electronics

radio, sound, communications and industrial applications of electron tubes . . . design, engineering, manufacture

Electronic progress looks ahead

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Problems of cathode ray television

✦

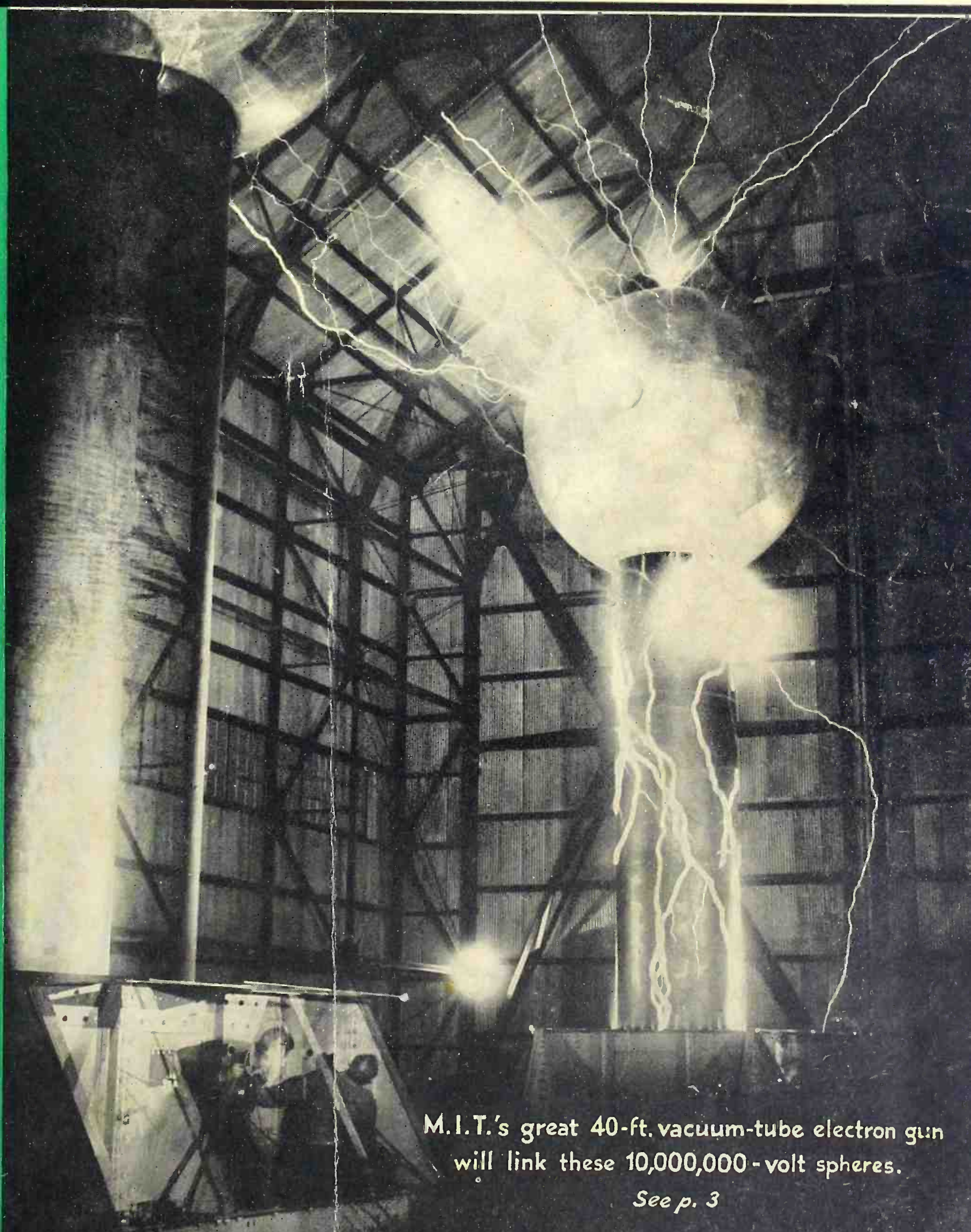
Mercury arc rectifiers for broadcast power

✦

Hook-up wire for radio sets

✦

High-speed counting by electron tubes



M.I.T.'s great 40-ft. vacuum-tube electron gun will link these 10,000,000-volt spheres.

See p. 3

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Definite economies result with the specification of Goat modern tube-shields because — the cost of the set chassis and exterior is less — the actual cost of the tube-shield itself is much less.

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GOAT RADIO TUBE PARTS

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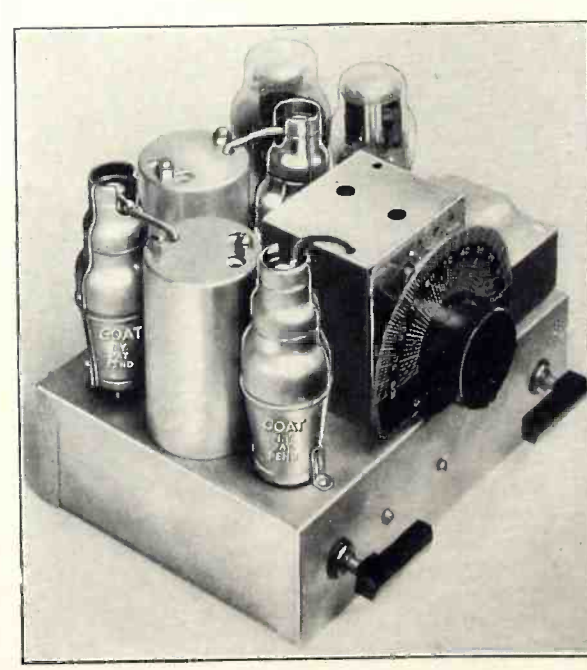

Goat Radio Tube Parts, Inc. 314 DEAN STREET, BROOKLYN, N. Y.

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O. H. CALDWELL
Editor
KEITH HENNEY
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electronics

McGRAW-HILL PUBLISHING COMPANY, INC.

New York, January, 1934

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radio
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photo cells
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phonographs
measurements
receivers
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musical instruments
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Electronic progress looks ahead

THE YEAR 1934 opens with many new developments in electronics in sight. Not only is research driving further into the fundamental characteristics of electron behavior, but phenomena of the laboratory are being harnessed and put to work in the shop, while applications already made in everyday life are bound to spread and increase in number.

ELECTRON velocities such as never before attained, short of the cosmic-ray particles themselves, are the basis of new experimentation in Massachusetts and California. Television has become myriad-eyed, with new possibilities of detail and new intensities of screen projection. The new science of "electron optics" is receiving special study, as new uses loom ahead for the cathode-ray tube. Facsimile may become as common in the home as the loudspeaker. And the millions of hours of enforced leisure under the New Deal will result in increased markets for radio sets, sound-pictures, and other electronic amusement devices, with an accelerated special prosperity of which the electronic industries already had a taste in the closing months of 1933.

IN RADIO broadcasting, the 500-kw. station commands the American scene, and undoubtedly others will be installed to keep WLW company during 1934. Even the Federal Radio Commission now accepts "high power" to the extent of 50 kw. for regular operation, and the value of strong signals to override static and carry entertainment to far-off farm dwellers, is recognized. Improvement in tone-quality of transmission is still a primary concern, although the broadcasters are apparently still far ahead of the average home installation, with its carelessly slapped-up antenna and inadequate

[*Continued on following page*]

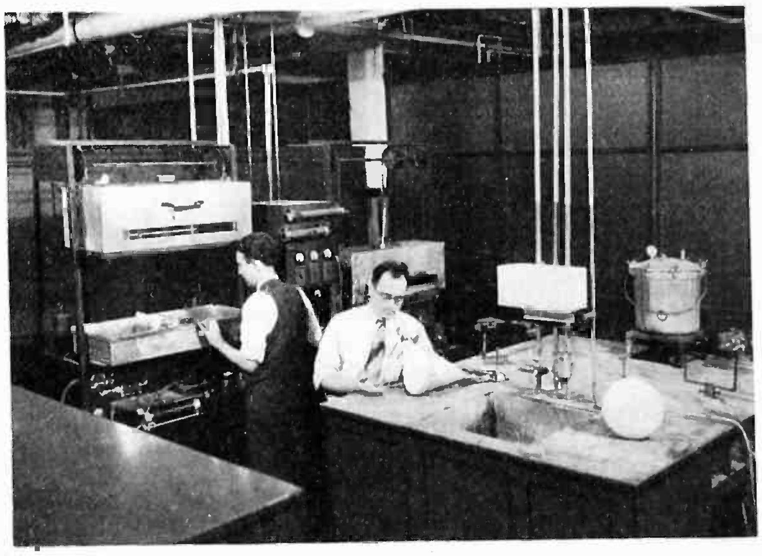
RECENT DEVELOPMENTS SET

receiver. The present difficulty of improving tone fidelity, by extending the upper limit beyond 3000 cycles, is the vast quantity of man-made and natural static and the comparative weakness of even the largest of the broadcast stations to override extraneous noise. The electrical and mechanical apparatus is ready for making radio receivers essentially flat from 60 to 6000 cycles if, and when, it is possible to use such receivers. But the inter-station beat notes, the monkey chatter from over-modulation and other unnecessary racket forces the average listener to turn his tone control so far toward the bass that he gets little or nothing beyond the frequencies transmitted by the poorest telephone. No one expects (except the purchaser) that a very small radio can have much bass response; the crime is not in making and selling such skimped sets, but in not educating the purchaser to consider them in their true light. Even here there is no excuse for all too prevalent shoddy construction.

The problem of international broadcast allocation on the North American continent is still unsolved. Provision for the growing requirements of our sister nations, seems to make imperative either the widening of the broadcast band on both ends, as already provided for by some of the newer radio receivers, or the assembly of a number of stations carrying the same programs on a limited number of channels. by the use of synchronization. Experimental installations already in use show that such synchronizing is practical. A reallocation growing out of synchronizing of stations, may even make possible wider individual channels, up to 15 to 20 kc, permitting higher frequencies than the present 5000-cycle limit.

In granting licenses to operate broadcast stations in the regions at the upper and lower limits of the present broadcast bands, the Commission has arranged that channels be placed 20 kc. apart so that an experiment in wide-band transmission might be tried. There remains the problem of finding someone who would attempt this experiment—but the present list of applicants for station assignments indicate that these extra-broadcast band channels would soon be filled. If it proved worth while to transmit higher frequencies additional pressure could be brought to force the synchronizing of stations transmitting identical programs.

CATHODE RAY TUBES IN THE MAKING



After playing its role in the discovery of the electron in the hands of Crookes, Thomson, Roentgen, Millikan, the cathode ray tube enters upon routine duties in industry. Here H. G. Biggs (Hygrade Sylvania) builds a modern high vacuum tube

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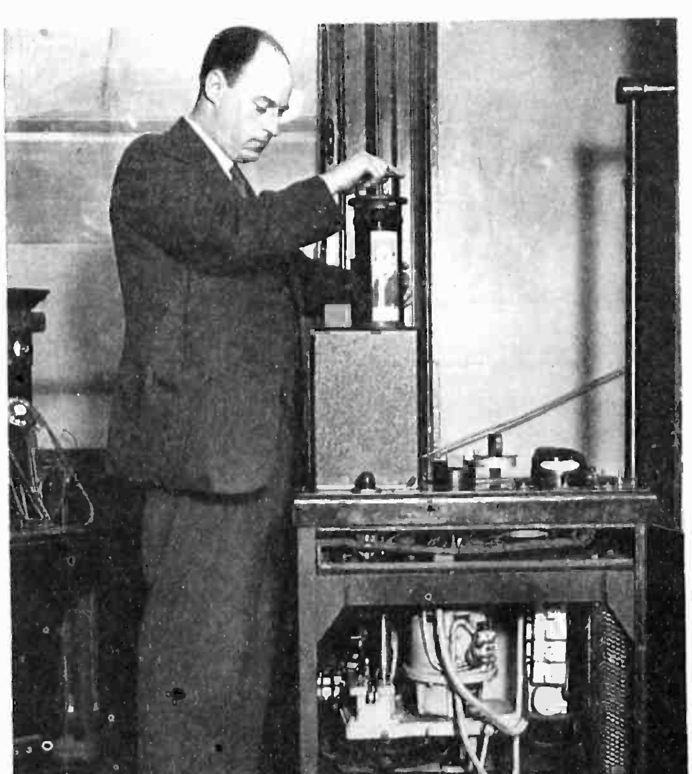
FACSIMILE IS READY



This German transmitter is typical of facsimile systems. The possibilities of adding a picture service to broadcast receivers is considered especially as a means of getting accurate and complete program announcements to the listener.

Facsimile newspapers

Use of the broadcast channels during the hours from 1 a.m. to 6 a.m. to carry facsimile impulses and deliver tabloid newspapers to every home which can purchase a $25 to $50 facsimile printer to be plugged in in place of the loudspeaker, is another distinct possibility for 1934. With the newspapers taking broadcast programs out of their columns, and the broadcasters needing some form of advance printed program laid down in the homes of listeners, facsimile provides the answer over the broadcast channels during the hours when they otherwise stand useless. Such facsimile newspapers, available to the family at breakfast-time, would carry news, headlines, cartoons, fashions, display advertisements and everything.

Another frontier into which broadcast reception can develop, is the extension of the hours of listening for

PACE FOR PROGRESS IN 1934

the average man. Today, broadcasting is primarily an evening service for the family and the man of the house, with some hours of daytime listening for the women members of the household. The 700,000 automobile radio sets installed during 1933 have added a great daytime audience to the broadcast stations. Office radios can further increase this, especially with a news service of interest to business men. Some means of signalling the set-owner from the broadcast station, ringing a lamp or bell to let him know when some feature of special interest is on the air, would further increase the listeners for daytime programs. And real self-contained pocket radio receivers, complete with their own battery power, which the user could carry everywhere, and use on the sidewalk, on street cars, in railroad trains, etc., as conveniently as he consults his watch, will be the final capstone in this radio structure of linking the broadcast stations with Everyman, everywhere.

M.I.T.'s 10,000,000-volt electron gun

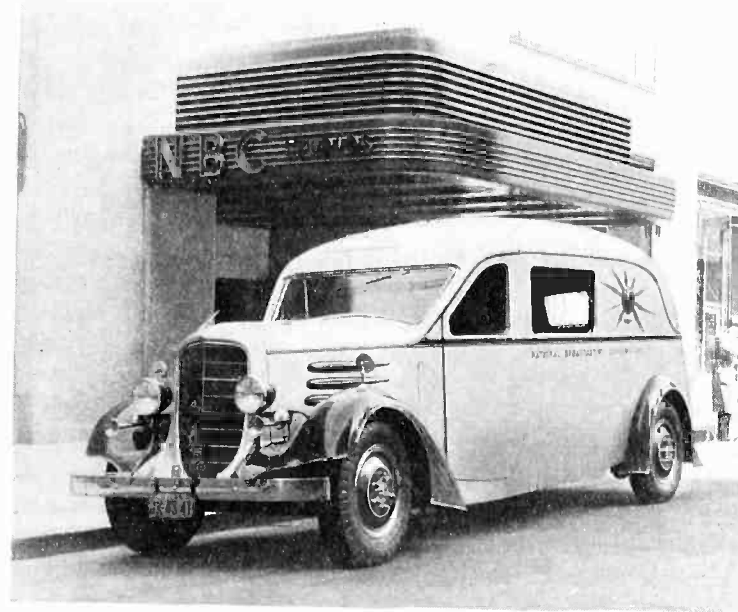
Electronic experimentation fraught with the most tremendous scientific import is that now going on at South Dartmouth, Mass., under the auspices of Massachusetts Institute of Technology with the great 10,000,000-volt electro-static generator pictured on the cover. This huge Van de Graff generator employs endless paper belts onto which charges are sprayed at 20,000 volts from rectifier-tube outfits. Conveyed by motor power to the huge 15-ft. polished aluminum spheres, the charges escape to the surfaces of these great balls, charging them 5,000,000 volts above and below ground, or 10,000,000 volts between terminals.

Between these huge spheres will be installed a great vacuum tube, 40 ft. long, and 12 inches in diameter, built up of laminated paper, thin sheets carefully cemented together with shellac under pressure. This tube will be exhausted until only one-billionth of the original number of air molecules remain.

At one end of the great vacuum tube will be placed a source of electrified particles, such as hydrogen ions or protons. The electric field will pull these down the tube with all the energy of 10,000,000 volts, causing them to bombard as high-velocity particles, the target at the far end of the tube connected to the other electrode. Reaching speeds of over 100,000 miles per second, and almost approaching the velocity of the cosmic-ray electrons, it is expected that these electron bullets may entirely penetrate the outer guard-rings of the atoms of the target and smash through the inner potential barrier into the atomic nucleus, a trillionth of an inch in diameter.

From the target under such bombardment are expected to come the most powerful X-ray radiations ever produced; also atoms of new elements, synthesized by this new high-voltage transmutation of the atoms. The research being conducted will include the study of the new X-rays of very short wave-length, for both penetrating power and therapeutic use; also the acquiring of new light on inter-atomic energy, and transfer of electrons in the transmutation of modern elements.

NBC'S NEW MOBILE PICK-UP TRANSMITTER



Built on a special truck body, this 150-watt transmitter can send 100 miles while stationary, and 50 miles while moving at high speed. Operates on 8, 11, 125 and 190 meters

THE BIG BOTTLES BEHIND THE NEW 500-KW. WLW

There are ten of these great 100-kw. transmitting tubes in the new Crosley 500-kw. station, WLW, Cincinnati

Photocells in industry

Of the electronic devices in industry, the photoelectric cell leads off with the largest number of applications in everyday life and in factory use. The year 1933 has witnessed the further widening of these electronic uses, but also the concentration of the photocell and electronic tube into those applications where no other means will do the work. This has meant the temporary dropping of attention to problems which can be solved by the older

[*Please turn to page 24*]

Metal-clad grid-controlled mercury rectifiers for radio stations

By SAMUEL R. DURAND

Allis-Chalmers Mfg. Company, Milwaukee, Wisconsin.

ONE of the major problems in high-power radio transmitting stations is to obtain a reliable and efficient rectifier with the longest possible life. The metal-clad mercury-arc rectifier inherently possesses an unlimited period of service, and this is one of the chief factors influencing its selection by a constantly increasing number of radio broadcasting and telegraph transmitting stations throughout the world.

More than 2,000 of these rectifiers have been used in traction and industrial power supply systems during the past 20 years. The first installation of a metal-clad rectifier operating at a high d-c voltage was made in 1927 by the Brown Boveri Company in an electro-chemical plant in Germany. Two years later a rectifier delivering 400 kw. at 12,000 volts d-c was installed in the experimental laboratories of the Marconi Company at Chelmsford, England. The immediate success of this first unit in radio service has resulted in the installation of such rectifiers in practically all of the new broadcasting stations in Europe. Eleven of the twelve high-power radio stations in Germany are now equipped with this type of converter, and several installations have been made in eight other countries.

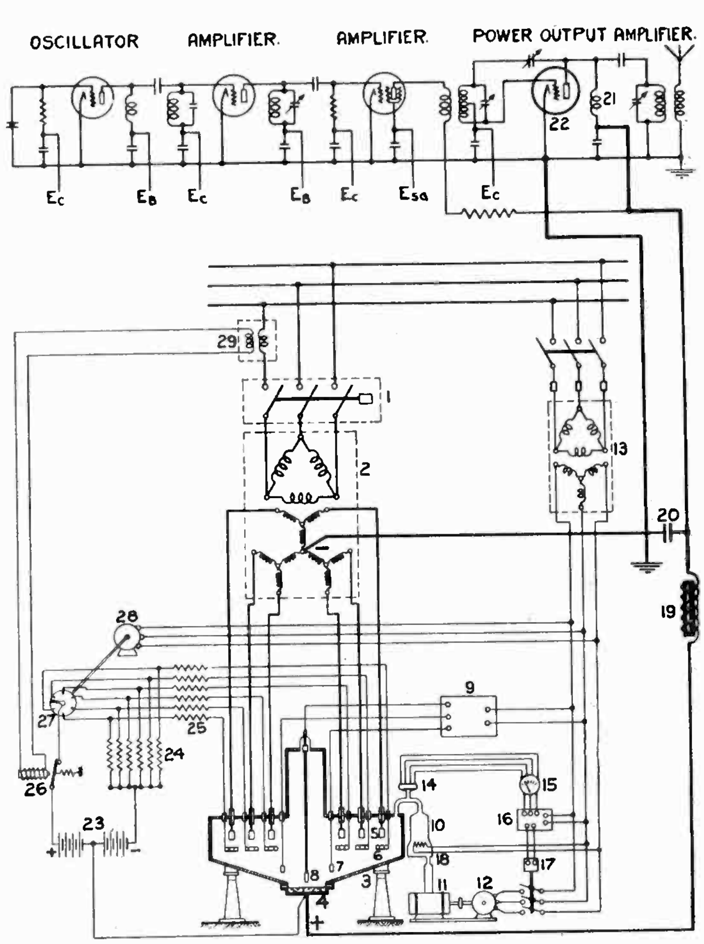


Fig. 1—Fundamental circuit and lay-out of metal clad rectifier for use in radio transmitting station

In contrast to a vacuum-tube rectifier which contains several filament-operated tubes exhausted to the required vacuum and sealed off, a metal-clad mercury-arc rectifier consists of an iron tank unit in which a vacuum is maintained by a mercury vapor pump in conjunction with a small rotary oil pump. Within the tank is a mercury-pool cathode. Mounted on the cover plate of the tank by insulator bushings are the main anodes, an ignition rod for starting an excitation arc, two small anodes for maintaining the excitation arc, and grid elements associated with each main anode.

