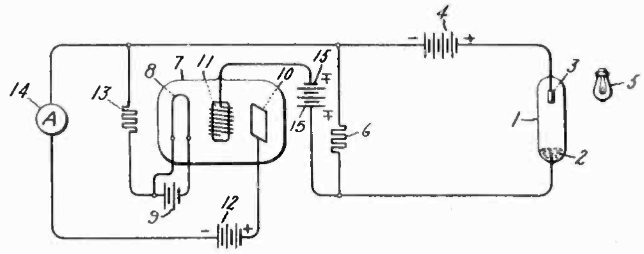

Fig. 1—Diagram shown in Langmuir patent, No. 1,273,627 for connecting light-sensitive cell and vacuum tube

APPLICATION of the vacuum tube or the phototube to the solution of many of industry's technical problems has been cited as the next great technological advance, coming with certainty in the next decade. Because of the newness of this rapidly expanding use of these electronic devices, the patent situation surrounding the art is as yet shrouded in much uncertainty.

The vacuum tube in any of its several functions as amplifier, generator or modulator may be applied directly to industrial service; the phototube, or other form of light sensitive device, may also be applied but probably not without the intermediary vacuum tube. In other words, the vacuum tube will serve industry by itself; but it must also be used wherever a phototube is used, so small is the present output of light sensitive devices.

Thus in all phototube services there must also be an amplifier tube, and these two tubes must be properly connected together. Two patents generally conceded to be of considerable importance deal with this combination the Langmiur patent No. 1,273,627 and the Nakken reissue patent No. 16,870.

These patents, and there are undoubtedly others, may be considered as fundamental patents, *i. e.*, dealing with methods of connection without regard to what the tube or combination is to do. Other patents like the Logan patents described briefly here deal with particular processes in which electronic devices enter.

The Langmuir patent, assigned to the General Electric Company, is the oldest of the patents described. It deals with th resistance connection between phototube and amplifier tube. The Nakken patent deals with combinations of phototube and triode where light impulses are transformed into current impulses. The Logan patents deal with specific applications. The Langmuir patent has been called to the attention of makers and advertisers of light sensitive relays using an amplifier tube; the Nakken patent is now the basis of a suit against the Westinghouse Electric & Manufacturing company.

▼

WORKERS in the electronic art will be interested in three patents granted by the United States Patent Office described here. One deals with a fundamental circuit involving a phototube and amplifier tube with a resistance coupling them, and the other two with specific applications of the use of light sensitive cells for controlling industrial processes.

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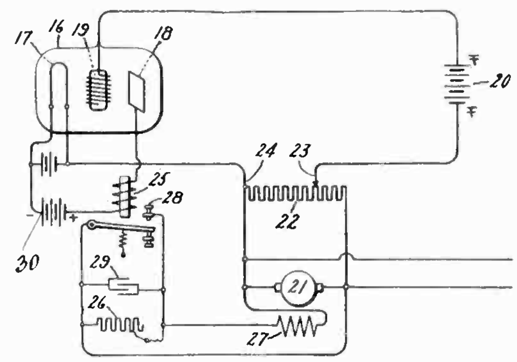

Fig. 2—Maintaining output generator voltage constant by amplifier tube

A patent applied for February 5, 1914, by Irving Langmuir and issued July 23, 1918, No. 1,273,627, assigned to the General Electric Company shows a light sensitive device coupled by means of a resistance to an amplifier tube and shows a relay in the plate circuit of an amplifier tube which closes when the voltage across a generator changes with the result that this voltage is stabilized.

Quoting from the patent, "the invention relates to means for controlling and regulating electric current or potentials in such a way that variations in the potential or current of one circuit produce desired changes in the potential or current of another circuit."

As an example, Fig. 1 shows a "photoelectric cell having a cathode of sodium, potassium or other metal which gives off electrons when subjected to the influence of light." The current output of the cell flows through a high resistance which is connected to the grid and, through another resistance, to the cathode.

In Fig. 2 variations of voltage output of a generator are impressed on the grid-cathode circuit of a triode in whose plate circuit is a relay controlling some means to regulate the voltage of the generator. For example, a variable resistance in series with the shunt field of the generator is short-circuited when the voltage of the generator falls below the desired value.

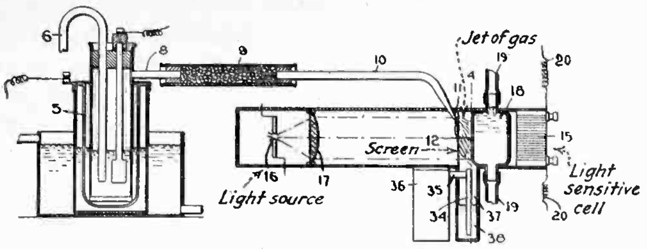

Fig. 3—Logan method of using light-sensitive cell for regulating flow of gas in sulphuric acid manufacture

The claims of which there are seventeen relate to a combination of a triode "two sources of emf. connected in opposition to each other in an external circuit between grids and cathodes whereby the two forces are maintained substantially equal to each other—means rendered operative by a change in one of the emf.'s whereby the two emf.'s are maintained equal—methods of operating triodes by causing the current to flow in an external circuit, whereby two potentials are maintained equal to each other—means for amplifying small unidirectional currents by triodes and two resistances."

Claims 7 and 8 refer to "photometric means comprising a photoelectric cell and an amplifying device whereby a small current in the photoelectric device is amplified by that of the tubes." The other claims relate to means for amplifying small electric currents in which the electron tube is the essential device.

The Logan patents

Two patents granted to Lloyd Logan of Pittsburgh, Pa., on means for controlling production processes through variations in radiant energy, are of interest. The patents No. 1,455,795 granted May 22, 1923, and No. 1,471,342 granted October 23, 1923. The first "invention relates to means for automatically controlling various operations" with "particular reference to a controlling means which is rendered operative by, or through the use of radiant energy." Quoting from the patent papers: "The invention is capable of a wide range of use and may be arranged to exercise a control over an operation or process by limiting the amount of production, or by stopping or starting machinery, or by varying the character of the operation or process, as circumstances vary, or by operating alarm or indicating devices, or in fact by accomplishing a large variety of other operations which affect in some way the operation or process in question. The patent illustrations and the descriptions of them are given herewith.

There are five claims to this patent of which this is the first, "Combination with means for producing radiant energy, of other means to cause variations therein by the quantity produced in a process or operation in which the material is acted upon, and means rendered operative by said variations to control said process or operation."

The second Logan patent involves "The provision of means for automatically controlling a production process by variations in radiant energy caused by variations in some factor or factors affecting such production process for the purpose of maintaining a predetermined character in a product resulting from said process. For example, the inventor refers to its use as "controlling the manufacturer of chemical products by making use of variations in an optical quality of a sample of the product during some stage of manufacture for the purpose of controlling the process, thereby to eliminate the formation of any undesirable constituent in the product; or its use in obtaining temperature control by making use of variations in the intensity of light emitted from or transmitted through material subjected to the temperature which is being controlled."

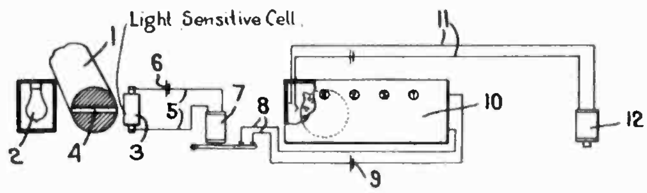

Fig. 5—In this Logan patent a light sensitive cell is controlling shaft revolutions

For example, in the co-called "Marsh" apparatus, arsenic or arsenic compound in the sample in the contact process of making sulphuric acid is converted into arsine and passed through a jet burner at which ignition takes place, the flame being arranged to impinge on a transparent screen. The presence of arsenic or arsine will result in a deposit of a black stain upon the screen indicating the presence of the undesirable element. In Fig. 3 the jet of gas is shown impinging on a screen through which light from a source is transmitted. If the screen is blackened by the presence of arsenic, light does not get to the screen and therefore does not reach the light sensitive cell which operates a relay and shuts off the mechanism. The inventor also shows the apparatus so constructed that the control will be effected by means which will react selectively to light of a certain wavelength, as well as to be used in the production of liquids which rotate the plane of polarization, for example in the manufacture of sugar or through variation in the refractive index of liquids being controlled.

The inventor also explains that his invention can be used to control supply of fuel oil to a furnace by means of a light sensitive cell associated with an optical pyrometer. The first claim is characteristic and reads "The combination with means for treating inanimate material during its process of manufacture, whereby it undergoes some change, of separate means for producing radiant energy of a character which is affected by factors affecting such treatment of the material, but which does not, of itself, produce the above mentioned change in the material, means to subject a portion at least of the material to the action of said radiant energy, whereby variations in such factors cause distinctive variations in said radiant energy, and means controlled by said variations to exercise control over the process."

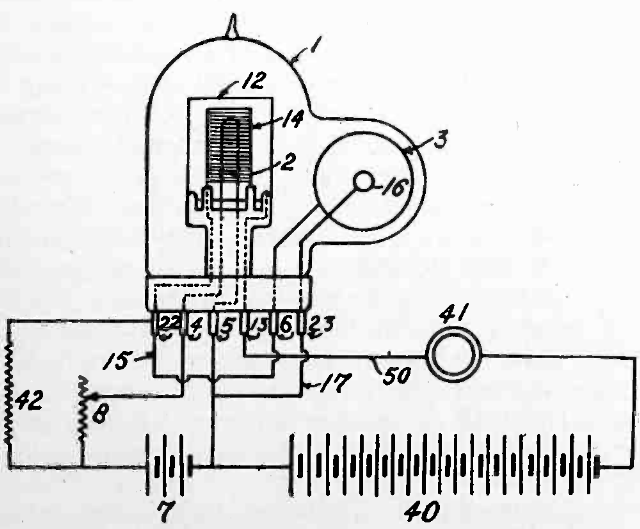

Fig. 4—From Nakken patent showing combination of light sensitive surface and triode

Electron tubes in traffic-actuated control systems

RELIABILITY of vacuum tubes is proven by their practical use in traffic control systems. One hundred and sixty-nine municipalities have installed traffic-actuated devices to date. Potentialities exist for millions of dollars worth of equipment in this field. Rising tide of accidents (1,000,000 in 1930) will necessitate safety signal systems. Only four companies now in field.

APPROXIMATELY 99,000 people[1] were killed by accidents in the U. S. during 1930, the largest number in our history, for which motor vehicles alone accounted for 33,000. The exact figures on the number of automobile accidents not resulting in fatalities are not known, but using the general experience table of 30 accidents to each fatality in this class, means that there were approximately 1,000,000 such accidents in 1930.

An analysis which has been made of the type of accidents falling in the latter class indicates that 32 per cent of the non-fatal accidents were due to the driver not having the right-of-way, and 22 per cent attributed to crossings at intersections *with no signal apparatus installed*. The number of accidents thus occurring at street crossings without traffic signals or due to confusion of drivers as to the right-of-way (usually at intersections), indicates the importance and possibilities of traffic control devices. Such a high percentage of accidents, due to crossings alone, in view of the multiplicity of other possible causes, is quite significant. Some form of traffic-actuated signal device should play an important rôle in decreasing the rising toll of accidents on our highways.

The development of electronic and other types of equipment suitable for signal control purposes, is already making progress in this field. Several companies have commercial apparatus available and installed in hundreds of municipalities. Future growth will be as rapid as the public becomes acquainted with the reliability and efficiency of these systems.

Four general types of equipment have so far been developed. These include: (1) Sound amplifying equipment, which amplifies the sound of the vehicle passing over a box in the street; (2) pressure type detectors, using an electro-static timing method of charging condensers; (3) electro-magnetic control equipment, actuated by the magnetic flux induced by a passing car, and (4) photo-cell control equipment, actuated by the interception of a light beam.

Sound amplification system

Apparatus which depends upon the amplification of sound waves produced by a moving vehicle for operating the necessary signal lights, has been developed by Charles Adler, Jr., of Baltimore, Md. An empty hollow steel box is buried in the right hand channel of a cross street, 50 to 75 ft. to either side of the intersection with the main highway. The function of the box is to act as a "drum," which concentrates and amplifies the sound produced by the motor wheels in passing over the top of the box.

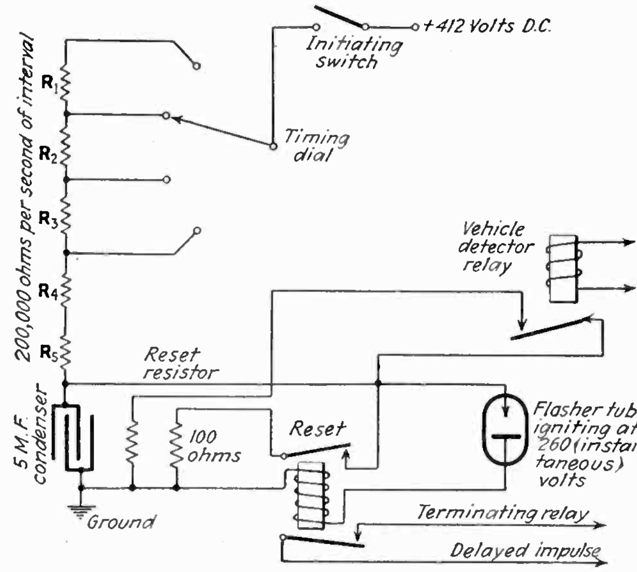

Fig. 1—Schematic circuit of the electro-static timing system which uses condensers for the timing mechanism

The sound waves produced are conveyed through a short tube to a microphone, the output of which is amplified and the electrical impulses are used to actuate and control the time-signal mechanism. In practical operation of this device, the driver of a car on a side street approaches the main thoroughfare with the lights against him, passes over the signal box, the initial impulse is given to the control unit and after a pre-determined interval, the signal lights change on the main thoroughfare to allow him to enter. After allowing sufficient time for the cross-street traffic to clear, the signal apparatus again gives the right-of-way to the main street. For this type of crossing, it allows the traffic on both thoroughfares the same freedom of movement permitted by automatic signals, and adapts the control to the actual flow of traffic, instead of causing arbitrary changes in the light irrespective of the temporary absence of cross traffic.

A button is provided on the control box, which permits pedestrians to secure the right-of-way across the high-

[1]Report of the National Safety Council, Inc., Chicago, Ill.

way when desired. This signal will not, however, operate a second time until after a pre-determined period of time, during which traffic on the main highway has the right-of-way.

Electro-static timing equipment

Equipment designed by the Automatic Signal Control Corporation, New Haven, Conn., uses pressure-type vehicle detectors for starting the initial impulses in the electro-static timing unit. The latter presents several unique features to meet the complicated requirements of traffic-actuated control apparatus. Interval timing presents many more problems than does that of the fixed time control such as is used in ordinary street traffic signals, because of the time intervals required to meet the demands of variations in traffic.

Electro-static timing as used in this unit, is based on the principle that a definite time interval is required to charge a condenser to a definite difference in potential, through a fixed value of resistance. The elementary circuit used in this equipment is shown in Fig. 1 The initiating switch, pressure operated by the vehicle passing, is closed to start the interval. The condenser, having previously been drained of residual charge, begins to charge at the rate of inversely proportional to the total amount of resistance in series with it. This relation may be expressed as follows:

$E_c = E\,(1 - e^{-t/RC})$ where

E_c = Voltage across the condenser terminals, t seconds after the initiating switch is closed
E = D.C. voltage applied to the circuit (412 in this case)
t = Time in seconds after the initiating switch is closed
R = Total charging resistance in ohms
C = Capacity in Farads

This expression assumes the residual charge in the condenser to be zero at the moment the initiating switch is closed, which is true within practical limits in this application.

The tube shunted across the condenser through the terminating relay, is a glow tube of special design, which will conduct practically no current (less than 2×10^{-7} amperes) until the voltage across its terminals reaches the ionizing point. The tube upon ionizing, instantly reduces its internal drop to a value considerably less than the flash over value, and maintains this reduced drop until it is extinguished. When the voltage across the condenser reaches a critical value for the flasher tube, it flashes over and the difference in potential between the condenser and tube-drop is developed across the terminating relay. This produces an inductive resistive current impulse in the relay, which lasts until the surplus energy in the condenser is exhausted and the tube extinguishes.

The relation between the ionizing value for the tube and the d.c. supply voltage has been made such, that the condenser reaches the critical value in a time numerically equal in seconds to the product of the capacity in Farads and resistance in ohms. This value is 63.1 per cent of the applied voltage and was selected for convenience in the choice of condenser and resistor values.

The accuracy of the time interval is controlled by the limiting values of the five various circuits which control it within definite time limits. These values are: the line voltage, capacity, resistance, tube flashover voltage, and insulation resistance. In practice, these values have been held within 3 to 5 per cent. Line voltage variations are generally neglected, while special apparatus to maintain constant timer supply has not been found necessary.

Fig. 2—Adler traffic-actuated control system which uses a sound-drum under the street and microphone pick-up for operating the timing signal

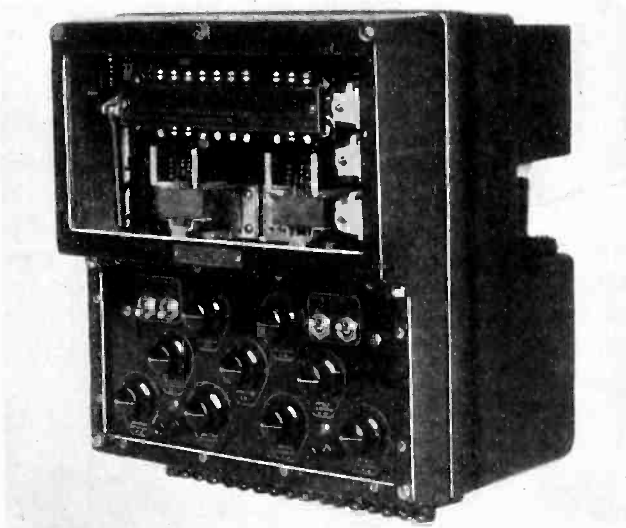

Fig. 3—Electro-static signal control unit designed by the Automatic Signal Corporation, showing dial panel for adjusting all time intervals

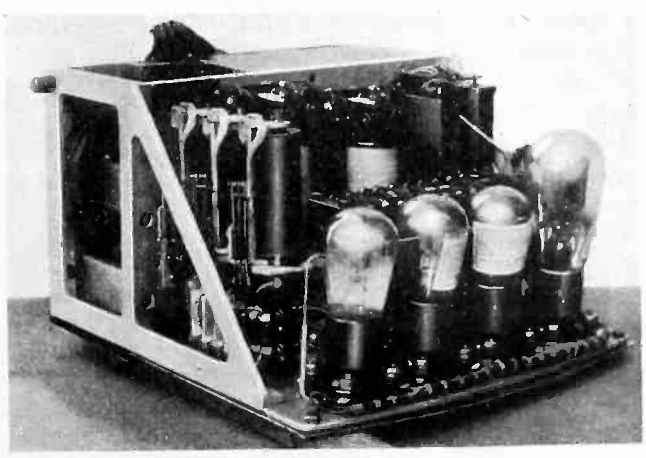

Fig. 4—Open view of the electro-static control unit, showing three grid glow tubes and thermionic rectifier used in this system

Re-setting of the timer relay is done at the end of the interval by a pair of contacts on the terminating relay, and during the interval of the vehicle protection timer only, by a pair of contacts on the vehicle detector relay. The impulses which the detector relay receives may be as short as 0.005 second and the timer must re-set completely within this time. As the condenser discharges at a rate which is inversely proportional to the shunting resistance, and because the length of the impulse to the detector relay is approximately inversely proportional to the speed of the car, a partial re-set may be accomplished by the choice of a suitable resistor. This will give a time interval protection proportional to the speed of the car and increases the efficiency of control. In practice, 2,000 ohms is found to be generally satisfactory. No means has been found by which this feature could be accomplished practically with other types of timers.

Tubes found reliable in operation

The signal control unit designed for controlling two crossing streams of traffic, is shown in Fig. 3. This unit is wholly enclosed in a dust-tight aluminum casing with a glass window for viewing all contacts and moving parts. The dial panel mounted below provides means for adjusting all time intervals from the outside. The whole unit is mounted inside a weatherproof housing for protection against the elements and unauthorized persons tampering with it.

An open view of the control unit, showing mounting of the glow tubes, is shown in Fig. 4. The timing mechanism operates on a step by step principle, rather than by cyclic timing. This is accomplished by using a cam-shaft with a fixed position cycle, one position for the amber light and two for green, on each street. The cams operate a system of contacts and set up electrical connections for each position. The cam-shaft is notched over by an a.c. solenoid and ratchet system, which in turn is operated by the terminating relay of the proper interval-timer at the end of each interval. When the cam takes a new position, it lights the proper traffic signal lights and closes the initiating switch of the proper interval timer. Each time the solenoid operates, it closes the discharge contacts of all timing condensers, thus draining them for a fresh start on the next interval. Each of the nine time-intervals operated by the dials on the front of the control panel is individually adjustable and completely independent of the other.

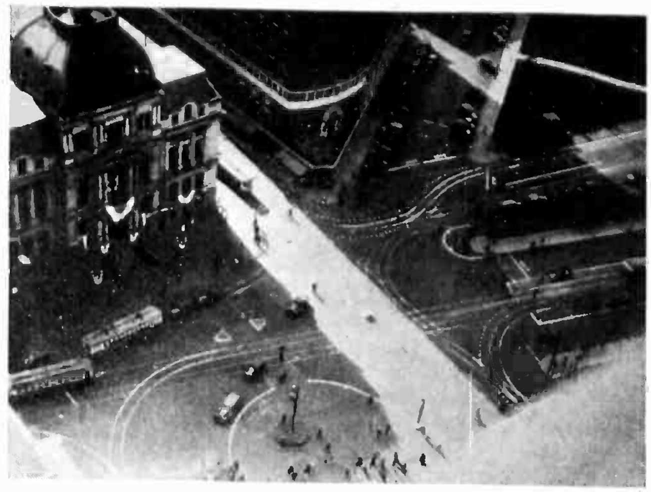

Fig. 6—Exchange Place, Providence, R. I., with 13 intersecting streets and five trolley lines is equipped with traffic-actuated apparatus replacing three police officers

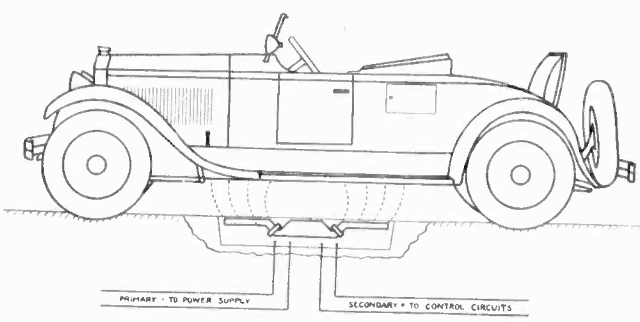

Fig. 5—Electro-magnetic detector used in the Miller control system which operates by a reversal in magnetic flux in a circuit, caused by a passing car

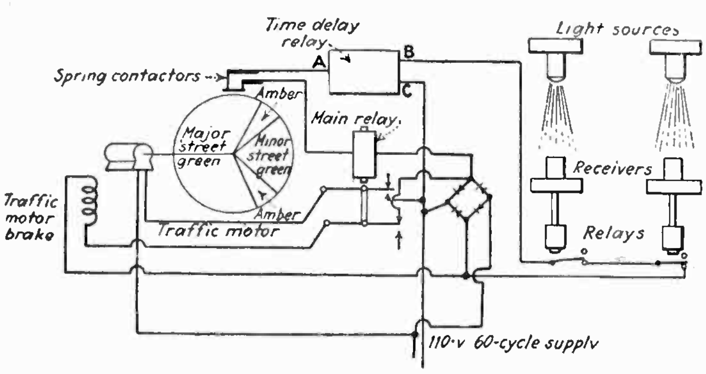

Fig. 7—Photo-cell circuit diagram used in the Westinghouse, traffic-control system, showing arrangment of relays

The glow tubes used with this equipment are especially designed to maintain a stable igniting voltage over long periods of service. Accelerated life tests on the tubes now used indicate they maintain a practically constant igniting voltage for over one hundred million timer impulses. Service experience with these tubes over a year has shown no appreciable change.

The condensers used with this equipment are oil impregnated, with one exception. A full wave thermionic rectifier is used in the 412-volt direct-current supply.

Electro-magnetic control system

The Miller Train Control Company, Staunton, Va., has developed a two-phase traffic demand signal actuated by a magnetic coil buried under the street. This system comprises three units, the detector, a combination relay and rectifier, and a condenser. This equipment is also adaptable to intersections having as many as five, six or seven intersections.

The detector unit proper is housed in a reinforced concrete structure imbedded in waterproof material, and protected by a steel cover. It has no make-or-break electrical contacts and depends upon its action by changes in reluctance in the magnetic field of the detector. This unit which operates on the magnetic Wheatstone bridge principle, consists of two cores of laminated transformer steel upon which four coils—two primary and two secondary—are wound. A primary magnet in the detector is connected through an underground cable to a source of alternating current. The secondary coil in the detector normally energizes a relay in the control cabinet. The steel structure of the motor car in proximity to the detector attracts the magnetic flux from the primary, and redirects it from its normal lateral direction to a longitudinal direction. This reversal of magnetic flux deprives the secondary coil of its energy, and allows the relay armature in the control box to drop on its back contact starting the timing signal.

[*Continued on page 123*]

The dollar cost of tone quality

By W. ROY McCANNE
President, Stromberg Carlson Telephone Mfg. Co.

TONE quality is not be attained by merely juggling one of the many factors which collectively make a receiver sound natural, i.e., like the original.