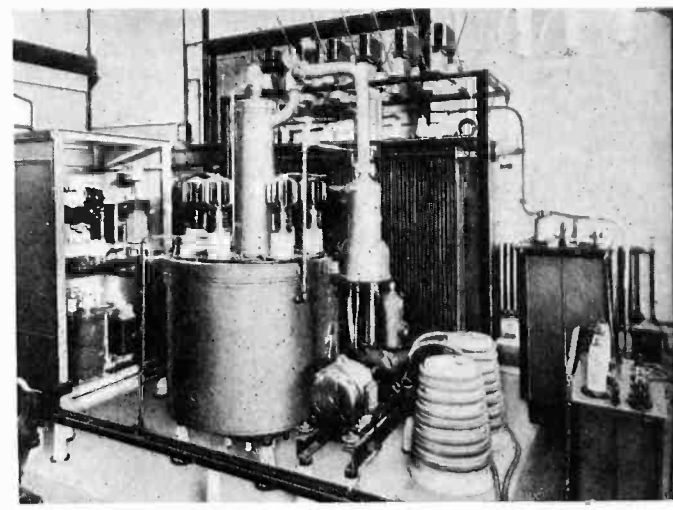


Fig. 2—Typical rectifier installation for high power broadcast station

In general each rectifier in radio service has six main anodes so as to provide six-phase rectification. The total power required by the vacuum pumps and excitation circuits is about the same as that required by the filaments of rectifier tubes, so that the metal-clad rectifier is equivalent in operating characteristics to a vacuum-tube rectifier employing six three-element mercury-vapor tubes with the exception that the life of the metal-clad unit is unlimited.

Requirements of radio service

The use of metal-clad rectifiers in the radio field cannot be adequately appreciated without first reviewing the unusually severe requirements demanded for this service.

1. The smallest rectifiers must be capable of delivering efficiently about three kilowatts at 3,000 to 5,000 volts d-c, whereas the largest units must deliver with very high efficiency several hundred kilowatts of power at about 30,000 volts d-c for use with the latest types of high-power transmitting tubes.
2. The overall efficiency of a rectifier plant including the main power transformer and all auxiliaries must be the highest economically attainable, and as a rule should be at least 95 per cent.
3. All of the equipment should be capable of being

operated continuously for indefinite periods of time without attention or servicing.

4. The plant must be designed for automatic control, and for high-speed automatic protection of all of the station equipment in case of short-circuits or breakdown.
5. The ideal rectifier must not require periodic replacements of expensive parts. The maintenance cost of the rectifier itself should be practically negligible.

It is interesting to see how metal-clad mercury-arc rectifiers meet these requirements. The smallest unit of this type is rated at 40 kw., 12,000 volts d-c, and is employed in a broadcasting station in Turin, Italy. The largest plant is installed in a broadcasting station in Villa Acuna, Coahuila, Mexico. It consists of two rectifier tanks in series, each supplied with a-c power from a single transformer unit containing two secondary windings. This plant at present is rated at 800 kw., 18,000 volts d-c, but is designed for an ultimate rating of 1,800 kw., 18,000 volts d-c. The highest voltage rating at present of a rectifier in actual service employing but a single tank is 22,000 volts d-c. This unit is used to furnish 500 kw. power to the Lakihegy broadcasting transmitter of the Hungarian Government. Metal-clad rectifiers have been fully tested at the present time for voltage ratings of 30,000 volts d.c. at a power output of 1,200 kw. The efficiency of these rectifiers is excellent, and at high power outputs is not exceeded by any other type of converter.

Many of the rectifiers in operation today only need to be shut-down for a few hours once in about every five years in order to inspect the anode seals. The design and materials used in these seals enable a high vacuum to be maintained over many months when the rectifier is not in operation, so that a rectifier unit may always be kept available to be put into service at very short notice. The cost of replacing seal gaskets, when necessary, is low. The maintenance cost of a high-voltage unit is about $30 to $40 per year.

Figure 1 shows the basic circuit of a rectifier plant as employed in a transmitting station. On the primary side of the main power transformer, the whole set is protected by a three-pole alternating-current circuit breaker 1. No circuit breaker is necessary on the d-c side.

The main power transformer 2 is of the oil-immersed, self-cooled type. Most of the larger size units are double three-phase connected with inter-phase transformer, though under conditions where a very low voltage regulation is desirable between complete no-load and full-load, such as in a radio telegraph transmitting station, the secondary winding may be fork connected. The neutral or negative d-c terminal of the circuit is grounded, and each individual branch winding is connected to a corresponding anode.

The high-voltage rectifier unit 3 resembles the type used extensively in electric railway power service. Each unit of this type in radio service has a cathode 4, six main anodes 5, six corresponding grids 6, two excitation anodes 7, and an automatic ignition device 8.

The cathode 4 of the rectifier at the base of the tank attains a high positive d-c voltage during operation. The tank is at nearly the same positive potential, so must be mounted upon insulator supports. It is a general practice to attach a high vaccum water-cooled, mercury vapor pump 10 to the side of the tank, and to mount a rotary oil pump 11 and motor 12 on insulator supports on the floor directly beneath it. Both the ignition and the evacuating equipment receive a-c power from a small insulating transformer 13.

Metal-clad rectifiers up to ratings of 500 kw., 10,000 volts d.c. are usually of the self-cooled type. The largest size units at full load require about $\frac{1}{3}$ gallon per minute at 25 deg. C. water temperature. The flow may be automatically controlled by a temperature regulator.

Each rectifier is also equipped with an electric vacuum gauge 14 connected to a meter calibrated in microns, and a contact device provides automatic control of the vacuum-pump set through a relay 16 and an electrically operated switch 17. Under ordinary conditions, the rotary oil pump operates for a short period of time only about twice a week, whereas the heater 18 of the mercury-vapor pump is maintained in service continuously.

Six-phase, half-wave rectification is attained with a six- anode rectifier. This is equivalent in regard to the d-c output ripple to the rectification obtained from a three-phase, full-wave, six-tube rectifier set. To reduce the ripple voltage to the amount allowable for broadcast transmitters, a filter is required in the d-c output circuit. Various types of filters may be employed. The most general filter in use at the present time consists of an inductance 19 in the positive high-voltage lead, and a condenser 20 across the high-voltage d-c line. The positive high-voltage d-c terminal beyond the filter may be connected through a radio frequency choke coil 21 directly to the plate element of the transmitting vacuum tube 22 as illustrated. It is not necessary to employ protective resistors in this series circuit when high-speed automatic grid-control overload protection of the rectifier is provided, since the power is cut-off so rapidly that the transmitting vacuum tube does not have time to overheat.

Grid-control voltage regulation

The basic features of the circuit employed for grid-control voltage regulation of the d-c output are included in the circuit diagram. At the present time almost all of the stations are utilizing this simple method of adjusting the voltage from zero to its maximum value. This is preferable to using induction regulators, which lower the overall efficiency of the plant and increase the cost, or to using regulating transformers with tap changing switches, which are expensive to build. Since low voltages are used only in starting up radio transmitters, the undesirable increase in the ripple current below maximum voltage with grid control is of no consequence.

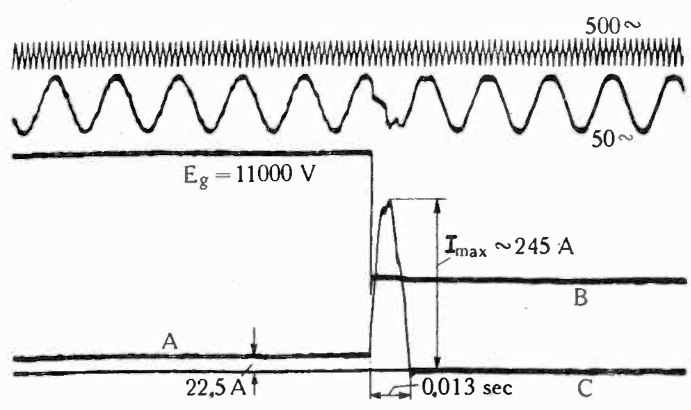


Fig. 3—Oscillogram of clearing of short circuit at 11,000 volt d-c. A, direct current; B, no-volt line of the d-c voltage; C, no-volt line of the d-c amperage; Eg, d-c voltage

The voltage regulation consists in controlling the instant at which each anode is permitted to ignite, and thus controlling the mean d-c voltage supplied by the rectifier to the load circuit. Each grid is normally maintained at a negative potential (in relation to the cathode) by the negative terminal of battery 23 through suitable current limiting resistors 24 and 25. A very short impulse of positive voltage to the grid of each anode in turn is sufficient to fire it. This is accomplished by momentarily connecting the positive terminal of the battery to each grid in successive order through the contacts of relay 26, a commutator type contact maker 27, and current limiting resistors 25. A small three-phase synchronous motor 28 drives the brush arm of the contact maker. Manual adjustment of the d-c output voltage of the rectifier from zero to its maximum value may be accomplished by electrically shifting the axis of the rotor of the synchronous motor with respect to its stator.

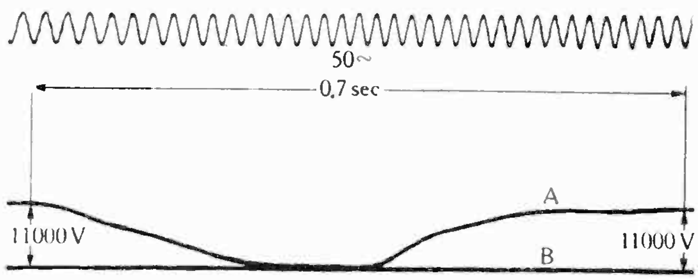


Fig. 4—Regulation of d-c voltage by means of control grids. A, d-c voltage; B, no-volt line of d-c voltage

For overload and backfire protection of the entire power plant and of the radio transmitting tubes and circuit apparatus, each rectifier is equipped with a high-speed relay 26, capable of opening the positive grid circuit in less than three-thousandths of a second. The relay is connected to the secondary of a current transformer 29, the primary of which is inserted in one phase of the incoming three-phase a-c supply. Operation of the relay instantly causes a negative potential to be placed on all of the rectifier grids. This prevents the ignition of any anodes that are not firing.

An additional feature of grid-control protection is a method of instantly dissipating the energy of the firing anode and filter system. The overload condition is cleared in about half a cycle, and power is immediately reapplied to the transmitting tubes. The total time taken to thus clear the overload condition and restore full power to the transmitting tubes is but a fraction of a second, so that only the most experienced listeners are able to tell that an interruption occurred in a broadcast program. On account of the high momentary overload capacity of a metal-clad mercury-arc rectifier, no damage can be done to the power supply equipment even on a direct short-circuit of the output terminals. If the overload condition persists and the circuit cannot be successfully closed after a number of attempts, the main circuit breaker will automatically open and sound an alarm.

Figure 3 shows an oscillogram of the clearing of a short-circuit at 11,000 volts d-c in thirteen-thousandths of a second. The current rose from its normal value of 22.5 amperes to a maximum of 245 amperes during the short-circuit without causing the slightest damage to the equipment on account of the extremely rapid interruption of the circuit by the grids of the rectifier. In obtaining this oscillogram a direct short-circuit of the d-c terminals of the rectifier was made.

Figure 4 illustrates the automatic voltage regulation of an 11,000-volts rectifier by means of grid-control. The voltage can be regulated from its maximum value to zero and back to its maximum value in a fraction of a second, as shown.

In radio telegraph stations certain factors such as voltage regulation between no-load and full-load deserve important consideration among the requirements of a d-c power supply plant. This is particularly true of equipment for high-speed code transmitters operating on short wave channels where the stability of operation and frequency adjustment of tuned circuits are dependent to a certain degree upon the constancy of the d-c voltage maintained on the plate circuits of the transmitting tubes. It is a general practice to use Class "C" amplification in all of the high power stages of a code transmitter, so that during the transmission of each signaling element, maximum power is demanded of the rectifier, and during the period of each spacing interval between signaling elements, no d-c power is required by the transmitting tubes. It is apparent that a very low voltage regulation between no-load and full-load is absolutely essential for the stable and efficient operation of these transmitters. The voltage regulation of a metal-clad mercury-arc rectifier is less than 6 per cent, and can be made practically zero with very little decrease in the efficiency of the plant.

In radio telegraph stations where several transmitters are operated simultaneously to send different code messages, it is possible to supply each transmitter with d-c power from a single large capacity rectifier unit. Since a metal-clad mercury-arc rectifier is capable of being operated at very high efficiency at light loads, as well as at full load, it offers a most economical source of power for this service. Moreover, the ability of this type of rectifier to be operated continuously day in and day out over an indefinite period of time, makes it particularly valuable for this type of station.

To materially reduce the capacity and cost of filtering equipment and improve the efficiency, it would be advantageous in some cases to employ a twelve- or an eighteen-anode rectifier in the d-c power supply equipment. High-voltage twelve-anode rectifiers are used extensively in electro-chemical plants at the present time, and may be readily adopted for use in radio stations.

Stations listed below are equipped with rectifiers of the type described by Mr. Durand. Granting that several have more than one transmitter and that, to compare them with American station power, the data must be divided by 4, it is still evident that other nations do not limit their broadcasters to a mere 50 kw.

Station location	Direct current Total output kw.	Voltage	Number of rectifier tanks
Chelmsford, England	400	12000	1
Warsaw, Poland	1000	15000	2
Beromunster, Switzerland	270	12000	1
Athlone, Ireland	460	13000	2
Turin, Italy	40	12000	1
Zeesen, Germany	1170	12000	2
Heilsberg, Germany	360	12000	1
Berlin, Germany	585	13000	1
Langenberg, Germany	1170	13000	2
Breslau, Germany	1170	13000	2
Leipsig, Germany	1170	13000	2
Munich, Germany	1170	13000	2
Frankfort/M., Germany	200	13000	2
Lakihegy, Hungary	500	22000	1
Monte Ceneri, Switzerland	60	15000	1
Hamburg, Germany	1170	13000	2
Villa Acuna, Mexico	800	18000	1
Bandoeng, Java	900	12000	3
Freiburg, Germany	109	13000	2
Berlin, Germany	90	12300	2

An electronic multiplier for high speed counting

By H. W. LORD and
O. W. LIVINGSTON

*General Electric Company,
Schenectady, N. Y.*

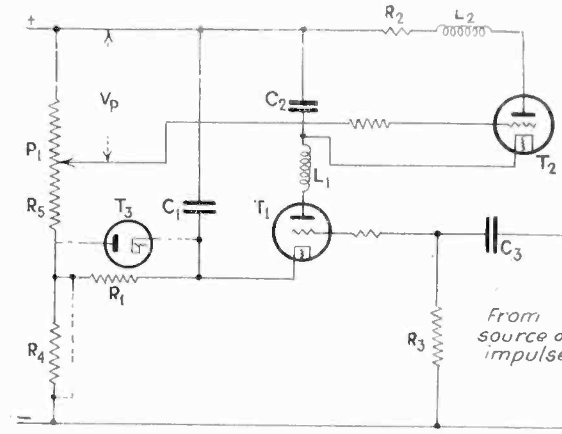


Fig. 1—Circuit for multiplier for high speed counting

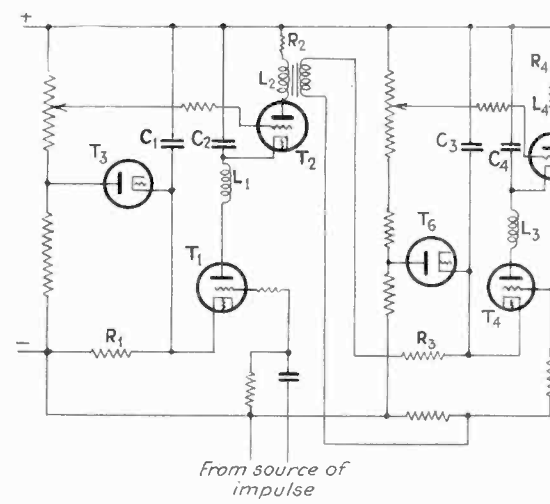


Fig. 2—Two cascaded cricuits for obtaining high ratios

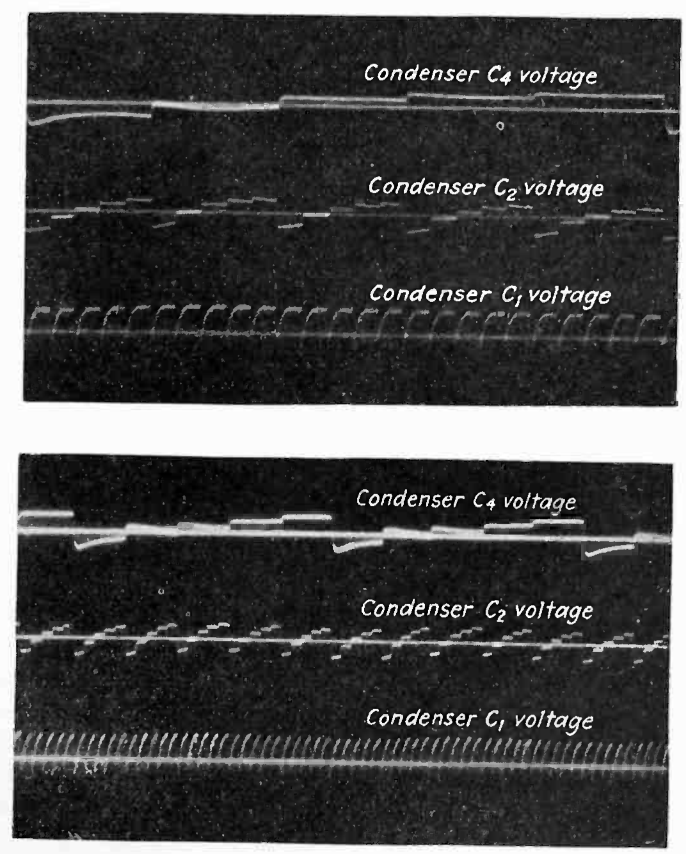


Fig. 3 — Oscillograms showing operation of circuit of Fig. 2. *a* (Above) Impulse speed 3,600 per minute. *b* (Below) Impulse 7,200 per minute.

THE problem of counting or grouping products of automatic machines has been solved by the use of electronic tools such as phototube relays and counters or notching relays. These methods are satisfactory so long as the product does not issue from the automatic machine at a rate exceeding that for which a dependable counter or notching relay may be built. The maximum rate for standard counters and relays is approximately 600 operations per minute.

One solution of the high speed counting problems has been made by an English inventor in a so-called "Scale of Two" counter, the fundamental circuit being that of the parallel-type Thyratron inverter. This circuit gives a counting ratio of two for each pair of tubes used, thus six tubes are required for an eight-to-one ratio. It is the purpose of this article to describe a multiplier circuit relying for its operation on the fundamentals of the single tube inverter circuit described in a previous article by the writers.[1] This multiplier is a new electronic tool by means of which higher ratios of multiplication may be obtained than is possible in a "Scale of Two" counter of an equivalent number of tubes.

The simple circuit

The principle of operation may be had by a study of the simplest form of this multiplier circuit as shown schematically by Fig. 1. The operation may be described as follows:

With no impulses being received capacitor C_1 is charged through resistor R_1 to the voltage drop across potentiometer P_1, tube T_1 is held non-conducting by the negative voltage across resistor R_4 applied through resistor R_3. Capacitor C_2, which is several times the capacity of C_1, will be assumed for the moment to have zero charge. Now let an impulse voltage be impressed across R_3 of sufficient magnitude and duration to "fire" T_1. Capacitor C_1 will then discharge through T_1 and inductor L_1 until the voltage across C_1 is less than the voltage to which C_2 has been charged. This difference of potential between C_1 and C_2 is brought about by the decay of the magnetic flux of L_1, built up by the flow of current through the windings during the early part of the discharge period, inducing an emf. in the windings of L_1 in such a direction as to maintain the current flowing in the circuit for a time even though the voltage of C_1 is less than that of C_2. Capacitor C_1 is charged again through R_1 but, since the potential of C_1 was less than that of C_2 for a time, the anode of T_1 was negative with respect to the cathode and for a sufficient length of time to allow the grid, which is again negative, to regain control. This cycle of operation is repeated until the charge received by C_2 causes the voltage across it to exceed the algebraic sum of the voltage V_p across potentiometer P_1 and the critical grid voltage of T_2, then thyratron T_2 will "fire" and discharge C_2 through R_2 and L_2.

To state the conditions for the "firing" of T_2 algebraically let V_g = critical grid voltage of T_2 (negative if the critical grid voltage is negative), let V_c = voltage of C_2, and let V_p be the voltage determined by the setting of the slider of potentiometer P_1. Then T_2 will "fire" when $V_c \geqq V_p + V_g$. When T_2 conducts C_2 discharges through T_2, L_2, and R_2, the relation between C_2, R_2, and L_2 being such that C_2 is completely discharged before the next impulse is received by the counter circuit. The discharge of C_2 returns the condition of the circuit to that existing at the start.

From the preceding description of the operation it may be seen that tube T_2 will "fire" once for every definite number of times tube T_1 is "fired" by the received impulse, the ratio being controlled by changing the setting of potentiometer P_1. If the operating coil of a counter is substituted for inductor L_2 the counter will operate each time C_2 discharges through T_2.

Constant ratio circuit

In the foregoing description it was assumed that capacitor C_1 charged to the voltage across potentiometer P_1 before the next impulse was received. Since capacitor C_1 is charged exponentially through resistor R_1, theoretically it will never reach the full voltage of potentiometer P_1. The error introduced by this is not serious so long as the time constant of the C_1—R_1 circuit is small compared with the time between impulses. At high speeds the circuit of Fig. 1 changes ratio, the ratio increasing owing to the discharge of capacitor C_1 into capacitor C_2 before capacitor C_1 is fully charged, requiring more operations of T_1 before capacitor C_2 is charged to a sufficiently high potential to "fire" T_2. This change in ratio at high speeds is overcome by the addition of a rectifier shown at T_3 and by the slight change in connections in Fig. 1, given in dotted lines. The rectifier stops the charging of capacitor C_1 when it reaches a potential sufficiently negative with respect to the anode of the rectifier to cause that tube to conduct. By limiting the maximum charge on capacitor C_1 to some value such as 60 per cent of the charging voltage only the steeper portion of the exponential charging curve is used, thus shortening the time required for charging without changing the constants of the C_1—R_1 circuit and making this time a definite and known value. This circuit has a constant multiplying ratio from a very low speed up to such a speed that the time between impulses is equal to the time constant of the C_1—R_1 circuit.