The larger the cabinet (larger area of cabinet front) the better the response to low fundamental frequencies. The function of the loudspeaker is to change electrical impulses into sound vibrations. To do this the loudspeaker diaphragm must get the air of the room into motion. If the push which the loudspeaker gives to the air in front of it can quickly slip around the edge of the speaker and fill in the corresponding void created immediately back of the diaphragm, then the speaker is simply moving a small amount of surrounding air and is failing to get the air in the room into motion. The speaker thus needs a partition or a baffle between the two sides of its diaphragm to prevent the air from being pushed bodily from one side of its diaphragm to the other. The ideal baffle would be a board 5 ft. square with the speaker in its center. Such a baffle would enable the speaker to reproduce all frequencies above approximately 60 cycles. A baffle 4 ft. square will enable the speaker to reproduce all frequencies above approximately 75 cycles. A baffle 3 ft. square will enable the speaker to reproduce all frequencies above approximately 100 cycles. A baffle 2 ft. square will enable the speaker to reproduce all frequencies above approximately 200 cycles. A baffle one foot square will enable the speaker to reproduce all frequencies above approximately 300 cycles.

In this connection it should be noted that the difference between 60 cycles and 300 cycles is about two and one-half octaves, viz. about two octaves below Middle C, and half an octave above Middle C, on the piano. Radio cabinets for the sake of appearance and utility must be of the box type but the area of the front of the cabinet absolutely limits the loudspeaker's response. If even the best loudspeaker is housed in a small-sized cabinet it cannot reproduce the lower pitched fundamental tones of speech and music.

Construction of radio cabinet

NOT only should the cabinet be large enough to guarantee reproduction of low audio frequencies, but the materials used in the cabinet walls must be selected to give rigidity and avoid vibrations which will be added to the normal reproduction and thereby cause distortion. We have found from experience that a plywood panel at least $\frac{3}{4}$ in. thick is required. Such panels cost much more than thin panels which are often used in large consoles, or the very thin panels which are used in portables and midgets.

Shape of radio cabinet

IN addition to the requirements listed above, the cabinet should be so shaped as regards depth, opening at back and at bottom, as to avoid resonance effects which cause "barrel tones" and which introduce peaks and valleys in the reproduction. A cabinet which will meet these critical requirements is more expensive to design and produce than one which will serve merely as a housing for the chassis and loudspeaker.

Audio range of loudspeaker

EXPERIENCE in measuring commercial types of loudspeakers shows that costly refinements in design and construction must be used, in order to provide 60-cycle to 5,000-cycle range and in particular to get rid of peaks and valleys which result in a bad form of distortion. The cone material, its shape, and the construction of the cone as regards corrugations, etc., all play an important part in the design. The materials for supporting the edge of the cone and the center of the cone, must be selected with great care and unfortunately the materials giving the correct result, cost much more than the materials employed in low-priced designs. The loudspeaker unit should be designed to meet the cabinet requirements, so that the overall sound response should be practically flat, from about 60 cycles to about 5,000 cycles.

Loudspeaker efficiency

THE efficiency of the loudspeaker unit as regards sound output in comparison to electrical input, must be as high as possible, in order that the energy from the output system of a receiver will be capable of driving the loudspeaker at desired maximum volumes without overloading the tubes in the receiver. Tests made of commercial loud speaker units show that the lower-priced speaker units usually are very inefficient and thereby easily overload the output tubes in the receiver, at good "room volume" of reproduction. The reason why this overload distortion is not noticed is that most of these receivers fail to reproduce the necessary higher audio frequencies, or resort to tone controls, so that the owner can cut the higher audio frequencies and thereby reduce the effect of the overload distortion to the listener.

Long-range audio system

THE audio amplifying system of the receiver should be designed so as to pass frequencies between 60 cycles and 5,000 cycles with a fairly flat characteristic (this characteristic being selected so that the overall fidelity of the receiver, including the loud-speaker, will be flat, any compensation being made in the audio system

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NINE points of radio receiver design in which increased outlay by the manufacturer makes for greater fidelity of reproduction for the listener.

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or in the loud-speaker characteristics). The materials and construction of a good audio system meeting these requirements, cost much more than the systems usually employed in low-priced receivers, in which the audio range of the loudspeaker is limited on the one hand by small cabinet size and on the other hand by inability to reproduce the higher audio frequencies.

Radio amplifier

THE radio amplifier plays an important part in tone fidelity, inasmuch as any tendency to obtain a high degree of selectivity usually results in side-band cutting; that is, the loss of the necessary higher audio frequencies. Receivers designed to give uniformly high selectivity at all tuning positions of the dial, cost much more to produce than receivers which may give desired selectivity at one part of the tuning dial and be very broad in tuning for the remainder of the dial. Also, stability is one of the requisites of good tone fidelity and a receiver which is stable under all operating conditions, costs much more to produce than one which depends upon a certain amount of regeneration for high sensitivity, as well as for high selectivity. A receiver having regeneration, even though it may be controlled, is not capable of giving good audio quality under all conditions.

Reliability of construction

THIS includes the selection of materials. selection of dielectrics and the design and construction of all of the critical parts of the receiver which have to do with the maintaining of the original adjustments and the original overall efficiency of the receiver. For example, very few receivers will stand up under a vibration test or a humidity test, both of which are necessary in order to determine the reliability of any design of receiver, in order to anticipate possible damage in shipment or in regular operation and any possible decreases in efficiency which may be occasioned when the receiver is operated in damp atmospheres, such as is encountered along the sea coast and in certain periods of the year in practically all parts of this country. A receiver which will not stand up under adverse climatic conditions and which will not hold its original adjustment, will suffer in tone fidelity or become completely inoperative.

Adequate power-supply system

THE rectifying and filtering system which is used in the power supply portion of the receiver chassis must be of ample capacity to furnish all the operating voltages and current to the receiver and loudspeaker without overload, without inter-circuit couplings and without appreciable hum. In receivers having a restricted audio range, low cost filters can be used, as the frequencies below 150 cycles are not reproduced and, therefore, the 60-cycle fundamental and the 120-cycle harmonic of the alternating-current supply need not be filtered to the same extent as in receivers capable of giving a high degree of tone fidelity. The use of extremely small transformers and choke coils, low-cost filtering condensers, and especially types of electrolytic or chemical-filter condensers which may introduce noises into the reproduction, detract from the tone fidelity. Such savings of money make inexpensive receivers possible but often give the listener a poor idea of radio.

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A NEW BOOK ON TELEVISION

Television—its methods and uses

By Edgar Felix, McGraw-Hill Book Company, New York. 272 pages; 73 illustrations. Price $2.50.

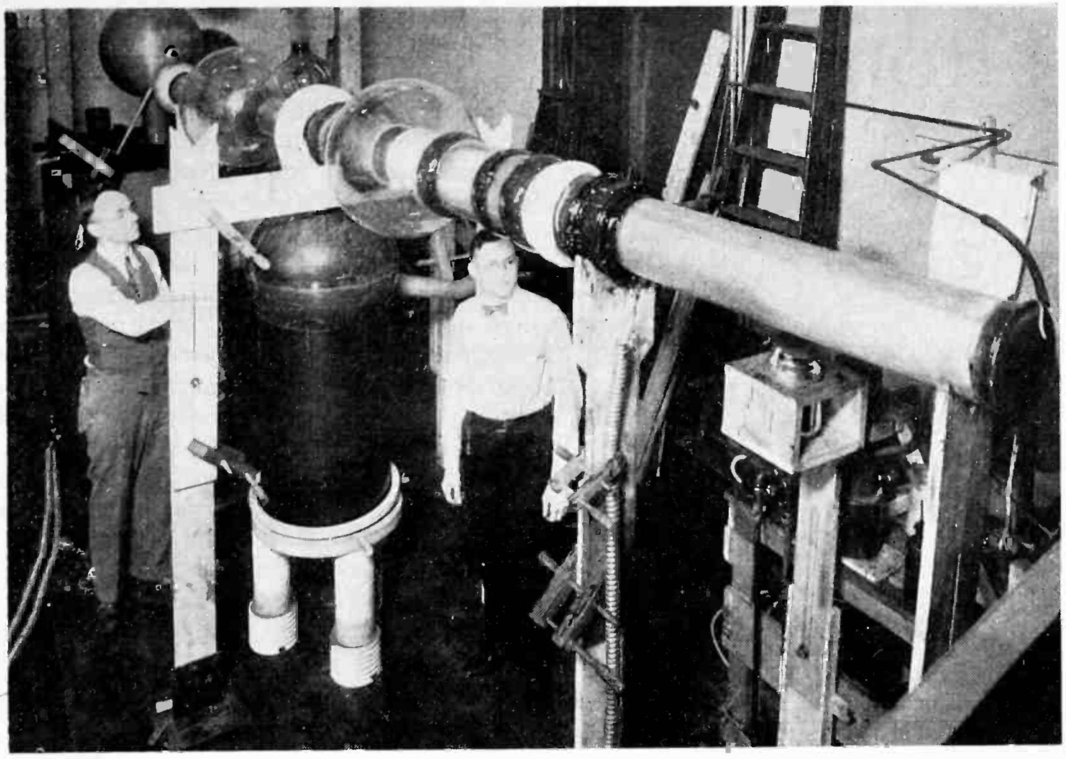
IN THIS BOOK, which was the August selection of the Scientific Book Club, the present status of the television art is accurately defined:

"The instrumentalities of television have recently improved tremendously by virtue of scientific progress in other fields, such as the electrical transmission of audible frequencies, photoelectric tubes, vacuum-tube amplifiers and motion-picture projection. But the well-established principles remain unaltered; the basic methods are only superficially modified. It is to the new tools of exquisite responsiveness and accuracy, replacing the crude instrumentalities of the pioneers, rather than to new fundamental inventions, that we owe our recent progress. The successful accomplishment of a reproduction ¾ in. by 1 in. is too readily accepted as proof that the image can be increased to 4 in. by 5 in. without changing the viewing distance, for example, by reasonable increase in the size and capacity of the apparatus involved."

Mr. Felix points out that to enlarge a ¾ in. by 1 in. television image, which is the size of a frame of motion picture, to one 4 in. by 5 in., without reducing the quality or detail, means somewhat more than "two-hundred-folding" the capacity of the television apparatus a difficult technical task.

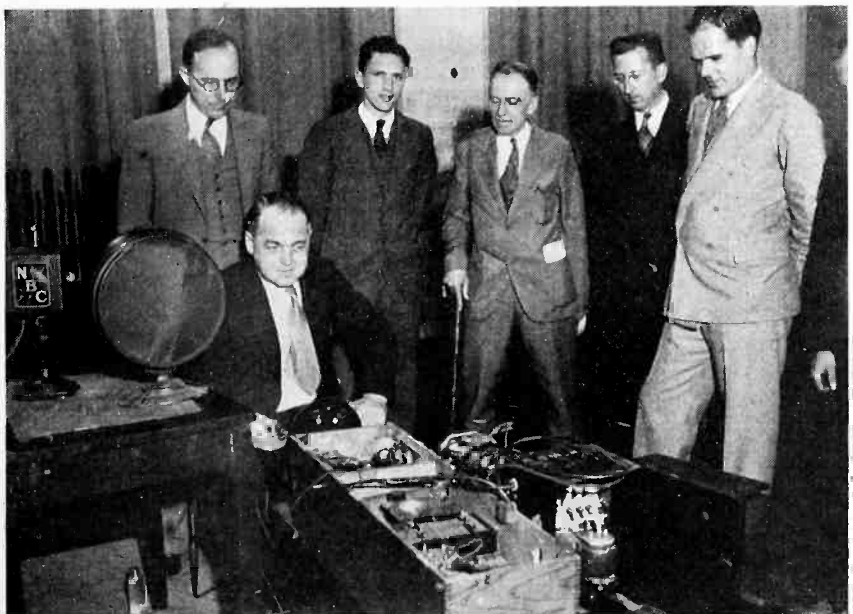
"Two hundred and fifty folding the speed of any process, particularly one involving such delicate accuracy as television, is not to be considered without the deference which is its due. Automotive engineers, for example, do not hesitate to build racing automobiles capable of speeding 150 miles an hour, but they would hardly consider an order to build a car to travel 250 times as fast, as a reasonable demand. It is no more likely that such a speed will be attained by merely increasing the power, speed or dimensions of a motor vehicle built along present-day conventional lines than that a high-quality commercial television reproducer of 1,000,000 picture elements per frame will be perfected merely by detailed improvements of established instruments and methods. Fundamentally new principles must be applied, involving ingenuity of a far higher order than is required for mere enlargement or general speeding up, or else the hope of large reproductions of perfect texture must be abandoned."

"The most important needs to produce a practical television service are minds and imaginations which approach its technical problems with a fresh point of view, and which do not merely accept the orthodox methods already exhaustively investigated by numerous inventors. The problems of television are not insuperable, nor are they more difficult than those which faced the inventors of any generally accepted entertainment or communication device. Their solution will have the inherent simplicity characteristic of every practical invention. We are familiar with so many elements of the ultimate television system that it is no strain to prognostic powers to predict that television is 'just around the corner.' The probabilities are, however, that most of us are congregated hopefully on the wrong corner."

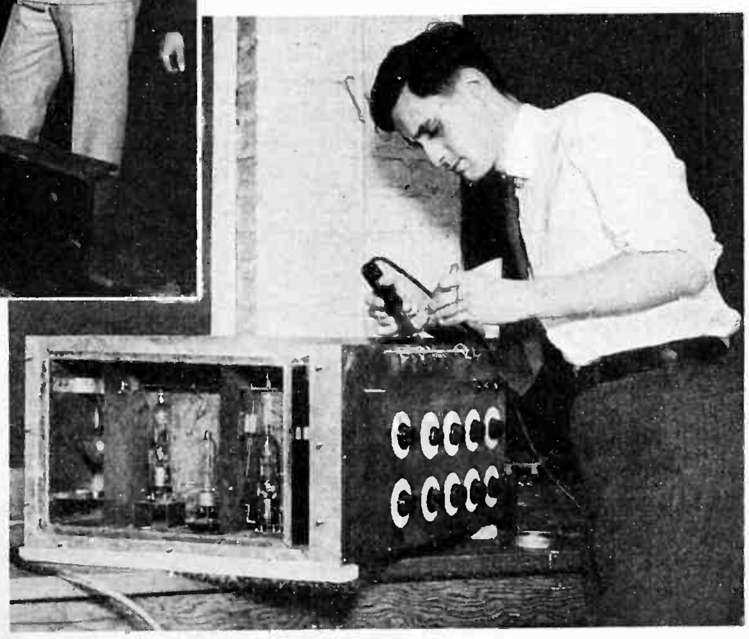


X-rays at 900,000 volts —highest voltage in a tube built for continuous operation—are produced in the giant two-section X-ray tube being built in the research laboratory of the General Electric Company, Schenectady, N. Y., by Dr. W. D. Coolidge

The electron in new roles



"Dropping the electron" that was heard across the continent. Representatives of Science Advisory Committee of Chicago 1933 World's Fair, demonstrate to NBC coast-to-coast audience patter of charges in Geiger counter



No fundamental improvement in telescopes has been made since Galileo. Now astronomers are giving thought to harnessing electronic amplifiers to existing instruments. Here is Dr. Theodore Dunham, Mt. Wilson Observatory, California, building an amplifier for photo-cell to record light from distant stars

A Lenard-ray tube, with thin glass window, developed by Dr. Slack of the Westinghouse Lamp Co., being used to check fluorescent properties of synthetic willemite used in cathode-ray tubes

Interference from shared-frequency broadcasting

By C. B. AIKEN

Bell Telephone Laboratories

WHEN two radio transmitting stations operate simultaneously on the same frequency assignment and are located sufficiently near together so that each is within the sphere of influence of the other, interference effects of a complex and often highly objectionable character frequently arise. Within the region where the field strengths from the two stations are comparable, there will be impressed on the detector of a receiver both carriers with their sidebands. As a result the receiver output will contain, in addition to the desired signal, a group of interfering signals.

Where the difference between the carrier frequencies is very small, it may be considered as a difference in phase which changes slowly with time. For the present, attention will be directed to the case where the difference in carrier frequencies amounts to several cycles or more. Here phase relationships need not be considered, and the two carriers with their sidebands may be treated as separate groups of frequencies. Under this condition the six groups impressed on the detector are as shown in Fig. 1. All of these, in amplified form, will appear in the output of the detector, but since they are radio frequencies, they will be rejected by the audio-frequency circuits and so are of no further interest. Due to the non-linearity of the detector, however, the six components will also inter-act with each other. Noting that in all cases of practical interest the carrier of the desired station is by far the strongest component impressed on the detector the heavy lines of Fig. 1 indicate that its reactions with the other currents are of most importance.

The first group of reaction-products is that formed by modulation in the detector between the carrier and the sidebands of the desired station. This constitutes the undistorted desired program, and is identical with what would be received if the undesired station were absent.

The second group contains but one frequency, the whistle between the two carriers. This is the strongest interfering component present and if the difference between the carrier frequencies is well up in the audible range it may be responsible for very objectionable interference. On the other hand if the difference in carrier frequencies is below the audible range, this component may be relatively unimportant.

Cause of sideband noise

The third group consists of frequencies due to the modulation between the desired carrier and the undesired sidebands. It is audible as highly distorted and extremely displeasing music or speech which may be almost unintelligible. This component of the detector output has been designated on the diagram as sideband noise. It is made up of two distinct spectra, each corresponding to the original program of the undesired station but displaced respectively upward and downward in frequency by an amount corresponding to the difference in frequency between the two carriers. Were the carriers of the same frequency, the difference would vanish and the two spectra would coalesce into an undistorted program from the undesired station.

Modulation between undesired carrier and desired sidebands is usually negligible as compared with other interference components. If the desired sidebands are strong, corresponding to a loud passage in the original program, the reception of the desired program will override this source of noise, while if the desired sidebands are weak, the noise will be less than that from other sources.

Also negligible is the ordinary cross-talk due to modulation between the undesired carrier and its sidebands. Unless this is true, reception from either of two stations transmitting different programs on the same channel is impossible. If the programs are identical, the cross-talk merges with the desired program. Analysis shows that there are still other frequencies present in the output of the detector, but they may be neglected as interference in comparison with the other components.

From the foregoing discussion it is evident that the carrier whistle and the sideband noise are the predominant components of the interference.

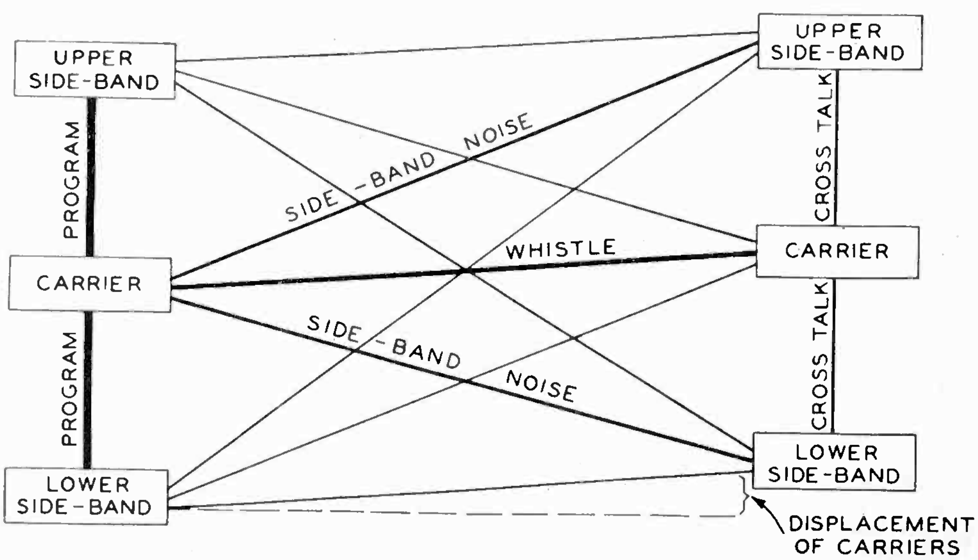


Fig. 1—Schematic arrangement of two carriers, slightly displaced, with their sidebands, and the various possible modulations

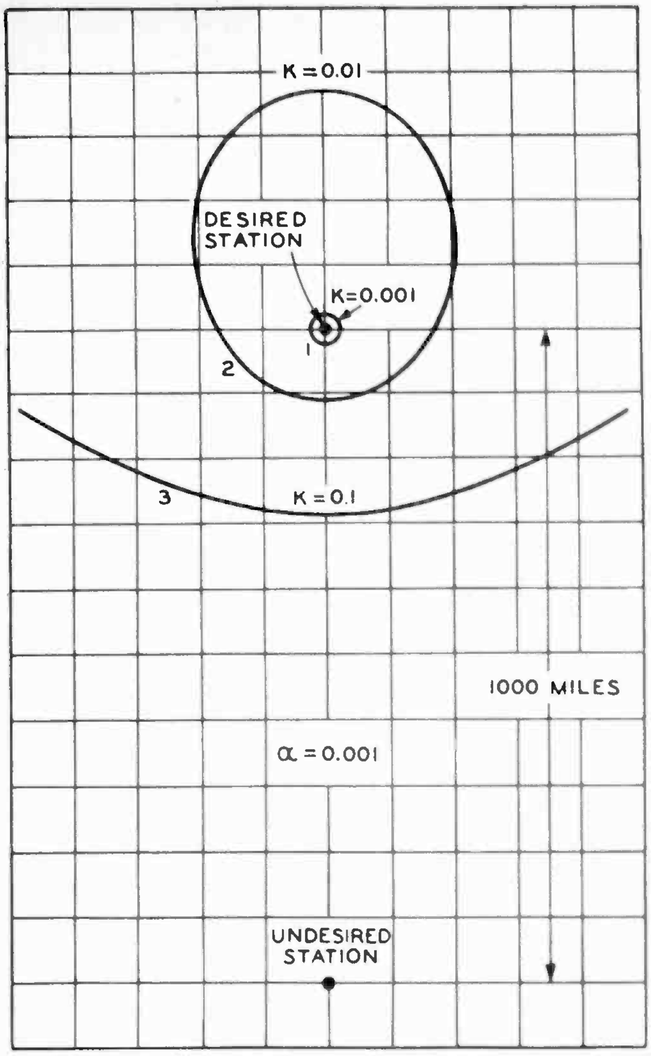


Fig. 2—A typical set of curves marking out areas where the intensities of various interfering frequencies are 20 and 40db. below the desired signal

For a given field-strength ratio a carrier beat will be most objectionable when its frequency comes within the frequency band of maximum efficiency of the transmission system consisting of the radio receiver, the loudspeaker, and the human ear. The efficiency of this system is usually highest in the neighborhood of about 1,000 cycles. With present day apparatus frequency differences of this amount are fortunately not very usual but whistles of a few hundred cycles are all too common and are responsible for extremely objectionable interference. Practically, for differences of less than 50 cycles, the carrier whistle may be neglected since the sideband noise will then be far more important. For a given carrier frequency difference the importance of the sideband noise relative to that of the carrier whistle is directly proportional to the modulation of the interfering station.

Square-law versus linear detection

So far, no reference has been made to the type of detector used in the receiver. In actual practice detectors are encountered which range from the parabolic or square-law type, exemplified by any detector operated at small input to those which approximate to the straight line or linear detector.

By means of formulae which have been derived elsewhere[1] it is possible to compute the amplitude of the carrier beat and of the components of the sideband noise in terms of the field strength ratio and the percentages of modulation of the two signals. Thus if the field strengths of the desired and interfering stations are measured at a number of points throughout the region it is possible to predict the type of interference which will occur and to estimate the expected service areas.

Consider, for example, two stations of equal power located 1,000 miles apart. By assuming some simple formula of propagation for the waves, it is possible to plot curves marking the region within which the beat frequency, for example, will be any desired number of db. below the desired frequency. Typical curves for an attenuation constant of .001 are shown on Fig. 2.

Here the small curve marked 1 represents the area within which the beat frequency will be down 40 db. from the desired frequency when the modulation is 10 per cent. This represents an intermediate degree of modulation. During very soft passages the beat frequency will be of greater relative importance and during the louder passages, of less. Curve 2 marks off an area for similar conditions but where the beat frequency is only 20 db. below the desired signal.

For sideband noise the factor of modulation does not enter if the two stations are broadcasting the same program since the modulation at any instant will be at the same value at the two stations and will thus cancel out in the formula for relative intensity. Also the sideband noise is 20 db. below the intensity of the beat frequency so that curve 2 marks the area within which the sideband noise is 40 db. below the desired signal, and curve 3 has been added to define the area within which the sideband noise is down 20 db. If the two stations are nearly enough at the same carrier frequency so that the beat frequency is below the audible range, curve 3 will thus mark off the area within which all interference will be 20 db. below the desired signal.

Transmission of different programs on same carrier frequency

If the stations transmit different programs, however, the situation is somewhat less favorable, and varies from time to time since the modulation at the interfering station will not be at the same value as at the desired station. It may be a maximum when that at the desired station is a minimum. The area bounded by curves corresponding to 2 and 3 for such a condition will be considerably reduced in area. The situation regarding the beat frequency, however, will remain the same.

These curves graphically illustrate the importance of the various types of interference that the analysis has shown to exist. The value of attenuation used is low which is of particular interest when the distance between the stations is large since with high values of attenuation neither station will have much effect on the service area of the other. At night, of course, the signal strength may correspond to a simple inverse-distance law with zero attenuation, and thus form a serious limitation to shared-frequency broadcasting at night.

One fact that stands out is that satisfactory reception can not be expected in the region midway between two transmitters when the carrier frequencies are several cycles apart. The field strength of one station must be at all times predominantly higher than that of the other for satisfactory reception so that shared-frequency broadcasting should be restricted to widely separated stations. It should then be possible to furnish high grade service to relatively small densely populated areas in the immediate vicinity of each transmitter. If the carriers are strictly isochronous, however, areas several times as large should be feasible.

[1] "Detection of Two Modulated Waves which Differ Slightly in Carrier Frequency," C. B. Aiken, *Proc. I.R.E.*, 19, pp. 120-137, January, 1931.

Noiseless sound-on-film recording

By GEORGE LEWIN

Recording Engineer
Paramount Publix Corporation

MANY different factors contribute to the general background of extraneous noises which we hear when reproducing a film record. For convenience we usually refer to these collectively as surface or ground noise, but if we are to discuss intelligently the question of ground noise reduction, it is important that we classify these various factors, and consider each separately. It will then be found that different means must be employed to reduce the different factors, and that while the system of noise reduction to be discussed in this article reduces some of these factors very effectively, the others will actually become more noticeable as a result.

Surface noise in film recording is generally composed of six distinct elements:

1. Amplifier and emission noises in the recording system itself.
2. Background noises actually picked up by the microphone during recording.
3. Amplifier and emission noises of the reproducing system.
4. Emission noises of the photoelectric cell.
5. Modulation of the scanning light by the film granules.
6. Modulation of the scanning light by dirt, scratches and defects in the emulsion.

The first three are the smallest constituents of the total noise, and are usually quite negligible in standard recording. They become more important, however, in noiseless recording, since the action of noiseless recording, as will be seen, is to reduce only the other constituents.

The emission noise of the photoelectric cell is usually quite a bit louder than that of the amplifier system, although with the introduction of the latest type of Caesium cell it has been materially reduced, and is considerably less important than the next two constituents. It is, moreover, effectively reduced in level by the action of noiseless recording.

The modulation of the scanning light by the film granules is the major source of surface noise, and it is mainly this noise which is acted upon when we resort to any form of noiseless recording.

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THE author discusses the theory of noiseless sound-on-film recording as obtained with a light-valve and methods of reducing background noise. In a following issue of *Electronics* the problem is treated further from a practical viewpoint in studio production.

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Methods of reducing noise

The logical method to reduce surface noise would be to reduce or eliminate the various sources of noise by extreme care in recording, processing, and reproducing the film. The reduction of emission noises and extraneous sputterings in the recording and reproducing equipment is simply a matter of careful maintenance. By using extreme care in the developing processes, the film granules can be made so small and uniform that the surface noise due to this cause is scarcely more objectionable than the emission noise of a high-grade amplifier. The prevention of dust and scratches is likewise merely a matter of care in handling the film during the course of recording, processing, and reproducing it. It has, in fact, been successfully demonstrated, that, without resorting to any artificial means of noise reduction whatever, it is possible to produce film records with even less surface noise than is found in the best available specimens of commercial noiseless recordings.

From a strictly commercial standpoint, however, it is not practicable to go to such extremes in order to obtain a material reduction in surface noise. If we could modulate the light valve 100 per cent at all times, and at all levels, we would never be troubled by surface noise. This effect is obtained by automatically varying the spacing of the valve, so that at low levels the valve is practically closed, and as the level increases the average valve opening increases so that it is always open just enough to accommodate the amount of volume which is being recorded. At low levels, therefore, the average exposure of the negative, and hence the transmission of the print is low. As the recording level increases, the exposure of the negative, and therefore the transmission of the print, increases. Since, for a given percentage of modulation, the reproduced volume is proportional to the transmission of the print, it will be seen that while the percentage modulation of the valve is always high, regardless of the recording level, the transmission of the print varies correspondingly. The original volume variations are restored when we convert the record back into sound.

This pre-supposes that the print transmission is proportional to the negative exposure—a condition which obtains only when the true overall gamma is equal to unity. It is important to bear in mind, then, that with noiseless recording the maintenance of an overall gamma of unity is even more important than it is in standard recording, because if the gamma is other than unity, it will result not only in a wave-form distortion, but also in a volume distortion.

Fig. 1 shows two sound track prints, made from simultaneously recorded negatives, one with noise reduction and the other with standard recording. The noiseless

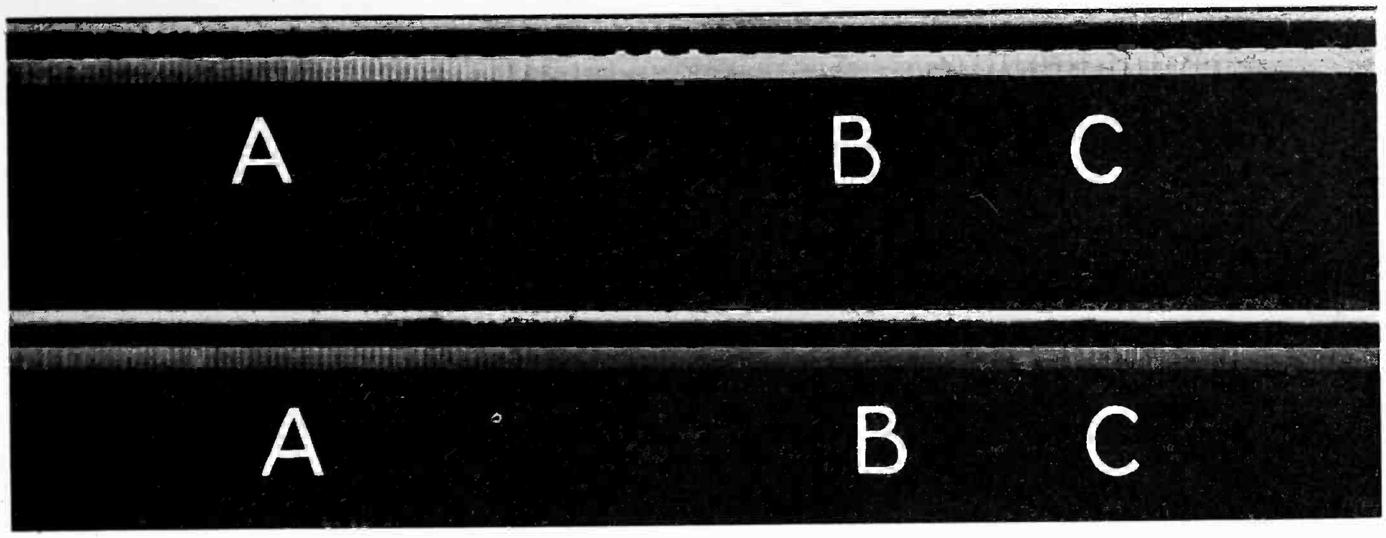

Fig. 1—Two sound track prints made from simultaneously recorded negatives. The lower print is made with noise reduction equipment and the upper with standard recording

recording print is easily distinguished by its varying transmission, while the standard recording has a constant transmission. In the heavily modulated portion at *A*, it will be noticed that both prints have practically the same transmission, while in the unmodulated portion at *B*, the noiseless recording print becomes quite dark, thus suppressing surface noise.

Notice also, that the low level modulations at *C* are rather indistinct in the standard print and quite conspicuous in the other. In fact, close observation of the portions which, at first glance, appear to be completely unmodulated in the standard print, show noticeable modulation in the noiseless recording print. This will make it clear why modulations which are ordinarily covered by surface noise in standard recording, become distinctly audible when noiseless recording is used.

Noise reduction equipment

The principal additions to the recording equipment necessary to provide noiseless recording include an additional amplifier, known as the noise reduction amplifier, and a rectifier. The relation of this equipment to the recording channel is shown in Fig. 2.

The operation of the system may be briefly described as follows:

A biasing current from a battery is applied to the light valve strings through a suitable rheostat and milliameter. The polarity of this current is such as to move the strings in a closing direction, and is adjusted until the valve is closed down to a definite spacing which determines the amount of noise reduction. The main recording amplifier which actuates the light valve, also feeds some energy to the noise reduction amplifier, the output of which is then rectified, resulting in a pulsating uni-directional current which, after proper filtering, follows the envelope of the recording signal. The polarity of the rectified current is such as to oppose the static biasing current, and therefore causes the valve to open by an amount proportional to the level of the recording signal. The gain of the noise reduction amplifier is adjusted so that the d.c. output of the rectifier is just equal to the static bias when the level is just high enough to overload a normal one mil light valve. In other words, as the recording level increases, the valve automatically opens up until, when the overload level is reached, the valve is open to its normal spacing.

The standard type of light valve has a certain amount of friction between the ribbons and the bridges on which they rest. This makes the spacing somewhat unreliable. That is, after being modulated the spacing does not always return to its original value. If a curve is plotted for a standard valve, showing the relation between current and spacing an actual hysteresis loop is obtained. This condition is especially unsatisfactory for bias recording as it makes it difficult to establish a satisfactory relationship between biasing current and valve spacing. Laboratory processing technique for noiseless recording, as will be discussed later, is based largely on measurement of the biased and unbiased unmodulated tracks, and it is therefore essential that these be constant enough for accurate measurement.

The modifications in the light valve consist principally of improvements in the bridges and spacers so as to reduce the friction to a minimum. The hysteresis loop has therefore been practically eliminated. This has resulted in a noticeable improvement in tone quality as well, since the hysteresis loop in a standard valve has always introduced a considerable percentage of harmonics. This can readily be noticed in listening to an oscillator tone through both a standard and modified valve. The modified valve is distinguished by its almost complete freedom from extraneous harmonics.

Limiting factors imposed

The principal limiting factor is the range of the film emulsion itself. If the relation between negative exposure and print transmission were a straight line, starting from zero exposure and continuing to some definite point, we could allow the valve to close completely during the silent spots. Actually, we know that the exposure must be kept between certain limits, if we are to avoid photographic overloading of the emulsion.

A safe minimum allowable value for the density in the negative is about 0.3, which is just about the density we get from an exposure through a valve closed down to 0.2 mil.

Another limitation is imposed by the light valve ribbon itself. If the edges of the ribbon were perfectly smooth, they could be closed up completely without difficulty. In practice, however, we find that when the ribbons approach a spacing of 0.2 mils or less, the irregularities in the edges become apparent, and very pronounced streaks begin to appear in the sound track. Even with the best ribbon obtainable, the high spots will begin to actually clash when the average spacing is still in the neighborhood of 0.1 mils or more.

Experience has shown that if the surface noise in the average film record is reduced by 10 db. or more, it becomes practically inaudible in the average theater. By this, we mean that the surface noise drops below the level of the other noises in the theater, principally the ventilator noise and the general audience noise. Hence, even if it were possible to obtain noise reductions of greater than 14 db., it would be of no advantage. As a matter of fact, 10 db. noise reduction is ample in the theater, although a higher reduction in the original recording is desirable since it allows us to re-record sequences for scoring and synchronizing without worrying about the surface noise becoming objectionable.

It should be borne in mind that while the action of noiseless recording is primarily to reduce the noise due to the film granules and to reduce the emission of the photoelectric cell, there is also a reduction of the noise due to dirt and scratches on the film. It is apparent that scratches and specks of dust will have less effect on a very dark track than they will on a light one, especially in spots of little or no modulation. By the time a negative has gone through all of its cutting processes, and after eight or ten test prints have been made from it, the surface noise has gone up several db. and for this reason, if we desire a final noise reduction of 10 db. in the release prints, we should obtain about 14 db. reduction in the original recordings.

The amount of noise reduction is measured by the ratio of the biased and unbiased unmodulated print transmissions. For example, if the transmission of the print resulting from a normal 1 mil exposure is 30 per cent.

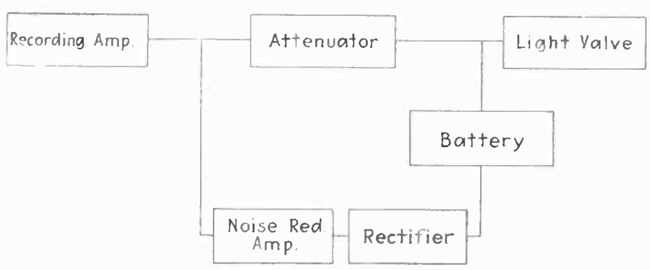

Fig. 2—Block diagram of a recording channel with noise reduction equipment

and that of the biased exposure is 6 per cent. the ratio is 5 : 1. The noise reduction expressed in db. is then

$$20 \log 5 = 14 \text{ db.}$$

Assuming an overall gamma of unity, the ratio of transmissions in the print is equal to the ratio of exposures in the negative. Then if we use a light-valve with a normal spacing of 1 mil, and desire to obtain a noise reduction of 14 db., the valve must be biased down to 0.2 mils during periods of no modulation. This is about the maximum amount of noise reduction it is practical to use. For a noise reduction of 10 db. the valve is biased down to 0.3 mils spacing.

These figures refer only to the difference in noise levels which would be heard between biased and unbiased recordings during the unmodulated portions. If the surface noise is to remain unnoticeable at all times, then, as modulation at various levels is impressed on the light valve, it is essential that the valve open up just enough to accommodate the modulation without film overload. If the characteristics of the circuit are such that the percentage of modulation changes radically with change of level, we are apt to hear an unpleasant swish of surface noise superimposed upon some of the modulation should the valve open more than necessary, and we are also apt to get valve clashing on film overload

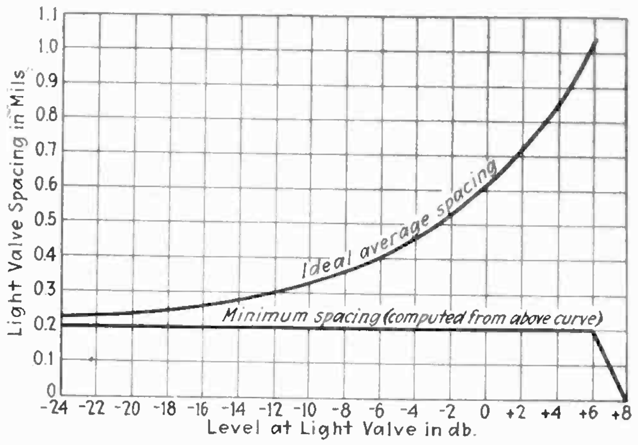

Fig. 3—Ideal spacing curve for 14 db. noise reduction

should the valve fail to open sufficiently. These conditions are purely a function of the electrical design of the circuit and also the proper operating adjustments.

Ideal ribbon spacing

Figure 3 shows the ideal characteristic of a 14 db. noise reduction set-up. In this ideal set-up we assume that the maximum modulation of the valve is 80 per cent, and that as the level is decreased, the modulation decreases so that the minimum closure of the valve during a cycle is always 0.2 mils. This will prevent the possibility of film overloads. The overload level of an average 1 mil light-valve is +8 db. (relative to 0.006 watts or zero level), hence in the ideal curve we show the valve opening up to 1 mil at a level of +6 db. As the level decreases the curve shows how the spacing should change in order that the minimum distance between the ribbons during each cycle shall be 0.2 mils.

The points on this curve are readily determined by bearing in mind that for every 6 db. reduction in level, the amplitude of vibration becomes half its former value. It will be noted that if at any point on the curve we measure down the total excursion of the ribbons in the closing direction, we will always reach the 0.2 mil line. That is, regardless of what level we put on the valve, the minimum opening between the ribbons during each cycle is always 0.2 mils. In other words we are always modulating the film the maximum permissible amount, hence this may be called the ideal condition for noiseless recording, taking into account the limitations of the film emulsion.

In practice, however, we must make still further allowances. While the conditions called for in the ideal curve can actually be obtained by proper adjustments in the circuit, they will hold true only for constant tone tests at a given frequency. If we were to plot an experimental curve at some other frequency, we would get a different result, due to the fact that the noise reduction amplifier, the rectifier, and the light-valve, all have slightly different frequency characteristics. Moreover, in actual recording we encounter transients to which the rectified current cannot respond as quickly as the light-valve itself, due to the time lag which is inherent in any form of filter circuit. In other words, the static or constant tone characteristics of the circuit as shown by the curve are not the same as the transient or dynamic characteristics which are encountered in actual recording.

In a following article, in *Electronics,* the modifications in the characteristics of the circuit to meet the conditions of actual recording will be discussed.

Tube amplifier equivalent parallel circuit

By GORDON D. ROBINSON

THE fact that the control action of the grid in an amplifier tube can, for purposes of a.c. computation, be replaced by a fictitious emf. μE_g in series with the space path of the tube has long been known. This substitution leads to a three-branch network containing emfs. in two branches. If the circuit may be simplified by neglecting the grid-to-plate capacity this network becomes a simple series circuit. A parallel circuit which may be used to replace the latter in so far as results in the load are concerned has previously been published by the author and others separately and independently.

It is now intended to show that the parallel substitution for the simple series circuit is merely a simplification of the general parallel equivalent circuit, in which the internal plate resistance, the load, and the grid-to-plate reactance are all treated as being in parallel.

As a starting point, consider the original equivalent circuit of the amplifier. A form of this circuit is shown in Fig. 1. Given the constants of a circuit, which operates under such conditions that these values do not change, any desired a.c. component of current or voltage may be computed.

To establish the parallel equivalent circuit relationship, consider next Fig. 2. Assume (1) that a source provides an emf. F_x between terminals A and B when the load is disconnected, (2) that it provides a current I when the terminals are short-circuited and (3) that it has linear characteristics. The source has no other limitations. The impedance of the source is E_x/I. (Call it Z).

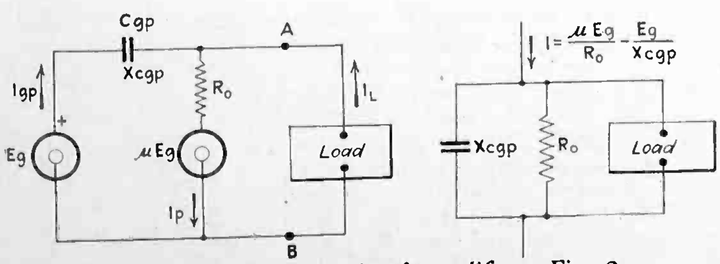

Fig. 1—Equivalent circuit of amplifier. Fig. 2—Parallel equivalent circuit

Call the impedance of the load Z_3, and the current, which flows as a result of connecting the load across the terminals A and B, I_3. By simple inspection, and using complex algebra procedure, $I_3 = E_x/ (Z \div Z_3)$.

To prove that passing the short-circuit current I through Z and Z_3 in parallel will cause the same current as above to flow through Z_3: Assuming for the moment that the procedure is correct, $I_3 Z_3 =$

$$\left(\frac{1}{\frac{1}{Z}+\frac{1}{Z_3}}\right) = \frac{E_x}{Z}\left(\frac{ZZ_3}{Z+Z_3}\right) = \frac{E_x Z_3}{Z+Z_3}$$

Therefore $I_3 = E_x/(Z + Z_3)$. Since this is the same result as that obtained before, the procedure is justified.

To apply the preceding to the vacuum tube circuit, consider Fig. 1 to have a short-circuit placed between points A and B. The current which will flow will be the resultant of $\mu E_g/R_o$ and E_g/X_{cgp}. It may be shown that, since E_g and μE_g tend to send current through the short-circuit in opposite directions, this resultant is in fact the vector *difference*. In terms of complex algebra, the short-circuit current will be $\mu E_g/R_o - E_g/X_{cpg}$. Applying the relationship demonstrated in connection with *a* source *AB* we see that the preceding current passed through a parallel circuit consisting of the capacity reactance from grid to plate, the internal plate resistance, and the load impedance, will result in the true voltage appearing across the load and the true current passing through the load. This parallel equivalent circuit is shown in Fig. 2.

If the capacity reactance between grid and plate (X_{cgp}) is assumed to be infinite this circuit reduces directly to the simpler parallel equivalent circuit previously published.

The current through either R_o or C_{gp} in Fig. 2 is not that actually flowing in the real circuit. This may most easily be seen by observing that each has across it the same voltage as the load. The currents actually flowing in these two may be found with relative ease after finding the voltage across the load. Still in terms of complex algebra, and calling the voltage across the load E_L, $I_{gp} = (E_g + E_L)/X_{cgp}$ and $I_p = (\mu E_g - E_L)/R_o$.

Applying the paralllel equivalent circuit to the screen-grid tube and transformer-coupled audio-frequency amplification, let us compare a screen-grid tube having a certain mutual conductance with a three-element tube having the same mutual conductance. If the transformer suitable for use with the three-element tube is used with the screen-grid tube and a resistor, of such size that the resultant parallel R is the same in the diagram for either tube, is placed in parallel with the primary of the transformer, it is seen that the results for small a.c. voltages in the one case will differ from those in the other case only due to different size of capacities and different amounts of d.c. passed through the transformer. Both of these differences will usually be in favor of the screen-grid tube. It would consequently appear that, at least for small voltages, the screen-grid tube suitably loaded with resistance may give better quality results in transformer coupled amplification than will a triode. This does not seem to have been the line of thought followed in the past.

The expression for short-circuit current used in Fig. 2 may be rewritten as $E_g(g_m - 1/X_{cgp})$ or $E_g(g_m - j2\pi f C_{gp})$. This suggests the possibility of creating a new term similar to mutual conductance, but written in complex form, to include the effect of the grid-to-plate capacity. This new term would be $g_m - j2\pi f C_{gp}$.

The calibration of microphones

By HARRY F. OLSON and STANFORD GOLDMAN

RCA Photophone, Inc.

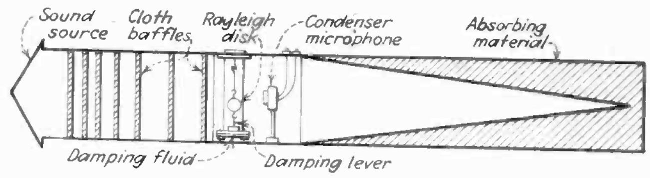

Fig. 1—An acoustic transmission line with graded dissipation

THE purpose of this article is to indicate the most convenient methods of calibrating microphones and their associated amplifiers, for those who have occasion to do so in the field. No attempt will be made to elaborate on all possible methods, nor will the exact theory of several of the methods be given.

The frequencies of importance today range from 40 to 10,000 cycles, and, in the ideal case, a good microphone should be equally sensitive throughout this range to give the most natural reproduction. Limitations of other parts of a transmitting system, however, such as frequency characteristics of loudspeakers, transfer loss in film, and 60-cycle hum, make equal reproduction of all of these frequencies impracticable, but it is nevertheless important to know just what the microphone's response characteristic is throughout this range.

A good microphone should at least be sensitive enough to overshadow completely the inevitable tube hiss of a vacuum tube amplifier, but beyond this, its sensitivity is only important in determining the necessary size of its associated amplifier.

Most high quality microphones at the present time have a sensitivity which is too small to be measured conveniently without an accompanying amplifier. Consequently, what is ordinarily done is to calibrate the microphone in conjunction with an amplifier, and then to calibrate the amplifier and correct for it.

In calibrating a microphone and amplifier, what we desire to know is the volts output into a convenient impedance (usually 250 or 500 ohms) for a given sound pressure in free space at the microphone. To do this directly, the simplest method is to use a Rayleigh disk. This consists of a very light disk hanging vertically on a fine suspension, such as used in a galvanometer. When sound passes such a disk, the disk tends to turn itself so that its plane is perpendicular to the direction of the velocity component of the sound wave. The angle through which it is turned by the sound wave, is proportional to the intensity of the sound, and the absolute intensity of the sound may then be calculated from a knowledge of the constants of the system.[1]

The Rayleigh disk actually measures the velocity component of a sound wave. Consequently, when calibrating a pressure indicator, such as a condenser microphone, a plane wave is essential so that pressure and velocity should be in phase. In an unobstructed medium at a considerable distance from a sound source, the wave front is practically plane. However, the use of a Rayleigh disk in free space is practically impossible due to its sensitiveness to small air currents. For low frequencies, even the use of a well-damped room is precluded, because of standing wave systems. The logical

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METHODS are presented for calibrating various types of microphones including a Rayleigh disk, an actuator method and the thermophone method. Comparative curves are given for different microphones.

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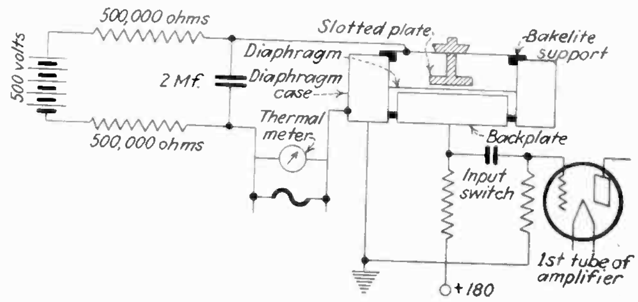

Fig. 2—Diagram of electrical connections when using an actuator

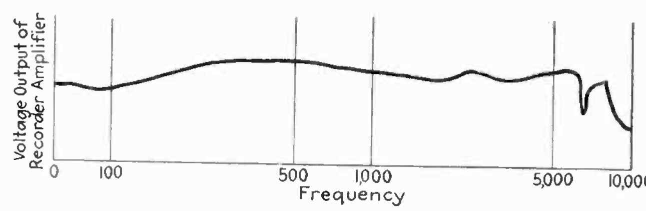

Fig. 3—Actuator—characteristics of a condenser microphone diaphram

[1]For a plane wave in which pressure and velocity are in phase, the sound pressure in bars is given by

$$p = \left[\sqrt{\frac{3\pi^2 \, mc^2\rho}{4T^2a \sin 2\theta}}\right]\phi$$

where m is the mass of the disk
c is the velocity of sound
ρ is the density of air
T is the period of free vibration of the disk
a is the radius of the disk
θ is the angle between the direction of sound and the equilibrium position of the normal to the disk
ϕ is the angle in radians through which the disk is turned.

solution is an acoustic transmission line in which pressure and velocity are in phase. The simplest solution is an infinite non-dissipative line. A suitable substitution for the infinite line is a finite line with properly graded dissipation.

Such a line is used for Rayleigh disk calibrations in the acoustic laboratory of RCA Photophone. A diagram of this is shown in Fig. 1. The section in which the Rayleigh disk or microphone is placed is joined to the other two sections by means of short strips of one-quarter inch felt. This prevents vibrations of the walls of the adjoining sections being transmitted to the measuring instruments.

Past the point of observation it is desirable to absorb the sound without reflection. This is accomplished with a gradually increasing thickness of felt.

In order to calibrate a microphone in this chamber, the cone is made to give out sound of a definite frequency. The intensity of the sound is measured by the deflection of the Rayleigh disk while the electrical output of the microphone is measured with a meter. As the frequency of the sound is varied, we get a frequency calibration of the microphone.

It is found at frequencies above 1,000 cycles that it is necessary to remove the microphone while measuring the sound intensity to prevent reflection. A frequency calibration of a condenser microphone and amplifier by this method is shown in Fig. 6.