An experimental set-up of this circuit was set to produce a ten-to-one ratio. It would count accurately at speeds as high as 3600 per minute and still held ratio at two per minute. At the higher speeds Thyratron T_2 "fired" six times per second and at the lower speed it "fired" once every five minutes. There was no indication that two per minute was the lower limit. The upper limit is set by the C_1—R_1 circuit but the lower limit is determined only by the leakage resistance of capacitor C_2 and the associated wiring. Although a ratio of ten has been attained experimentally without loss of accuracy, tests indicate that the ratio should be limited to a maximum of five with a 250 volt d-c supply to prevent slight changes in tube characteristics affecting the ratio.

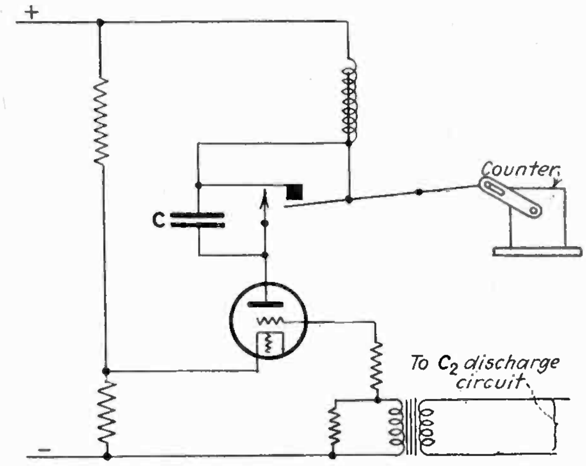


Fig. 4—Operation of mechanical counter by thyratron amplifier

High ratios by circuits in cascade

A method of connecting two circuits in cascade to obtain higher ratios is shown in Fig. 2. Inductor L_2 has a secondary winding which impresses an impulse voltage on the grid of Thyratron T_4, "firing" this tube each time T_2 "fires." The second multiplier circuit, which includes tubes T_4 and T_5 and the rectifier T_6, functions in the same manner as that described for Fig. 1. The overall ratio for this circuit between the impulse applied to the grid of T_1 and the output of T_5 will be the product of the ratios of the two circuits. The oscillograms in Fig. 3a and Fig. 3b show the operation of this circuit. The three traces indicate the voltages of the three capacitors C_1, C_2, and C_4. The capacitor voltage of C_2 and C_3 appears to have considerable leakage, indicated by the slope of the lines. This slope however is caused by poor regulation of the rectifier supplying voltage to the amplifier used to make the oscillographic tests. Fig. 3a was taken at an impulse speed of 3600 per minute. At this speed capacitor C_4 is charged in slightly less than half the period between impulses, as indicated by the flat portion of the voltage trace of capacitor C_1. Fig. 3b was taken at an impulse speed of 7200 per minute. The trace of capacitor C_1 here shows there is very little time left after the capacitor has reached full charge before the next impulse arrives to discharge this capacitor. If it were desired to operate at speeds in excess of 7200 per minute the constants of the C_1, R_1 circuit must be changed to reduce the time constant of this circuit. The glow in the rectifier T_3 provides a good indication of the speed above which the circuit loses accuracy. So long as the glow is uniform and blinking at the impulse speed the circuit speed is not being exceeded. When the speed is too high for the circuit the glow in T_3 goes out entirely for periods of time exceeding that between impulses.

Ratios other than that shown in the oscillograms may be obtained by proper adjustment of the circuits. Without exceeding a 5:1 ratio for each of the two circuits in cascade the following ratios may be obtained between 6:1 and 25:1—6:1, 9:1, 10:1, 12:1, 16:1, 20:1, 25:1.

One of the requisites given in the description of the simple ratio circuit was that the constants of the C_2, R_2, L_2 circuit be such that capacitor C_2 is completely discharged before the succeeding impulse is received to discharge capacitor C_1 into capacitor C_2. Many counters and relays require current application for a period in excess of the time between impulses and too, the inductance of the operating coils may not properly fit the circuit. To permit the operation of standard relays and counters a circuit similar to that of Fig. 4 may be used. The tube is normally biased sufficiently negative by the voltage divider across the d-c supply to hold this tube off. The discharge of capacitor C_2 through the primary of inductor L_2 induces a voltage in the secondary that "fires" the tube. The tube conducts until the counter armature operates to open the contacts in the anode circuit, stopping the current flowing in this circuit and permitting the grid to regain control. The use of this circuit allows the full time between discharges of capacitor C_2 for the counter to operate and return to the normal position, and in addition enables the counter to take more energy than could be stored by capacitor C_2 in an economically designed circuit.

Sources of impulses

In the foregoing discussion of the several ratio circuits the source of control is an impulse of certain characteristics impressed on the grid of tube T_1. The impulse is such that the grid of tube T_1 is held positive for longer than the ionization time of the tube but falls to a value somewhat less than the fixed bias applied to the grid of T_1 before capacitor C_1 has recharged to the maximum value in order that T_1 "fires" but once on a single impulse. The impressed impulse must of itself be of sufficient duration to "fire" the tube. The circuits show the impulse applied to the grid through a capacitor (C_3 in Fig. 1) and shunted by a resistor (R_3 in Fig. 1). The time constant of this capacitor-resistor circuit is made such that the impulse on the grid is of sufficiently short duration regardless of the duration of any impulse of reasonable amplitude.

The phototube and associated amplifier forms a convenient source of impulse when objects moving at high speeds are to be counted or grouped. No trouble is encountered with a straight amplifier with d-c excitation so long as the light beam is concentrated and the objects move at a high enough speed to cut the beam rapidly in order that a steep wave front be produced that will pass the input capacitor-resistor network to the grid of tube T_1. This low-speed limitation is removed by resorting to a special amplifier that may be termed a regenerative d-c amplifier. Such an amplifier is shown in Fig. 5.

The circuit includes two high vacuum tubes T_7 and T_8 and a phototube T_9. The load resistance of T_7 is the resistors R_1 and R_2. The voltage drop across resistor R_1 supplies the anode voltage for T_8. The bias on T_8 is the algebraic sum of the voltage drops across resistors R_2 and R_4. With light falling on the phototube the following conditions are obtained. The phototube impedance is low, resulting in a low negative bias or possibly a positive bias on T_8 and a correspondingly low internal impedance of T_8. The low impedance of T_8 places a high negative bias on Pliotron T_7 from the self-biasing action of resistor R_1, little current flows in the anode circuit of T_7

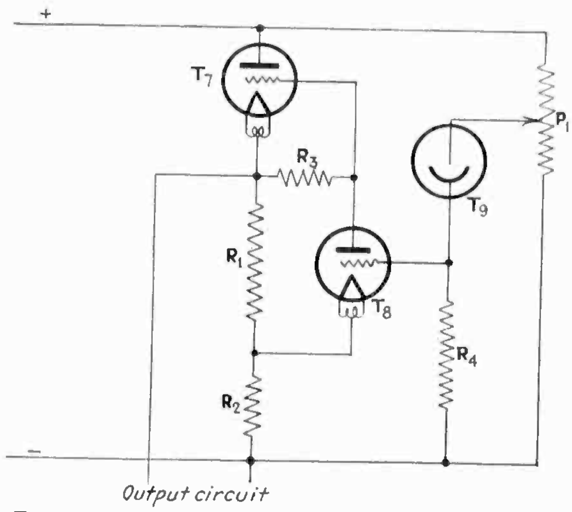


Fig. 5—Method of using phototube in high speed counting

and the output circuit voltage is small. Now if the light flux falling on phototube T_9 be slowly decreased the bias on T_8 will be made more negative, increasing the internal impedance of T_8 which in turn decreases the bias of T_7 and permits more current to flow through resistors R_1 and R_2. The increased current through resistor R_2 increases the negative bias on T_8, in addition to the increased bias from the phototube circuit, resulting in a regenerative action.

By proper adjustment of the circuit constants sufficient regenerative action may be obtained that as the light is slowly decreased on the phototube the anode current of T_7 increases slowly up to some critical value then suddenly increases at a rapid rate to several times the former low critical value. If then the light be slowly increased the anode current of T_7 decreases slightly at a slow rate and then quickly falls to a low value, the regenerative action being effective in both directions. The rapid increase and decrease of current through R_1 and R_2 produce a similarly rapid increase and decrease of voltage in the output circuit that may be utilized as an impulse source for operating the ratio circuit, the impulse being essentially independent of the rate of decrease of the light flux on the phototube.

While the phototube will probably be the principle source of control for high speed operations other sources of impulse may be used in certain instances where the phototube is not adaptable. One means of control might be a small impulse voltage induced in a stationary coil by a small piece of iron increasing the magnetic flux threading the coil windings during some part of the repeating operation. The impulse voltage obtained in this way could control the ratio circuit directly or amplified by the usual amplifier. This method of control is at a disadvantage at very low speeds since the duration of the impulse is inversely proportional to speed and the amplitude directly proportional to speed.

The ratio circuit is a newly developed tool and as yet has not been put to commercial use. It should be useful in the future for counting the products of high speed automatic machines. Many products, for example, gum, cigarettes and pills, are sold in containers marked as containing a definite number. A grouping form of this circuit would be adaptable to the packing of such products as an aid in speeding up this operation. The trend of automatic machines is toward higher speeds and the higher the speed attained the more this ratio circuit will become valuable as an industrial tool.

[1] *Electronics*, April, 1933.

Problems of cathode ray television

By I. G. MALOFF
RCA Victor Company, Inc., Camden, New Jersey

FROM an engineering standpoint television is approaching a reality, brought into existence by technicians previously engaged in communication work in general, and in radio communication in particular. Television is communication, or the transmission of intelligence from one point to another. Webster's definition of intelligence is "information communicated," and one of the well-known mediums of communicating information is speech. The fastest speech is about 200 words a minute. It covers a frequency range up to 5,000 cyles at least, and for its transmission requires an air channel 10 kilocycles wide. For television transmission at about 24 frames or pictures a second, or 1440 per minute, the channel required is around two megacycles, or 200 times wider. This television channel then would accommodate 40,000 words a minute. In other words we transmit one picture or frame for the cost of 28 words of air space.

For a long time, many decades in fact, television has existed in principle at least and in facsimile transmission.

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"TEN THOUSAND WORDS—"

"ONE picture is worth ten thousand words" says the old Chinese proverb. "Well, we improved on that," says Mr. Maloff, "we provide a picture for the equivalent of 28 words."

Such is television; near reality from an engineering standpoint, bringing with it many new problems, a new jargon, new technical and social possibilities and responsibilities. Several of the new engineering problems are discussed here.

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But not until certain inherent limitations of disc scanning and reproducing were overcome did television become a reality. The old disc employed what could be called instantaneous scanning; the signal output was proportional to the time integral of light intensity over a very short period of time, during which the light from the picture element passed through the hole in the disc, and on to the photocell. Dr. Zworykin's iconoscope integrates the light intensity of a picture element over the time of an entire picture frame. A detailed description of this cathode ray principle of scanning has been presented to the *Franklin Institute* and will soon appear in their Journal. The inverse of the iconoscope—the kinescope—has also been described and treated at length.

In broadcasting technique we deal purely with harmonic waves. They have always been of certain duration—a few cycles at least in most limiting cases. Phase shift of respective harmonics did little if any harm. Transients were talked about but caused little trouble. R.m.s. values, percent harmonic distortion, straight line frequency response, were the terms frequently heard.

The new cathode ray television technique has brought in a number of terms, meaning and sounding quite different. Detail, contrast, vertical and horizontal resolution, phase shift, return ratio, line width, spot size, focusing ratio, deflection sensitivity, beam efficiency, screen efficiency, etc.—are only a few of the new terms.

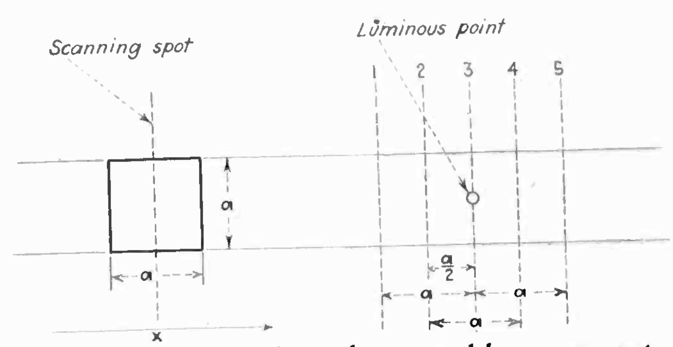


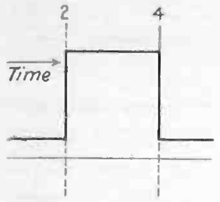
Fig. 1—Luminous point to be scanned by square spot

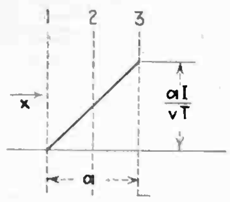
As far as the television transmission per se or the workings of the part of the system from the input of the modulator to the output of the detector are concerned, the principles of it, the technique and the analysis of it, are all of the usual radio transmission type, with ranges extended. It is true, we have to watch for the phase shift a bit more carefully and pay attention to a-c transients, but, in general, our old reliable conceptions of a carrier, side bands, sine waves and series expansions, in other words the a-c high frequency theory and practice, apply and hold very well.

In the pickup and reproducing parts of the system, the principles, the technique, and the methods of analysis are very different from those in radio.

One important reason for the difference is physiological. Here we deal with the sense of sight and all its phenomena, such as persistence of vision, optical illusions, etc., instead of the sense of hearing. The other important difference is the fact that all practical television systems utilize a scanning method of pickup and reproduction. Scanning is accompanied by a number of features which are inherent to the method.

As an example, an interesting problem will be outlined which comes up every time one attempts to estimate a frequency band sufficient to pick up and reproduce a picture which is being scanned in the transmitter and in the receiver by spots of a given size. Now, for an optimum condition regarding brightness of the picture and sensitivity of the pickup the exploring spot should be





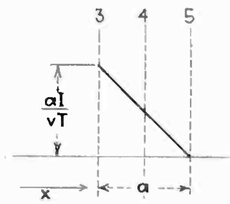


Fig. 2—Transmitter current as result of scanning luminous spot

Fig. 3—Apparent received illumination at receiver at beginning of spot

Fig. 4—Apparent illumination at ending of spot scanning

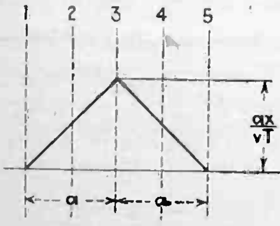
equal to that in the reproducing tube, assuming both pictures are of the same size. Furthermore, an approximation of a required band width for a transmission by wire of a given picture can be arrived as follows. Taking n as the number of lines in the picture, multiply it by itself and by k, the aspect ratio (ratio of the width of the picture to its height). We get n^2k, the theoretical number of picture elements which our system is capable of picking up. Assume a checker board picture with squares of same size as a picture element. For an infinitely thin exploring beam such a picture will give rise in the pickup tube to a periodic current of rectangular wave shape. A fair approximation to this shape is a sine wave having a duration of a complete cycle equal to the time the spot passes over two complete picture elements. To reproduce one complete picture or a frame will require $n^2k/2$ cycles. If we desire to send m frames per second our highest frequency will be $mn^2k/2$ and a 300 line 24 frame picture with a 4:3 aspect ratio will require

$$\frac{(300^2)\ (1.33)\ (24)}{2} = 1{,}440{,}000 \text{ cycles per second.}$$

Now suppose that at the transmitter we scan a luminous spot of negligible dimensions (we will call it a point) by a square spot of the same dimensions as that at the receiver and moving with the same velocity, of course. Also suppose that the rest of the picture is dark and that the luminous point is of such an intensity as to make the current in the pickup device jump to a certain value constant for all the time the transmitter's rectangular spot is covering the point.

Figure 1 shows such a luminous point. When the center of the scanning spot reaches position 2 the current in the pickup device jumps to a certain value and stays at that value until the center of the scanning spot reaches position 4. The current at the transmitter is shown on Fig. 2.

If, for a while, we assume an ideal frequency response of the system, the current at the receiver will also look like the one on Fig. 2. This means that at the receiver the beam is extinguished until the center of it reaches position 2. At this point it suddenly becomes bright, reaching the final and constant value instantaneously. It will stay bright until its center reaches position 4, where it becomes extinguished again. So at the receiver there will be some light thrown on all points along the scanning line beginning from point 1 and up to the point 5, which distance is exactly equal to a double width of the scanning spot. In other words, some light will be thrown on all points along the scanning line from one spot width before the true position of the original point until one spot width after that position. The rest of the picture will be as dark as before. We may now compute the apparent brightness of the various parts of the reproduced picture.



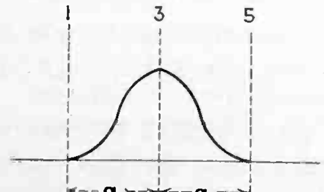


Fig. 5—Distribution of apparent brightness at receiver

Fig. 6—Actual distribution of illumination due to imperfect receiver

Let I be the brightness of the spot in the reproducing tube while the center of the spot travels from the position 2 to position 4. For all other values of x the brightness will be zero. Also let T be the period of one frame, V the velocity of the scanning spot and a the width of it. Since we are only interested in the apparent illumination of points along the x-axis between positions 1 and 5, let us count x from position 1.

An interval of time for which a point, or rather a vertical line through any point x, between $x = 0$ and $x = a$ is illuminated is x/v, which is equal to the time the left edge of the scanning spot travels from position 1 to position x. The apparent or average intensity of illumination of this line is

$$I \text{ (apparent)} = \frac{x\,.\,I}{v\,.\,T}$$

At the point 1, x is equal to 0, so that the apparent illumination at the point 1 is 0; similarly, at the point 3, x is equal to a, so that the apparent illumination at the point 3 is $\frac{aI}{vT}$ and between these points it varies along a straight line as shown on Fig. 3.

Now let us see what happens after the left edge of the scanning spot leaves the position 3. Let us start measuring x anew from the position 3. Here the time of illumination of a vertical line through any point x is $\frac{a - x}{v}$; therefore the apparent illumination may be expressed as below:

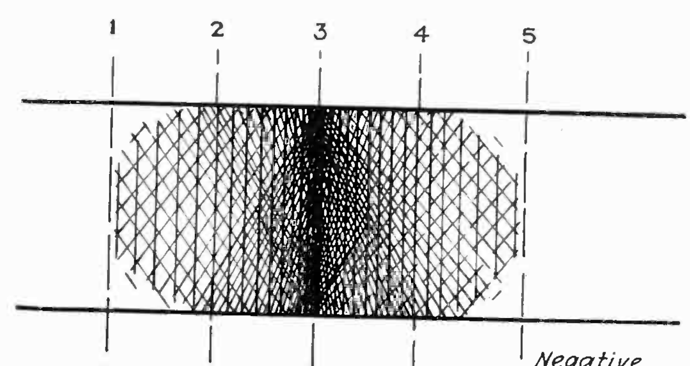


Fig. 7—Unequal vertical and horizontal resolution in reproduced image

$$I \text{ (apparent)} = \frac{(a - x)\ I}{v\ T}$$

At the point 3, x is equal to 0, so that the apparent illumination at this point is aI/vT; similarly at the point 5, x is equal to a and the apparent illumination at the point 5 is 0. Between point 3 and 5 it varies along a straight line as shown on Fig. 4. In this way we arrive at the distribution of apparent brightness of intensity of illumination along the scanning line as shown on Fig. 5. The appearance of the reproduced image of an illuminated point is shown on Fig. 7. If the system has a limited instead of an ideal response, and limited to the frequency calculated by the approximative formula already described, the received intensity of illumination will be distributed as shown on Fig. 6, and the appearance of the reproduced image will be close to that shown on Fig. 7.

The intensity has most of the general characteristics of that of Fig. 7. Let us see now what has happened to the image of our original point. Along the horizontal we have a maximum at the position 3, the exact location of the original point. Along the vertical our point could be anywhere along the vertical through position 3 inside of the scanning line. It is true that the image along the horizontal is somewhat blurred, but the general character and the location are the same as those of the original, while along a vertical an illuminated strip would give us the same image as the illuminated point.

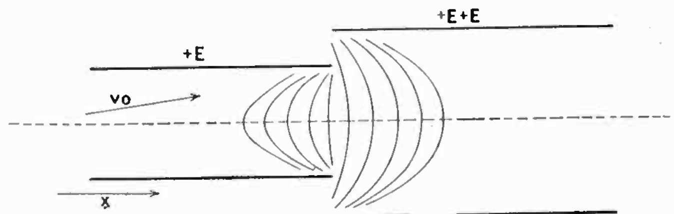


Fig. 8—Focussing of electron beam by effective lens system

Horizontal versus vertical resolution

After trying several other objects or patterns in place of the point, we will find that for nearly all of them the vertical resolution is poorer than horizontal. We may also mention that the diagonal resolution will appear poorest of all.

When viewing a television picture, any picture for that matter, the observer tends to adjust his viewing distance in such a way that the structure of the picture disappears and with it disappear the imperfections in detail reproduction. When there is unequal directional detail the observer will tend to adjust himself for the poorest and will lose some of the best. Therefore, the excess of detail along one direction over the other as a rule cannot be utilized and therefore is lost.