Comparison methods

Having once obtained the absolute calibration of one microphone and amplifier, the absolute calibration of others may be obtained by comparison with it. In order to do this, the following method may be employed. A large loud speaking directional baffle is placed vertically on the ground out in the open air in a quiet neighborhood. In this way room reflections are obviated. About 25 feet above this is stretched a cable from which microphones may be suspended. The standard microphone is then placed in position about 25 feet above the loudspeaker and the output of its amplifier into a 500-ohm line is measured for a given input into the speaker for the whole frequency range covered by the loudspeaker. Then the microphone and amplifier to be tested are placed in position and their output is obtained under the same conditions. Then all points in the frequency

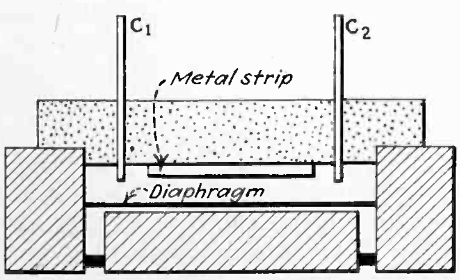

Fig. 4—Thermophone in position on a condenser microphone

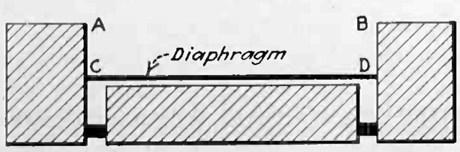

Fig. 5—Illustration of the cavity in a condenser microphone

calibration of the microphone under test may be obtained by use of the equation:

$$X = \frac{R_x}{R_s} S$$

where X = millivolts per bar of microphone and amplifier under test
S = millivolts per bar of standard microphone and amplifier
R_x = output volts into a 500 ohm line of microphone and amplifier under test
R_s = output volts into a 500 ohm line of standard microphone and amplifier.

If such an outdoor testing apparatus is available, as well as a standard calibrated microphone and amplifier, it will usually be found that this is the most convenient and most universally applicable method for testing microphones.

The above methods of calibration give the frequency response characteristics of microphones as they are usually used in the field. There are other methods, however, which are convenient and rapid in testing *pressure* operated microphones as they come from the factory. These are the so-called constant pressure calibrations.

The actuator method

We shall begin by describing one which is particularly applicable to the condenser microphone. This is the actuator method. The electrostatic actuator consists of a grill or slotted plate which is slipped into the front opening of a condenser microphone so that its surface is parallel to the diaphragm. The application of a voltage between the actuator and the diaphragm will produce a force on the diaphragm the magnitude of which depends upon the voltage, the spacing between the slotted plate and the diaphragm, and the effective area of the slotted plate. The application of an alternating voltage simulates a sound **wave. In** Fig. 2 is a diagram of the necessary electrical connections when using an actuator.

Let E be the polarizing voltage on the actuator.
Let $e = e_o \sin 2\pi ft$ be the a.c. voltage.
Let $V = E + e$ be the total instantaneous difference in potential between the actuator and the diaphragm.

Then the total charge on the diaphragm due to the actuator is

$$Q = CV$$

where C is the capacity between the actuator and the diaphragm.

The average charge per unit area on the diaphragm is

$$\frac{CV}{A} = \sigma_{av.}$$

Now it is well known from electrostatics that the force per unit area on any conductor is $2\pi\sigma^2$ normal to its surface.

Therefore the total force on the diaphragm is approximately

$$2\pi\sigma_{av}^2 A = 2\pi \frac{C^2V^2}{A} = \sigma_{av.}$$

This shows that the force on the diaphragm is proportional to the square of the applied voltage.

$$F = \frac{2\pi C^2}{A} (E + e_o \sin 2\pi ft)^2$$
$$= \frac{2\pi C^2}{A} [E^2 + 2E\, e_o \sin 2\pi ft + e_o^2 \sin^2 2\pi ft]$$
$$= \frac{2\pi C^2}{A} [E^2 + e_o^2 + 2E\, e_o \sin 2\pi ft - \frac{e_o^2}{2} \cos 4\pi ft]$$

The first two terms in this equation cause a constant extension of the diaphragm, but nothing that goes through the amplifier. The third term, however, causes the same periodic force on the diaphragm as a sound wave of frequency f, and intensity

$$\left(\frac{2\pi C^2 E\, e_o}{A}\right)^2 \frac{1}{2\rho c}$$

where, as before, ρ_o = density of air
and c = velocity of sound.

The fourth term causes the same periodic force on the diaphragm as a sound wave of frequency $2f$, and intensity $\left(\frac{\pi C^2 e_o^2}{A}\right)^2 \frac{1}{2\rho_o c}$.

These last two effects are both recorded on the output meter. In order to keep the effect of the double frequency term small, e_o is made small in comparison with E, and if necessary, a filter is used.

A simple calculation shows that using a spacing of 0.020 inch between the slotted plate and the diaphragm and a polarizing voltage of 500 volts, an alternating voltage of 50 volts is approximately equivalent to a sound wave of 4 bars intensity. An exact calculation of this effect is very difficult and tedious due to the fringing of the lines of force around the edges of the slots in the face of the actuator.

In practical use a frequency-response characteristic of the microphone is obtained for a constant a.c. voltage supplied by the actuator. Such a curve is shown in Fig. 3. These curves show the relative sensitivities of different microphones tested, and indicate any which have defective diaphragms, bad diaphragm resonance, or any such faults. Since such a curve may be obtained in a few minutes, when the apparatus is all set up, it is a very convenient production or routine test.

The thermophone method

There is another method of pressure calibration which is applicable to all pressure operated microphones. This is the thermophone method. In Fig. 4 we have a diagram of a thermophone in position on a condenser microphone. Its essential parts are a circular block, B, which completely closes up the measuring chamber, except for the narrow tubes C_1 and C_2 which allow for equalization of pressure inside the chamber and out, and a very thin metallic strip which is suspended from two conducting terminals. The strip may be made of platinum 2 in. by 10^{-5} in. thick or gold 3 in. by 10^{-6} in. thick. This is sufficiently thin so that if an alternating current is sent through the strip, the surface of the strip will be heated and cooled with the same frequency as the heat is generated.

Suppose an alternating current, I, of frequency f is sent through the strip. Then the heat generated in the strip is

$$RI^2 = RI_o^2 \cos^2 2\pi ft = \frac{RI_o^2}{2} + \frac{RI_o^2}{2} \cos 2\pi\ (2f)t$$

where $I = I_o \cos 2\pi ft$
and R = resistance of the strip.

The first term in this equation indicates that there is a steady rise in temperature of the strip, the second shows that superimposed upon this is a variable change in temperature of the strip of twice the frequency of the alternating current.

When the temperature of the strip changes, it causes a change in temperature of the air in its immediate vicinity. This causes a change in pressure which is propagated throughout the chamber with the velocity of sound. If the acoustical wavelength of these variations in pressure is large compared with the size of the chamber, the pressure will be practically the same throughout the chamber at any instant, and the pressure will vary with double the frequency of the alternating current in the strip. In order to increase the acoustical wavelength, the chamber is usually filled with hydrogen.

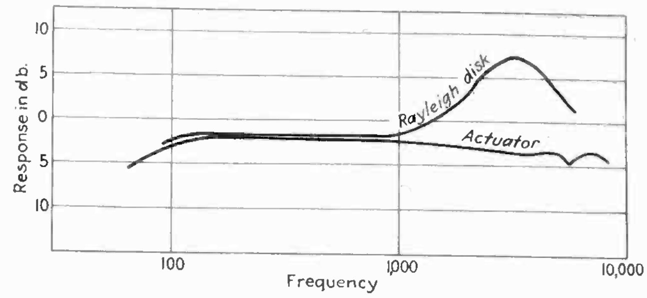

Fig. 6—Frequency response curves of a condenser microphone and amplifier obtained with a Rayleigh disk and an actuator

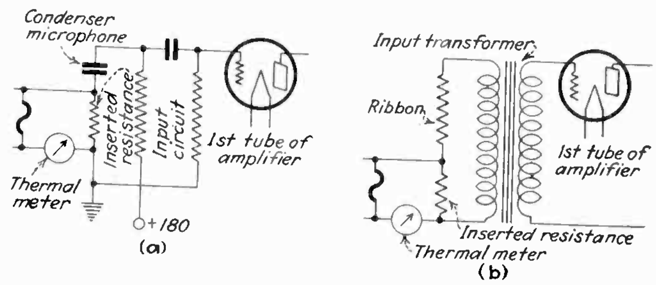

Fig. 7 (a)—Circuit diagrams for tests with condenser microphone and (b) for ribbon microphone

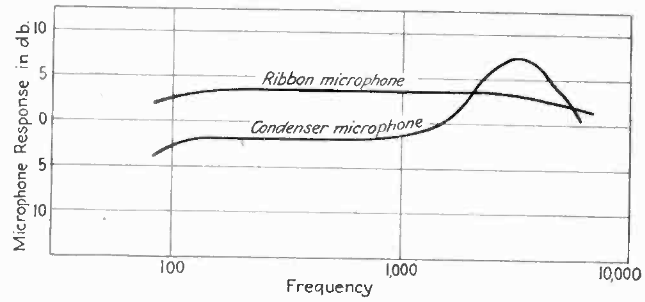

Fig. 8—Frequency response curves of two common types of microphones

In this way the equivalent of a sound wave acts upon the diaphragm of the condenser microphone in the chamber. By supplying alternating sound pressures of various frequencies, a microphone may then be calibrated. An absolute calibration is possible by this method, but as in the case of the actuator, it is very difficult and tedious. Therefore the method is usually used in testing production samples by supplying a definite acoustical pressure at every frequency to all the microphones to be tested, and then comparing their outputs.

For a given electrical input, the pressure supplied by a thermophone in the calibration chamber falls off rapidly with frequency. This is a distinct disadvantage of the thermophone as compared with the actuator.

The thermophone may be used to test any pressure

[*Continued on page 130*]

Vacuum tube voltmeter of high sensitivity

By H. J. REICH, G. S. MARVIN and K. A. STOLL

*Department of Electrical Engineering
University of Illinois*

FOR certain types of laboratory measurements some form of electrostatic voltmeter is indispensable. The detection type of vacuum-tube voltmeter supplies the need of an instrument capable of measuring small values of a.c. voltage. For larger a.c. voltages or for d.c. voltages the peak type of vacuum-tube voltmeter can be used, but as ordinarily constructed, using a three-element tube, the sensitivity is rather poor. In order to find a more suitable tube for this purpose a survey was made of the more recent types of tubes. The results of this work have made possible the development of the sensitive portable instrument which will be described in this paper.

With this meter all values of d.c. voltage can be read to within 0.05 volt; a.c. voltages can be read to within ½ per cent above 20 volts peak, and to within 0.1 volt below 20 volts. Greater sensitivity may be obtained if desired, at the expense of portability, but as the galvanometer type of d.c. meter which must be used in conjunction with the instrument is not likely to have an accuracy greater than ½ per cent, this is usually not justified. In designing this instrument no special attempt was made to secure low input capacity, and it is therefore not very suitable for radio-frequency work. By proper design the field of application may readily be extended to the measurement of radio-frequency voltages.

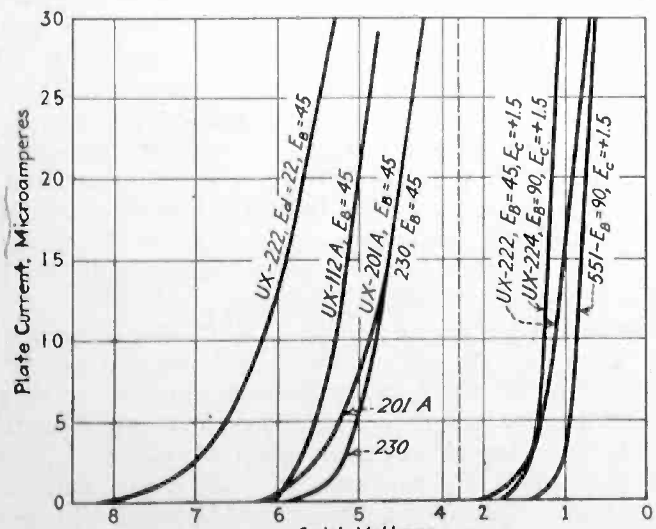

Fig. 1—Curves to determine best tube for voltmeter

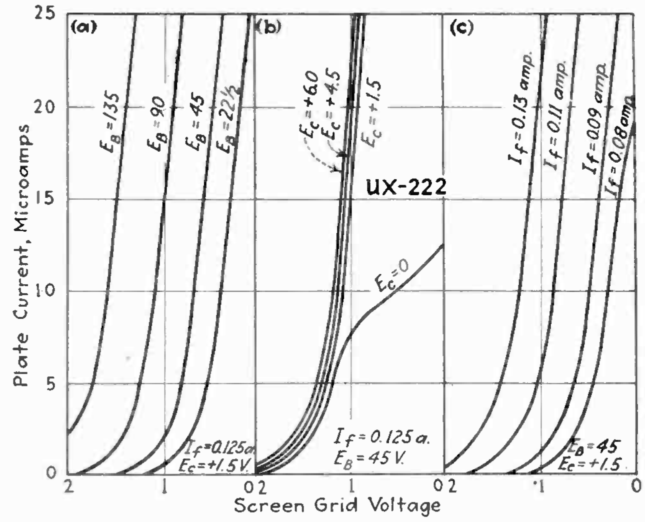

Fig. 2—Effect of variations in various voltages on tube characteristic

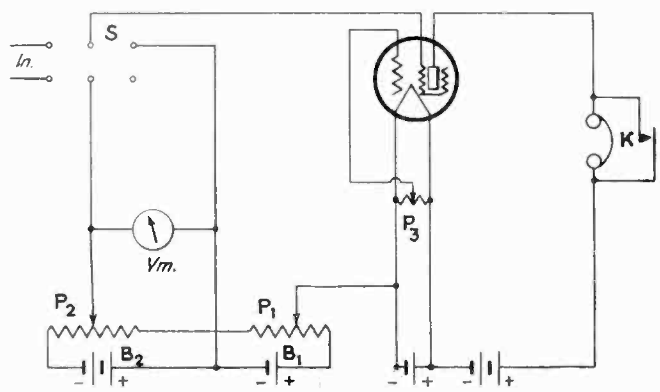

Fig. 3—Basic diagram, note use of screen grid as control grid

The tube used in this instrument must satisfy the following requirements:

1. Sharp plate-current cut-off.
2. High input resistance.
3. Transconductance which does not change materially in the neighborhood of cut-off with changes of battery voltages to be expected during the normal life of the batteries.
4. For a portable instrument, low plate voltage.

Unless extreme accuracy is desired, a pair of phones may be used in place of the usual galvanometer in setting the instrument. The least current which will give an audible click when the phones are shorted is about seven microamperes, and the most satisfactory range of current extends up to about 20 microamperes. This current range is also best when a microammeter is used in the plate circuit in making d.c. readings.

Choice of tube for voltmeter

Fourteen types of tubes, including two types of pentodes were tested on the basis of the above requirements. Figure 1 shows typical plate-current characteristics in the useful current range for the most satisfactory types. The 201A curve is also shown for the purpose of comparison. An examination of these characteristics indicates that the 224 and 551 tubes with the screen-grid used as control element are by far the best, and the 222 with the screen-grid as control element is in second place. The 112 A is the best three-element tube.

Curves of screen-grid current against plate current for various values of plate voltage for the 222, 551 and 224 make evident that in order to obtain high input resistance with the 551 or 224, considerably more than 45 volts must be used on the plate. This would necessitate too many B-batteries for convenience in a portable instrument operated entirely from batteries. For this reason the 222 tube was chosen.

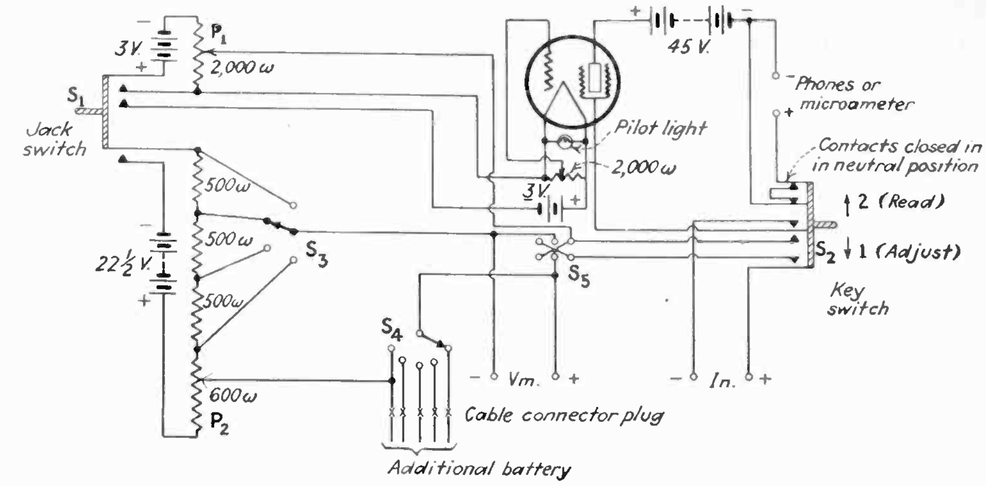

Fig. 4—Complete diagram of voltmeter, giving values of resistances

Effect of voltage variations

Figs 2 a, 2 b, and 2 c show $I_p - E_d$ curves for the 222 for various values of E_b, E_c, and I_f, respectively, other voltages remaining constant in each case. The effect of variation of battery voltages over relatively large ranges is seen to be a shift of the curves, with practically no change in slope. To maintain high input resistance it is necessary to use at least 45 volts on the plate, which is sufficient to keep the screen-grid current below $\frac{1}{4}$ microampere in the working range. Under certain conditions of use it may be desirable to use a higher plate voltage. The curves of Fig. 2 b show that the control-grid voltage, E_c, must be positive by a volt or so. Two new dry-cells in series will give a filament current of about 110 mils, which is well within the satisfactory filament current range, as shown by Fig. 2 c. Increase of battery resistance with age will not change the sensitivity until the current drops below 90 mils.

Two dry-cells, three standard $22\frac{1}{2}$-volt B-batteries, and a $4\frac{1}{2}$-volt C-battery will conveniently fit into a case whose internal dimensions are $10\frac{1}{2}$ in. long by 8 in. deep by $7\frac{1}{2}$ in. high, and leave ample room for the tube. These give all the necessary operating voltages and sufficient balancing voltage for readings up to $22\frac{1}{2}$ volts peak. For higher voltages additional external batteries must be used.

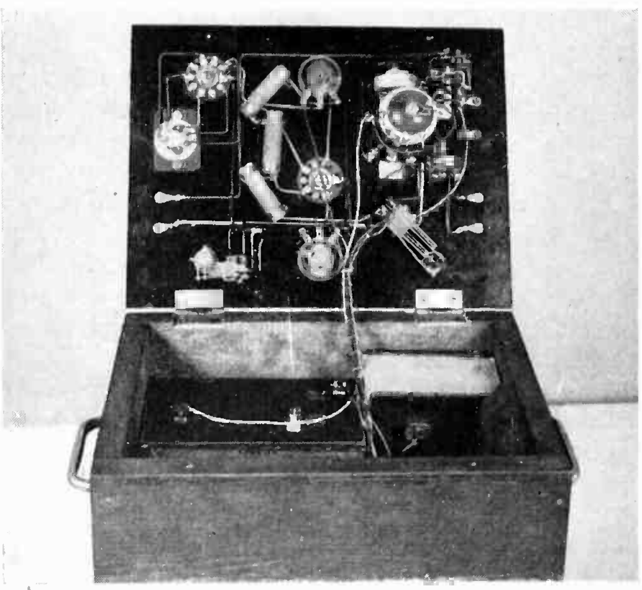
Fig. 5—Photograph of completed instrument

The basic circuit diagram appears in Fig. 3, and the complete diagram actually used in the wiring of the instrument in Fig. 4. The contacts of the key-switch are adjusted so that as the key is pushed backward a small amount (position 1), all voltage is cut out of the screen-grid circuit except the zero-adjustment voltage. Further motion of the key removes a short-circuit from the phones, producing a sharp click when the circuit is not balanced. As the key is moved forward (position 2), on the other hand, the input and balancing voltages are first introduced into the grid circuit, and then the short-circuit is removed from the phones. Switch S_1 opens all battery circuits when the instrument is turned off. In choosing the resistances for the $22\frac{1}{2}$-volt potentiometer a compromise was made between the desirability of low current drain to obtain long battery life, and the necessity of drawing sufficient current so that with a 150-ohm-per-volt d.c. meter the potentiometer sensitivity would be fairly constant throughout its range.

The usual method of using the meter is to set the zero-adjusting potentiometer so that the click in the phones is just inaudible when the key is in the adjustment position, and then snap the key to the reading position and adjust the balancing potentiometer so that the click is again just inaudible when d.c. voltages are being measured, or so that the hum just disappears when a.c. voltages are being measured. With this method of using the instrument d.c. readings are correct to within 0.05 volt and a.c. readings to within 1 per cent. An optional method of measuring d.c. voltage is to compare clicks of convenient intensity for the two key positions. Greater accuracy may be obtained, particularly in a noisy room, if a microammeter or galvanometer is substituted for the phones. In this manner no difficulty is experienced in measuring d.c. voltages to within 0.02 volt, providing the balancing potentiometer will provide sufficiently small changes of voltage.

Since the steepness of the $I_p - E_d$ curves decreases in the vicinity of cut-off, it would be desirable to use a finite value of plate current in taking a.c. readings. Unless the instrument is calibrated, however, detection introduces an appreciable error when this is done. When phones are used it is necessary to work with a minimum current of seven microamperes, and another source of error also arises from the difficulty of comparing a click with a hum. These two factors seem partly to annul each other, so that with phones the average person obtains readings correct to within 1 per cent except at very low voltages. With a microammeter in the plate circuit and a current of ½ microampere, readings are found to be 1 per cent low at 15 volts, ½ per cent at 40 volts, and at 80 volts and above are correct within the sensitivity of the meter. By using a 5 to 10 microampere plate current and calibrating the instrument, a.c. voltages can be read to within ½ per cent above 20 volts, and to within 0.1 volt below 20 volts.

In order to insure high input resistance before the meter is balanced it is sometimes better to apply d.c. voltages in such a direction as to make the grid negative, which necessitates connecting the balancing voltage with the positive side toward the grid. For a.c. measurements, on the other hand, the negative side of the balancing voltage must be connected toward the grid. For this reason the double-pole double-throw switch S_5 is provided for reversing the polarity of the balancing voltage.

This reversing switch also affords a convenient means of obtaining the maximum and minimum peak values of a voltage wave made up of d.c. with superimposed a.c. This may be seen by a study of Figs. 6 a and 6 b. If the voltage is applied to the meter in such a direction as to make the grid positive, the grid-voltage variations will be as shown by the dotted curve of Fig. 6 a. In order to prevent the grid from becoming positive during any part of the cycle a negative balancing voltage equal to the maximum peak of the applied voltage must be used. This will move the curve of applied voltage to the position shown by the full curve. The position of the reversing switch is the same as for ordinary a.c. voltage measurement. If, on the other hand, the voltage is applied in the direction which makes the grid negative, the grid-voltage variation will be as shown by the dotted curve of Fig. 6 b, and a positive balancing voltage equal to the minimum peak value will have to be applied before the grid will begin to be positive during any part of the cycle. The position of the reversing switch must be that used for d.c. measurements. Obviously the average voltage is equal to half the sum of these two readings, and the a.c. peak voltage (assuming a symmetrical a.c. voltage) to half the difference.

The greater sensitivity obtainable with the 224 (or 551) tube shows the desirability of designing an instrument using this tube. Without calibration this tube gives readings which are only ¼ per cent low at 15 volts and $\frac{1}{10}$ per cent low at 20 volts, and the sensitivity is almost double that of the 222, as may be seen from Fig. 1. The use of an eliminator for supplying all voltages at once suggests itself, but difficulty is encountered because of variation of a.c. line voltage. If this can be corrected by some sort of voltage regulator, an even more compact and portable, as well as accurate, instrument will be obtained. Development of such an instrument is now under way in this laboratory.

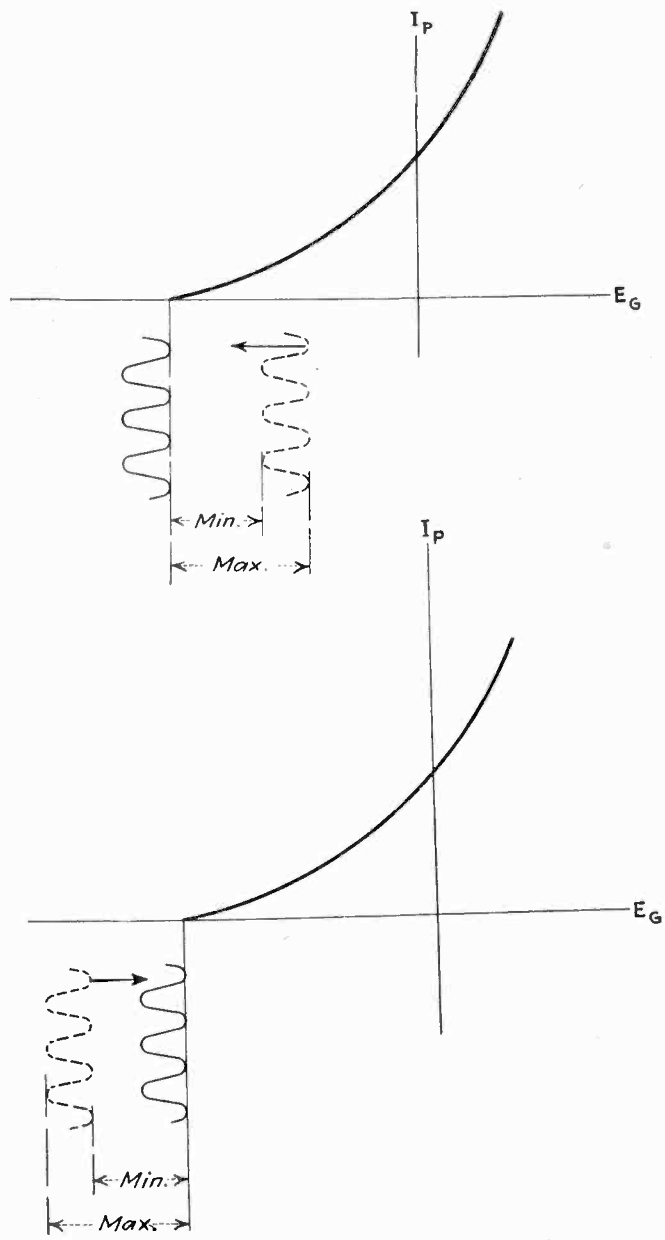

Fig. 6—Either positive or negative peaks of waves can be measured

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Dynamic loudspeaker design—II

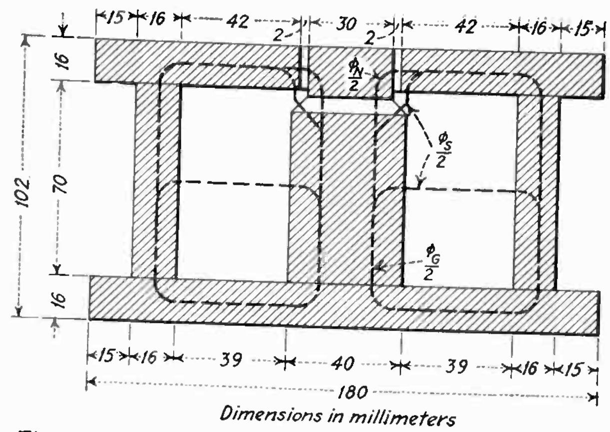

Fig. 1—Cross-section of typical magnetic circuit of speaker

By J. E. GOETH

In Fig. 1 we choose a core diameter of 40 mm., the upper end of which is turned down to 30 mm. The unreduced core cross-section then equals 12.6 cm.^{2}, the reduced cross-section being 56 per cent of this value. Yoke and shank cross-sections should in no case be less than 60 per cent of the core cross-section at the fixed end.

The air cross-section, that is, the section in the air gap which is cut by the useful flux, is equal to $Q_L = \pi$ (diameter of core in air gap + air gap width) $\times$ yoke thickness in cm.^{2}

Of the total flux ϕ_G, the useful flux ϕ_N in the air gap equals 0.7 ϕ_G. The strength of the field or the flux density in the air gap $B_L = H$ is then

$$B_L = H = \frac{\phi_N}{Q_L} = \frac{0.7\,\phi_G}{Q_L} \text{ Gauss.}$$

The length of the path of the lines of force through the air gap is equal to the width of the air gap δ in cm. For air the *A.T./cm.* (ampere turns per centimeter) equal 0.8 times the flux density in air. For a flux density B_L in air the *A.T./cm.* then equal $0.8\,B_L$. The A.T. consumption in the air gap is thereby

$$^{A.T.}\text{air} = 0.8\,B_L\delta\,.$$

From Fig. 2 we see that for a core the reduced cross-section of which is 56 per cent of the unreduced cross-section, we must figure as though the total flux ϕ_G (ϕ is 100 per cent of ϕ_G) passes through a core of the same length with a constant cross-section equal to the cross-section Q_W at the fixed end of the actual core. The flux density in the core is therefore (apparent)

$$B_K = \frac{\phi_G}{Q_W} \text{ Gauss.}$$

The *A.T./cm.* for the flux density B_K we find from the magnetization curve. The apparent length of the lines of force L_K, that is, the path over which the flux B_K acts, is equal to the actual core length

$$L_K = \text{Length of core in cm.}$$

The *A.T.* consumption in the core then becomes

$$^{A.T.}\text{core} = (A.T./cm.\text{ for } B_K)\cdot L_K$$

The cross-section of the yoke and shank is Q_j cm.^{2} Half of the useful flux and the largest portion of the stray flux pass through the upper yoke since the stray flux passes through the upper yoke in the vicinity of the air gap. Only a small portion of the stray flux passes at a greater distance to the upper yoke and into the shank. If we assume that half of the total flux passes through the upper yoke as well as the shank and the lower yoke, we obtain figures which are somewhat too unfavorable. But since the flux density and therefore the *A.T./cm.* are small the error in our figures will be small. The flux density B_j in the yoke and shank is therefore

$$B_j = \frac{\phi_G}{2\,Q_j} \text{ Gauss.}$$

The *A.T./cm.* for the density B_j we obtain from the magnetization curve.

The length of the path of the lines of force through the upper yoke, shank, and lower yoke is L_j = (Distance from shank to air gap along upper yoke + $\frac{\pi}{4}$ thickness of the upper yoke) + (Length of shank) + (Distance between core and shank along lower yoke + $\frac{\pi}{4}$ thickness of the shank + $\frac{\pi}{8}$ core diameter) cm.

The *A.T.* consumption in the upper yoke, shank, and lower yoke amounts to

$$^{A.T.}\text{yoke} = (A.T./cm.\text{ for } B_j)\cdot L_j$$

The sum $^{A.T.}$air + $^{A.T.}$core + $^{A.T.}$yoke represents the exciting *A.T.* which must be applied to the core in order to produce the assumed flux ϕ_G in the magnetic system and to maintain the assumed magnetic condition.

The dimensions of the magnetic system necessary for calculating are taken from Fig. 1. The width of the air gap is 0.2 cm. It is hardly desirable to make this width any less, since it otherwise becomes difficult to accom-

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SOME considerations of the design of the magnetic circuit of dynamic type loud speakers were given in August *Electronics*. In this concluding article the actual computation for a typical case is given.

▲

Translated from the German, "Funk Bastler," by C. W. Loeber.

modate the armature. Thus

$$Q_L = \pi(3.0 + 0.2)1.6 = 16 \text{ cm.}^2$$

and $\delta = 0.2$ cm.

The apparent core cross-section with which we must figure is equal to the actual core cross-section,

$$Q_W = \frac{\pi\, 4^2}{4} = 12.6 \text{ cm.}^2$$

and the apparent length of the lines of force in the core is equal to the actual core length

$$L_K = 8.6 \text{ cm.}$$

The yoke cross-section, which is equal to the shank cross-section, is

$$Q_j = 8 \text{ cm.}^2$$

and the length of the lines of force in the upper yoke, shank and lower yoke is

$$L_j = 19.2 \text{ cm.}$$

In table the values of the flux density, the *A.T./cm.*, the *A.T.*, and the sum of the *A.T.* for several values of ϕ are given.

If we now take the four given values of the exciting $A.T. = (^{A.T.}\text{air} + {}^{A.T.}\text{core} + {}^{A.T.}\text{yoke})$ as abscissa in a coordinate system with the corresponding values of the flux density in the air or the strength of the field as ordinates and if we draw a curve through these points we obtain the curve shown in Fig. 3, the final result of our computations. From this we can see what exciting *A.T.* we need in order to obtain a certain field strength in the air gap; how many ampere turns are required on the core.

The straight line shown in Fig. 3 indicates the strength of the field, dependent upon the exciting *A.T.*, which would be obtained if the excitation served only to produce the field in the air gap. The actual curves approach this line as the excitation is reduced.

The same calculations were made for a magnetic system having an unreduced core diameter but otherwise having the same dimensions. The final result in this case is shown in Fig. 3 curve *b*. If we compare these two curves, we see immediately the purpose of reducing the core diameter. With an excitation of 2,000 *A.T.*, for example, the strength in the air gap of the magnetic system employing a reduced core diameter is 8,700 Gauss while in the case of the core of uniform diameter the field strength is but 7,300 Gauss. Thus we have obtained an increase in field strength of 19 per cent without further expenditure merely by reducing the end of the core.

[*Continued on page 130*]

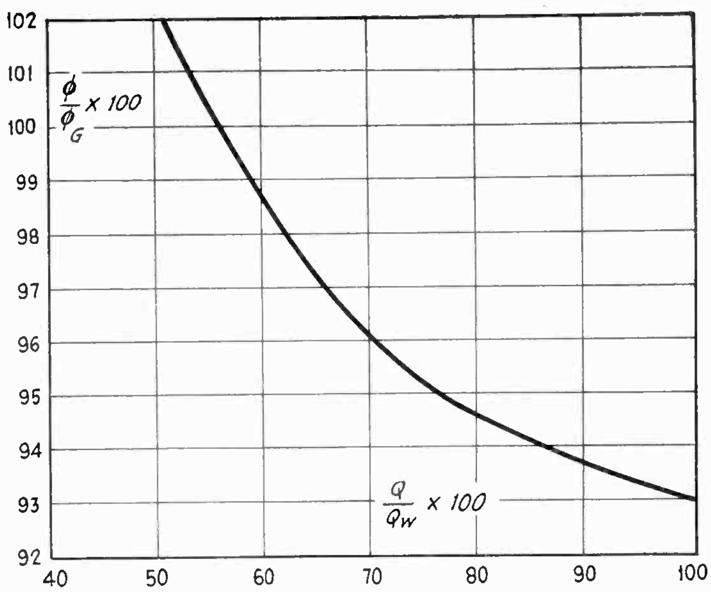


Fig. 2—Apparent flux in the core in per cent of the total flux shown in relation to the reduction of the free end of the core

Data calculated for typical case

Total assumed magnetic flux ϕ_G	0.12×10^6	0.15×10^6	0.18×10^6	0.21×10^6
Useful flux passing through air gap $\phi_N = .7\ \phi_G$	0.084×10^6	0.105×10^6	0.126×10^6	0.147×10^6
Apparent core flux $\phi = \frac{100}{100}\ \phi_G$	0.12×10^6	0.15×10^6	0.18×10^6	0.21×10^6
Flux passing through upper yoke, shank, lower yoke $\phi_G/2$	0.06×10^6	0.075×10^6	0.09×10^6	0.105×10^6

	Flux density (Gauss)	*A.T./cm.*	*A.T.*	Flux density (Gauss)	*A.T./cm.*	*A.T.*	Flux density (Gauss)	*A.T./cm.*	*A.T.*	Flux density (Gauss)	*A.T./cm.*	*A.T.*
Air gap cross-section $Q_L = 16$ cm.²												
Width of air gap $\delta = 0.2$ cm.	5250			6570			7890			9200		
Air flux density $B_L = \frac{\phi_N}{Q_L}$		4200			5250			6300			7350	
$^{A.T.}$air $= 0.8\ \delta\ B_L = 0.8 \times 0.2\ B_L$			840			1050			1260			1470
Core cross-section (Large Diam.) $Q_W = 12.6$ cm.²												
Apparent length of core $L_K = 8.6$ cm.	9500			11900			14300			16700		
Apparent core flux density $B_K = \frac{\phi}{Q_W}$		4.4			9.7			23			74	
$^{A.T.}$core $= 8.6$ ($^{A.T.}$*/cm.* for B_K)			38			83			198			635
Yoke cross-section (equal to shank cross-section) $Q_j = 8$ cm.²												
Length of yoke and shank $L_j = 19.2$ cm.	7500			9400			11200			13100		
Yoke flux density (equal to shank flux density) $B_j = \frac{\phi_G}{2Q_j}$		2.7			4.3			7.5			14.5	
$^{A.T.}$yoke $= 19.2$ ($^{A.T.}$*/cm.* for B_j)			52			83			144			279
$^{A.T.}$air + $^{A.T.}$core + $^{A.T.}$*yoke*			930			1216			1602			2384

+ + + ELECTRONIC TUBES

Life test for condensers

BY H. W. HOUCK*

ACCELERATED LIFE test of paper condensers can be made with d.c. voltages only. Excessive a.c. voltages produce heating, which in turn so alters the characteristics of the dielectric of the condensers that no definite relationship between these a.c. voltages and life has yet been obtained. While tests with a.c. voltages of higher than rated value have so far produced results that cannot be coordinated, high d.c. voltages have given fairly consistent results—so much so, that we have been able to express the life of condensers in terms of impressed voltage.

For years, engineers of the Dubilier laboratories have taken samples of all kinds of paper condensers and subjected them to voltages ranging from their rated to four times rated voltage, keeping them on until the condensers broke down. A record of the kind of condenser, voltage, and life at the particular voltage, was kept. When enough data was thus accumulated—which represented the test results of thousands of condensers, with dielectric thicknesses of from .8 to 6.0 mils, and voltages of 200 to 2,000—it was found that the life could be expressed conservatively in terms of the fifth power of voltage. In other words, the life of paper condensers on d.c. was found to vary inversely as the fifth power of the impressed voltage.

Expressed mathematically:

$$L = K\left(\frac{V_1}{V_2}\right)^5$$

where

L = life in hours
K = a constant depending upon the design of the condenser (usually 10,000).
V_1 = rated voltage
V_2 = applied voltage

It is therefore clear that if a proper sample is taken from a lot of condensers and is subjected to a higher voltage to hasten its breakdown, in a very short time, the sample will reveal the quality of the entire lot. As an example, twice the rated voltage will reduce the life to only about 3 per cent, and hence, instead of waiting about 10,000 hours to find the life of a condenser, only about 300 hours are required at the accelerated life test of twice rated voltage.

Of course, in this as in any other test, a sufficiently large sample must be taken to be really representative of the entire lot. This is governed by the well known probability laws of sampling.

It is well to bear in mind that the fifth power relationship is a most conservative one, and that in well constructed condensers, as high as a seventh power relation (between life and voltage) holds. At no time, even with the poorest of condensers, has a lower than fifth power been obtained.

*Dubilier Condenser Corporation.

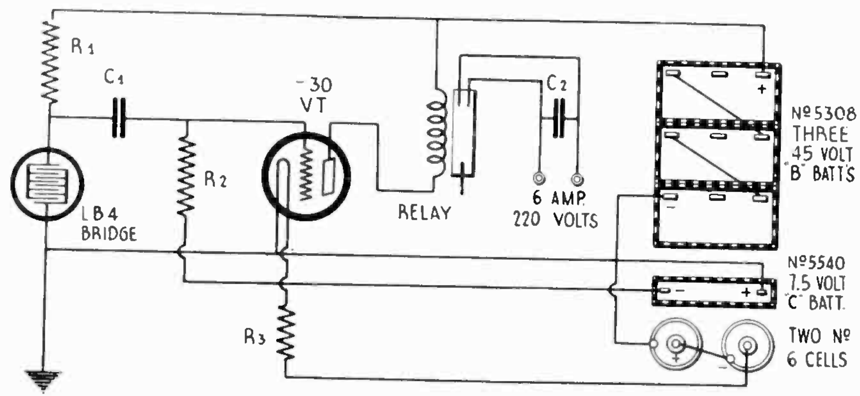
✦

Circuits for light sensitive cells

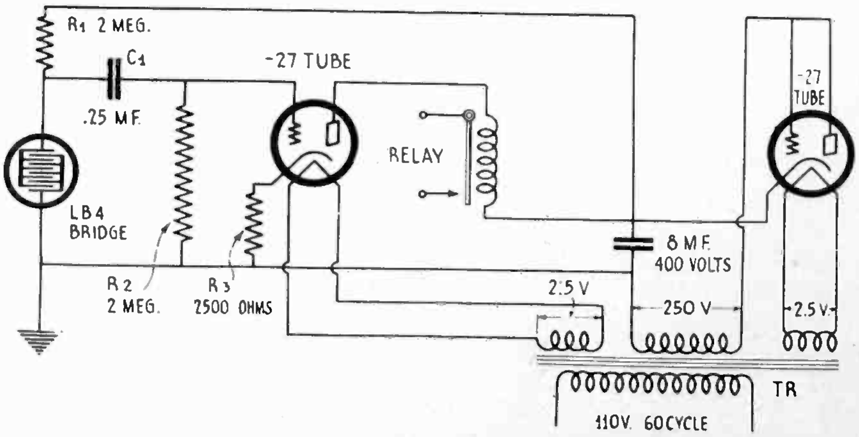
THE CIRCUITS IN THE accompanying diagrams have been developed by the engineers of the Burgess Battery Company, for use with the Radiovisor bridge, a light-sensitive cell having a high current output. The "bridge" or cell itself, consists of a glass tube with a 3-element prong base. Inside the bulb is a flat glass plate, upon the front side of which are two interlocking comb-like electrodes of gold, fused in place. These electrodes are covered over by a thin layer of selenium-like enamel, the conductivity of which changes with the amount of light falling on it. Owing to the amount of current that can be passed through the cell over the usual photoelectric cell, it is possible to use simple and inexpensive circuits in a large number of uses for light-control devices. The cell can also be used to operate a relay direct, for controlling a circuit handling a few watts of energy, while a second relay may be used for handling several hundred watts. A special vacuum-contact relay has been developed for this and similar purposes.

Each bridge has a maximum wattage rating of 0.1 watts per square inch of sensitive surface, the surface of the standard bridge being 1.5 square inches. The bridges can be used at various voltages, and are available in both d.c. and a.c. types. This bridge, in addition to its high output current, is responsive to high frequencies, as used in practical application in sound motion picture reproduction.

The bridge possesses a high ratio of dark resistance to light resistance when subjected to an illumination of 10-foot candles, and is practically independent of voltage. For maximum sensitivity the entire active surface should be employed, a suitable optical system being recommended.



Impulse circuit for dry battery operation with a vacuum tube and power relay fitted with vacuum contact



Impulse circuit for a.c. operation with bridge feeding heater type tube actuating power relay

IN THE LABORATORY + + +

Piezo-electric measuring devices

By J. Kluge and H. E. Linckh, P.T.R.
R. A. Webster,*
S. L. Brown and S. Harris.

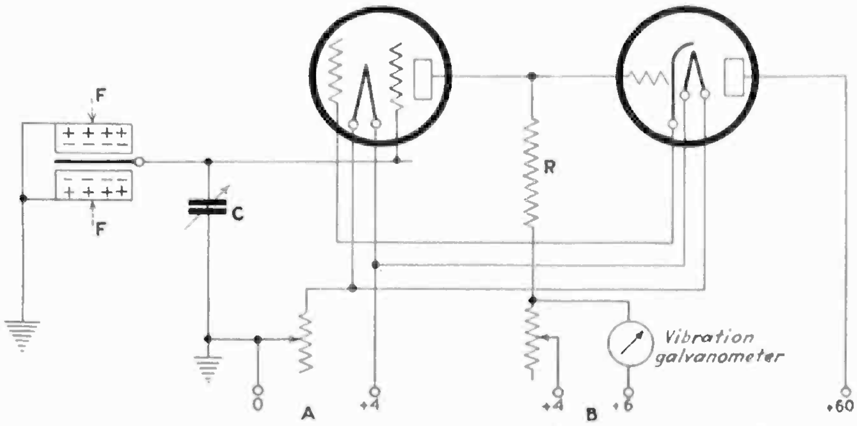
In the first article, the German Bureau of Standards, in response to a number of requests, gives information on the practical use which it has made of the piezo or pressure electric effects in quartz crystals in connection with vacuum tube devices. It is known that pressure applied, with the aid of metal plates, in the direction of one of the three electrical axes of the crystal produces a shift in the relative positions of the electric particles of which the quartz is made up and causes charges to appear on the metal plates. On heating, the crystal expansion is different in different directions and this unbalance makes charges of opposite sign appear upon the electrode. At temperatures above 300 deg. C., however, ordinary quartz becomes slightly conducting and the effects vanish more or less completely.

For all practical purposes a double prism of quartz is found most advantageous. The surfaces at which negative charges appear are brought into contact with a common, well insulated electrode, whilst one or both of the opposite outer surfaces touch a flexible membrane which, together with the metal container, is put to ground. The membrane transmits forces, pressures, accelerations, vibrations, etc. to the quartz surfaces. The potential differences are applied to a two-stage well insulated vacuum tube volt meter and measured with the aid of a vibration galvanometer (3 ma. range). The natural period of the meter is 2,000 cycles, or if necessary 4,000 cycles per sec., so that for all industrial uses it may be considered as dead-beat and distortionless.

For measuring forces (pressures applied to cutting tools, starting torques of d.c. motors) the amplifier gives about 2 ma. per kilogram and its sensitivity is adjustable by using condenser C. It measures pressures developed in explosion chambers from 1 to 15,000 lbs. per sq.in. Recently the pressure quartz sandwich has been used for studying mechanical vibrations set up by heavy machinery. The quartz, mounted on a flywheel, may be fastened upon the shaft of motors. The optical axis of the quartz pieces is set parallel to the diameter of the flywheel, so that tangential accelerations only, no centrifugal forces, will be measured (large deflections of the meter for accelerations of the order of 100 cm. per sec. per sec.)

R. A. Webster describes a piezo-electric gage and amplifier as applied to the measurements of gun powder gas pressures. (*Forschung V.D.I.* May, 1931. *Journal Franklin Inst.* May, 1931. *Review of Scient. Instr.* March, 1931.)

*Naval Research Laboratory.



Circuit for a vacuum-tube voltmeter used in connection with sandwich quartz

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Vacuum tube control for electric balances

By Fred Scoville Eastman

Forces on air-craft models in wind tunnels are measured by beam balances, often 3 or 4, operated automatically by small electric motors attached to the balance beam. The motor screws the movable weight to the left or right according to whether the beam moves downward or upward. There is much sparking at the control-contacts provided at the right hand end of the beam; the inertia carries the traveling weight a little too far and several adjustments are necessary each time. The remedy is to use a vacuum tube control. A UX-250 vacuum tube is ample to operate the small 1/200 hp. 110 volt motors used on the balances. Closing one of the mechanical contacts impresses a positive voltage on the grid of one of the vacuum tubes and allows current to pass between plate and filament. The motor responds instantly to the slightest pressure and the sensitivity of the balance is increased. (*Bulletin 55 University of Washington Engineering Station,* April 1931).

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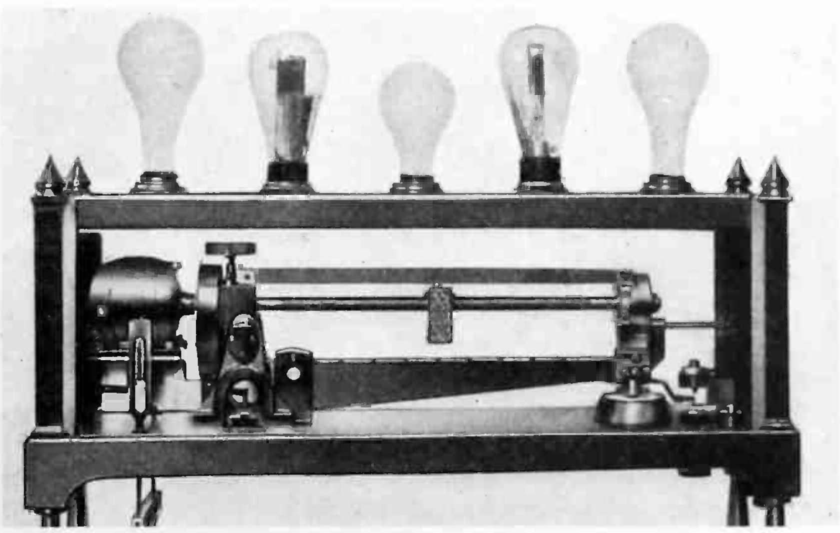

A balance constructed at the University of Washington which is equipped with vacuum-tube control

electronics

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O. H. CALDWELL, *Editor*

Volume III — SEPTEMBER, 1931 — Number 3

Radio production starts its autumnal spurt

EACH fall the production curve in radio factories turns sharply upward. August, September, October and November are the high months of the production year. This period antedates by thirty days the corresponding sales demand of the fall months (ending with December) when in past years, 50 per cent of the year's sets have invariably been moved to the public.

It can be reasonably predicted that in 1931 the public's demand for radio sets will again express itself in season with the coming of cool weather and Christmas preparations.

Production men therefore will have their work cut out for them from now till the end of the year. And this speeding-up is felt all along the line, in the supply of raw materials, parts and components!

Reliability of tubes in industry

THOSE uninformed of the many applications of vacuum tubes in industry, sometimes think of these fragile bulbs as impractical or unreliable for continuous use. But, on the contrary, examples are presented daily of the faith engineers in various fields have in tube application. To quote a few:

The newest Navy cruisers use vacuum tubes in the operation of all gyro-compass repeaters. The reliability and stability of tubes under severe service conditions have justified their use—and the percentage of errors in repeater readings are practically eliminated.

The use of tubes in elevator control, train signal control, automatic traffic signals and a multiplicity of other uses where hundreds of human lives are entrusted to the "reliability" of tubes to function properly, are instances where the novelty of such devices have long since been forgotten. Ingenious engineers will find countless opportunities for other similar applications in the future, and can count on tubes reliably doing their part.

American radio sets in Europe

OUR European cousins are quite frank in their comments on the American "midgets" now being imported into the markets of the Continent.

The bad taste of much of the cabinet work is criticised, but the technical excellence is praised. Particular mention should be made of the method being used to adapt U. S. sets to the European long waves by adding an "infradyning" tube, working on a fixed frequency, so that the normal tuner becomes the intermediate frequency amplifier and must be tuned to the summation wave. The absence of hum is admired by European engineers.

Prices in France vary from $120 to $160. A curious situation results in the case of some of the newer models, where the set operating on the shorter waves is a superheterodyne and on the longer waves an infradyne followed by a superheterodyne, for the intermediate frequency chosen by the American manufacturer is nearly that of the one outstandingly good French station (Radio Paris) so that this station can be excellently received directly on the intermediate-frequency amplifier!

"Kerosene headlights"

AN amazing lack of standardization exists in the marking of radio dials, even today. Despite the fact that marking in kilocycles is almost universal, and is admitted to be superior to marking in wavelengths, some thousands of receivers still get into the hands of listeners with the antiquated wavelength calibration.

Of those receivers marked in kilocycles, or in arbitrary numbers, some read from left to right and some from right to left. Thus if a dial is marked in numbers from left to right, the user must stand on his head, metaphorically speaking, to tell which way to move the handle if he wants a station on a higher frequency.

Dials should not be marked in wavelengths at all. They should be marked in arbitrary numbers so that higher numbers indicate higher frequencies. Or, they should be marked in kilocycles and carefully calibrated so that a 1440-kc. station will not be found on 1400-kc. or 1500-kc. as marked on the dial. In mass production such accurate making is probably impossible. Thus the arbitrary scale is to be preferred.