We may say, therefore, that for a given frequency band from zero to f, the number of scanning lines is considerably higher than that calculated from the approximative relation previously given, namely:

$$n = \sqrt{\frac{2f}{mk}}$$

It can be shown either theoretically by computing various patterns, or experimentally by trying various pictures, that the received picture improves in overall resolution for a given frequency band with number of lines increasing until this number becomes of an order between:

$$n = 1.25\sqrt{\frac{2f}{mk}} \quad \text{and} \quad n = 1.4\sqrt{\frac{2f}{mk}}$$

This means that a band required to reproduce a picture of m frames and n lines is only from

$$f = 0.5\frac{mn^2k}{2}\ cps. \quad \text{to} \quad f = 0.65\frac{mn^2k}{2}\ cps.$$

In other words, it is between 50 per cent and 65 per cent of the theoretical.

There is another group of problems that the cathode ray television technique brought to the fore. These problems have to do with generation and focusing of electron beams. Scientists brought out a new subject, or a new method of dealing with such problems, and called it *electron optics*.

Electron optics applies in its true sense only to cathode ray devices with high vacuum where the effects of magnetic and electric fields produced by various fixed electrodes and poles are not obscured by the action of ions which result from collisions of electrons with molecules of residual gas.

With the configuration of the field known, the formation, the concentration and paths of electrons in high vacuum can be predicted with a very high degree of accuracy, that is, if we have an analytical expression for the field. But, anyone of you who tackled a problem of a potential distribution due to, say, a pair of coaxial cylinders, knows that there is no simple, explicit, integrable expression that will define such a field. The practice, however, of focussing an electron beam by means of an electrostatic field produced by a pair of coaxial cylinders coaxial with the beam, such as shown on Fig. 8, is quite common.

Let us first review quickly the theory of motion of an electron through an electrostatic field. Suppose an electron moving with a known velocity v_0 enters a space, of which the electrostatic potential V is known at every point. The gradient of this electrostatic potential then at any point of this space is ∇V where ∇ is a vectorial differential operator of the form:

$$\nabla = i\frac{\delta}{\delta x} + j\frac{\delta}{\delta y} + k\frac{\delta}{\delta z}$$

The force on an electron in this field is: $e\nabla V$ where e is the charge on the electron. This force is related to the mass m of the electron and to the resultant acceleration a as follows:

$$e\nabla V = ma \quad \text{and} \quad a = \nabla V e/m$$

The electron while going through a portion of the path Δs will undergo a change of velocity Δv and its velocity will become:

$$v_1 = v_0 + \Delta v$$

where Δv is found as follows:

$$\Delta v = \int a\,dt$$

The actual path of the electron Δs is given by the expression:

$$\Delta s = v_0 t_1 + \int dt \int a\,dt$$

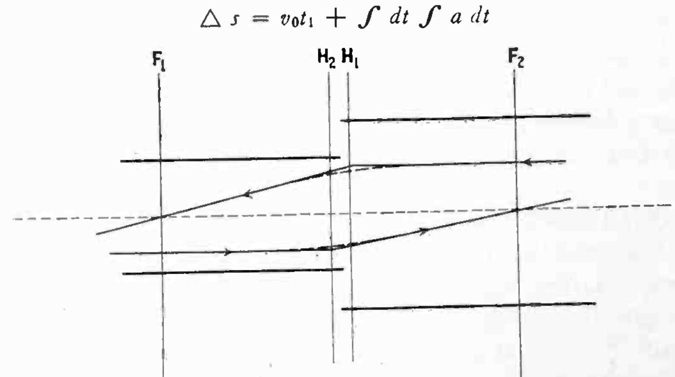


Fig. 9—Thick electronic lens system with typical cardinal points

The actual velocities and the path of electron through a known non-uniform electric field can be computed by successive approximations. By taking Δs of a magnitude small enough to consider the gradient ∇V as of a constant value through this element of path, the above equations can be very much simplified, becoming:

$$\Delta v = \nabla V e/m\, t$$

and

$$\Delta s = v_0 t + \tfrac{1}{2}\nabla V e/m\, t^2$$

[*Please turn to page 19*]

Further notes on

iron-core coils

for use at r.f. or i.f.

A communication by
W. J. POLYDOROFF

Johnson Laboratories, Inc.
Chicago, Ill.

THE application of iron in high frequency coils such as those described in Mr. Crossley's article is of particular interest when the inductance must be confined to a relatively small space as is often the case in radio receivers. A fews years ago I described the first attempt to use fixed iron cores in radio frequency coils. Quite remarkable results from the standpoint of Q or L/R may be obtained when proper balance between copper and iron losses is maintained.

It has been often pointed out to me that air coils can be made just as efficient and better. Quite true, but not in the spaces sometimes allowable. As the coil resistance is roughly proportional to W or $W^{1/L}$ and the core losses are approximately proportional to W^2, with a proper balanced copper and iron, the total r-f resistance of the combination may also be approximately proportional to W^2. This is very important, if the coil is to be used over a relatively wide band of frequencies such as the American broadcast frequency band.

Assuming that the losses in the condenser are negligible, and that the parallel resistance imposed by other circuit attributes is constant (which is not quite true), the selectance, or L/R, of a circuit is proportional to the square of the frequency. Such a combination, therefore, if used for a wide range of frequencies is unsuitable from the standpoint of selectivity variations. There are, however, special cases where the selectivity variation is not detrimental, such, for instance, as a midget superheterodyne with 450 kc. intermediate. The first image response from the broadcast band comes at about 600 kc. where, therefore, selectivity of the pre-selector should be at its best, which is exactly the case with fixed iron rf-coils. This, of course, does not entirely take care of frequencies above the broadcast spectrum, which may pour in as images at a frequency at which the selectivity of such a coil is relatively poor.

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THE article of Mr. Crossley entitled "Iron-core intermediate frequency transformers" discussed here by Mr. Polydoroff was published in *Electronics* in November, 1933. Mr. Polydoroff's own work with iron core coils is well known to the radio industry.

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The art of designing high frequency coils has advanced very rapidly in recent years, especially in England where a variety of types have appeared. These are intended primarily for the amateurs, who are still considered by the public as the leading spirits. Because of successful propaganda, and the really wonderful results obtainable in small space with iron cored coils, the manufacturers are giving this type of coil serious consideration.

I have recently measured iron core coils occupying not more than $\frac{3}{4}$ cubic inch of space (without the shield) whose L/R at 1000 kc, and with $L = 150$ μh. is of the order of 30×10^{-6}. This would really be remarkable even for air or iron cored coils of four times the volume. As the frequency for which coils are designed goes down, the L/R of the coils improves, so that at 456 kc. in a well-balanced coil L/R may be as high as 60×10^{-6} or even better. At the other extreme, I have measured coils intended for operation at 14 meters, employing extremely fine iron powder of the order of 1 micron particle size, but with so little of it that the effective permeability (inductance increase due to the iron) was only 1.4. One can readily see that a material having $\mu = 1$ and no losses, such as air, will be just as suitable.

In reading Mr. Crossley's paper I notice that he introduces a new measure of the quality of a coil which he calls "factor of merit" and which I understand is the product of amplification and selectivity, measured with a particular tube. Although this is quite satisfactory for comparative measurement purposes, I would myself prefer to express the quality of a transformer in the more usual way, in Q, or L/R, at a particular frequency. Knowing this figure, one can easily calculate the dynamic resistance and the gain obtainable with any type of tube.

As to the coupling of two identical circuits at or below the critical value there are certain rules which every engineer should keep in mind. Thus, for instance, at critical coupling (where flat tops occur) the amplification is usually reduced to about half of the amplification obtainable in a single circuit. I have found experimentally that at a coupling which reduces the amplification to about 30 per cent, optimum selectivity occurs. One must bear in mind however, in estimating the selectivities by the usual methods in band width that this does not represent the actual *merit* of an i-f transformer, but rather the degree of the distortion of side bands. With symmetrical circuits, the slope of selectivity curve remains constant, so that the rejectance of undesired signals remains the same as the frequency is varied.

Knowing L/R or Q one can easily calculate the selectance in kc.-band width with surprising accuracy with or without a tube (see my paper Proc. I.R.E. Volume 21, Number 5) and once the slope of selectivity curve is found, one can easily compute the slope of the curve for two loosely coupled circuits. This slope remains substantially the same whether the coils are critically coupled or under-coupled. As a further improvement of iron core transformers, it is my desire to see the inductance of the coil considerably increased, with the same or better Q, and then to couple the circuits so as to obtain a more or less square shouldered curve. This will produce far better tone quality which, even in the cheapest receiver, should not be overlooked.

Photocells enter textile field

PHOTOELECTRIC CONTROL DEVICES, reaching into hundreds of industries, have now been successfully applied to the textile field and their use promises to increase. The Rose Patch & Label Company, Grand Rapids, Mich. has adapted the photoelectric principle to the cutting of cloth labels of ribbon widths, but experts say the same principle may be used to cut loom-width strips of cloth.

In the Grand Rapids factory strips of starched cloth are printed with the label design which later becomes the name-mark for a suit of clothes, towel, or blanket. Separating each label the printing presses stamp a dark line of ink crosswise on the strip of ribbon.

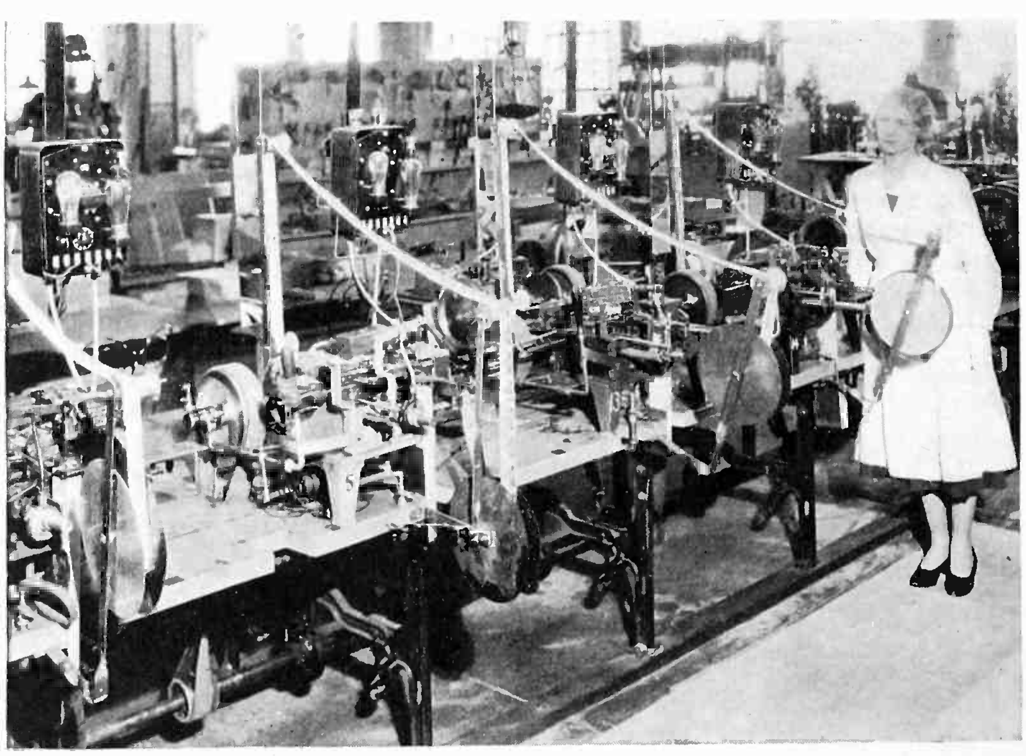
This cross-strip, when it passes through a lamp housing and before a photoelectric cell, sets up a disturbance which is amplified by a thyratron tube to operate a knife which cuts the ribbon into proper label lengths. Having been cut, the labels are folded and ironed and packed in containers by the same device. Continuous movement of the ribbon is insured by a finger-like contrivance which recently has also been applied to feeding engraving presses.

Each label is cut exactly on the dark cross-strip by the knives. The sensitivity of the electric eye is such that it will permit the printed matter of the label itself to pass by without setting up a disturbance, but the cross-strip of ink —about an eighth of an inch thick—instantly affects the cell.

The cutting knife does not function on the forward movement of the ribbon, but operates when the cloth momentarily comes to rest. This is made possible by a device which acts as a back-stroke to the forward movement, thus slowing the movement down and making the photo-cell more effective.

Should a botched or badly printed label be presented to the electric eye it immediately rejects the entire label. One girl can watch four machines equipped with the photo-electric controls, where formerly a girl for each machine was required.

The cutting principle used by the machines can be applied to cloth of widths up to several yards, Arthur Rosenthal, president, believes. Blankets, sheets, carpets and bolt-length cottons or wools can be cut into proper lengths by electric eyes and re-wound ready for commercial use, he thinks. A printing device could be attached to looms and geared to the weaving process in such a way that an impression would be accurately made at intervals of so many feet or yards, and this ink impression could operate photo-electric cells for cutting. Such a method of production would insure continuous operation of looms. No racking or stacking of such things as woolen blankets for cutting would be necessary. Mr. Rosenthal said the process could be similar to that used in packaging food products with waxed paper which is cut by electric controls.



At the Rose Patch and Label Company, Grand Rapids, photocells cut cloth labels of ribbon width automatically and accurately

Noise survey puts street-car baritone above Niagara Falls soprano

THAT NIAGARA FALLS ROARS loudest in the extremely high soprano between two and three octaves above Middle C of the piano, while the street noise of Buffalo, New York, resembles that of New York City in rumbling most loudly in the alto or baritone less than one octave above Middle C, is one result of a noise survey of Buffalo just completed by the E. E. Free Laboratories of New York City for the *Buffalo Evening News*.

In Buffalo as in New York City nearly all city noise turns out to be due to street traffic; including street cars, buses, trucks and other automobiles. New York, however, has the extremely noisy elevated railway no equivalent of which exists in Buffalo. This is believed to explain the fact that Buffalo is about 7 decibels quieter. Buffalo street cars proved, however, to average 86 decibels while New York street cars average only about 80 decibels. Dr. Free suggests that this difference may be due to the use in New York City of underground electric rails reached by plow-like projections underneath the cars, instead of overhead trolley wires. This method necessitates firmer and evener track than is needed with the overhead trolley.

Buffalo automobile traffic, on the other hand, is slightly quieter than in New York; the average Buffalo automobile creating 73 decibels of noise whereas the average Manhattan article makes approximately 77 decibels. Buffalo auto trucks, however, are slightly noiser than New York's, the average figures being 86 decibels for Buffalo and 82 decibels for Manhattan. Buffalo's noisiest street corner measures 78 decibels, against New York's noisiest of 81 decibels, a difference again ascribed to the New York Elevated. Buffalo's quietest street averages 45 decibels in the daytime and drops as low as 27 decibels at night, these being the quietest normal streets yet measured in any city. A cat's purr is almost as loud as the Buffalo night-time minimum, having been measured as 25 decibels.

The loudest noise encountered in Buffalo was that of a railway train, measured as 102 decibels. Three separate street cars produced 97 decibels and one empty and badly-serviced automobile truck gave 95 decibels. One newsboy whistled 91 decibels but could shout only 84 decibels. The loudest automobile horn encountered was 93 decibels. The noisiest automobile bus was 91 decibels.

These Buffalo records exceed the roar

DEVICES IN INDUSTRY + +

of Niagara Falls. The Falls' noise was measured as 90 decibels, believed to be nearly correct in spite of earlier measurements 5 decibels higher.

The survey included what are believed to be the first pitch analyses ever made of the noise of Niagara, showing the musical tones which predominate in the roar to be much higher in pitch than was expected. The maximum sound intensities were found between pitches of 1,000 and 2,000 vibrations per second, even higher than the notes reached by most sopranos. Similar pitch analyses of Buffalo street noise showed its predominant tones to be two full octaves lower, chiefly in the first octave above Middle C instead of the third.

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Definite frequency attacks "furunculosis"

Experiments are being made with induced high-frequency waves in the treatment of disease at the West Penn Hospital in Pittsburgh, Pa. Instead of passing the current through the body with contact pads, induction is used, after the manner of "radio fevers." One ailment, "furunculosis," has been found to be affected by only a single certain wavelength, leading to the hypothesis that by employing special frequencies it may be possible to control various diseases.

✦

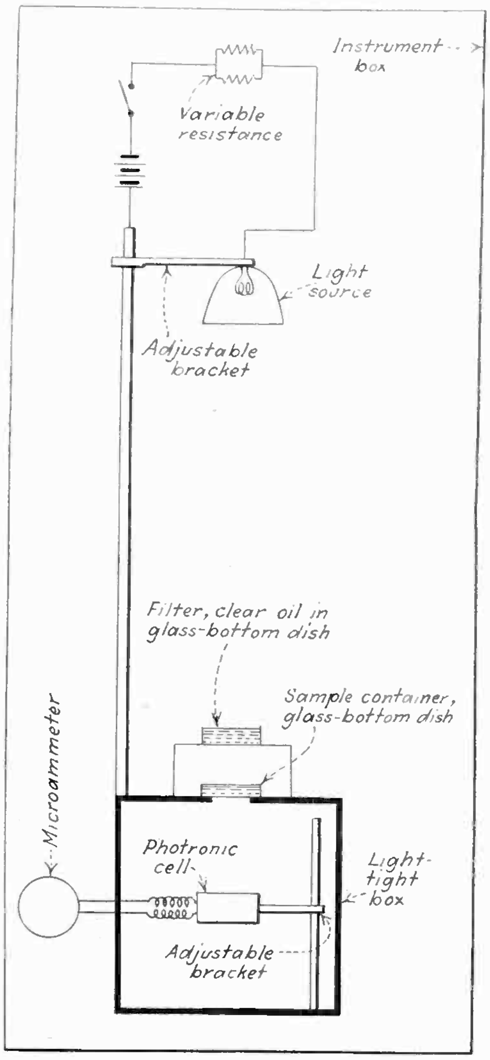
Automatic elevators need photocell protection

Automatic push-button elevators, such as are used in apartment houses, without operators, are proving a new field for photo-cell protection. Several distressing accidents have happened, caused by children attempting to operate such elevators, and on leaving the cars, letting the spring doors roll shut behind them, imprisoning them in the narrow space between the car door and the shaft door. Then if someone on another floor wants the car, and pushes the local button, to bring the car in the usual way, the child is almost sure to be crushed, and is powerless to help himself.

A solution has now been found in the method of mounting a photo-cell and light-beam spanning the doorway, so that if any object or body is in the space between car door and shaft, the car door is automatically opened and the car is prevented from being moved by a call from another floor.

Measuring fineness of cement

The fineness of ground cement is determined accurately by means of a new photo-electric type of apparatus, called the "suspension turbidimeter," which was developed at the University of California, Berkeley. Rather than by the percentage passing a given sieve, fineness is expressed in terms of the *specific*



The photocell measures the light coming through the oil in which the cement is suspended

surface, or surface area of particles in square centimeters per gram. The finer the cement, the greater the specific surface. It has been determined that the reduction in intensity of a light beam as it passes through a suspension of particles is dependent upon the surface area of the particles; hence, the method employed is to measure, for a given concentration of the cement in a suitable suspending medium, the intensity of transmitted light from a fixed source, as compared with the intensity of light transmitted through the clear medium alone.

The apparatus consists of a light source producing a beam of parallel rays, a heat filter, a sample container, and a light-tight box containing a photronic cell that is connected to the terminals of a microammeter. Clear castor oil is used as the suspending medium. The use of the apparatus is independent of room temperature or of temperature and viscosity of suspending medium.

Results can be closely reproduced by men of average technical caliber. Determinations of fineness are made quickly and at low cost. The method has been used in the control of grinding the final compositions of cement in the Boulder Dam cement investigations, and is in use by several producers of portland cement.

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Deep-sea fishing levels studied by photocells

Photo-electric cells are showing scientists of the Oceanographic Institution at Woods Hole, Mass., how daylight moves the great fish-feeding grounds vertically up and down in the sea, according to Howard W. Blakeslee, science editor of the *Associated Press.*

This investigation may lead ultimately to better charting of the movements of the huge commercial schools of fish. The study is conducted by George L. Clarke, Ph.D., of Harvard.

The feeding grounds observed are swarms of zooplankton, which are minute marine animals. They swim at varying depths, but generally maintain formations resembling vast blankets, which rise and fall under the water.

From the deck of the Oceanographic Institution ship, *Atlantis,* all the way from the Gulf of Maine to the Sargossa Sea, Dr. Clark has lowered dip nets which spotted the depths of the copepods, and electric "eyes" which measured the intensity of under-water light.

The nets and the electric cells show two important facts. First, the copepods change their depths with the changes in light. At night they rise close to the surface, being nearest about dawn. With increasing light, they descend deeper and deeper.

Second, the depth of light penetration is greatly different in different areas of the ocean. In the Gulf of Maine the light drops to 75 per cent at one meter and to 1 per cent at thirty-two meters. But near the Azores the 1 per cent intensity is not reached until ninety to ninety-five meters. In the Sargasso Sea, which has the clearest water of all, the 1 per cent limit is at 146 meters.

Linear modulation by a 55-tube

By S. BAGNO and S. S. EGERT

Wireless Egert Engineering Inc.
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IN THE design of a low-priced signal generator whose modulation was to be linear and variable, several methods of the modulation were found to be so expensive that the cost of instrument became prohibitive. With this in mind an investigation was made of the possibilities of full wave rectification by a 55-type tube with various biases on the diode plates. Making use of the double frequency component in such modulation not only is linear modulation possible over almost the whole range, but this double frequency component can be attenuated without excessive leakage, due to the fact that magnetic fields set up by the various tank circuits are all at one-half the output frequency.

Figure 1 shows the general layout of the generator. Tube 56 generates an r-f signal which is then fed through coupling coils to the rectifier plates of the 55 and there converted to a pulsating d-c signal. Due to the constant relationship between the d-c component of the fundamental and the second harmonic it is possible to measure the latter by recording the strength of the d.c. rectified signal. The triode portion of the 55 generates an audio modulating signal attenuated by a resistor.

Our study here deals wholly with the action of the 55 in Fig. 1. For theoretical analysis a separate full-wave rectifier and a three-element tube will be assumed instead of the 55. Fig. 2 shows the essentials of the modulating circuit. Modulation is accomplished by fluctuating the bias of the full-wave rectifier tube.

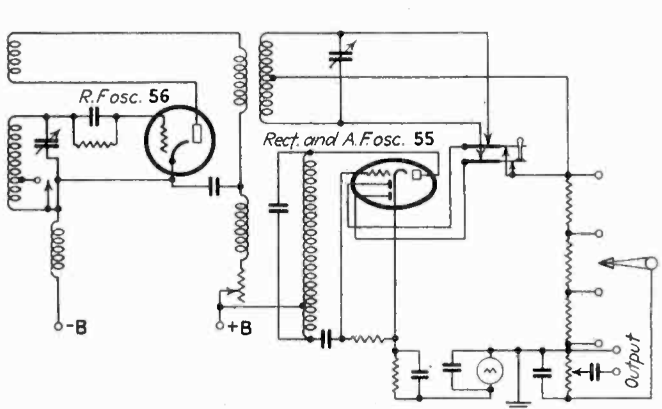

Fig. 1—General circuit used in the double wave modulation signal generator

Fourier's equation for the harmonic content in any periodic function is given as

$$h_n = \left[\left(\frac{1}{\pi}\int f(t)\sin nwt\,dt\right)^2 + \left(\frac{1}{\pi}\int f(t)\cos nwt\,dt\right)^2\right]^{\frac{1}{2}} \qquad (1)$$

where h_n is the amplitude of the nth harmonic, $f(t)$ is a periodic function, nwt is the frequency of the nth harmonic.

In full-wave linear rectification with various biases on the diode plates over certain portions of the cycle the rectified current is zero. The results of the integration over a full wave of the fundamental during these portions must likewise be zero. Since the rectification function is discontinuous, by integrating between the limits of the function, at which it is not zero, we can obtain the second harmonic component. Assume the following:

e = second harmonic amplitude.
k = constant depending on the amplitude of the periodic function.
θ = instantaneous angular displacement of voltage.
h = amplitude of voltage bias in percentage of the total cutoff voltage.

Then

$$e = \left[\left(\frac{K}{\pi}\int_{\pi - A}^{A}(\sin\theta - \sin A)\cos 2\theta\,d\theta\right)^2 + \left(\frac{K}{\pi}\int_{\pi - A}^{A}(\sin\theta - \sin A)\sin 2\theta\,d\theta\right)^2\right]^{\frac{1}{2}} \qquad (2)$$

Since the second term integrates to zero, the first term gives us our result. This integrates as follows:

$$e = \frac{K}{\pi}\int_{\pi - A}^{A}(\sin\theta - \sin A)\cos 2\theta\,d\theta$$

$$e = \frac{K}{3\pi}\cos 3A - \frac{K}{\pi}\cos A + \frac{K}{2\pi}\cos A - \frac{K}{2\pi}\cos 3A \qquad (3)$$

$$= -\frac{K}{2\pi}\left(\cos A + \frac{1}{3}\cos 3A\right)$$

The above derivation assumes half-wave rectification. To get the condition for full-wave rectification we add to this function what happens to the second harmonic between π and 2π and by a similar derivation we get

$$e_2 = -\frac{K}{2\pi}\left(\cos A + \frac{1}{3}\cos 3A\right) \qquad (4)$$

Therefore, the total second harmonic component becomes

$$e_t = -\frac{K}{\pi}\left[\cos A + \frac{1}{3}\cos 3A\right]$$

or, since $\cos^3 A = \frac{1}{4}\cos 3A + \frac{3}{4}\cos A$

$$e_t = -\frac{4K}{3\pi}\cos^3 A = -\frac{4K}{3\pi}(1 - h^2)^{\frac{3}{2}} \qquad (5)$$

Plotting equation 5 we get the curve shown in Fig. 3. Note that the curve between about 35 per cent of the cut-off bias and about 96 per cent is linear. By operating the bias in the center of this region and modulating by varying the bias we can obtain linear modulation.

As this method of modulation was designed primarily

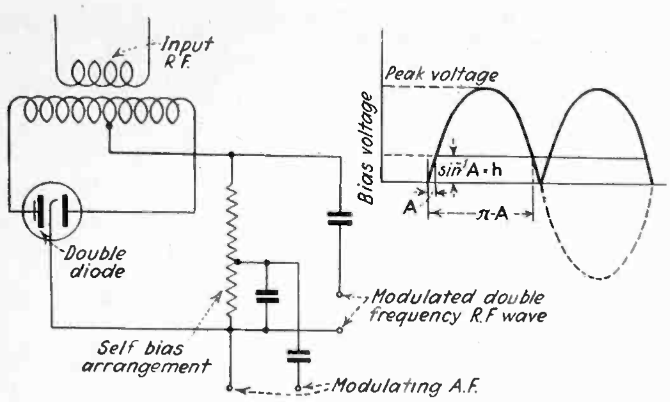

Fig. 2—Modulating circuit and characteristic

for signal generator work, it is necessary to know the relation between the d-c component and the r.m.s. value of the second harmonic at the point of bias at which the greatest percentage of linear modulation can be obtained. Figure 3 shows 64 per cent of the cut-off bias to be the normal operating point, since this is the center of the straight portion of the curve. The r.m.s. value of the second harmonic is given by the following calculations:

$$I = \frac{K}{\pi}\left[\cos A + \frac{1}{3}\cos A\right] \times .707 \qquad \text{where } \sin A = h$$

h	$A°$	$3A$	$\cos 3A$	$\frac{\cos 3A}{3}$	$\cos A$	$\cos A + \frac{1}{3}\cos 3A$
.64	39.7°	119.1°	—.486	—.162	.770	.608

$$\text{Therefore } I = \frac{K}{\pi}(.608)(.707) = .137\,K$$

The d-c component can be obtained from the following derivation. Using the same notation as in the previous derivation we get—

$$e_{dc} = \frac{2\,K}{\pi}\int_{\pi - A}^{A} (\sin\theta - \sin A)\,d\theta$$

$$= \frac{2\,K}{\pi}\left(\cos A - h\left(\frac{\pi}{2} - A\right)\right)$$

h	$A°$	A radians	$\frac{\pi}{2} - A$	$h\left(\frac{\pi}{2} - A\right)$	$\cos A$	$\cos A - h\left(\frac{\pi}{2} - A\right)$
.64	39.7	.693	.878	.568	.770	.202

$$I_{D.C.} = \frac{2\,K}{\pi}(.202) = 1.29\,K \qquad (6)$$

$$\frac{I_{R.F.}}{I_{D.C.}} = \frac{1.37}{1.29} = 1.06$$

From this calculation we see that the d-c component is almost equal to the r.m.s. value. An attempt has been made to calculate the harmonic content of the modulated wave at 100 per cent modulation with the proper bias for maximum linear modulation. Although it is possible to do this by pure mathematical analysis, the process is too tedious to justify the extreme accuracy that we can obtain. The Fisher-Hinen method of graphical analysis gives us a sufficient indication of the results we can expect. Neglecting any possible change in carrier amplitude due to modulation, we obtain 1.2 per cent second harmonic; 5.4 per cent third; 1.8 per cent fourth; and .6 per cent fifth.

Another important consideration is the plate current efficiency—that is, the relation between the r.m.s. values of the double-frequency component and the d-c current. This consideration is important, as it determines ratio of heat dissipated by the plate current to the available output power.

The effective value of the modulated r-f current has been given in

$$I_{RF} = .137\,K$$

The r.m.s. value of the total plate current can be calculated from the following formula

$$I_t = K\left[\frac{2}{\pi}\int_{\frac{\pi}{2}}^{A} (\sin\theta - \sin A)^2\,d\theta\right]^{\frac{1}{2}}$$

$$= K\left[\frac{2}{\pi}\left[\left(\frac{\pi}{2} - A\right)\left(\sin^2 A + \frac{1}{2}\right) - \frac{3}{4}\sin 2A\right]\right]$$

$$= K\left[\frac{2}{\pi}[.799 - .737]\right]^{\frac{1}{2}} = .199\,K$$

$$\therefore \frac{I_{R.F.}}{I_t} = \frac{.137\,K}{.199\,K} = 68.8\%$$

This compares favorably with class A amplification in which the peak value of the wave is equal to the d-c and the total r.m.s. current is

$$K\sqrt{1 + (.707)^2} = 1.23\,K$$

The r.m.s. value of the r-f is .707K.

$$\frac{.707\,K}{1.23\,K} = 57.5\%\ \text{efficiency.}$$

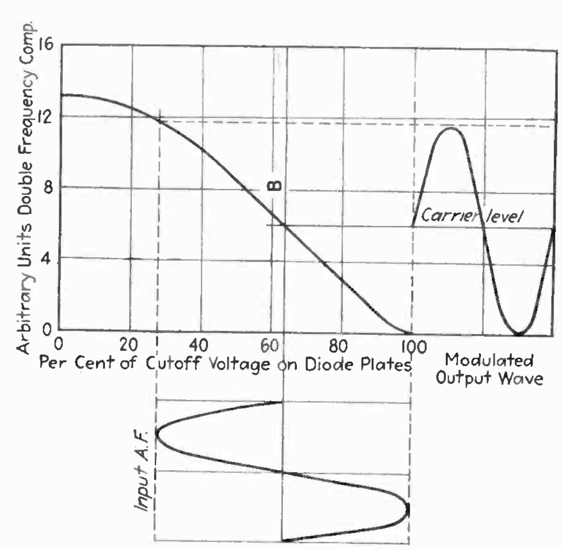

Fig. 3—Relation between modulation and cut-off bias

By using two oscillators 90° out of phase feeding two linear rectifiers in a push-pull arrangement, it is possible to attain efficiencies as high as that of a class B amplifier.

Editor's Note—It is hoped the author will present data on this method in a future issue of *Electronics*.

Characteristics of insulated wires

used in radio set production

By RAYMOND G. ZENDER

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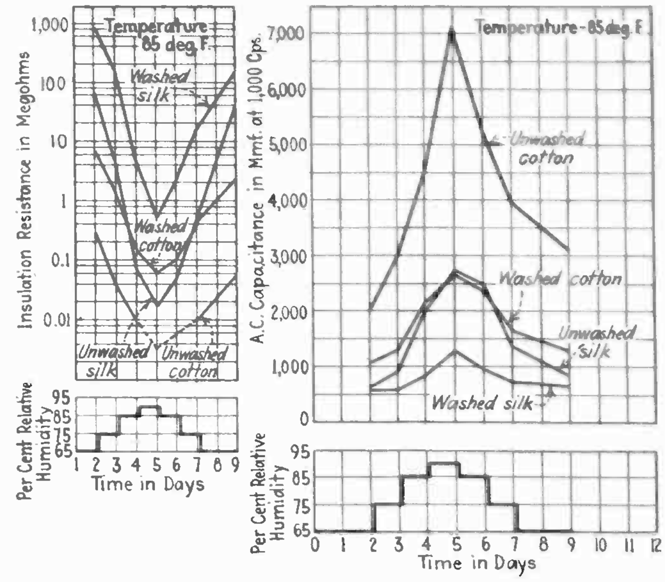
Chicago, Ill.*



Characteristics of 50 ft. of twisted pair wire insulated with double serving of equal thickness

BECAUSE of the tendency of rubber insulation to deteriorate when subjected to excessive heat, the writer desires to pass on to design and production engineers information he has secured on the voltage breakdown, moisture absorption and capacitance of textile insulated hook-up wire. These data are substantiated by experiments and exhaustive tests.

Radio engineers will recognize the fact that moisture absorbing insulation creates excessive leakage and results in substantial reduction of insulation resistance, increased capacity and ultimately in the complete disintegration of textile fibers. Since the resistance and capacitance of textile insulation will change due to the presence of electrolytic solution formed by mineral salts absorbed in moisture it is important that we consider only these textiles which have been subjected to a thorough cleansing or purifying process. In addition, tests show that thorough impregnation in moisture-resisting compounds is necessary to resist failure of insulation. Only those compounds should be accepted which do not soften at operating temperatures and which do not break down at these temperatures to form any of the series of weak organic acids which create electrolytic action.

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The "forgotten" component

INTERESTING and valuable material has been published on many of the components entering into modern radio receivers. The lowly hook-up wire, however, seems to have escaped the attention of researchers and writers. Mr. Zender has measured the characteristics of various types of wire used for chassis hook-up, and as leads for speaker field coils and transformers. His data are presented here.

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The following data on the comparative merits of various types of insulation are the result of considerable laboratory tests. In making the comparative voltage breakdown tests No. 20 B & S gauge wire was used because this seems to be the present standard for chassis hook-up wire.

VOLTAGE BREAKDOWN

Table 1 Insulation: two cotton braids: waxed	Table 2 Insulation: one silk wrap: two cotton braids: waxed	Table 3 Insulation: two silk wraps: one cotton braid: waxed	Table 4 Insulation: two silk wraps: two cotton braids: waxed
1900	2600	2150	3000
1800	2900	2400	3000
1900	2900	2200	3000
2000	2800	2200	3050
2000	2700	2050	2900
1900	2700	2300	3100
1850	2650	2200	2900
2000	2700	2000	2950
1950	2650	1900	3000
1950	2600	2000	3100
Average 1925	2720	2140	3000

Comparing the above breakdown tables with the insulation resistance results bears out the fact that there is no direct correlation between the breakdown voltage and insulation resistance of samples tested. for example when comparing two cotton braids shown in Table 1 with two silk wraps and one cotton braid in table 3.

In this connection note the excellent results recorded in Table 3 as compared to Table 1. This is accomplished by the substitution of two wraps of purified silk in place of one of the cotton braids. Where higher dielectric characteristics and greater mechanical strength are needed, insulation comprised of two silk wraps and two cotton braids waxed or lacquered is suggested. This particular combination as shown in Table 4 has been successfully adopted as speaker field coil leads and power transformer leads.

Virtues of purified silk

Through the courtesy of Messrs. H. H. Glenn and E. B. Wood of the Bell Telephone Laboratories, three graphs are shown to emphasize the superiority of purified silk. In analyzing these graphs, the most significant fact to be observed is the greatly increased dielectric characteristic of purified silk over impure silk and cotton insulations.

Through the courtesy of the Underwriters' Laboratories, the writer is privileged to set forth other interesting information. As is generally known the Underwriters are chiefly concerned in those destructive hazards that may create property damage or personal injury. Consequently, their interest centers on component parts and their proper assembly into complete units functioning efficiently with wide safety margins. They specify

Insulation Resistance

Megohms per foot. Immersed in Mercury.

After being subjected to 68°F, 90 per cent Relative humidity — 100 hours.

Table 1 Insulation: two cotton braids: waxed	Table 2 Insulation: one silk wrap: two cotton braids: waxed	Table 3 Insulation: two silk wraps: one cotton braid: waxed
9.3	63.0	593.0
8.6	58.0	536.0
7.6	60.7	572.0
9.6	72.0	548.0
8.9	64.0	587.0
Average 8.8	63.5	567.0

After being subjected to 140°F, 90 per cent Relative humidity — 100 hours.

Table 1	Table 2	Table 3
0.28	25.4	371.0
0.20	45.0	386.0
0.32	46.0	342.0
0.34	62.0	361.0
0.32	32.0	373.0
Average 0.29	42.1	367.0

Moisture Absorption

90 percent humidity—100 hours

Table 1	Table 2	Table 3
68°F 0.60 per cent	68°F 0.83 per cent	68°F 0.34 per cent
140°F 0.94 per cent	140°F 1.10 per cent	140°F 0.55 per cent

that insulation must withstand a breakdown test involving a potential of three times the maximum open-circuit voltage to which wires are subjected. Therefore, since the average peak voltage in most radio circuits is 500 volts, it follows that any combination of insulations shown in the breakdown tables will suffice. However, insulation resistance and moisture absorption must also be considered for efficient performance.

In selecting hook-up wire for radio chasses the efficient performance of insulation depends not alone on the voltage break-down but also on two additional important characteristics, namely, insulation resistance and ability to resist moisture at high temperatures and greater relative humidity.

The following information is taken from the published pamphlet entitled *"Underwriters' Laboratories Requirements For Power-Operated Radio Receiving Appliance,"* dated April, 1933, show the attitude and refinement of these laboratories on temperatures to which several types of insulation may be subjected.

"Materials will be considered adversely affected if temperatures higher than the following are attained:

90° C—On conductors having fiberous textile materials such as cotton, silk, etc.

90° C—On conductors having slow-burning insulation.

49° C—On conductors having rubber insulation."

The writer desires to express his appreciation to the Bell Telephone Laboratories and Underwriters' Laboratories for their courtesy.

Problems of cathode-ray television

[Continued from page 12]

where t is the time duration of the electron going through the path Δs.

Now if we determine either theoretically by rather laborious computations or by measurements on enlarged models filled with water, the exact value and shape of every equipotential surface on Fig. 8, we can predict the path of an electron through the field, or the electron lens as it is more often called. The writer prefers the experimental determination of the field configuration as more dependable and reasonably accurate.

We may take an electron moving with speed corresponding to a drop through the voltage E ($v = 5.97 \times 10^7 \sqrt{E}$ cm/sec.) entering the field on Fig. 8 and initially moving from left to right along a line parallel to x axis. By the method just described we may compute step by step its path through the field and find the intersection of its path with x axis. Similarly we may compute also step by step the path of an electron entering the field from right to left along a line parallel to the axis and with a speed corresponding to $E + E_1$ and find the intersection of the path and x axis.

Now we may consider the system as a thick electronic lens with constants or cardinal points, rather, as shown on Fig. 9. These constants may prove very useful in actual practice. We may produce an electron beam and may make it cross over in the equipotential space to the left of the lens. We may also make it enter the field as a divergent stream or bundle with the axis of the symmetry coinciding with that of the lens. If we know the diameter of the crossover and its distance from the first focal point, we may readily determine the distance from the second focal point at which distance it will come to the focus, also the magnification and the size of the image of the cross over.

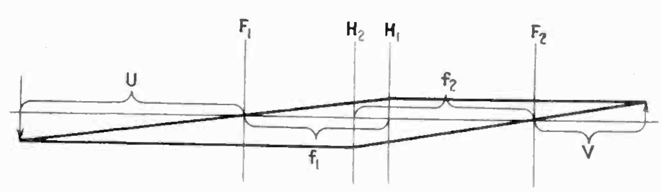


Fig. 10—Diagram of lens system showing magnification, image size, etc.

The theory of thick lenses gives directly all these relations:

$$f_1 f_2 = UV \quad \text{and} \quad V = f_1 f_2 / U$$

$$\text{also} \quad m = \frac{V}{f_2} = \frac{f_1}{U}$$

where U is the distance between the object and F_1; V is the distance between the image and F_2, and m is the optical magnification. If A is the size of the object and B is the size of the image, then

$$B = mA$$

These quantities are shown on Fig. 10.

Of course, if an electronic lens has large spherical aberration the diameter of the image is larger than the one computed from these expressions. But, our step by step method applies for the computation of spherical aberration as well as for computations of optical constants of electronic lenses. By computing paths of two electrons starting from one point of the object and tracing them through the field, we can find the amount of lateral aberration in any particular case.

+ + ELECTRON TUBE

Analog between dry-disc phototube and chemical cell

WHEN TWO DISSIMILAR METALLIC electrodes are suspended in an electrolyte, a voltage is developed at the terminals of the cell which is independent of the size of the plates and other physical factors. It depends upon the nature of the materials used. The internal resistance, however, is a function of the area of the plates and other physical dimensions.

In a dry-disc type of light-sensitive cell, such as the copper-oxide cell or the Weston Photronic cell, the terminal voltage is independent of the size of the plates and depends upon the nature of the electrodes used. At a given intensity of illumination, therefore, the internal resistance varies as the size of the plates and the conductor between them. The power that can be secured from either a chemical cell or a light-battery of the dry disc type depends upon the internal resistance in relation to the external load resistance and therefore upon the area of the plates.

✦

Amplifier noise—a bibliography

THE IMPORTANCE OF tube noise as a limiting factor in amplifier or radio receiver design has been pointed out recently in several publications. The subject is not new, but evidently is becoming of greater importance. Continued work in the field may develop new types of tube in which noise is of lower order, or discover new facts about the ultimate constitution of matter.

The recent articles are as follows: "The spontaneous background noise in amplifiers due to thermal agitation and schrott effects," E. B. Moullin and H. D. M. Ellis, read before the *Institution of Electrical Engineers,* London, December 6, 1933; "Noise as a limiting factor in amplifier design," O. E. Keall, *Marconi Review,* July-August and September-October; "Fluctuation noise due to collision ionization in electronic amplifier tubes," Stuart Ballantine, *Physics,* September 1933; and finally "Influence of circuit constants on receiver output noise," J. M. Stinchfield, Radiotron - Cunningham *Application Note No. 25,* October 19, 1933. Practical data are included in the last publication enabling a receiver designer to keep output noise to the lowest value.

✦

The ultimate nature of electrical resistance

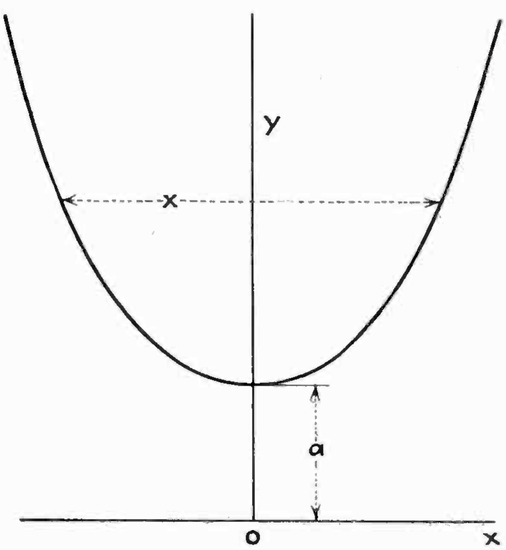
IN AN ARTICLE ENTITLED "electrical resistance and heat in metals," *Journal of the Franklin Institute,* November 1933, Charles Underhill has shown some interesting examples of the relationship between the heat content and the electric resistance for copper and iron, as determined from the absolute zero of temperature. It turns out that when the increase in heat in joules is numerically equal to the mean resistance in ohms in a thermally insulated metal wire due to 1 coulomb passing in 1 second, the uniform cross-section of wire for that condition is such that the number of atoms per lineal centimeter is of the general order of the number of electron charges in a negative coulomb, i.e., *N* billion billion; *N* being less for copper than for iron which has a higher resistance.