But equipping a receiver with a wavelength scale is like equipping a Cadillac with kerosene headlights, as someone has said.

Turning television into a stock-selling racket

IN New York and other cities television is now being made into a stock-selling racket, preying on the savings of the ignorant trusting public to an extent that has already attracted the attention of the District Attorney's office.

Regiments of stock salesmen are being hired to call on sucker lists and sell securities under the pretense of letting the investor share in legendary profits of "this new billion dollar industry." New television corporations are being organized daily in Delaware and other states, in a frantic rush to get in on the present bonanza of television stock selling.

Even reputable Wall Street firms are making open inquiries among radio men, seeking television companies to promote. Meanwhile the Federal Department of Justice, the New York District Attorney's office and the Better Business Bureau are watching some of the high-pressure stock-selling methods now under way, with a purpose of action. Already the use of the mails by several television "tipster sheets" has been stopped.

Research and changing business conditions

THE dollar value of the research laboratory is receiving increasing attention from hard-thinking business men, in times of changing conditions. Out of the research laboratory has come a flood of new ideas, methods, products. The business world now knows that "research pays!"

It is significant therefore that research activities in the electrical field as carried on in some of America's foremost research institutions are to be shown at first hand to 100 business men and bankers this fall during a tour of laboratories sponsored by the division of engineering and industrial research of the National Research Council, it has been announced by Maurice Holland, director of the division.

The tour, October 5 to 15, is the second of its kind, and is being arranged, to give members of the party an opportunity to see the workings of thirteen outstanding laboratories in order to acquaint them with the advances made in those industries, small and large, that have adopted scientific research methods as a means of solving major problems in a period of constantly changing business conditions.

"DOWN TO THE SEA" WITH TABLOIDS

Apparatus for sending and receiving a small four-page newspaper to ships at sea using short waves, is now in regular use on the "Leviathan" and other American vessels. Receiving machines translate radio impulses to printers' ink on miniature pages

The march of the electronic arts

National Radio Week, Sept. 21-27

UNDER THE AUSPICES OF the National Federation of Radio Associations, National Radio Week will be observed in many cities throughout the country Sept. 21 to 27, the date also set for the Radio Worlds Fair in New York.

National Radio Week will celebrate radio broadcasting's eleventh birthday. During this event in 1930, 32 chain programs, carried over more than 200 stations were dedicated to radio, and similar features are planned this year.

H. G. Erstrom, 32 West Randolph St., Chicago, is in charge of arrangements.

✦

Munich Congress on electrical music

BY OUR EUROPEAN CORRESPONDENT

On the whole this "Tagung" (which is perhaps better translatable as "Session"; something less elaborate than a "Congress" being implied) was a disappointment from the practical technical point of view. Considerable time was given up to somewhat vague dissertations as to radio aesthetics and the like, which seem as yet to have little practical important.

From the engineer's point of view, the outstanding features were undoubtedly the demonstrations by Wagner of the Heinrich Hertz Institute, and by Trautwein of the Berlin Academy of Music. The former presented an apparatus for the direct recording of the volume of sound, consisting essentially of a microphone, amplifier, rectifier, and recording apparatus, the most striking feature being the great range available, from the pp to the extreme fff of an orchestra and not merely between the closer limits of radio reproduction.

Dr. Trautwein's apparatus has already been described (see *Electronics* July, page 18); it appears to have received comparatively little modification and one is inclined to believe that the improvement is due to the greater experience of the players. In any case, the new Hindemith "Concertino" for the Trautonium and string orchestra was undoubtedly the outstanding musical feature of the whole session.

Other instruments presented were the Hellertion (see August *Electronics*, page 77) and Vierling's "electrical organ" and "electrical piano." The first of these three is interesting because of the very simple principle used to control the pitch, merely by altering the grid polarization of an audiofrequency oscillator. Although one would be inclined to suspect a simultaneous alteration of quality, it must be admitted that such was not clearly appreciable.

On the whole, however, all the latter instruments gave an impression of incompleteness, both as regards technical details and performance.

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RADIO CONTROLLED NAVY DESTROYER

The U.S.S. Stoddert off San Diego, Calif., with none of the crew on board was entirely controlled during bombing practice by the keys in this radio control box from a sister ship

Many communities to get airways radio station

THIRTY NEW RADIO range beacons for the guidance of aircraft in flight and 10 new airway communication stations for broadcasting weather and other information to pilots will be installed along the federal airways during the current fiscal year, according to the Aeronautics Branch, Department of Commerce. In addition, 15 uncompleted radio-beacon stations are to be placed in operation before July 1, 1932.

The 15 beacon stations to be completed are at Pittsburgh; Harrisburg, Pa.; Wichita; Amarillo, Tex.; Winslow, Ariz.; Kingman, Ariz.; Aubuquerque, N.M.; Willows, Cal.; Fontana, Cal.; Daggett, Cal.; Shasta City, Cal.; Medford, Ore.; Dallas, Ore.; Portland, Ore., and Seattle.

The 10 new weather broadcasting stations are to be located at Mobile, Ala.; Titusville, Fla.; Miami, Fla.; Houston, Tex.; San Antonio, Tex.; Springfield, Mo.; Minneapolis-St. Paul; Pueblo, Colo.; Milford, Utah, and Spokane, Wash.

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Argentine "goes midget"

LIKE THEIR NORTHERN COUSINS, dwellers in the Argentine, who enjoy a radio broadcasting service that ranks only behind that of the United States and Canada in the western hemisphere, have "gone midget." The depression has hit them too, and they are buying diminutive receivers that sell around $140 there. Purchases are made largely through an electric power company, which sells the sets on an installment basis, according to Charles H. Ducote, assistant American trade commissioner at Buenos Aires. American sets lead the market, though the Philips company of Holland is a strong competitor. Last reports showed there were 400,000 radios in the Argentine. There are 43 stations, 20 in Buenos Aires. Sets must be registered but no license fee is charged.

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SMPE to hold fall meeting at Swampscott, Mass.

AT A MEETING of the board of governors of the Society of Motion Picture Engineers, held August 10, it was decided to hold the fall 1931 meeting at Swampscott, Mass., October 5 to 8 inclusive, with headquarters at the New Ocean House. Swampscott is located on the Atlantic Coast about 12 miles north of Boston, in the center of a location full of points of historic interest.

Short waves for audio-typewriter net

FIVE SHORT WAVES have been added to the two long waves granted by the Federal Radio Commission to the American Radio News Corporation, Hearst subsidiary, which is developing an automatic radio-typewriter system of news distribution to newspapers in various parts of the country. The system is the invention of William H. G. Finch, radio engineer, who is supervising its installation.

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First 16-mm. exposition Sept. 21-26 in New York

CONCURRENTLY WITH THE Eighth Annual Radio-Electric Worlds Fair, to be held in New York Sept. 21-26, the first 16-mm. sound motion picture exposition and convention will be held in the ballroom of the Victoria Hotel, 51st St. and Seventh Ave. All the leading manufactures of 16-mm. equipment will have apparatus on display which will include sound and silent projectors, cameras, films, supplies and accessories. This exposition is being sponsored by the "16-mm. Board of Trade" of which Julius Singer is president. Exhibit space in the Victoria Hotel is being provided free. This association maintains a permanent information bureau at the hotel in charge of A. D. V. Storey, secretary.

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Farnsworth claims for narrow television band

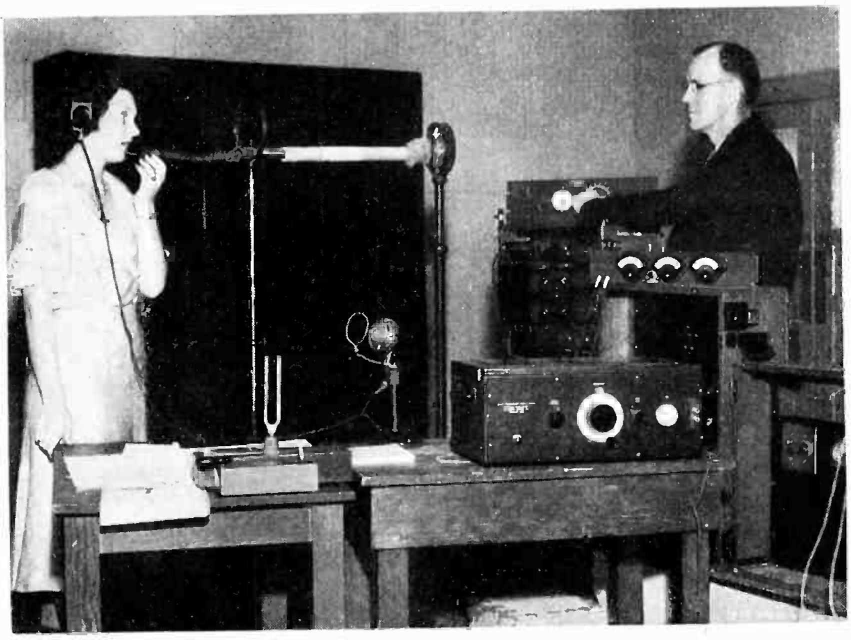
BROAD CLAIMS THAT the Farnsworth system of television requires only 1 per cent to 10 per cent of the kilocycle width of the channels heretofore regarded as necessary for television, are made in an application for television wavelengths filed with the Federal Radio Commission by Television Laboratories, Ltd., of San Francisco, the patent-holding company exploiting the inventions of Philo T. Farnsworth, of Salt Lake City.

The application states that $150,000 has already been expended by the Crocker interests of San Francisco on the Farnsworth development; that 10,000 of the 20,000 shares of no par stock have already been subscribed to are now selling at $125; that 20 patents have been applied for and four have been issued, and that the Philadelphia Storage Battery Co. of Philadelphia, manufacturers of the Philco Radio, has been licensed to use the patents.

It is proposed to erect a 1,500-watt station in San Francisco using 2,100-kilocycle frequency or such other channels as may be assigned.

The application is signed by B. J. McCarger, as president of the patent holding company, and names A. H. Brolly as chief engineer.

SINGERS DISCOVERED BY NEW METHODS



Professor C. F. Lindsley of Occidental College has devised mechanical and acoustical equipment for analyzing the voices of prospective singers in determining those having special talent

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Radio for New York Police

NEW YORK CITY'S police department has been authorized by the Board of Estimate to spend $125,000 with which to equip all squad cars, police launches and the force's two police airplanes with radios. Although it has one long-wave radio station for its harbor police, New York City has never radioized the rest of its force, as have some 50 other American cities. Short-wave transmitting stations covering the five boroughs will be built.

✦

ELECTRONS IN MOTION

Drs. DuMond and Kirkpatrick of the California Institute of Technology designed this crystal spectograph to show electrons in atoms of solid matter are in constant motion and move at high speeds

China-America radio-circuit officially opens

A NEW AND IMPORTANT LINK was forged in America's world-wide radio communications facilities when the latest circuit of RCA Communications, Inc., connecting San Francisco directly with Mukden, China, was officially opened in August for traffic.

This is the second direct circuit to China to be placed in operation by RCA during the past few months, the first being between San Francisco and Shanghai. The new Chinese station at Mukden will serve the three north-eastern provinces of Kirin, Liaoning and Heilungkiang, the principal cities of which are Mukden, Kirin, Harbin and Chang Chun. This station is one of a series of powerful radio stations now in project for closer contact with the provinces of China as well as with other countries of the world. Although the new circuit has been open commercially since June 22nd, the official inauguration of service Aug. 1st places its operation on a continuous, 24-hour basis.

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Coming meetings

Electrochemical Society—Hotel Utah, Salt Lake City, Sept. 2-5. C. G. Fink, Columbia University, New York City.

Society of Motion Picture Engineers—fall meeting, Swampscott, Mass., Oct. 5-8. J. H. Kurlander, Secretary, Westinghouse Lamp Company.

Illuminating Engineering Society—William Penn Hotel, Pittsburgh, Pa., Oct. 13-16. E. H. Hoffie, 29 W. 39th St., New York City.

Institute of Radio Engineers—fall meeting, Rochester, N. Y., Nov. 9-10. Virgil Graham, executive chairman, Stromberg Carlson Telephone Manufacturing Company.

REVIEW OF ELECTRONICS LITERATURE

HERE AND ABROAD

Telefunken Company and ultra-short waves

[H.G.] Notes from the Trade Journal of this company, in which especial mention is made of the fact that multiple-program modulation of one ultra-short wave has not as yet proved practical.—*Radio B.F.f.A., Stuttgart, July, 1931.*

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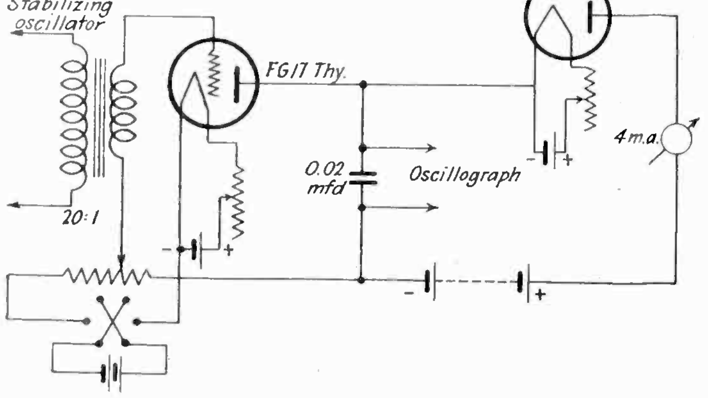
Characteristics of small thyratrons

[W. B. NOTTINGHAM, Bartol Research Foundation] The d.c. and a.c. characteristics of several small grid-controlled hot-cathode mercury discharge tubes of the controlled rectifier and inverter type are carefully examined, and the relative advantages for photo-tube work of the phase-shift a.c. and the more sensitive critical potential d.c. method of control are discussed in detail. The maximum voltage drop in all the tubes is 24 volts, the minimum 10 volts, the average current a few amp. The grid current flowing in the grid circuit before the discharge begins is measured; it amounts usually to a fraction of a micro-amp. In the case of the inverter type thyratron where both anode and cathode are surrounded by the grid, the grid current grid voltage characteristic may become very complicated.

A thyratron circuit was set up to produce a linear time axis for use with a cathode ray oscillograph. With a 10,000 cycle wave and the time axis operated at one third that frequency, it is not only possible to study the waveform, but also the current voltage relationship as a function of time. The time required to set up good conduction is less than 30, perhaps even less than 10 microseconds even though the plate potential is only 35 volts.—*Journal Franklin Institute, March and June, 1931.*



Circuit used by Nottingham in thyratron research

Preparation of potassium photocells by electrolysis

[M. FORRO and E. PATAI] The now well-known simple method of depositing sodium metal inside a lamp-bulb dipping into a molten sodium salt by sending a current from the salt across the glass to an incandescent filament fails in the case of potassium. Cracks develop in the glass and pure potassium glass is expensive. But when a potassium salt is first placed in the bulb and a current passed between it and the molten sodium salt outside, then potassium pentrates into the inner layers of the glass to a depth of 15/1000 mm. and replaces sodium. With such a treated glass bulb it is afterward possible to obtain potassium films and potassium cells from the salt. Cells containing rubidium and cesium may be prepared in a similar way.—*Zeitschr. Techn. Physik, May, 1926.*

✦

Radio patents

[L.] German 519999, in which a short-wave oscillator is built into the tube itself, the oscillatory circuit (condenser and inductance in series between anode and grid) being composed of a metallized portion of the tube-wall and of the capacity from this to one of the elements. Choke-coils and grid-resistance can also be built into the tube.—*Funk, Berlin, July 10, 1931.*

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Space wave suppression

Mention of the Lorenz experiments in Berlin with a very low antenna covering great surfaces (e.g. a quarter of a square kilometer) in order to suppress the space wave and thus remove fading effect.—*Radio B.F.f.A., Stuttgart, July, 1931.*

Preparations for ultra-short-wave radio

[SCHWANDT] Largely based on lectures by Schröter (Telefunken) and Leithauser (Heinrich-Hertz-Institute). Points of interest are: The increase in power to 8 kw. of the present Telefunken 1 kw. sender in Berlin is for television experiments. This sender is five-stage, crystal-controlled, with frequency-doubling in each stage, and its range with a 50-meter high dipole antenna is of 15 to 30 kilometers normally, with 120 kilometers in one exceptional case. The choice of a 6-8 meter wave is governed by the very rapidly increasing absorption by buildings below 6 meters, and by the presence of a space-wave above 8 meters. Telefunken uses a simple regenerative detector, coupled to the antenna by a resistance and connected to the audio-frequency amplifier of any normal receiver, regeneration control being by a resistance in the anode lead. This is however not suitable for television, owing to the cutting of sidebands; it is probable that a super-heterodyne will be necessary in this case, possibly with a radiated heterodyning frequency. On the other hand, the H.G.I. sender works on 8.9 meters, and produces this wave in the first stage. —*Radio B.F.f.A., Stuttgart, July, 1931.*

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Advances in low pressure art

[S. DUSHMAN] It is significant that all the books published on the production and measurement of low pressures (Dushman, Dunoyer, Goetz, Kaye Newman) have been published in the course of the last ten years, that is since the production of vacuum, oscillograph and X-ray tubes in large quantities. The lines along which greatest progress has been made during recent years are (a) higher speed pumps (Gaede two-stage pumps with backing pressure of 20 mm). (b) getters and electrical clean-up, the latter not yet well understood, but of great use in obtaining lowest pressures (c) vacuum treatment (fusion) of metals that enter into the production of vacuum devices. Most of the gas is evolved after the metal is fused; normally, there is obtained from 1 kg. of fused metal (iron, nickel) 2 to 3 liters of gas and sometimes as much as 15 l., a volume 16 to 120 times that of the metal. The most recent method for measuring low pressure is that published in *Electronics, April, 1931.* — *Journal Franklin Institute, June, 1931.*

Theory and performance of modern loudspeakers

[N. W. McLachlan and G. A. Sowter] About half of the 54 pages making up this article deal with the theory and the performance of the elastic reed driven loudspeaker disc (in particular, the author's Lion loudspeaker), the other half with the properties of coil driven loudspeaker cones. In practical reproducers the diaphragm is supported by some form of elastic material. The coil being constrained to move axially only, there are, apart from a possible wobble frequency caused by bad centering, two major low frequency resonances in the coil-driven diaphragm; the coil and diaphragm moving as a whole on the elastic surround at its periphery (when the support is stiff the resonance may occur above 50 cycles and produce distortion); the surround moving for itself between the diaphragm and the outer framework. Serious resonance can occur due to the surround; the (roughly calculated) frequency varies from 50 to 200 cycles per sec., and depends on radial tension, temperature and humidity. As far as speech and music consist, not of steady state oscillations, but of transients, that is, a sum of many frequencies, the acoustic wave-form of a sound will be changed owing to the presence of the different natural periods of vibration of the loudspeaker. Examples of square wave input illustrate this point: they are reproduced as two main oscillations of low (surround) and high, 2,000 cycles, frequency. In general there is more than one resonance in the upper register. According to the author the high pitch resonance is attributable to the system formed by the coil and the diaphragm, the whole acting as a complex elastic structure with an elastic member between the coil and a rigid disc. The electrical analogue would be an audio frequency generator in series with an inductance (mass of coil) and a condenser (compliance of elastic member between coil and disc), and a second inductance (mass of disc) in parallel with this condenser. In the case of a reed driven speaker the different elements have to be put in series. The measurements are made by means of a microphone with resistance coupled amplifier. —*Phil. Magazine, January, 1931.*

✦

New form of Wheatstone bridge

[Greve] Description of the type used at Jena under Esau, in which readings are made directly from the scale (or need to be multiplied by a power of 10 when the standard resistance is not 100 but 10,1000, etc.): and of its applications to radio measurements. — *Funk. Berlin, July 10, 1931.*

Televising the Derby

S. A. Moseley reports on the combined sound and sight transmission of race-course scenes. A few readers testify that the parade of the horses before and after the race could be seen quite clearly. Occasionally interference from telegraph and telephone lines wiped out the picture. — **Television (England), July, 1931.*

*(Note): This issue contains in addition the English translation of F. Schroeter's article on: "Latest Form of Photo-Electric Cells" which has appeared in Funk and in Phys. Zeitsche., see Electronics Digests.

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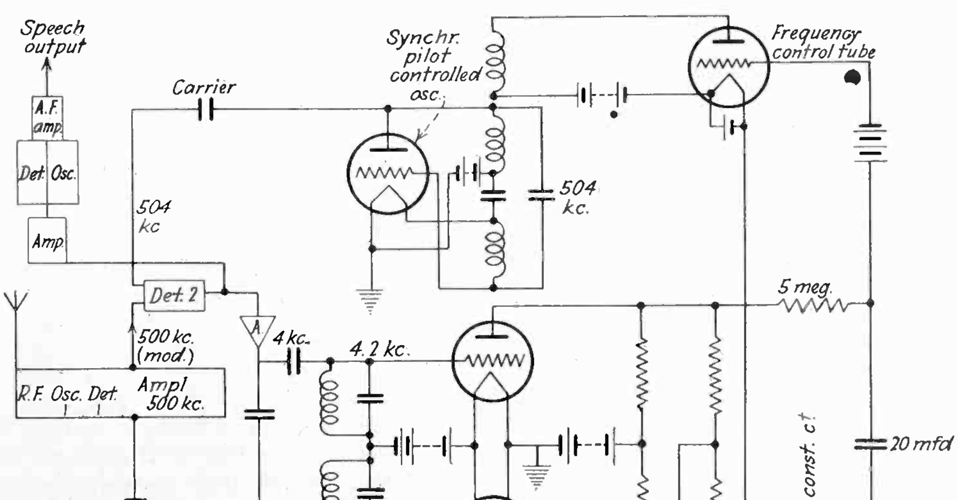
Phototube and amplifier for measuring ozone

[G. M. Dobson] Photographic methods for measuring ozone are very cumbersome; the amount of ultra-violet energy to be determined is small. The radiations from two ultra-violet regions, one absorbed, the other not absorbed by ozone, are allowed to fall alternately by means of a rotating sector wheel, on to a gas-filled sodium phototube. The phototube is connected to the first grid of a four-stage low frequency amplifier. The stronger radiation is attenuated by putting an absorbing quartz wedge in its path. As long as there is a difference in the strength of the two beams, the fluctuation will be amplified. When they have become equal, the output of the audio amplifier has fallen to zero. From the thickness of the wedge the amount of ozone through which the sunlight has passed can be calculated. There are a number of other fields open to this method.—*Proceedings Physical Society, May, 1931.*

Short-wave telephony with single sideband pilot wave

The pilot wave (see *Electronics Digests, July, 1931)* is kept about 20 db. below the side-band; its frequency is 18,004 kc., its width 30 cycles. If the resupplied carrier frequency differs from the original carrier by more than about 20 cycles, bad quality results; quartz oscillators would not be sufficiently steady. In the receiver the frequency of the incoming side band and pilot is first lowered to 500 kc. The output at this intermediate frequency is applied to the second detector, in addition to the output from the synchronous pilot controlled oscillator which is kept 4 kc. above the intermediate frequency. From here the 4,000 cycle oscillation is admitted through a tuned audio amplifier to two tuned circuits connected to two detectors; such a circuit is extremely sensitive to slight differences at the grids. It is arranged so as to be balanced at 4,000 cycles; if the input frequency deviates from this value the resulting plate current changes the grid bias and the plate current in the frequency control tube, and changes the effective inductance of the synchronous oscillator in the appropriate direction. Maintaining the frequency difference means keeping transmitter and receiver in step. The 5 megohm resistor and the 20 mfd. condenser slow down the rate at which the control works. An automatic gain control is added to keep the pilot wave at a constant level; the time constant of this control is made short enough to follow the most rapid fading. —*Wireless World June, 1931, Television July, 1931, La Nature and The Electrician May, 1931.*



Disposition of apparatus used in single sideband pilot wave transmission on 18,000 kc.

Loudspeaker response measurements

[P. K. Turner, B. Olney, N. W. McLachlan] Ever since loudspeakers became a common part of a radio set, attempts have been made to estimate their actual performance and to detect possible electrical and mechanical defects in design by electrical instead of by sound measurements, that is, by measuring the impedance (input resistance and reactance) of the speaker coil at different frequencies under 3 different conditions: (1) with the coil held fast (by adding load or gluing it to the magnet or by short-circuiting the magnet coil); this gives $R_c + jX_c$, (2) in vacuum, with the coil free (coil impedance plus purely mechanical impedance of the parts $R_m + l\ (2\pi f m - k/2\pi f)$, where M is the mass and k is the elastic constant, (3) under normal conditions introducing acoustic impedance ($R_a + jX_a$). It is then necessary to convert the observed electrical impedances to their mechanical and/or acoustic equivalents. The equation giving the force acting on the voice coil in the magnetic field B shows that a mechanical impedance $R + jX$ is equivalent to an electrical impedance $B^2l^2 : 10^9\ (R + jX)$ in series with the impedance $(R + jX)$ of the coil proper which consists of a length l of wire. As ($R_c + jX_c$ is measured directly the difference between (1) and (2) permits of computing $R_m + jX_m$, or as *"M"* is known, of B^2l^2 and k; whereas comparison of (1) and (3) furnishes the acoustic components. The different *R's* and *X's* are measured at different frequencies by means of a bridge circuit with a three-stage amplifier for testing the balance. A 0.2 watt beat oscillator is used constant to within ±5 per cent between 20 and 10,000 cyces with less than 1.5 per cent harmonics. Definite conclusions are drawn for the range of 40 to 800 cycles only, the difference between the three sets of readings being too small to be reliable at shorter wavelengths under the experimental conditions. But the values found for resistance and reactance components may be used, of course, for computing approximate results valid at higher frequencies. In the directly measured range (coil of 60 turns of 2.5 cm. diameter, projected radius of cone 12.5 cm., surround 2 cm. wide) the efficiency is better at the higher frequencies than might be expected on theoretical grounds (for moving coil speakers in general). The author sees the reason in the falling off of the impedance of the coil itself; at 800 cycles the apparent mass has fallen from 16 to 5 grammes, and the acoustic reactance falls to far below the value holding for a rigid disk, in fact all the masses giving useless reactance fall as the frequency goes up, but the useful component, the acoustic resistance, is in excess of theoretical value. When the relative output (air pressure proportional to square root of output power) for a fixed input voltage or current is calculated, an unusually smooth curve is obtained (5 db. down at 800, 10 db. at 2,300 and 15 at 5,000 cycles). This point was criticized in an extended discussion in which ten well-known sound engineers took part. All agreed that the excess output over the rigid disk is due to the large number of natural modes of vibration, the fundamental of which is very low (80 according to Dutton, 20 for McLachlan). The rubber surround in part acts as an auxiliary, resonant diaphragm and enhances the lower register. McLachlan finds that when the edge of a conical diaphragm is free, so that it can bend readily, sharp resonances occur from 50 up to 200 cycles, but they last only a few cycles. The extent of the upper register depends to a large extent upon the material of the cone (C. Garton); if a very soft paper is used the cut-off occurs at about 2,000 to 3,000 cycles, with harder paper at 5,000 to 6,000, whereas with duraluminum (3 or 4 mils thick) or aluminum, the register may be extended to well beyond 10,000. It is, of course, asking a great deal of a loudspeaker to be able to sound like a flute or a violin or a drum.

Turner's output curves are confirmed in a general way by Olney's response measurements made indoors and outdoors using acoustical devices.—*Journal Institution El. Engineers, May, 1931. Wireless World, May, 1931. Proc. Inst. Radio Engineers, July, 1931.*

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Acoustical reactance of a loud speaker

[N. W. McLachlan; H. M. Clark] Rayleigh has shown that in the case of a rigid vibrating disk of surface S, owing to the waves diverging from the source, there is a mass M to be added to that of the disk (accession to inertia), the amount being comparable to that of a cylinder of air whose radius R is that of the disk and whose length is 16 $R/3\ \pi$. For a disk of 10 cm. radius at 50 cycles M is 7 grammes at 1,000 cycles 2.4 grammes; for smaller disks it is constant up to 1,000 cycles, for larger disks it varies rapidly. This component is in quadrature with the useful component, the acoustic pressure, and accounts for the decreased efficiency at higher frequencies. For cones the accession to inertia must be determined experimentally. The direct way is to measure the inductance of the coil with the coil fixed, free to move in air and in vacuum. When vacuum equipment is not available, the necessary conditions can be simulated by using the moving coil without the diaphragm, the coil being suspended by elastic threads (accession zero). In some cases the coil was wound with 40 turns, others had 1,000 turns, coil diameter 5 cm. cone 25 cm. The results obtained are in good agreement with Rayleigh formula for a rigid disc. The frequencies examined were below 250 cycles. — *Philos. Magazine and Journal of Science, June, 1931. Experimental Wireless, June, 1931.*

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Light-sensitive glow discharge tubes

[H. Wolfson] To use a rare gas discharge tube as a light sensitive cell it must be put in series with a large resistance shunted by a condenser and be supplied with an electric current, whereby an intermittent discharge is produced in the tube. The tube may also have a condenser in parallel. If one of the electrodes is made of a light-sensitive metal or compound, and if the tube is illuminated progressively by a suitable source of light, the number of oscillations varies in a continuous manner, and for a certain value ceases entirely. At the same time the current increases and may become 50 times stronger than the dark current. For certain values of resistance and capacity a reverse effect may be produced.—*Television (London), March, 1931.*

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New type bridge balance indicator

[F. T. McNamara, *Yale University*] The sensitivity of a Wheatstone bridge for measuring impedances may be greatly enhanced without adding expensive instruments by using two vacuum tubes in push-pull for testing the equality of voltage. The two input posts A, B of the bridge are shunted by means of a potentiometer, the grid return of the tubes going to the sliding contact. The grids themselves are connected each to one of the two remaining corners C, D of the bridge. If no current flows when the slider is at A and at C, the voltages at points B and D are equal in phase and magnitude. Now these two readings depend not on the square of a difference as in ordinary detector methods, but on the differences of the squares of the two voltages (for instance $5.1^2 - 5.0^2 = 1.01$ in place of $(5.1 - 5.0)^2 = 0.01$). In case the two tubes are slightly different, a 500,000 ohm potentiometer is put across BD and one of the grids is connected to the sliding contact instead of to D. At 60 cycles and with a Weston 322 meter the precision is 0.01 per cent.—*Review of Scientific Instruments, June, 1931.*

NEWS

OF THE ELECTRON INDUSTRIES

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RCA Victor Company has announced the transfer of sales and manufacturing facilities of the RCA Victor Company (Mass.) formerly the Wireless Specialty Company, makers of the well known "Faradon" condensers, to the Camden, N. J., plant.

A new sales section known as the Industrial Products Section has been formed to handle the sales of products formerly manufactured at the Boston plant, together with those formerly handled by the Component Parts Section of the RCA Victor Company, Inc. This new section, as the name implies, will handle the sale of industrial products to manufacturers, laboratories, colleges, etc.

The Telephoto & Television Company has been incorporated under the laws of the state of Deleware for the purpose of taking over the Telephoto Corporation of New York which company has been engaged in the manufacture of photo electric cells and television tubes for a period of 18 months at its factory 133 West 19th St., New York City.

The Pilot Radio & Tube Corporation has announced the appointment of A. Van Santen of Holland, Amsterdam, as commercial vice-president in charge of European sales. He will make his headquarters in Amsterdam.

The Erie Resistor Corporation, of Erie, Pa., manufacturers of moulded type resistors, announces the opening of a Canadian plant at Toronto, Canada. The new plant, in charge of Rodney Wese, is already in production and it is reported that a very satisfactory volume of business has already been attained.

The Trav-Ler Manufacturing Corporation, St. Louis, Mo., pioneer midget and portable radio manufacturer, announces the granting of a license under patents of the Radio Corporation of America and affiliated companies to manufacture radio receivers, radio-phonograph combinations, and television receivers and apparatus.

The Freed Television and Radio Corporation on September 2, announced that it would present to the public a four-tube tuned r.f. radio receiver employing a variable-mu, screen-grid, pentode and a 280 rectifier. In addition to the Freed-Eisemann television receivers, superheterodynes, radio tubes and other announced parts of its line.

Clement Studebaker III, of South Bend, Ind., has purchased the Fricker-Irvine patents and patents pending on a system for suppressing inductive interference and minimizing fading and atmospherics, from William C. Grunow. Mr. Grunow retains a non-transferable license. Mr. Studebaker has also secured the services of R. H. Fricker, inventor, and Chas. C. Henry, who have conducted research on radio noise suppression for Mr. Grunow since January.

The Central Radio Corporation, Beloit, Wis., announces that it has been granted three Canadian patents on "CRC" sockets and contacts. Two of the patents particularly cover steel spring reinforced sockets and contacts. These sockets are manufactured in Canada by Hale Brothers, Limited, 6224 Chambord St., Montreal, Quebec, and A. C. Simmonds, 218 Front St., East, Toronto, Ontario, is sales agent for the eastern half of Canada.

Westinghouse Electric & Manufacturing Company has announced the appointment of A. C. Streamer as sales manager of the Diversified Products Department. The major lines segregated under the new department are interior and exterior lighting products; micarta; insulating materials; gearing products; commercial cooking units; and broadcasting and radio material, other than domestic receivers.

The Newark Wire Cloth Company, Newark, N. J., manufacturers of wire cloth products for all industries, has announced the appointment of F. C. Ryan as sales manager. Mr. Ryan is a graduate of Lehigh University in Chemical Engineering. During the war he was connected with the U. S. Bureau of Mines. He will be remembered by many readers as former sales manager of the New Jersey Zinc Company and later as staff manager of the Johns-Manville Sales Corporation.

The National Union Radio Corporation, at a recent meeting in New York City, elected S. W. Muldowny as chairman of the board and H. R. Peters as president of the organization. Mr. Muldowny is connected with Lehman Brothers, international bankers, and has been a director of the National Union Radio Corporation since its formation in December, 1929.

Electron tubes in traffic-actuated control systems

[*Continued from page 96*]

The output circuit of the detector may be varied between zero and 0.500 milliamperes or more, due to this change in reluctance. Its sensitivity and output is sufficiently great so that in traffic signalling or other applications, the detector circuit directly controls either an electro-pneumatic valve or relay.

The control unit operates on a modified principle of standard traffic signal timers, with a series of rotating cams, to alternately energize the red, amber and green signal circuits. Absence of cross traffic causes the timing equipment to come to rest at a point indicating green for the main street, and remains thus until the cross traffic passes over the detector. When this occurs, the detector relay drops on its back contact, energizing the driving coil of the timing motor, which drives the timing mechanism through a complete cycle.

The Westinghouse Electric & Manufacturing Company has developed a traffic control system using photocells. This system has been adapted to various forms of street intersections and traffic conditions. It depends upon its operation by the interruption of a light beam by the motor car or other vehicle passing between the light source and photocell. The latter sets in operation the necessary signal timing device. The circuit and arrangement of the photocell relay, as used in this traffic control system, is shown in an accompanying diagram. The output of the phototube is used to actuate the grid circuit of a grid glow tube (see *Electronics,* February, 1931, Pg. 515).

The first installation of this system used vertical light beams, but dirt and grease which collected on the lower units suggested a change to a horizontal beam, as used at present. One interesting problem presented by this system, was that cars turning from the main street would cross the minor street light-beams, and if no provision were made for this, the light would be flashed green on the side street with no cars wanting it. To overcome this, a time delay was installed, requiring a car to stop in the beam for several seconds before any action took place. This was so timed that cars making the turn would not stay long enough in the beam to cause operation.

As shown in Fig. 7 the major street signal is green, the main relay is up, power is off the motor, and the brake is on. When a car crosses the light momentarily, as in turning from the major street into the minor, the light control relays pull up, and the circuit wires A and B of the time delay relay are open-circuited. However, unless the car remains in the beam for the specified time delay, there is no other action in the controller.

+ NEW PRODUCTS

THE MANUFACTURERS OFFER

All-electric theater amplifiers

To SOLVE THE PROBLEM of power supply and amplification for sound-on-film and disk talking motion picture projectors, the Webster Company, 850 Blackhawk St., Chicago, Ill., announces its new style V-81 all-electric a.c. amplifier. This is a compact unit small enough to install between projectors and eliminates the need of all batteries or other incumbrances. It provides complete control of power supply for exciter lamp with polarizing potential—variable in 10-volt steps for the photoelectric cell. It handles all amplification between photoelectric cell (or disk reproducer) and loudspeakers. Specifications are as follows: Output impedance—4,000 ohms or to specification; size—$15\frac{1}{2}$ in. by $15\frac{1}{2}$ in. by 13 in.; net weight—54 pounds; power supply—110 volts or 220 volts; 50-60 cycle.—*Electronics, September, 1931.*

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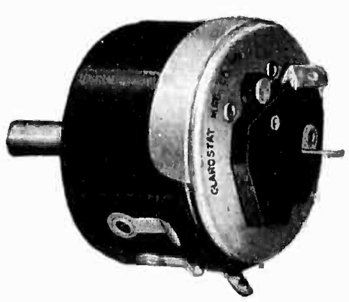
"Built-in" power switches for volume controls

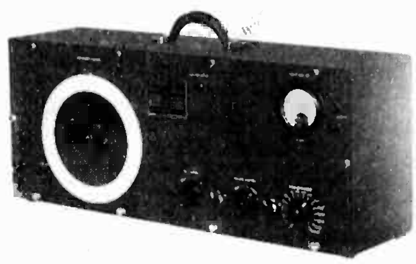
IMPROVEMENTS IN A new type of on-and-off 110-volt line switch, which is built into the volume control, has been announced by the Clarostat Manufacturing Company, Inc., 285 N. 6th St., Brooklyn, N. Y. The mechanism is positive in action, being enclosed in a Bakelite case and mounted so as to form



an integral part of the control. The switch employed is approved by the Underwriters' Laboratory, for 1 ampere at 250 volts, or 3 amperes at 125 volts. The recently announced Clarostat Model P-5 graphite element volume controls are now being equipped with the new type power switch. This unit is quite compact, being only $1\frac{3}{4}$ in. in diameter and $\frac{7}{8}$ in. deep. Other control units made by this company are incorporating this new switch mechanism. Descriptive folders are now available. They will be gladly sent on request.—*Electronics, September, 1931.*

Laboratory beat frequency oscillator

THE RCA VICTOR COMPANY, INC., Camden, N. J., announces manufacture of a new laboratory beat frequency oscillator, known as the TMV-28. This instrument has a frequency range of 30-10,000 cycles, with an output of .75 watts. The output is very nearly constant over the entire frequency range and the harmonic content is less than



5 per cent for frequencies above 100 cycles. The frequency control is calibrated directly in cycles per second and the scale is approximately 14 inches long. A vibrating reed frequency meter is included for adjusting the calibration. Push-pull detectors and amplifiers are used throughout. Impedances of 2 to 24,000 ohms may be matched with the output circuit.—*Electronics, September, 1931.*

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Midget loud speaker

IN KEEPING WITH THE trend of the trade toward smaller midget receivers, the Rola Company, 2570 Superior Ave., Cleveland, Ohio, has announced a new Model F-5, speaker especially designed for compactness and simplicity. Its overall diameter measures $6\frac{1}{2}$ in., depth $3\frac{1}{2}$ in., weight $3\frac{1}{4}$ lb., and effective cone diameter 5 in. Because of its light weight and compactness, this unit may be incorporated in the smallest of midget receivers.—*Electronics, September, 1931.*

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Beat frequency oscillator

THE GENERAL RADIO COMPANY, Cambridge, Mass., recently announced a new beat frequency oscillator having the following characteristics: Range 10-10,000 cps.; single frequency control; calibration accuracy 2 per cent; tuned-reed frequency check; output 30 milliwatts; good wave form; and complete a.c. operation. Complete specifications of this instrument are described in Part 2 of Catalog "F-X" issued by this company.—*Electronics, September, 1931.*

Tubular paper condensers

IN KEEPING WITH the trend towards individual condensers inserted in the point-to-point wiring, in place of expensive condenser blocks in cans, the Dubilier Condenser Corporation, 4377 Bronx Boulevard, New York City, announces a new line of tubular paper condensers. The Dubilier Type 706 is an outside wound or non-inductive standard paper section wound on the standard mandrel and surrounded by several turns of heavy craft paper. Pigtail leads permit of ready wiring in any circuit. The tightly wound paper covering provides ample mechanical and dielectric strength. Due to thorough impregnation of the completely wound section and its cover, together with the special means whereby the paper wrapping shrinks tightly over the section, the resultant unit is fully protected against moisture and mechanical effects. The leads are securely held in place and cannot be pulled loose without destroying the condenser. The ends are fully insulated, so that only the leads themselves present "live" parts. These units are available in various capacities from .0001 to $\frac{1}{2}$ mfd., and in d.c. working voltages from 200 to 600 volts.—*Electronics, September, 1931.*

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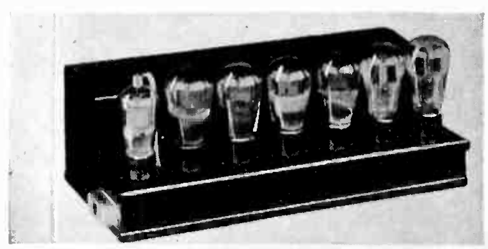
Two-stage power amplifier

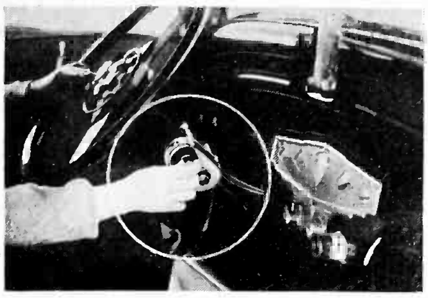
MODEL GA-80, is a two-stage amplifier employing one '24 tube in the first stage, and four type '47 pentode tubes in the output stage, which has been announced by the General Amplifier Company, 27 Commercial Ave., Cambridge, Mass. The pentodes are connected in



parallel push-pull arrangement. This unit provides approximately 10 to 12 watts of undistorted energy to the speaker. The input circuit may be used for any value of impedance from 500 ohms up. When used with a microphone, it is only necessary to add a microphone transformer, the secondary of which is connected directly to the input of the amplifier. List price, $70. —*Electronics, September, 1931.*

Automobile remote control

Remote control for the automobile radio set is accomplished by equipment designed by the Carter Radio Company, 407 So. Aberdeen St., Chicago, Ill. It



provides a positive, smooth manual control of the receiver through a ⅛-in. flexible cable. This cable is made up of a non-stretching, galvanized piano wire running free through a tubular housing, to the condenser pulley mounted at the receiver. The control unit case measures 4⅛ in. by 2⅝ in. by 1 in., and is black enamelled. It fits onto any standard steering column, and locks firmly in place. The volume control furnished is either rheostat or potentiometer type, and is provided with a lock switch. Complete details will be furnished by writing the company direct. —*Electronics, September, 1931.*

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Low-grid current high vacuum tube

The Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., has announced a low-grid current, high-vacuum type amplifier tube known as the RJ-553. This tube has been designed to operate a relay or meter directly from a phototube or other sources of very small current and may be operated on either a.c. or d.c. Characteristics at one test point are given below:

Filament voltage	6.0
Anode voltage	95
Grid voltage	—12
Amplification factor	3.85
Plate resistance	3200 ohms.
Mutual conductance	1200
Plate current (Milliamperes)	8.5
Gridcurrent (Maximum)	.008 microamperes.

Electronics, September, 1931.

✦

Split-core test set

An instrument designed for convenience in measuring alternating current without interrupting service, has been announced by the Rubicon Company, 29 N. Sixth St., Philadelphia, Pa. The set may be used to measure current as low as ½ ampere, or as high as 200 amperes. The set consists of two units; the transformer and the meter, which are permanently connected to each other by means of a 6 ft. three-conductor rubber-covered flexible cable. The meter is direct reading for currents down to 5 amperes. When smaller currents are to be measured, the general practice is to loop the conductor a number of times through the transformer. In such cases, the indication of the meter must be divided by the number of loops. With this arrangement, currents as low as ½ ampere may be read with precision.—*Electronics, September, 1931.*

✦

Portable oscillograph

Designed especially to meet the requirements of broadcasting stations, a new portable oscillograph is announced by the General Electric Company, Schenectady, N. Y. This unit is known as Type PM-12 oscillograph, is simple to operate, easily portable, and entirely self-contained, mounted in a high-grade walnut case and weighing only 30 lb. It requires a single power source of 110-125 volts, 60 cycles. The light source is a standard automobile headlight lamp. Kodak film No. 120, used in recording phenomena, is a standard size, and can be obtained in any store handling camera supplies. The instrument is supplied in three designs which differ only in convenience of making photographs. Complete description is furnished in Bulletin GEA-1377-A.—*Electronics, September, 1931.*

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Invertible type condenser

The Elkon Division of the P. R. Mallory Company, Inc., Indianapolis, Ind., has announced an inverted type 8 mfd. condenser. This new condenser has the standard features of the regular Elkon non-aqueous hi-volt condensers, and conforms to the standard dimensions of the inverted round mfd. type. It is designed to withstand d.c. operating voltage requirements up to 450 volts; low temperatures are not injurious, and they can withstand, without injury, peak voltage of all properly-designed sets. They have an extremely low normal rated leakage, and are stable in operation. With the addition of this new type, Elkon non-aqueous hi-voltage condensers are now adaptable to all mounting arrangements — *Electronics, September, 1931.*

Microphone stands

Four new types of microphone stands, finished in attractive shades of light brown electroplated bronze, have been announced by the Samson Electric Company, Canton, Mass. These stands all follow the same general type and design. No. 880 is for use on tables, decks, etc.; No. 881 is an adjustable table stand whose height may be regulated to suit the individual; No. 882 is a full length and may be used for speakers, orchestras, etc., and No. 883 is a full length stand with two microphone holders. Prices and further information may be obtained by writing the company direct. — *Electronics, September, 1931.*

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Binding post

Improvements over previous models are claimed by the Alden Mfg. Company, 715 Center St., Brockton, Mass., for its new type of binding post. It will accommodate various kinds and sizes of wire, and serve for connections from lead-ins. It may be quickly and economically attached to the receiving set. The binding post tops cannot be unscrewed and thus lost. The threaded post is molded solid in the knob and the end of the screw enlarged after it is screwed in place.—*Electronics, September, 1931.*

✦

New bulletins available

The American Transformer Company, 178 Emmet St., Newark, N. J., has recently issued Bulletin No. 1145, illustrating its line of transformers, amplifiers and component parts.

The Carrier Microphone Company, 525 So. Commercial St., Inglewood, Calif., has issued Catalog "B," describing its complete line of microphones and equipment.

Electrad, Inc., 175 Varick St., New York City, has issued a new circular covering its complete line of amplifiers for general purposes, as well as portable equipment for sound installations.

The Littelfuse Laboratories, 1772 Wilson Ave., Chicago, Ill., has released a circular describing tests made at Northwestern University to determine the time required to burn out delicate electrical equipment under short circuit conditions. These tests were made by means of oscillograph measurements.

Rawson Electrical Instrument Company, Cambridge, Mass., has recently issued a bulletin describing its line of electrical meters, with price reductions on many units.

American Piezo Supply Company, 1101 Huron Bldg., Kansas City, Kans., has issued Bulletin No. 27, describing its various types of Piezo crystals and constant temperature ovens, for use with radio transmitters.

Ward-Leonard Electric Company, Mount Vernon, N. Y., has released Bulletin No. 1101, describing various types of speed regulators designed for use with constant torque and variable torque a.c. and d.c. fractional hp. motors, also Bulletin No. 19, covering Ribflex vitrohn resistors.

Any of these bulletins may be obtained by writing the respective companies direct.

PATENTS

IN THE FIELD OF ELECTRONICS

A list of patents (Sept. 1) granted by the United States Patent Office, chosen by the editors of *Electronics* for their interest to workers in the fields of the radio, visio, audio and industrial applications of the vacuum tube

Electronic Applications

Train control. A method of using vacuum tubes for automatically controlling train speed by transmitting radio waves along the right of way on three different frequencies. F. C. Williams and G. H. Williams, Harrisburg, Pa. No. 1,816,628.

Cardiotachometer. An amplifier relay counter device for registering heartbeats. E. P. Boas and Benjamin Liebowitz, New York. No. 1,816,465.

Photometer. A photo-electric photometer. Carl W. Keuffel, assigned to Keuffel & Esser Co., Hoboken. No. 1,816,047.

Telegraph reading machine. A method of converting a telegraph code by a scanning system, and reading it by means of light-sensitive devices. R. D. Parker, assigned to A. T. & T. Co. No. 1,815,986, also No. 1,815,996 granted to Allen Weaver and assigned to A. T. & T. Co.

Means of transmitting motion. In filament circuit of oscillating tube are relays connected to resonant circuits. Remote means of producing oscillations to operate relays. W. L. Luehr, assigned to G.E. No. 1,817,753.

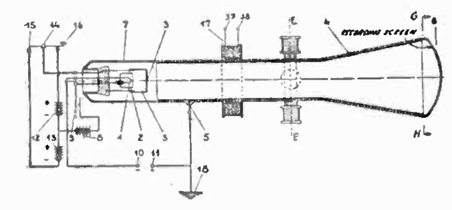
Telemetering system. Use of rectified current and protective means in a telemetering system. H. B. Rex, assigned to G.E. Co. No. 1,817,765.

Remote sounding equipment. Plummet in a sounding station is released from a remote point. Ernst Wilckens, Berlin, Germany. No. 1,817,864.

Piezo-electric meter. Glow tube across piezo-electric crystal to indicate resonance. H. Eberhard, assigned to RCA. No. 1,817,030.

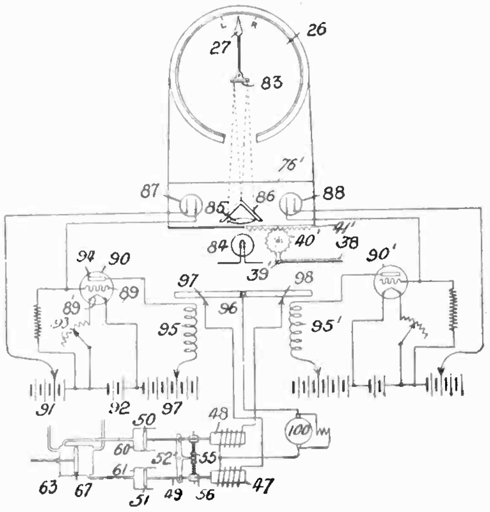
Airplane control. Continuous series of radio signals control ascent of airplane and intermittent series of signals maintain predetermined rate of descent. J. H. Hammond, Jr. No. 1,818,708.

Picture recording. Charged particles on screen of cathode ray tube permanently record images. Paul Selenyi, Budapest, Hungary. No. 1,818,760.



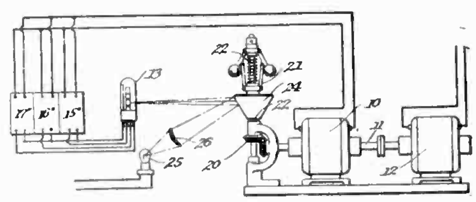
D. C. meter. Direct current is chopped, amplified and rectified as a measuring system. P. S. Bauer, Cambridge, Mass. No. 1,820,212.

Automatic pilot. Automatic steering device for dirigibles using photocells and amplifier tubes to operate rudder. E. A. Sperry, assigned to Sperry Gyroscope. No. 1,818,103.



Vision-tone device. Method of making audible in earphones changes in light intensity falling on light-sensitive surface. L. O. Lindstrom, and A. D. Ruedemann, Cleveland. No. 1,820,357.

Speed regulating system. A photo-electric system for controlling the speed of motors, etc. E. L. Peterson, Riverside, Calif. No. 1,819,439.