Mr. Underhill states that he has found this general relation to hold for many other metals also.

✦

Catenary volume control

ONE OF THE FEATURES of Howard Radio receivers is a "catenary" volume control designed to bring out the low notes at low volume levels. The characteristic



$$y = \frac{a}{2}\left(e^{\frac{x}{a}} + e^{-\frac{x}{a}}\right)$$

of this volume control follows the well-known mathematical formula describing the position taken by a chain or cord suspended freely from its two ends. This equation and the curve are given in the figure.

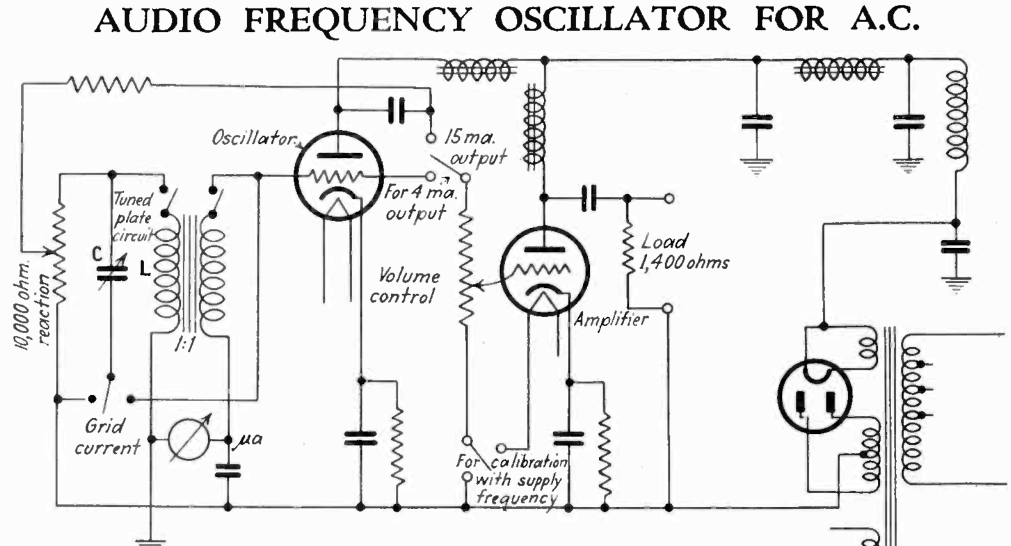
✦

Inverse method of solving tube problems

ENGINEERS FACED WITH a problem involving vacuum tubes usually begin at the beginning (the grid) and work toward the end (the plate) I. G. Maloff, RCA Victor stated before the 1933 Annual IRE Convention that in many cases it was easier to work the problem backwards. In the November, 1933, issue of *Broadcast News* he explains in some detail his inverse method of solving tube problems and illustrates it by the following case: Suppose a 247 pentode with normal voltages is to feed an inductive load of 7,000 ohms and delivers to this load 150 peak volts at the fundamental. What is the second and third harmonic content, and the necessary grid swing?

✦ ✦ ✦

AUDIO FREQUENCY OSCILLATOR FOR A.C.



Oscillator designed by C. H. W. Brooks-Smith, Standard Telephones and Cable Ltd., covers range of 20-10,000 cycles ±0.2 per cent in which L is a set of three toroids of 7.5, 0.25 and 0.025 henries and C is variable from 0.00075 to 2 μf. After three hours operation the frequency was constant. Harmonic content was 2 per cent between 200 and 4,000 cycles

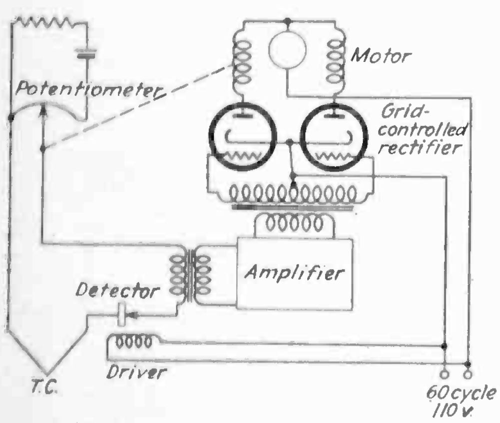
CIRCUIT NOTES + +

Mr. Maloff works the problem backwards, i.e., by calculating the necessary peak volts and current and effective voltamperes and then derives the necessary grid voltage. He announces that the next issue of *Broadcast News* will contain the method of "isoclines," also described at the Chicago IRE convention.

✦

Speedomax—an electron tube recording potentiometer

A HIGH SPEED RECORDING INSTRUMENT suitable for making permanent records of variations in small d-c voltages, such as developed in thermocouples, and employing amplifier tubes and grid controlled gaseous rectifiers has been produced by engineers of the Leeds and



Northrup company. The instrument is a high-speed null recording device in which the usual mechanical system composed of a galvanometer and balancing system have been replaced by a faster electrical system.

The circuit for the ingenious circuit is shown. The output of the thermocouple, or other source, is, of course, direct current and can be amplified only with difficulty. If however, it is modulated, amplification is not difficult at all. Therefore in series with the thermocouple is a microphone mechanically driven by a 60 cycle armature. This modulated current is applied to the grids of push-pull controlled rectifiers. The plates of these tubes are supplied from the same a-c source as the modulating armature and therefore have the same phase.

The unbalance current (thermocouple) may flow in either direction, and the phase of the grid voltage to the rectifiers depends upon this direction. Either one or the other of the two rectifiers will conduct current if an unbalance current occurs. The plate currents of the rectifiers drive a split-field series reversing motor which drives the potentiometer slide wire which balances the system.

By coupling a tachometer magneto to the shaft of the driving motor and using its e.m.f. to oppose the e.m.f. generated by the thermocouple circuit, tendency to overshoot is eliminated. Since the e.m.f. generated by the magneto varies as the rapidity of the change sudden unbalances are ironed out in their effect.

The recorder pen can cover the 10 in. chart width in two seconds without difficulty from overshooting.

✦

Linear rectification

By Ray Lambert

FOR CERTAIN PURPOSES a rectifier which operates linearly on weak signals is highly desirable. This may be closely approximated by a combination of a diode and a tube capable of delivering a reversed plate current and having a straight I_pE_p curve beyond the reversed current portion of the characteristic.

The familiar curve of the 24 is shown by the dotted lines in the figure. The diode is employed to prevent the current from reversing and the combination of the two produces a rectifier having a sharp cut-off as shown. As tested in a d-c. circuit, this combination will pass three ma. at an increment of 10 volts (corresponding to ten volts of signal) with a straight characteristic.

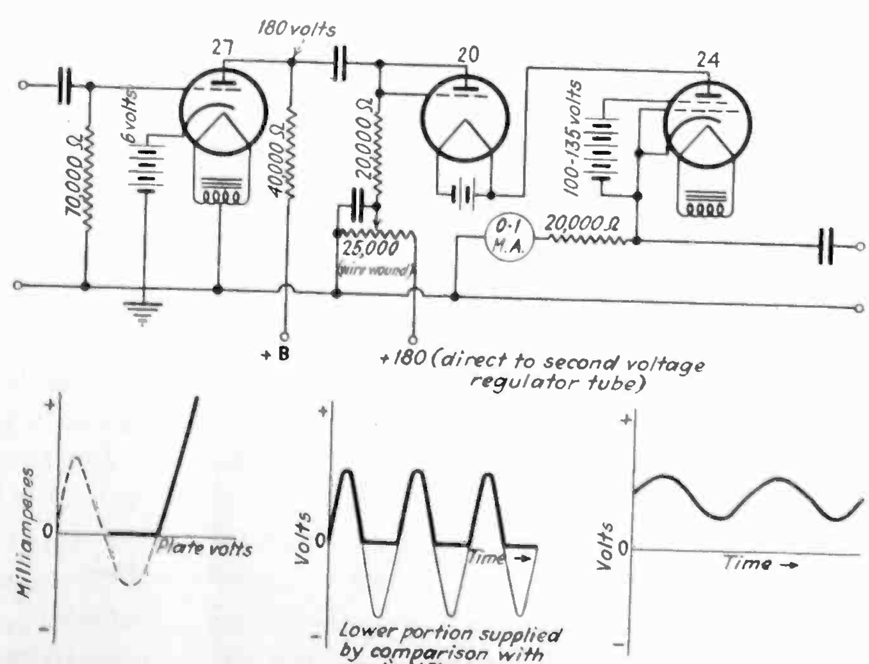
Various methods of coupling have been tried but the most satisfactory from the viewpoint of dynamic characteristics is that shown. The values were determined by means of a cathode-ray oscillograph, using Allen B. DuMont's Type 34 tube. An audio signal having a frequency of 1865 and of quite pure wave form was employed. The drawing, made from an oscillograph trace, shows the negative half of each cycle cut off sharply. Rectification of a radio-frequency signal of about 75 kc., slightly modulated by a 60-cycle wave, is also shown.

The 27 was selected as an input coupling unit largely because its impedance is easily matched to that of the detector circuit. However, its limitations in handling a signal limit the entire device to an undistorted rectified signal current of about 0.6 ma., using the coupling resistances suggested in the diagram. When used with the voltages and output resistance as shown, the value of the grid leak as given is important for maximum undistorted signal.

Before applying a signal voltage, the voltage on the rectifier should be adjusted by the potentiometer to the maximum that just fails to move the milliammeter off zero reading. This voltage should be stable.

With the preceding values of resistance as given, it was found that the output resistance should not exceed 20,000 ohms for a sharp cut off. The appearance of the curve on the oscillograph suggested that, with a higher output resistance, stray capacity bypassing was the source of the distortion. It is, of course, out of the question to use an impedance here.

The filament current of the 20 is derived from two dry cells. With a radio frequency signal a filament transformer here bypasses most of the energy and causes radiation with undesirable consequences in preceding stages of amplification.



Circuit and oscillographs showing linear rectification

electronics

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New York City

O. H. CALDWELL, *Editor*

Volume VII —JANUARY, 1934— Number 1

"Perfected" television— Will it then be visible?

TO get finer and finer detail by present methods of television scanning, more and more lines per picture are being attempted. This follows the principle by which increasing the number of lines in a half-tone, getting finer dots, gives greater detail.

But in present television this process of increasing "lines" cannot be kept up indefinitely. Finally a point will be reached where the flying spot must be so small and must cover such a proportionately larger area and travel, many frames per second, that the intensity of illumination of the picture will suffer. A threshold minimum of the retinal stimulus will be reached, also a rapidity beyond the ability of the optic nerve to respond—so that the "perfected picture" of ultimate fineness may totally disappear from human vision!

Is this the paradox toward which modern television "advances" are heading?

Analysing and reproducing the sensations of odors

THOSE who like to dream of the universality of electrical transmission—of sound, of sight, of thought, etc.—have given some consideration to the problem of reproducing the sensations of odors by electrical oscillations. For in the final analysis the nerves of the nasal passages must respond to vibrations somewhat after the manner of the rods and cones of the retina, and local mechanical stimulation of these delicate nerve loops in the nose might well produce definite illusions of smell.

Preliminary research in this direction is the classification of odors just made by Dr. Arthur D. Little under four qualities: Fragrance, acid, "burnt," and "caprylic" (goatish). Using an index number of nine for each quality, a rose might be classified by the figure 6523, indicating 6 as its fragrance, 5 its acidity, 2 its "burnt" component, and 3 its evil-smelling or goatish characteristic.

This approach simplifies the problem considerably. We may yet be able, with a little nasal applicator, and the setting of several dials, to sniff at will any or all of the sweet perfumes of Arcady!

That curious instrument, the ear

INTERESTING light into some of the dark corners of human hearing is contained in a recent publication of the Acoustical Society. The wide difference in sensitivity of the ear for high notes and low notes, for instance, greatly concerns all radio and sound engineers.

The average ear possesses its greatest sensitivity in the 2,000-4,000 cycle per second, which is near the highest A on the piano keyboard. On the other hand a hum of 120 cycles, such as comes from 60-cycle alternating-current machinery, must be nearly 10,000 times as intense as the 3,500-cycle tone, in order that both may be just audible.

Thus the human ear is seen to have a non-linear tonal response with a fairly sharp peak near the 2,000-4,000 cycle region and most fortunately insensitive near the subway noise region.

For simple noise tests, the ticking of an ordinary watch has been used successfully by Dr. Free. After the watch has been "calibrated" by measuring the distance at which it can be "just heard" against noises of known loudness, such watch tests may give an experienced person almost as good a noise survey as a noise-meter.

The supersensitive photocell

That the photocell is far more sensitive than the eye or the photographic plate in the detection of faint illumination intensities, now seems well established, by astronomical measurements. First the "gegenschein," that faint glimmer in the night-sky opposite the sun's position, was accurately localized by scanning with a photocell and meter. And now Dr. Stebbins has scanned the Andromeda Nebula, and finds that its detectible outposts—which have *never been seen or photographed*—indicate a diameter twice that originally supposed. As its distance is accurately known, this new discovery interprets the Andromeda galaxy as one comparable in size to our own Milky Way galaxy. And so the little photocell calipers the universe!

Welcome to 20-kilocycle broadcasting

THE Federal Radio Commission has just set aside three groups of frequencies in the 1500-to-1600-kilocycle band below the present broadcast region, for experimental use with 20-kilocycle broadcasting. On these channels no longer will the piquancy of the high notes be rudely chopped off at 5000 cycles, but a full 10,000-cycle range will be legally available, consistent with modern microphone and speech-input equipment.

It will be interesting to see whether such 20-kc. channels in the 1500-kc. range attract commercial stations of importance. The experiment is reminiscent of the earlier attempt by the Commission to popularize the higher broadcasting frequencies by permitting high-power locals to operate in this region. Not only the poorer transmission characteristics but the more important "social" stigma of the high frequencies prevented all but a few stations from seeking channels at the bottom of the dial. Yet several striking broadcast successes have been put over in this region.

Whether 20-kc. broadcasting at the nether edge of the listener's dial will be a fair test for full-range tone quality, remains to be seen. But the open-mindedness of the Commission's engineers in assigning for the purpose the only available band deserves commendation.

NEWS NOTES

Electronics No. 46—With this issue the publishers of *Electronics* present its forty-sixth monthly number, publication of which commenced with April, 1930. The present staff has been actively producing the paper from the beginning; O. H. Caldwell, editor; Keith Henney, associate editor, and Helen Sheridan in charge of make-up and production.

KYW to have directive antenna—Westinghouse station KYW will shortly be moved from Chicago to Philadelphia. A special directive antenna is to be used to deliver maximum signal into Philadelphia. Interference will be prevented through a new "null indicator," giving warning in event of failure of the directive apparatus. Walter C. Evans is manager of the Westinghouse radio division, with headquarters at Springfield, Mass.

RMA protests 5 per cent excise tax—Paul B. Klugh, general manager of Zenith Radio, Chicago, and chairman of the RMA legislative committee, has appeared before the House Ways and Means Committee at Washington, to point out that the tax on radios is discriminatory, has reduced sales and employment, has failed to produce the expected revenue, and should not apply to a non-luxury as radio is today. He urged taxation no higher than the 2 per cent applied to automobiles.

Urge 40 to 110 megacycles for television—D. E. Replogle, of Hygrade-Sylvania, and Walter Holland of Philco, chairmen of RMA television committees, have requested the Federal Radio Commission to reserve for television a continuous band of frequencies from 40 megacycles to at least the neighborhood of 110 megacycles. Individual television bands not less than four megacycles wide, are recommended.

Dr. Kennelly to receive Edison Medal—Dr. Arthur E. Kennelly, now of Harvard, who independently proposed the existence of the ionosphere reflecting layer for radio waves, was awarded the Edison Medal for 1934, during the annual convention of the American Institute of Electrical Engineers at New York, Jan. 24.

NOBEL PHYSICS PRIZE

Professor Werner Heisenberg of Leipzig who was awarded the Nobel Prize in physics for 1932. The prize of 1933 was divided between Professor E. Schroedinger of Berlin and P. A. M. Dirac of Cambridge, England. Both awards were made in 1933.

Recent developments set pace for progress in 1934

[*Continued from page 3*]

electrical principles and should lead to even more rapid progress on those uses where electronic devices are irreplaceable and supreme.

Photocells are now becoming rather commonplace as the actuating means for "magic doors" in restaurants, office buildings, department stores, etc., and for elevator-door safeguards. The large Radio City installation of 60 elevators thus equipped, will give further impetus to this important safety mechanism. The leveling system by which the 800-ft. express cars in Radio City are adjusted for the stretch in their long steel cables, as passengers go aboard, is another unique photocell use.

Photocells have played a unique part in the introduction of cellophane wrappings of merchandise, for where such transparent coverings carry printed legends, photocell actuated machinery provides the only means of making sure the label is trimmed and applied correctly.

Light-sensitive units have been built to respond more rapidly, to count fast-moving objects, and to register vehicles passing in two directions separately. Some of the new counters accumulate a predetermined number and then perform a preset operation. One new ultra-high-speed photoelectric relay responds to light or dark impulses one-tenthousandth of a second in duration. In this unit, the amplified phototube impulse changes the voltage on the grid of a three-element gaseous tube which, supplied with direct current, continues to conduct after the kindling impulse has passed. The anode circuit must then be interrupted before the next impulse is received.

Infra-red burglar alarm installations of photocells have also been a resultant of the kidnaping scares of 1933. Many wealthy persons have eagerly paid high prices to have their premises protected. With the infra-red or dark-light beams, the installation becomes almost indetectible.

Space control systems (electrostatic or electromagnetic) have also been developed in several laboratories, for protection against burglars and kidnapers. With these new oscillating systems, the maurauder merely needs to come in the vicinity of the alarm wire, and the alarm is sounded. The complete absence of any light-beam whatever, makes such an installation wholly undiscoverable until operated. A private dwelling at Bronxville, N. Y., has been entirely protected with circuits of this kind. Even the approach of an automobile in the driveway will sound the alarm. The principle is also being applied to industrial counting and industrial control, and to the operation of advertising displays.

The year will undoubtedly see the development of new types of electromagnetic or electrostatic relays much more sensitive than present types, and probably capable of opening or closing circuits carrying much greater current and power. Already experimental relays have been worked out which operate directly from an emissive type photocell without the necessity of an amplifier. What is necessary here is a voltage-operated relay, such as a piezo-electric crystal, or an electrostatic principle of some kind. Such relays are already in the laboratory. Further extension of the use and capability of the dry-disc type of light-sensitive cell seems certain.

In the field of power tubes, particularly controlled rectifiers, there have been developed new principles and also larger capacities and ratings. The inert-gas filling of tubes, and the shield-grid principle give new flexibility and control possibilities. Inert-gas filling gives a tube that is independent of the surrounding temperature, adapting the tube for intermittent operation, as the characteristics are constant, even when voltage is first applied to the tube. In the new shield-grid construction, the shield-grid protects the discharge from extraneous charges, and shields the control grid from both the anode and the cathode. This permits an extremely small control grid having low interelectrode capacity and small emitting properties.

New short-wave oscillator tubes, employed as electronic oscillators, in which the frequency of oscillation is a function of the time of transit of the electrons, make possible frequencies of 700,000,000 cycles per second, with one watt output. Very small water-cooled tubes have been produced, which develop several hundred watts at 300,000,000 cycles per second.

The first grid-controlled rectifier frequency-changer built for commercial service has a rating of 300-kw, transforming from three-phase 2300-volt 60-cycle energy, to two-phase 25-cycle 220-volt power for a machine shop. The frequency of output is held at the required ratio to that of the input, by means of a small pilot motor-generator set supplying the control power for the tubes, which are of the heavy-duty copper-bodied type.

Grid-controlled mercury-pool tubes

The closing year saw the installation of tubes of the grid controlled mercury pool type as power supply rectifiers in the 400-kw. Villa Acuna, XER, Mexican radio station. Furthermore during the year grid controlled rectifiers were demonstrated in which complete control of the flow of current is possible. Present types of tube have only partial control; the grid can prevent the firing of the tube but once current passes the grid can no longer modulate it in any manner. Inasmuch as these new completely controlled tubes will be of the high power type further extension of electronic devices into the power field seems inevitable.

Combination of phototubes with amplifiers or controlled rectifiers during the year will follow the expansion that took place during 1933. It has been found, for example, that electronic tubes of these types speed up various processes or functions. As one example, in the field of recording instruments, such as temperature or other variable recorders, substitution of electron tubes for older mechanical or electrical devices has permitted not only high speed recording but recording at a distance —telemetering. In one case the direct current produced by a thermocouple is modulated by a motor driven buzzer; this modulated current is amplified and applied to grid-controlled rectifiers whose plate current drives a motor in either direction depending upon the temperature rise or fall. This motor not only rebalances a resistance bridge of which the thermocouple is part and automatically records the temperature variations but the device may be turned into a control system which automatically brings the temperature, or other variable, back to the desired value.

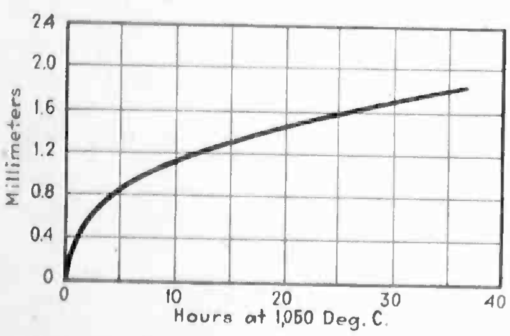
This is but one principle to which various combinations of amplifier-rectifier, or phototube-rectifier have been put. There are dozens of others, and as manufacturers of non-electronic equipment discover the possibilities of such apparatus, the extension of tubes to all manner of physical, chemical or electrical devices will follow.

REVIEW OF ELECTRONIC LITERATURE

HERE AND ABROAD

Improvements in cuprous oxide-copper elements

[F. ROTHER AND H. BOMBKE, University of Berlin] While it is not practicable to reduce the thickness of the one-millionth cm. cuprous oxide layers, its conductivity can be improved without injuring its rectifying action by covering the copper with a layer of silver a few thousandth cm. thick, before forming the cell. When the combination is brought to a high temperature (1050° C.), the oxygen diffuses through the silver and the copper penetrates in part into the silver to form an alloy, and in part through the silver, only to become oxidized. When keeping the silver (or gold, or platinum layer) very thin, a state is reached in which nearly the entire foreign layer diffuses into the cuprous oxide, and such cells are photoelectrically ten times more sensitive than the commercial cells now available. At the same time the tempera-



Thickness of cuprous oxide layer on copper

ture coefficient is distinctly reduced. (The development described seems to form the parallel to the cesium cells on cesium oxide with silver and cesium interspersed.—*Phys. Zeits.* 34: 865-870. 1933.

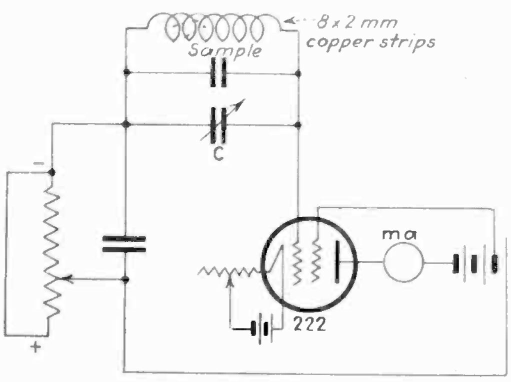
✦

Improved blind landing methods

[E. KRAMER, Laboratory of the C. Lorenz Co.] The device, originally developed by the U. S. Bureau of Standards, in which the flier guides himself to the ground by receiving a beam of ultra-short waves with constant intensity is changed so as more nearly to yield the ideal straight line forming an angle of four or five degrees with the ground. As soon as the flier decides to land he starts a timed attenuating device which gradually reduces the sensitivity of the receiver until the end of the straight line has been traversed. By varying the rate of changing the sensitivity any landing curve may be obtained by simply flying for constant intensity. —*El. Nachr. Tech.* 10: 451-453. 1933.

Improved resonance method for dielectric constant study

[J. G. MALONE, A. L. FERGUSON and L. O. CASE, University of Michigan] In the voltage tuning method, if the value of the variable condenser C is adjusted to give a maximum voltage



across it, this maximum will be independent of the resistance in parallel with the condenser. The plate current is initially zero because of the d-c grid bias. When resonance is approached an increase in the plate current of the tube results which is measured by a milliammeter; when the plate current is a maximum the voltage across the condenser is likewise a maximum, and both are obtained at resonance ($\omega^2 = 1/LC$). To get trustworthy results it is necessary to eliminate the influence of the oscillator upon the detector, the change in wavelength caused by the resonance circuit, carefully to shield the condenser holding the sample and avoid causing changes in the position of the wires. Despite the precautions taken, the results are not decisive, and the question remains open whether the dielectric constant of dilute electrolytes is higher or lower than that of pure water.—*Journal of Chemical Physics* 1: 836-846. 1933.

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The inner-grid dynatron and the duo-dynatron

[TATUO HAYASI] The inner-grid electrode of a double-grid tetrode possesses a remarkable secondary electron emission phenomenon. Consequently the author proposes that dynatrons should be classified into anode, outer-grid and inner-grid dynatrons. Taking advantage of the falling characteristics of the inner-grid circuit an undamped oscillation can be obtained. The properties of these oscillations were studied and their characteristics discussed.—*J. Inst. Elect. Eng. Japan*, *53*, 686-94. 1933.

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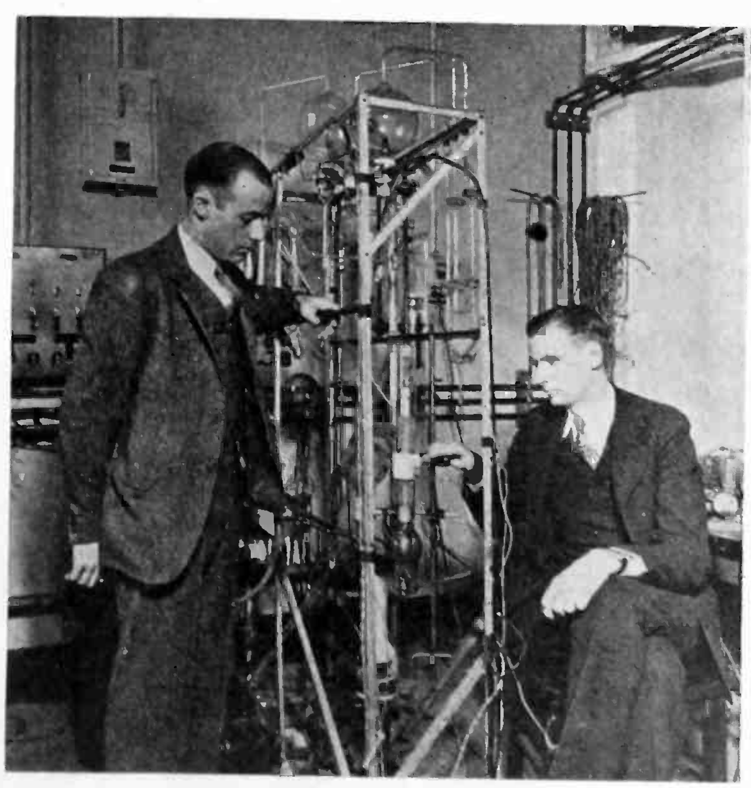
NEW PROTON GUN



Dr. E. S. Lamar and Dr. Overton Luhr, M.I.T. examining a vacuum tube acting as a prolific source of protons. An arc in hydrogen between a filament and a metal electrode furnishes the protons increased in numbers by a third electrode nearby

Superregeneration as a means of fading-proof reception

[H. O. Roosenstein, Telefunken Laboratory] When superregeneration is used for the reception of ultra short modulated waves, the strength of the signal after detection is nearly independent of the field strength over a wide range, the same, for instance, whether the sender (3.8 meters) one watt is at 2 meters or (in a moving train) at 2,000 meters. Theory and experiment show that the detector functions according to a logarithmic law, the reason being the periodic building up of a forced and much stronger free oscillation as the amplifications of the tube varies rhythmically between zero and the normal value. The strength of the rectified signal depends only upon the degree of modulation. The logarithmic demodulation causes distortion, but not more than a square law detector so long as the degree of modulation is below 50 per cent. Reception is free from distortion when the sender is modulated according to a logarithmic law.—*Hochfr. El Ak. 42: 85-89. 1933.*

✦

Wired Radio

According to a note in *Elektro-Technische Zeitschrift*, 54: 849. 1933, the technical improvements in the devices for distributing sound and music over telephone lines have been such that the German Post Office has decided to make the system extensively available to the public thus bringing to fruition preliminary work carried out in Bavaria, Switzerland (see these Digests, Jan., 1932) and elsewhere. The telephone system is hooked up with the radio lines and it is hoped that in view of the cheap receivers required in this case, the service will be welcome wherever reception suffers from sudden interference and fading.

✦

Beat frequencies and synchronization

[H. Subra, French Post and Telegraph Office] The author discusses in detail the effects produced by two oscillators having nearly the same frequency when one oscillator, called the local oscillator f_L is slightly influenced by the distant oscillator f_d owing to unintended one-sided coupling. A small pick-up coil of the kind used when generating audio frequencies by the beat method and loosely coupled, was found convenient for studying the synchronization of the two oscillators. The conditions are deduced under which the distant oscillator, particularly when it is strong forces the local oscillator into step before both frequencies are exactly equal. When f_d varies, synchronization sets in whenever f_d comes sufficiently close to f_L from above or from below. When f_d equals f_L the two oscillations are in phase; when they differ so much that synchronization is just barely possible, they are 90 deg. out of phase. When the difference becomes greater still, the local oscillator does not immediately regain its independence, but goes through a rolling sound and even beyond this point the beat note is not exactly equal to $f_d - f_L$.—*Onde. el. 12: 353-384. 1933.*

✦

Screen grid tubes as transmitters

[C. J. Lussanet de la Tabloniere, Philips; Eindhoven] Screen grid tubes used as oscillators have decided advantages over three electrode tubes (small feed back and smaller r-f power required). The positively charged screen is put to earth over a condenser, grid and anode leads being carefully shielded so that any feedback is due to the plate-grid capacity which varies between 0.001 and 0.02 $\mu\mu f$. For maximum power and efficiency at a given load R, the screen potential V must be so chosen that the alternating voltage component of the plate is equal to the difference between plate and screen d-c voltage. But instead of working with a constant load and adjusting the screen potential it is often preferable to change the load by varying the coupling. Correct adjustment is indicated by the fact that both the d-c plate and the antenna current decrease when V is decreased or increased, whereas when R is varied only the d-c plate current passes through a maximum.—*Onde electr.* 12: 415-440. 1933.

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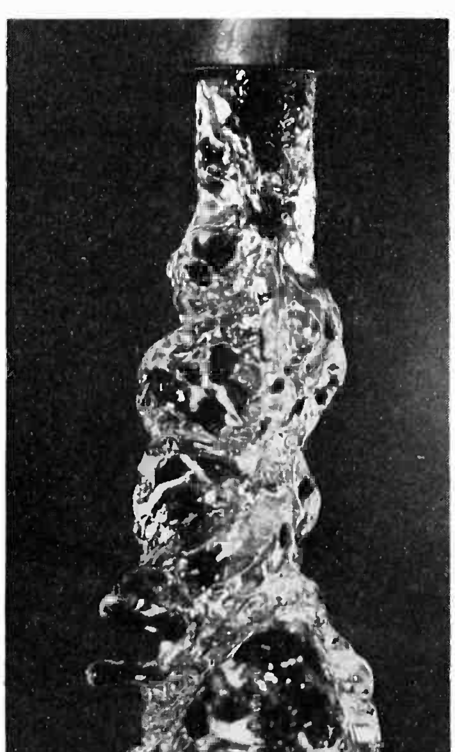
A SNAPSHOT AT ONE-50,000TH SECOND



How water flowing freely from a faucet looks, when photographed in the light of the Edgerton stroboscope, which can take 6,000 pictures per second by means of electron tubes

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Thunderstorms and conducting layers

[E. V. Appleton, C. T. R. Wilson, R. A. Watson Watt.] Abnormally high noon values of ionization in the lower conducting layer at 100 km. suggest the influence of thunderstorm activity. In October, 1932, a thunderstorm with locally audible thunder occurred in connection with which the ionic density in the lower conducting region ran up to something like one million electrons per c.c., while the density in the higher or Appleton region was down to half that value. A three to one increase took place in a single hour in a May, 1933, observation, a two to one increase within half an hour or an occasion when thunderstorms were observed within 25 km. High electron densities have been noted on June 16, 1933, for instance, when the ionization was so intense that waves of a frequency as high as 7 megacycles did not penetrate the lower layer, and the small variation of the equivalent path with frequency indicated a very sharp gradient of ionization with height.—*Proc. Roy. Soc. 141: 697-722. 1933.*

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New German vacuum tubes 1933-1934

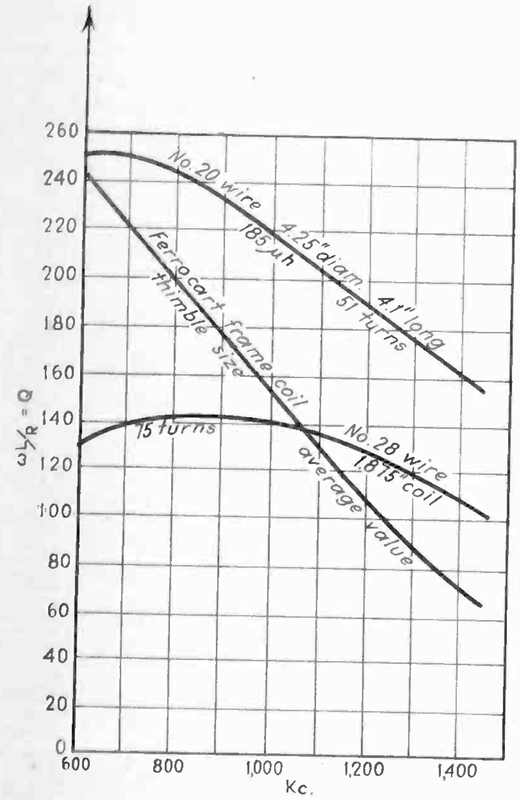
[A. Hamm] Tubes produced by Telefunken and Valvo are brought in line, bifilar filaments being used by both firms for indirectly heated tubes in hexodes, binodes (combination of r-f tube and diode), exponential tubes and high frequency pentodes with normal and with exponential characteristic. All a.c. tubes take 1.0 to 1.2 amp. at 4 volts for the filament and the maximum plate voltage is 200; other data are as follows:

	$R\rho$	Gm	μ	C_{gp}
Triode REN 914 Valvo W 4110.	40,000	2.5	100	1.65$\mu.\mu$
Screen grid RENS 1274, H 4115.......	350,000 to 10 meg	2 to 0.005	700	0.003
Pento de RENS 1284 for r.f. H 4128D.......	2 meg	2.5	5000	0.002
RENS 1294 H 4129 D	1 meg to 10 meg	2 to 0.005	2000	0.002
Binode REN 924	16,000	2	30	

The price varies between 12 (binode) and 15 (hexode) German marks. The article is followed by the description of a tube tester for all the tubes used and a.c. operation.—*By A. Hamm. Funkt. Monatsh. 2: 355-363. 1933.*

Improvements in Ferrocart coils

[A. Schneider, Berlin] Cylindrical coils give better results than the toroidal coils formerly used on condition that the ferrocart layer be placed outside and the copper wire inside (pot coils). An air gap is provided to reduce eddy losses. Good results are also obtained when the windings are placed inside an



iron frame in the manner of choke coils. Winding the coil in two halves allows the inductance to be adjusted to the desired value by merely displacing one half with respect to the other, or by varying the air-gap, a feature useful in gauging. The weight of r-f coils has been reduced from 130 grams to 7 grams. As produced at present the magnetic particles have a diameter of 5 to 20 μ, and form an emulsion in the insulating material. By dipping strips of paper, 8 μ thick, into the emulsion, a layer, 110 μ thick is obtained on both sides. The strips are dried and then covered with adhesions and shaped into plates 2 to 13 mm. thick by applying a slight pressure.—*Funkt. Monatsh.* 2: 439-443. 1933. Zeits. V. D. I. 77: 1233-1235. 1933.

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Inter-electrode capacity at high frequencies

[Bhabani Charan Sil, Indian State Broadcasting Commission] The method used is to determine with the aid of Lecher wires the capacity of the condenser formed by the plate and the grid when the filament is cold or when it is lighted so that electrons can be drawn into the space between grid and plate. When the plate is slightly more positive than the filament, the hot tube has a lower capacity than the cold tube owing to the presence of electrons and ions reducing the dielectric constant. When the plate voltage is slightly lower than that of the filament, the hot capacity exceeds the value of the cold tube, owing to the presence of ion sheaths around the electrodes. But when the plate voltage is much higher (or much lower) than that of the filament, no change is detected owing in one case to the short time that the electrons sojourn in the space and in the other case to their absence. — *Philos. Mag.* 16: 1114-1128. 1933.

✦

The light intensity of a quartz mercury-vapor lamp

[Tsunesaburo Asada] The relations between the spectral intensity of light and both, the amperes and volts of a current flowing through a quartz Hg-lamp, were determined by means of a monochrometer and a vacuum phototube. The results can be expressed by the general formula: $G = kI \times (V-V_o)^n$ where G is the amount of luminous intensity, V_o the minimum voltage required for the operation of the quartz Hg-lamp, I and V the amperes and volts and k and n represent constants. It was found that n is the same for all those spectral lines for which the final energy levels are the same. The higher the final energy level, the greater will be n. The absolute energy of the spectral lines was determined by comparison with the radiation of a black body. Finally an arrangement is described which permitted the measurement of the amount of light absorbed by the Hg atoms within the lamp.—*J. Inst. Elect. Engin. Japan, 53,* 680-85, 1933.

✦

Application of small currents

[K. Zuber, University of Zurich] When the photocell is placed in the grid circuit, the current is amplified by the factor: mutual conductance $g \times R$ (grid resistance). A change v in anode potential changes the meter reading by gv/μ and when the fluctuation is not to exceed 1/10 scale division meaning a current i/10, it is necessary to make $i/10 = gv/\mu$. The smallest current i/10 which can be detected with certainty is equal to $v/R\mu$, and the smallest voltage change v/μ. The bridge circuit eliminates the influence of v. Its advantages can also be obtained with a single tube having two grids, the one nearest to the filament acting as space-charge grid and taking up part of the space charge current. Plate and space charge grid are connected over high resistances, R_p and R_s to the positive pole of the supply and directly shunted over the galvanometer used for indicating equilibrium. The equilibrium is independent of v if $g\ R_p = g_s\ R_s$ at various loads.—*Helvetica phys. acta* 6: 495-503. 1933.

Detecting impurities in sand with the photocell

For accurate determination of the organic matter present in sand, a photocell is used to measure the depth of the color. The sand is digested in a dilute solution of sodium hydroxide and the resulting color is made to affect the readings of the current passing through the photocell, as measured with a microammeter. The result is more reliable and more accurate than that obtained from the ordinary tests (in which the color obtained from the sand is compared with that produced by known solutions of tannic acid and sodium hydroxide) and permits to forecast quite accurately the mortar strength of the sand with a known cement.—Bulletin 28, Maine Technology Experiment Station, and abbreviated in Rock Products 36:27 (October), 1933.

✦

Thermostatically controlled quartz oscillators

[R. Bechmann] The increasing number of broadcasting stations requires a high degree of constancy in the emitted frequencies. A new type of quartz oscillator is described which furnishes an exceptionally high degree of frequency due to its efficient thermostatic control and its installation in conjunction with a double-electron-tube system resulting in a frequency for which the crystal has a minimum of electric resistance. *Elektr. Nachr. Technik, 10,* 371-76, 1933.

✦

The natural frequencies of loudspeaker cones

[M. J. O. Strutt, Th. Van Urk and G. B. Hut, Philips' Research Laboratory, Eindhoven.] When a very thin sheet of material is used for manufacturing the truncated cone, such as is formed by loudspeaker cones, with its wider edge firmly clamped, its shorter edge carrying the voice coil, which is practically free, it is possible to derive a formula for the natural frequency of vibration with different numbers of radial nodes. Tests on aluminum cones with a radius of 8.8 cm. at one side, 2.45 cm. at the other and the two generating lines in the same plane, meeting at an angle of 115°, if prolonged, give poor agreement with the theory. For a sheet 0.2 mm. thick the computed frequency is 485 cycles when there are six radial nodes, whereas the experiments show 362, for a thickness of 0.04 mm., the results are 140 resp. 76. With eight radial nodes the values are 720 and 160 computed, and 635 and 133 observed, with ten nodes 1,000 and 210, as against 975 and 205, etc.—*Ann. Physik 17: 729-735. 915-920. 1933.*

+ NEW PRODUCTS

THE MANUFACTURERS OFFER

Selenium cell

The Acousto-Lite Corp., Ltd., 2908 S. Vermont Ave., Los Angeles, Calif., has developed a new small selenium cell for use on burglar-alarm systems, light-beam control of all kinds of relay circuits, chemical densitometry, pickup for sound on film, and many other uses.

This cell consists of a drawn brass shell, or casing, ¾ in. in diameter by ½-in. in length, closed at one end with a hard rubber disk, and provided with binding posts for connecting the cell into circuit. The other end of the brass case is provided with a glass window behind which is sealed the moisture-proof compartment of the selenium cell. Price of cell for relay work, $7.50.—*Electronics.*

+

Modulation meter

General Communications, Ridgefield Park, N. J., have put on the market a new 66-A modulation meter which gives continuous direct reading in per cent on programs or steady tone (both positive and negative peaks), and also indicates carrier shift—a direct sign of distortion. Its construction eliminates upkeep cost and replacements, and the meter has a uniform audio frequency response from 0 to 24,000 cycles per second. The instrument operates on any frequency from 100 kc. to 40 megacycles. There are no batteries. The unit is all a-c operated, is equally valuable in station or laboratory, weighs only 16 lb., takes only 7 in. of mounting space on standard 19 in. relay rack. It is completely shielded and no transmitter change is necessary, the meter obtaining its energy by means of a coupling coil.—*Electronics.*

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Aircraft and airport transmitters

The Lear aircraft transmitter is designed for use where a light, compact airplane radio is desired, meeting all the requirements of the Department of Commerce.

With this aircraft transmitter properly installed, tests indicate it has a reliable working range exceeding that of present units having twice the power output and four times the power required from the battery, not to mention additional weight. The tubes are standard and can be obtained in any radio store, making it possible for the average radio service man to effect whatever adjustments or repairs may be necessary.

The airport transmitter normally puts into the antenna about 10 watts. However, upon modulation this wattage is increased. It should have average range of 25 to 30 miles. The airport transmitter requires only a 110-volt 60-cycle current source to operate it and can be set up in an hour's time after unpacking.