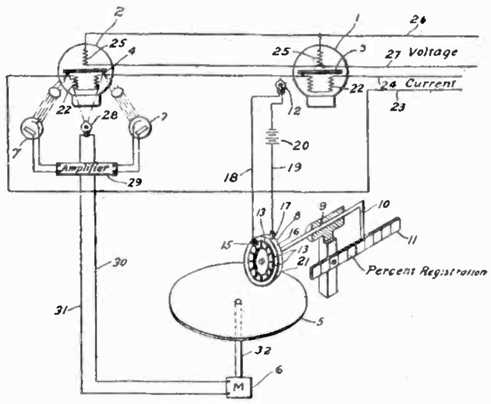
Transmitter testing circuit. Vacuum tube method of testing working circuits of transmitter. A. D. Ring, assigned to G.E. Co. No. 1,820,833.

Timing circuit. Condenser-resistance combination for circuit control. C. P. Stocker, assigned to B.T.L. No. 1,818,018.

Intensity control-picture transmission. Eliminating intensity variations in picture transmission by using an area of shade on one edge for controlling sensitivity of reproducing apparatus. O. Von Bronk and Hans Rukop, Berlin, assigned to GDT. No. 1,820,335.

High frequency reception aid. Method of preventing trills in beat note reception from signals generated by high speed alternator. Walter Hahnemann, assigned to C. Lorenz. No. 1,820,223.

Meter testing method. A photo-electric cell method of testing meters. Samuel Aronoff, assigned to Westinghouse E. & M. Co. No. 1,819,494.



Acoustic Apparatus

Piano with tone modulation. Electrically operated reflectors in a piano. J. H. Hammond, Jr., Gloucester, Mass. No. 1,818,709.

Loud speaker diaphragm. Hollow cylindrical member and radially placed hollow tubular members. W. K. Kearsley, assigned to G.E. Co. No. 1,818,854.

Binaural system. Recording and reproducing simultaneously two records of the same sound to simulate binaural hearing. F. M. Doolittle, assigned to RCA. No. 1,817,177.

Acoustic impedance measurement. Impressing equal sound waves on two paths, one a variable known acoustic impedance and the other the unknown. E. H. Smythe and P. B. Flanders, assigned to BTL. No. 1,816,917.

Television, Picture Transmission, Etc.

Television receiver. A means of confining the light from the glow-lamp into a beam. V. G. Gustafson, Joliet, Ill. No. 1,814,382.

Transmitting pictures in colors. A method of producing color pictures by analyzing the colored objects for each of several primary colors, transmitting separate series of impulses for these colors, and combining them at the receiver to reproduce the original object. A Weaver and D. E. Branson, assigned to A. T. & T. Co. No. 1,814,987.

Scanning system. A scanning device comprising a stationary screen having a number of openings, and a reciprocating shutter having an opening adapted to overlap such beam openings during motion of the shutter. Louis Oskow, Brooklyn, N. Y. No. 1,814,181.

Television screen. A grid provided with a plurality of points adapted to be made luminous when energized by currents of high frequency, and a distributing system. Frank Gray, assigned to B.T.L. No. 1,812,828.

Television system. A resonance circuit system whereby the characteristics of the circuit are varied according to the amplitude of the signalling current. Frank Gray, assigned to B.T.L. No. 1,812,402.

Light control system. A mirror on a tuning fork deflects light on the subject to be scanned into one of two photocells, both of which work into amplifiers. R. H. Ranger, assigned to R.C.A. No. 1,811,895.

Synchronizing system. Television system for synchronizing and automatically correcting phase. W. B. Funk, and E. P. Kruglak, Jackson Heights, N. Y. No. 1,812,778.

Image-producing system. Several light-controlling elements, each having two opaque portions, one of which surrounds the other, and a light transmitting portion between the boundaries. H. E. Ives, assigned to B.T.L. No. 1,815,203.

Scanning device. Light permeable element having a plurality of opaque regions. V. K. Zworykin, assigned to Westinghouse E. & M. Co. No. 1,817,502.

Speed control. Annular rings on rotating machinery used to maintain television apparatus at predetermined speed. J. L. Baird, London, England. No. 1,816,106.

Picture recording. Use of heat sensitive surface for reproducing pictures transmitted from a distance. R. H. Ranger and F. G. Morehouse, assigned to RCA. No. 1,819,264.

Miscellaneous Patents

Apparatus for measuring a plurality of values. Circuit and moving coil system for indication or registration of two groups of values, one produced by variations in resistance, the other by variations of emf. Heinz Gruess, assigned to Siemens & Halske. No. 1,818,847.

Magnetic material. Iron-nickel alloy containing about 33 to 48% nickel, 0.3 to 3% silicon and the rest iron. G. W. Elmen, assigned to W. E. Co. No. 1,818,054.

Electrical musical system. Generating tones and harmonics by a generator, supplying tones to reproducer via amplifier and filter. Joseph Bethenod, Paris, France. No. 1,809,503.

Facsimile system. Lens, prism and phototube system. G. M. Wright, assigned to R.C.A. No. 1,809,617.

Pick-up device. Permanent magnet forms part of the support structure. F. W. Lanchester, Mosely, England. No. 1,809,483.

Generation, Detection, Etc.

Direct-coupled amplifier. A resistance-coupled multitube amplifier of a direct-coupled type. Hollis S. Baird, assigned to Shortwave & Television. No. 1,816,462.

Oscillator amplifier system. A master oscillator followed by two amplifiers, one of which is modulated. N. E. Davis and W. T. Ditcham, assigned to RCA. No. 1,819,596.

Constant potential device. An electronic method of smoothing out currents to be applied from a pulsating direct current source to a load. Andreas Jaumann, assigned to Siemens & Halske. No. 1,819,604.

Harmonic suppressor. Coupling system between load and oscillator for prevention of harmonic radiation. W. Kummerer, assigned to G. D. T. Berlin. No. 1,819,469.

Tuning system. A pre-tuning circuit for providing additional discrimination against undesired oscillation frequencies. J. M. Miller, assigned to Atwater Kent. No. 1,819,299.

Static frequency changer. A method of reducing static frequency, involving a saturated magnetic core. R. K. Bonell, assigned to A. T. & T. Co. No. 1,819,069.

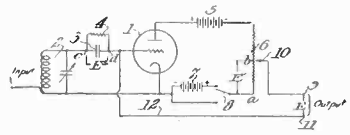
Antenna regulator. A method of regulating impedance variations in an antenna. J. E. Love, assigned to G. E. No. 1,819,904.

Control system. A condenser shunted by a resistance in the input circuit of a vacuum tube, for controlling various time intervals. E. F. Carter, assigned to G.E. No. 1,819,869, also No. 1,819,868.

Impedance-coupled amplifier. A method of preventing feed-back between output and input of each stage of a resistance impedance-coupled amplifier. H. J. Round, assigned to RCA. No. 1,819,845.

Vacuum tube circuit. A method of substituting for a non-working vacuum tube in a multi-stage amplifier of an equivalent impedance to maintain voltage constant. D. F. Whiting, assigned to B.T.L. No. 1,819,629.

Detector circuit. In a grid leak and condenser detector, the output is made up by combining the rectified plate voltage produced by grid circuit rectification with the rectifiex potential developed across the grid condenser. K. C. Black, Boonton, N. J., assigned to RCA. No. 1,820,114.



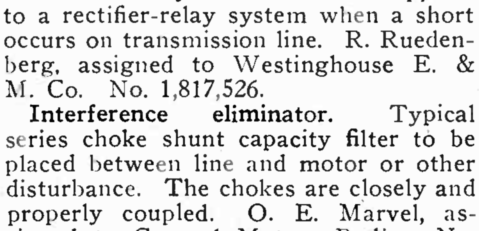
Oscillator-amplifier. Oscillator has series connected capacities and an inductance; amplifier tube grid and plate connected to oscillator through capacities. P. D. Andrews, assigned to G.E. Co. No. 1,817,795.

A.C.-D.C. telegraph. Method of combining d.c. and a.c. telegraph circuits over same pair of wires. R. V. Morgenstern, assigned to W.U. No. 1,817,702.

Protective system. A.c. is supplied to a rectifier-relay system when a short occurs on transmission line. R. Ruedenberg, assigned to Westinghouse E. & M. Co. No. 1,817,526.

Interference eliminator. Typical series choke shunt capacity filter to be placed between line and motor or other disturbance. The chokes are closely and properly coupled. O. E. Marvel, assigned to General Motors Radio. No. 1,817,443.

Current supply apparatus. Familiar rectifier filter system where power is taken out by a parallel system of variable resistors shunted by capacitors. W. C. Grunow, assigned to Grigsby-Grunow. No. 1,818,947.



Heater type tube circuit. A patent applied for in 1925 by F. S. McCullough on circuit using heater type tubes with the control grids, cathodes and plates removed from the inductive field of the heater current. No. 1,819,783.

Anti-regeneration system. R. H. Holmes, assigned to Westinghouse E. & M. Co. No. 1,819,511.

Frequency variation communication. C. W. Hansell, assigned to RCA. No. 1,819,508.

Time delay apparatus. A condenser, resistance and glow discharge tube for controlling time delays. W. K. Kearsley, assigned to G.E. No. 1,819,999.

Frequency stabilizer. An amplifier associated with a tuning fork for controlling frequency of time intervals. J. A. Smale, assigned to RCA. No. 1,819,487.

Sound reproducing system. An oscillator supplies sufficient superaudible energy to operate loud speaker. This energy is modulated at audio frequency, rectified and supplied to speaker. Palmer Craig, assigned to Invex Corp., N. Y. No. 1,817,612.

Protective circuit. Hot-cathode two-element tube used in a transmission circuit protective system. E. A. Hester, assigned to Westinghouse E. & M. Co. No. 1,817,486.

Gain control. Radio gain control comprised of three winding transformer, output winding connected equally but in the opposite direction to the other two windings in series with each of which is a capacity and the two inductance-capacity circuits connected in parallel. Fulton Cutting and J. L. Taylor, New York, N. Y. No. 1,817,294.

Gain set. Oscillator generates discrete frequencies, tuning system chooses each of these frequencies, amplifier-rectifier indicates transmission equivalent. A. B. Clark, and F. H. Best, assigned to A. T. & T. Co. No. 1,816,958.

Secret transmission system. Signal is modulated against several carriers which are caused to change continuously and cyclically, and suppression of all but a band width equal to original band. Ralph Bown, assigned to A. T. & T. Co. No. 1,816,953.

Protective circuit. Circuit for indicating anode overloading. J. C. Schelleng, assigned to B.T.L. No. 1,816,913.

Communication system. Communicating with several stations in different combinations by means of filters having overlapping bands. J. W. Horton, assigned to B.T.L. No. 1,816,905.

Light valve amplifier. Vacuum tube for feeding light valve string, and switching means for shorting string and de-energizing vacuum tube. R. A. Miller, assigned to B.T.L. No. 1,816,862.

Wave changing system. Method of simultaneously moving two contacts away from a center tap equal amounts. L. A. Gebhard, assigned to Wired Radio. No. 1,818,316.

Zero corrector. Vacuum tube amplifier in which current impulses in the output take place only when some predetermined maximum is exceeded. Also relays operated by these impulses. A. M. Curtis and E. T. Burton, assigned to B.T.L. No. 1,818,463.

Feed-back suppressor. Use of an energy absorption network to prevent feed-back. B. S. McCutchen and C. V. Sandell, East Orange, N. J. No. 1,819,298.

Oscillating detector. Plate feed-back detector arrangement. M. M. Phillips, Pittsburgh, Pa. No. 1,818,157.

Tube testing circuit. A method of testing an electric valve consisting in passage between anode and cathode for one interval of time a relatively low potential current of the same order of magnitude as the rating of the valve, and impressing between anode and cathode for a second interval of time a potential of opposite polarity and of the same order of magnitude as the inverse potential rating of the valve. H. T. Maser, assigned to G.E. No. 1,819,908.

Neutralizing circuit. From grid to anode is connected an inductance through capacities. The cathode is connected into this inductance by a tap at the proper position to prevent oscillation. A. D. Ring, assigned to G.E. Co. No. 1,820,832.

Radio Circuits

Direction finder. Auxiliary directional antenna receptive to vertical component combined with goniometer output in phase opposition. A. Meissner, assigned to GDT. No. 1,818,639.

Radio-wire combination. Signals are sent by wire to a group of stations out of range of the radio wave and at same frequency. A. Beckmann, assigned to GDT. No. 1,818,669.

Heterodyne circuit. Method of introducing beat note through cathode circuit. E. W. Kellogg, assigned to G.E. Co. No. 1,820,809.

Directional antenna. Double loop antenna and method of connecting them. G. G. Kruesi, assigned to Federal Tel. No. 1,820,571.

Secret comunication system. A method of generating several related frequencies, radiating each of them, and sending a message by altering the relationship of certain of the frequencies as to phase and amplitude. J. H. Hammond, Jr., Gloucester, Mass. No. 1,816,579.

Automatic switching device for electric phonograph. A. N. Goldsmith, assigned to RCA. No. 1,816,577.

Short-wave receiver. A combination of a long-wave, multi-phase radio receiver and a short wave adaptor. H. S. Baird, assigned to Shortwave & Television Corp. No. 1,816,461.

R. F. coupling circuit. Inter-stage gain control system. Byron B. Minnium, assigned to Story & Clark Radio Co. No. 1,816,227.

Vacuum Tubes, Phototubes, Etc.

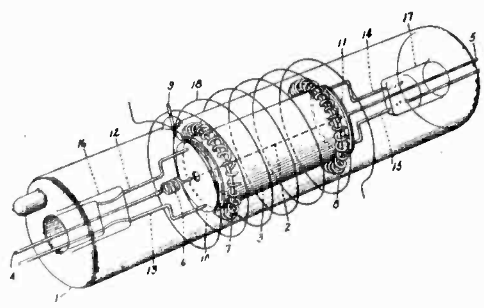
Electron emissive material. Exposed to ionic bombardment is an emissive surface composed of an alkaline earth metal salt forming an amphoteric compound less acid than titanic acid. F. Meyer and H. J. Spanner, Berlin, Germany, assigned to Electrons, Inc. No. 1,817,636.

Light sensitive layer. Surface composed of diazonium, aryl, etc. P. Schmidt, W. Neugebauer, R. Franke, assigned to Kalle & Co., Wiesbaden. No. 1,816,989.

Thermostat, mercury vapor tube. Tube in which is a two-metal thermostat. Andre Becq, assigned to G. E. Co. No. 1,817,799.

Anti-space charge filament. Additional filament is placed to get rid of negative space charge. J. V. Capicotto, assigned to Dubilier. No. 1,817,674.

Space charge device. A method of generating an electron discharge accompanied by an amount of positive ionization which is sufficient to materially neutralize the space charge; a kind of magnetron. Irving Langmuir, assigned to G.E. No. 1,816,682.

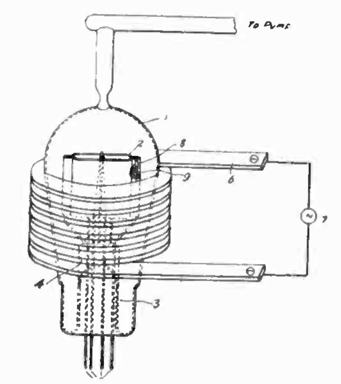


Gaseous rectifier. C. G. Smith, assigned to Raytheon, Inc. No. 1,816,619.

Vacuum tube. Two-plate tube. S. Scognamillo and Paul Arndt. No. 1,820,836.

Method of introducing calsium. E. Y. Robinson, assigned to Associated Electrical Industries, Ltd. No. 1,817,445.

Introduction of caesium. D. C. Ulrey, assigned to Westinghouse E. & M. Co. No. 1,817,448.



Aeo light. Glow lamp with alkaline earth metal electrode, allowing direct current to flow through another electrode for a period of time and then connecting high voltage alternating current source to tube until characteristic spectrum of coating material is produced. Willard Case, assigned to Case Research Laboratory. No. 1,816,825.

Patent Suits

[Notices under sec. 4921, R. S., as amended Feb. 18. 1922]

1,122,011, J. E. Lilienfeld, Process and apparatus for producing Roentgen rays, C. C. A., 2d Cir., Doc. —, *The Chemical Foundation, Inc.*, v, *General Electric Co et al.* Decree affirmed (notice May 4, 1931).

1,698,668, Ballantine & Hull, Demodulator and method of demodulation; 1,760,-871, S. Ballantine, Method of and means for preventing radiation and extra reradiation in radio receivers; 1,760,872, L. M. Hull, Apparatus for amplifying electric oscillations, D. C., S. D. N. Y., Doc. E 56/256, *Radio Frequency Laboratories, Inc.*, v. *Danega, Inc.* Dismissed without prejudice May 15, 1931.

1,342,885, E. H. Armstrong, Method of receiving high frequency oscillations, D. C., N. D. Ohio, E. Div., Doc. 3237, *Radio Corp. of America et al.* v. *The G. W. Walker Co.* Dismissed without prejudice May 19, 1931.

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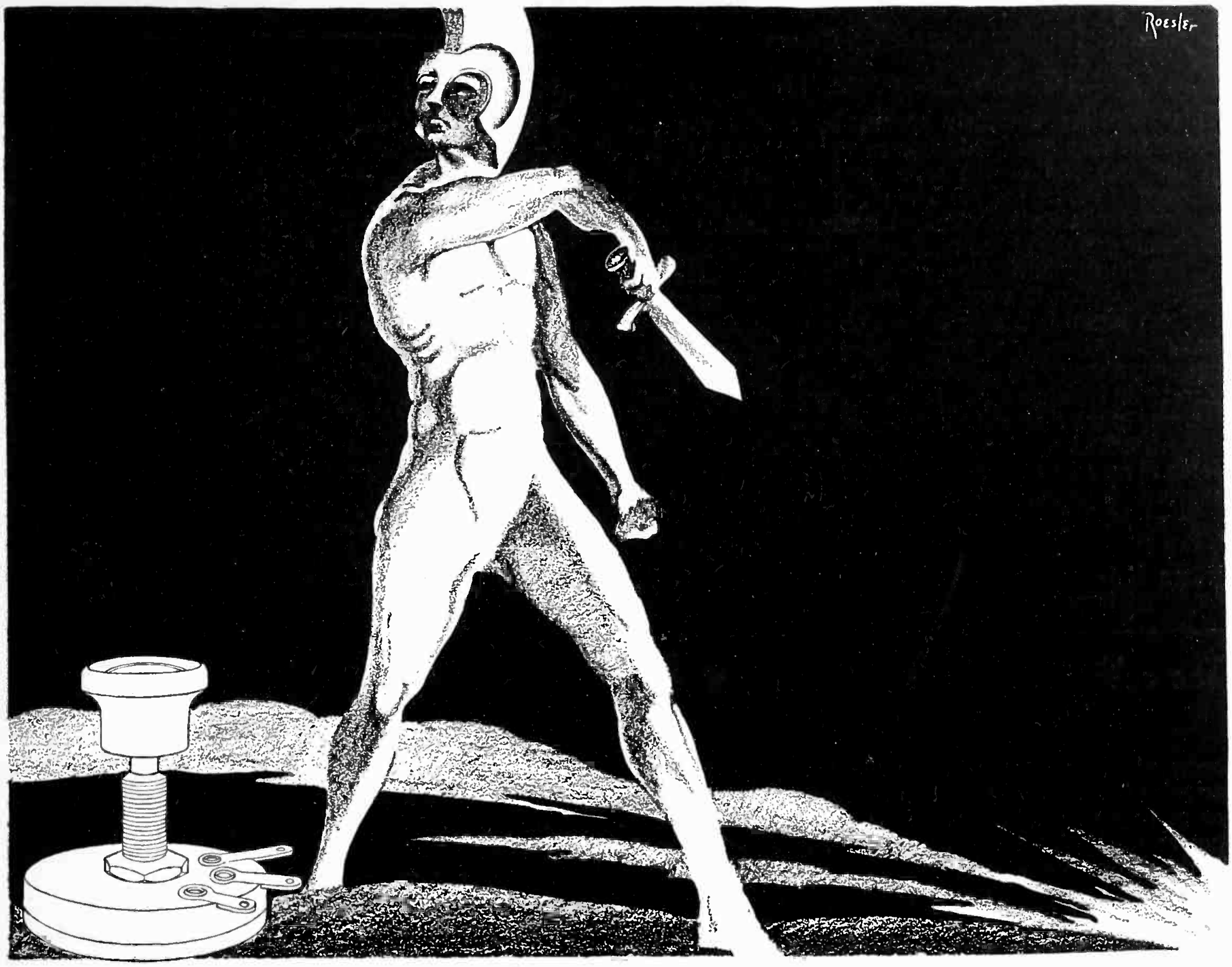

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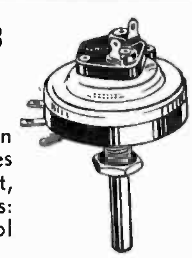

Dynamic loudspeaker design—

[*Continued from page 113*]

This reduction obviously cannot be carried too far because a very great reduction of the core cross-section at the free end of the core results in an enormous increase in the iron *A.T.* The result might be that with a given excitation we obtained a smaller field strength in the air gap than if an unreduced core were used.

It is hardly advisable to continue the reduction of the cross-section to a greater extent than was done here.

From Fig. 3 it is seen further that in the case of the magnetic system under consideration it is useless to produce more than 2,000 *A.T.* of excitation, since a further increase in exciting *A.T.* produces only a relatively small increase in the air gap field strength.

As a criterion of the output of the loud-speaker the force *P* may be considered. For the speaker described above, with an *A.T.* of 2,000 excitation and a current *I*

$$P = H.\ W.\ lm.\ I = 8{,}700 \times 420 \times 10 \times I = 365\, I \times 10^5$$

where H is the ampere turns
W is number of armature turns

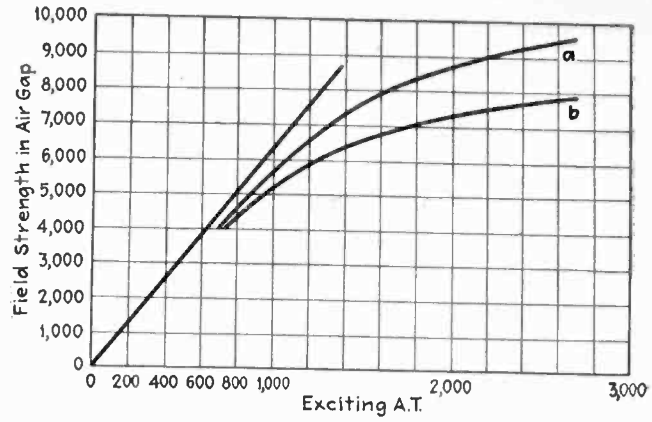

Fig. 3.—Relation between exciting ampere turns and gap field strength

and lm is the mean length of a turn of armature winding.

Thus to determine whether one design is better than another, it is necessary to make the above calculations and determine whether one or the other design furnishes more power to the armature.

The calibration of microphones

[*Continued from page 108*]

operated microphone, and has the advantage over the actuator that it may be used on microphones with curved or corrugated diaphragms. It is obvious that it could not be used with a velocity operated microphone, such as the ribbon microphone.

Cavity resonance and pressure doubling

The disadvantage with pressure calibrations is that they ignore two important acoustical properties of microphones. The first of these is known as cavity resonance and the second as pressure doubling.

If a plane wave of sound falls on *AB* Fig. 5, it is well known that the pressure at *CD* will not be the same as the free space value. The ratio of the pressure at *CD* to that in free space shows a distinct maximum with respect to frequency, and for quite a frequency range on either side of this maximum, the pressure at *CD* is considerably greater than it is in free space. This phenomenon is known as cavity resonance.

Consider a plane wave of sound falling on the face of the microphone. If the wavelength of the sound is large compared with the diameter of the microphone, the sound is diffracted around the microphone with very little reflection. On the other hand, if the wavelength of the sound is small compared to the diameter of the microphone, sound will be reflected from the microphone. In this case, the sound pressure at the face of the microphone will be double what it is in free space. For wavelengths in between, there is a gradual rise from the free space sound pressure to double that pressure as the wavelength is decreased.

These two effects make the condenser microphone have a response curve as measured by the Rayleigh disk, quite different from what it is as measured by an actuator. Figure 6 shows these curves. The Rayleigh disk calibration is more nearly correct for the conditions of actual use.

So far we have considered the calibration of microphones only in conjunction with their associated amplifiers. We will now consider the calibration of the amplifiers alone, so that we may subsequently obtain the calibration of the microphones alone.

Calibration of amplifiers

The action of a microphone is to generate an alternating e.m.f. in the circuit in which it is located. Therefore, to calibrate an amplifier (of which the microphone itself may be considered an electrical part), we insert an e.m.f. in series with the microphone circuit, which simulates the e.m.f. generated by the microphone without inserting any appreciable impedance into this circuit. This is done by inserting a small resistance into the circuit and applying a definite e.m.f. across this resistance. In the case of a high impedance microphone circuit, such as that of the condenser microphone, this inserted resistance may be several ohms. In the case of a low impedance microphone circuit, such as that of the ribbon microphone, which is about 0.2 ohms, this should be less than 0.01 ohms. Care should be taken in this case that the inserted resistance should be non-inductive. In Fig. 7, (a) and (b) are shown circuit diagrams for doing this with the condenser and ribbon microphones.

After the amplification of the amplifier has been obtained for the frequency range of interest, the millivolts per bar generated in the microphone alone may be obtained by dividing the millivolts per bar of the microphone and amplifier by the amplification of the amplifier. Figure 8 gives the frequency-response curves of two common types of microphones calibrated in this way.

In order to compare the sensitivity of a microphone in a low impedance circuit with that of a microphone in a high impedance circuit, one should compare the voltage that each will impress on the grid of the first vacuum tube in an amplifier in which all impedances are properly matched. This is true because in an amplifier with good resistors, transformers and condensers, it is the tube noise of the first tube which limits the amount of amplification which can be used. Thus in the case of the commercial ribbon microphone a 700:1 step-up transformer is necessary to match the impedance of the microphone circuit to the input impedance of the first vacuum tube.