These two instruments are built by Lear Developments, Inc., of 847 W. Harrison St., Chicago, Ill.—*Electronics.*

+

Dielectric test-set

Sound Engineering Corporation, 416 Leavitt St., Chicago, Ill., has designed for the market a new dielectric testing apparatus, for testing insulation value of sheet materials, paper, rubber, mica, cloth, etc. The apparatus assures safety to the operator, accuracy, smooth control of voltage, from 200 to 10,000 volts, simplicity of operation, and rugged con-

struction. It measures approximately 16 in. by 18 in. by 8 in., and weighs 65 lbs. Power supply is 110 or 220 volts, 60 cycles.

By grounding the transformer at mid-point, potentials above 5000 volts can not be obtained. The secondary circuit is so designed that at the instant a breakdown in the test sample occurs, the voltage on the meter drops to zero, thus affording accurate indication of the exact potential at which failure occurred.—*Electronics.*

Amateur transmitter tube

Raytheon Production Corporation, 55 Chapel St., Newton, Mass., announces a new vacuum-type high voltage rectifier for the amateur, to be known as Raytheon Type RK-19. It is a full wave vacuum rectifier, having the advantage of low voltage drop, approaching that of the mercury vapor type, combined with freedom from RF noise generation. The RK-19 makes possible a compact and economical power supply for tubes of the 750-1,000 volt class such as Raytheon RK-18, with good voltage regulation required for Class B modulation.

Rating

Heater Voltage............7.5 Volts
Heater Current..........2.5 Amperes
Maximum RMS Voltage per anode. 1250 Volts
Maximum Peak Inverse Voltage. 3500 Volts
Maximum Peak Plate Current. 600 Ma.
Anode Connection......At top of bulb
Heater Connections. Medium Four Prong Base
Overall Height...............6½ In.
Diameter ....2½ In.

Price, $7.50.

The RK-19 is a narrow space rectifier of the same general class as the Raytheon Type 83-V, but with much heavier plates and better insulation for amateur use. It fills the gap between the type 866-A and 83-V tubes, and operates efficiently at low temperatures. —*Electronics.*

+

Sensitive relay

Extreme sensitivity combined with low internal resistance permits this new relay to be operated directly by the output of self-generating and photronic type photocells without amplification, and with a reduction of operating light value to ½ foot-candle.

The type A Keane cell closes contacts firmly on a variation of 1/500 foot-candle. A knurled knob allows the relay to be quickly set, by its own accurate scale reading, for closing its contacts on a current variation of 1 microampere to 200 microamperes.

Contacts carry 3 amperes at 110 volts a.c. and are positive locking. The operation of the relay is not affected by vibration. The Ashcraft Automatic Control Co., Hollywood, Calif. Price $35. —*Electronics.*

Graphite-anode 205D tube

Having succeeded in adapting the unique graphite anode—which takes the place of the usual metal plate—to the popular 205D type the Hygrade Sylvania Corporation of Clifton, N. J., now announces a tube of unusual mechanical and electrical characteristics.

The graphite anode, which is not only a getter but also a keeper, makes this tube sturdier, freer from gas and capable of dissipating more power than has

hitherto been possible. Thus the grid inside the anode is operated at cooler temperatures, reducing the possibility of gas from this element. Also longer insulation paths are provided, which reduces the possibility of leakage between elements. In this tube cobalt nickel alloy is employed for the filament, offering a greater emission area and high tensile strength when hot.—*Electronics.*

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Piezo phonograph reproducer

The Proctor piezo phonograph reproducer represents a decided improvement because of its unique electrical and mechanical features. It employs a piezo-electric crystal as the reproducing element which overcomes the difficulties inherent in the electro-magnetic type.

The unit has been designed for use in broadcasting stations, sound studios, theaters and other places where a high degree of fidelity and consistent performance must be maintained. Its electrical and mechanical features make it particularly well suited for reproducing acetate and aluminum records.

The B. A. Proctor Company, 17 West 60th St., New York City, is the manufacturer.—*Electronics.*

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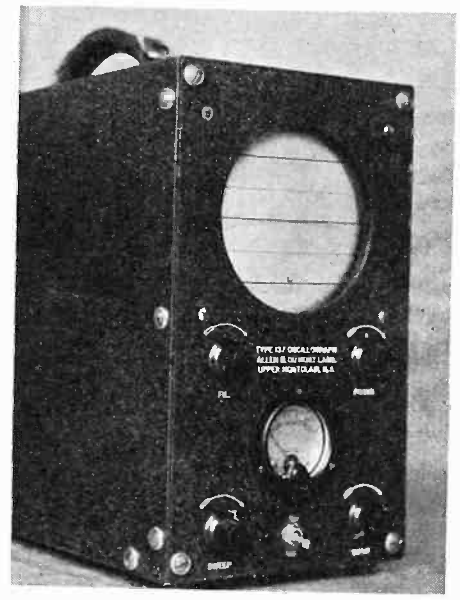
Cathode-ray oscillographs

The Allen B. DuMont Laboratories, Upper Montclair, N. J., have produced two new cathode-ray oscillographs — type 137 with a five-inch tube, and type 138 with a three-inch tube.

The type 137 has been developed to enable broadcast stations to determine more accurately and monitor the percentage modulation of the transmitter. In contrast to the meter type instrument it shows the percentage modulation at any given instant rather than showing an average value over approximately one-quarter of a second. This is of considerable importance as it is essential to know the percentage modulation existing on sudden peaks.

The unit consists of a type 54 DuMont cathode ray tube with a high intensity screen, a power supply which furnishes the voltages necessary for the operation of the cathode ray tube, a sweep circuit and the necessary controls and binding posts. An engraved glass is mounted in front of the cathode ray tube and marked with suitable lines so that the percentage modulation may readily be observed. The unit is entirely self contained and operates from the a-c line.



The type 138 is extremely useful for many determinations in the laboratory and in the field. It consists of a type 34 three-inch DuMont cathode ray tube with a high-intensity screen, a power supply which furnishes all the voltages necessary for the operation of the cathode ray tube, a sinusoidal sweep circuit and the necessary controls.

The price of the type 137 is $165 complete, and the type 138, $85 complete.—*Electronics.*

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Nuts proof against loosening

Elastic Stop nuts (each of which includes a fiber collar that prevents the nut from loosening once it is tightened), have been applied by the American Gas Accumulator Company, Elizabeth, N. J., to a variety of uses, including electrical and radio assemblies. In radio sets, such nuts are used as trimmer adjustments, and for cushion mountings, terminal connections, cabinets, shield fastenings, high-frequency connections, etc. For loudspeakers, for example, the nut must hold the speaker firmly in the mounting, without compressing the rubber grommet beyond the point of maximum resiliency. For electrical apparatus, such Elastic Stop nuts are also used in a variety of ways, and, made in copper or brass, are finding increasing uses for current-carrying connections of all kinds.—*Electronics.*

Police radio

The Westinghouse radio division in Chicopee Falls, Mass., is actively developing radio transmitting equipment for police service. These sets have a nominal rating of 250 watts, but are especially designed to give economical operation on powers as low as 50 watts.

The new sets are distinctively different in construction from the conventional radio transmitter, both in outward appearance and internal construction. Outwardly they have a base dimension of 45 in. by 22½ in. and stand 73 inches high. Meters across the top are used to monitor the operation of the radio circuits. Internally there are two vertical racks, each containing individual panels. Each panel is an individual unit of the transmitter and may be removed for inspection or replacement, without disturbing adjacent panels. All wiring is on a single plane and the rear is exposed to full view by opening the rear shields.

The circuit is of fixed frequency—the only adjustment necessary is that at time of installation provided through the use of a special wrench.

Accurately regulated quartz crystals are used to maintain constant radio frequency.

The input power for 100 watt operation is only 1250 watts so that complete set may be plugged into an ordinary 110-volt service receptacle. Rotating power equipment is not used and all parts are contained in the single cabinet.—*Electronics.*

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Converting 1-kw. broadcast set

In line with its policy of making latest improvements available to owners of its apparatus, the Western Electric Company, 195 Broadway, New York City, has produced a set of conversion parts for its 6 type (1 kilowatt) radio broadcast transmitters. This equipment, in addition of eliminating motor generators, will increase the modulation capability of transmitters of this type to 100 per cent by increasing the plate voltage applied to the last radio frequency power amplifier from 4,000 volts to 5,000 volts.

The essential unit in the set is a 5,000-volt mercury-vapor rectifier which replaces the existing 2,000/4,000 volt motor generator. The 5,000 volt supply permits operation of the final power amplifier tube of the transmitter at that part of its characteristic which allows full use of its capacity to pass all the power required for 100 per cent modulation, with an attending audio harmonic content well within the requirements of the Federal Radio Commission.—*Electronics.*

U. S. PATENTS

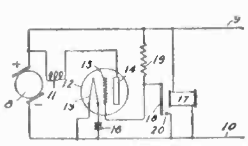
IN THE FIELD OF ELECTRONICS

Electron Tube Applications

Electric clock. Combination of a pendulum, impulse means for the pendulum adapted to contact therewith intermittently, a triode, and an electromagnet connected to the plate circuit of the triode and adapted to flex the impulse means and a contact device operated by the pendulum controlling the grid of the triode. A. F. Poole, Ithaca, N. Y. No. 1,937,529.

Telegraph system. Patents No. 1,936,947 and 1,932,997. The latter for a method of eliminating electrical disturbances in carrier current telegraphy due to transient currents produced at the inception and at the close of a pulse. The former is for a system of impulse telegraphy comprising means for transmitting a square-top wave. Both patents involve thermionic tubes.

Electric regulator. Using a vacuum tube for controlling some characteristic of a rotating machine. H. M. Stoller, W. E. Co. No. 1,936,692. Filed April 22, 1918, 29 claims.



Acceleration measurement. Apparatus for determining and measuring the size and moment of production of minute accelerations, consisting of a mass suspended by an elastic spring from a fixed support, a contact on the mass causing same to rest on one end of the beam of a double-armed balance, an anvil on one end of the balance beam, and means for adjusting the equilibrium of the balance to control the pressure of the contacting beam on the mass acting on said anvil. Richard Ambronn, Göttingen, Germany. No. 1,936,321.

Electrical musical instrument. Resistance shunted by variable condensers and in series with glow tube. Nicholas Langer, New York, N. Y. No. 1,937,389.

Conductivity test. Wire, for example, is run between two rollers so that when contact is made with the rollers, the voltage is applied to the grid of a triode in whose plate circuit is a registering device. D. S. Bond, C. S. Fuller and C. L. Erickson, B.T.L., Inc. No. 1,938,684.

Locking-in system. A relay system, for obtaining a lock-in response from an electrical signal of very brief duration in which the signal impulse is amplified and applied to an arc, which is subjected to a strong deionizing influence so that the arc will not re-strike even though the current is interrupted momentarily T. H. Long, W. E. & M. Co. No. 1,939,071.

Pressure recorder. A capacity bridge so arranged that a variation in pressure unbalances the bridge. J. W. Legg, W. E. & M. Co. No. 1,939,067.

Speed controller. A principal motor and an auxiliary motor and an amplifier tube in a circuit maintains the speed of the principal motor constant. P. R. Dijksterhius, Philips. No. 1,939,338.

Exposure device. Apparatus for making photographs by artificial light comprising a rectifier which charges a condenser which then discharges through an incandescent lamp, the condenser being so dimensioned as to cause an overload of the lamp during a time sufficient for a momentary exposure. Philips. No. 1,939,332.

Printing apparatus. Automatic control of exposure in photographic printing comprising light sensitive device, amplifier, etc. Frank Twyman, Eastman Kodak Co. No. 1,939,243.

Electrical musical instrument. Device for reproducing sonorous action previously recorded by means of first and second parabolic reflectors, light sources, photoelectric cells, etc. John Hays Hammond, Jr., Gloucester, Mass. No. 1,937,021.

Sound receiver. Method of receiving with directional selectivity from a fluid medium consisting in absorbing the energy of the sound at various points along the line of travel of the sound, and transmitting corresponding energy effects at the same velocity as the sound to a point in said line and there cumulating the energy effects and translating them to a desired form of energy. H. A. Affel, A. T. & T. Co. No. 1,936,706.

Fuel burner system. System for controlling an ionized region using electric discharge devices. H. Diamond, W. E. & M. Co. No. 1,936,784.

Automatic photographic apparatus. A photocell amplifier for effecting synchronization of a camera shutter movement with a flashlight. G. W. Goddard, Rantoul, Ill. No. 1,936,595.

Electrical prospecting. Method for electrically determining the characteristics of geologic structures beneath the surface of the earth by generating current of a frequency less than 100 cycles per second, applying this frequency to the earth and securing it therefrom again, converting it into a frequency greater than 100 cycles per second. L. J. Peters, assigned to Gulf Production Co. Nos. 1,938,535 and 1,938,534.

Dust and smoke density device. Method of measuring dust concentration or smoke raising gases by photoelectric means. A. W. Simon, Buckingham, Ala. No. 1,937,722.

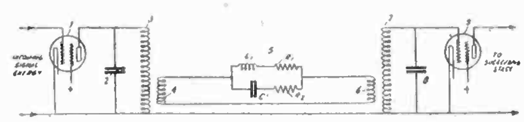
Photometer. Device consisting of a light tight box having a horizontally apertured opaque partition wall dividing the box into two superimposed chambers. The source of light in one chamber shines through the subject under test into a light sensitive cell in the other chamber. M. W. Baden, Wichita, Kansas. No. 1,938,004.

Radio Circuits

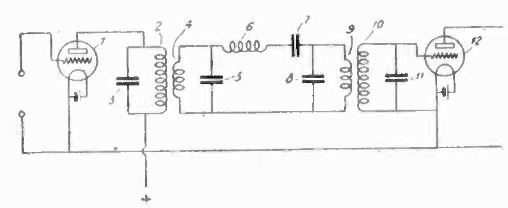
Micro ray system. A micro ray tube, a reflecting electrode and means for tuning the circuit. André E. Clavier, International Communications Laboratories. No. 1,938,065.

Automatic volume control. A method for reducing fading effects in broadcast receivers, involving a light sensitive cell, a luminous discharge device and control circuit. C. L. Davis, assigned to Wired Radio, Inc. No. 1,938,067.

Band pass amplifier. A network coupling the tuned plate and grid circuits of succeeding stages, consisting of inductive and capacitive reactances of such relative magnitudes that the coefficient of couplings between the circuits is proportional at any frequency to the difference between that frequency and the resonant frequency of the tuned circuit, whereby the coupling between the circuit is a minimum at said resonant frequency. Rene Braden, R.C.A. No. 1,938,620.



Intermediate amplifier. Interstage coupling unit comprised of series and parallel resonant circuits. K. Posthumus and T. J. Weyers, R.C.A. No. 1,938,640.



Bias system. In addition to the usual cathode resistance bias, a rectifying device connected from the cathode to a mid-point on the voltage divider for transmitting current when the potential of the plate circuit reaches a predetermined value. W. R. Koch, R.C.A. No. 1,939,398.

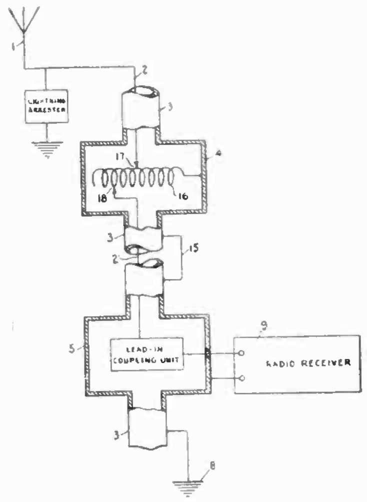
Ultra short wave system. Combination of a reflector having a principal and an object focus, and an antenna element at each focus disposed normal to the axis of the reflector and normal one to the other and a polarized grating between these elements, comprising several wires extending in a direction parallel to one antenna and normal to the other. René H. Darbord, International Communications Laboratories, Inc. No. 1,938,066.

Current generator. Method of using a gas-filled tube as an inverter. F. W. Schramm, A. T. & T. Co. No. 1,926,181.

Filter system. A resistance controlling device between the filter and the work circuit and means for varying the value of the resistance in consonance with the fluctuating component whereby the work circuit is protected from the fluctuating components of the source. B. F. Miessner, assigned to R.C.A. No. 1,927,689.

Direct coupled amplifier. Method of connection and method of stabilizing two tubes in a direct-coupled system. S. Y. White, assigned to E. H. Loftin. No. 1,927,560.

Antenna system. System for protecting a receiver from local interference comprising an antenna, a lead-in, and a radio receiver, the lead-in being shielded and comprising a system for matching the impedances thereof. E. V. Amy and J. G. Aceves, assigned to Amy Aceves and King. No. 1,938,092.

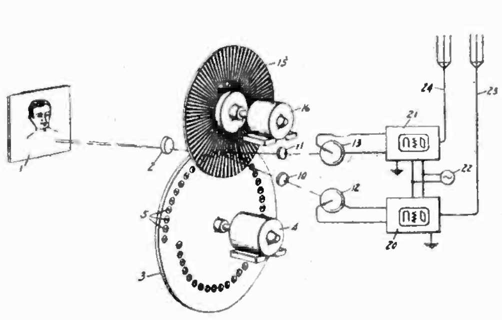


Insulator support. An antenna of the self-supporting vertical mast type and of a height permitting a substantial fraction of the wave-length to be transmitted, comprising a slender tower having a plurality of diverging legs, an insulator support under each leg, etc. R. L. Jenner, assigned to Lapp Insulator Co., Inc. No. 1,937,964.

Interference reduction. Method of reducing interference in transmission systems comprising vibrating a beam of light in accordance with sound waves, projecting the vibrating beam upon a light sensitive element to transform said vibration into current variation, controlling the projection to produce distorted current variations, etc., to limit interference to the same level as the weak components of the sound wave. M. W. Gieseking, assigned to R.C.A. No. 1,937,754.

Frequency multiplier A multi-vibrator system. R. N. Harmon, assigned to WE&M Co. No. 1,936,789.

Television apparatus. A scanning disk having light openings comprising a series of light openings arranged radially with respect to each other and a pair of prisms at each opening, arranged to deflect the light passing one portion with respect to light passing the other portion. E. F. W. Alexanderson, G. E. Co. No. 1,935,427.



Modulating system. Modification of the constant current Heising modulation system. R. A. Heising, assigned to W. E. Co. No. 1,936,162.

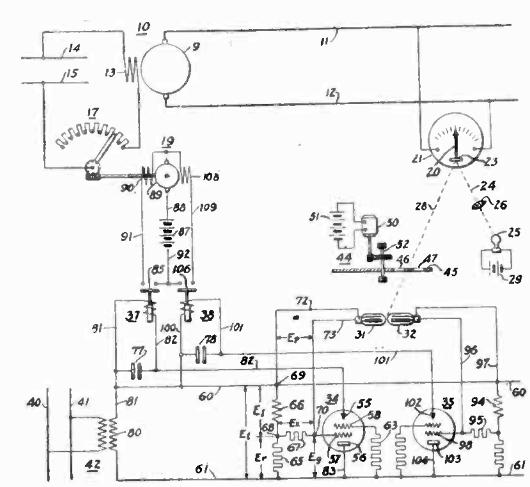
Sensitivity control. Method of compensating the volume control of a receiver so that the overall sensitivity of an amplifier at various frequencies is constant. M. W. Kenney, Elmhurst, Ill. No. 1,935,401.

Side band reversal system. Transmission system producing a complex wave form compounded of a carrier and two side bands, sending a signal by varying the phase of one of the three constituents which are necessary to produce a simple modulated wave form; at the receiver the side bands are independently detected and combined in the proper phase relationship to reproduce the original wave. John Hays Hammond, Jr., Gloucester, Mass. No. 1,935,776.

Power Applications

Inverter system. Three patents granted to C. J. Diver, assigned to the Ken-Rad Corp. No. 1,938,208-1,938,210, inclusive, on combinations of vapor electric tubes or thermionic tubes, direct-current load circuits and direct-current sources.

Regulator system. Method of controlling rotating machine speed by having an electrical meter across the outlet of the machine. The indicating needle of this meter carries a mirror which reflects light from a source into a photocell. The reflected light falls upon the cell only during definitely recurring time periods, the length of which varies from a minimum when the instrument element is at one extreme of its position range progressively to the maximum of the instrument element at the other extreme range. The photocell controls an amplifier which in turn controls the rotating machine. R. A. Geiselman, WE&M Co. No. 1,939,443.



Protective system. Protecting apparatus by charging a condenser which discharges through a glow discharge tube. W. A. Minkler, WE&M Co. No. 1,939,609.

Following patents assigned to G. E. Company on various applications of electron tube for power conversion, rectification, etc. No. 1,939,428; 1,939,-429; 1,939,432; 1,939,435; 1,939,437; 1,939,433; 1,939,455; 1,939,456; 1,939,458; and 1,939,462.

Traffic control system. Method using photocells, etc. Westinghouse E&M Co., R. W. Conn. No. 1,939,436.

Motor and elevator control. Patents assigned to Cutler-Hammer, Inc., on various methods of using electron tubes for elevator or other motor control or generator regulation. Nos. 1,936,620; 1,937,869; 1,937,917; 1,937,931 and 1,937,798.

Power conversion. Patents assigned to General Electric Co. involving electron tubes, direct current systems, alternating current systems, etc. Method for exchanging power from one system to another. Nos. 1,933,303; 1,936,407; 1,936,414; 1,937,361; 1,937,377; 1,938,667 and 1,937,369 to 1,937,372, inclusive.

Oscillograph. A television receiving apparatus using cathode ray tubes. Ernst Busse, Zeiss Ikon, Dresden, German. No. 1,939,434.

Patent Suits

(C. C. A. N. Y.) De Forest patent, No. 1,507,016, for radiosignaling system, claims 24 to 28. Held invalid. Radio Corporation of America v. Radio Engineering Laboratories, 66 F. (2d) 768.

(C. C. A. N. Y.) De Forest patent, No. 1,507,017, for wireless telegraph and telephone system, claims 15, 17 to 21. Held invalid. Id.

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