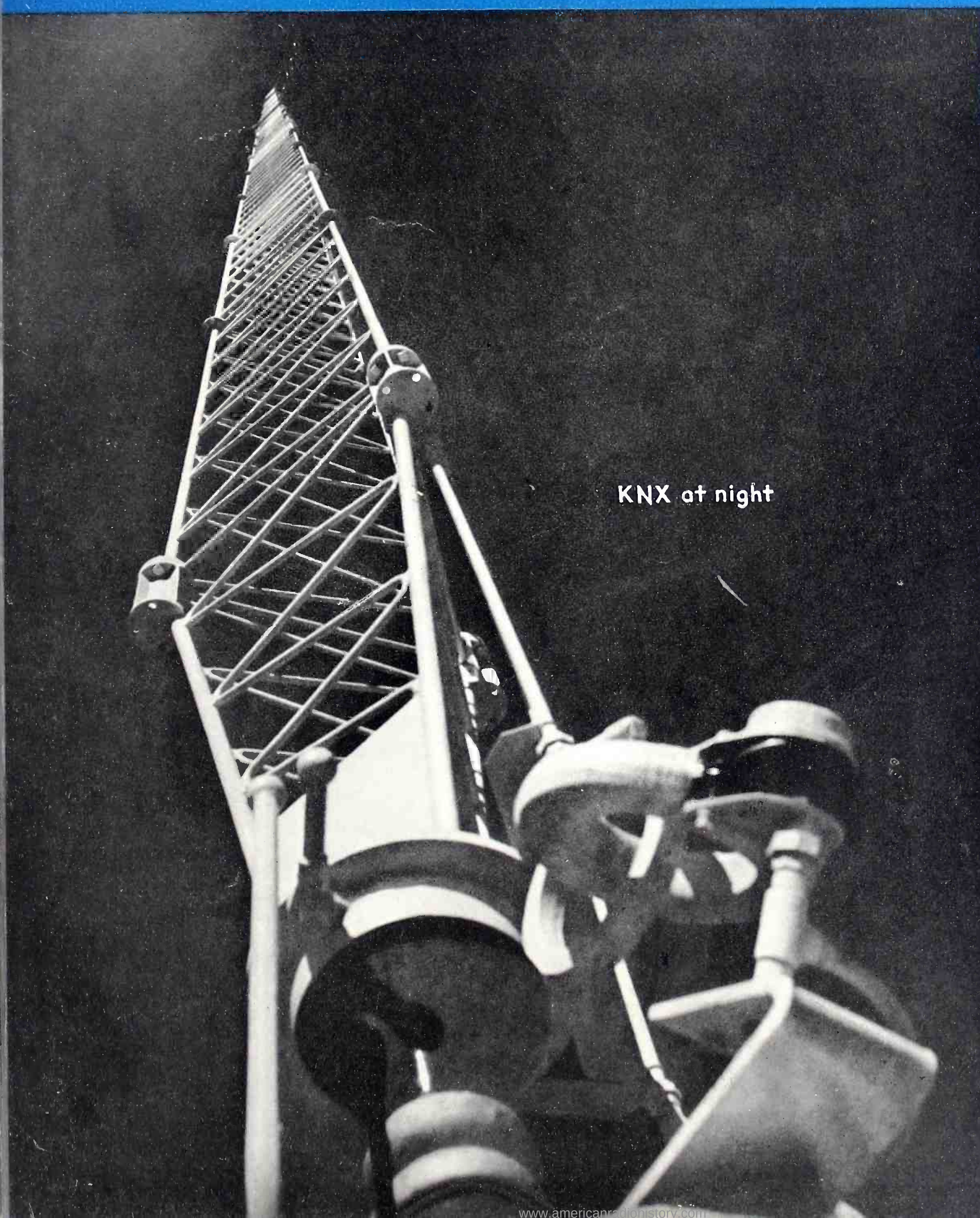
electronics

radio, communication, industrial applications of electron tubes . . . engineering and manufacture



DECEMBER
1938

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electronics

RADIO . . . COMMUNICATION AND INDUSTRIAL APPLICATIONS OF ELECTRON TUBES . . . DESIGN . . . ENGINEERING . . . MANUFACTURE

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CONTENTS—DECEMBER, 1938

DEPARTMENTS

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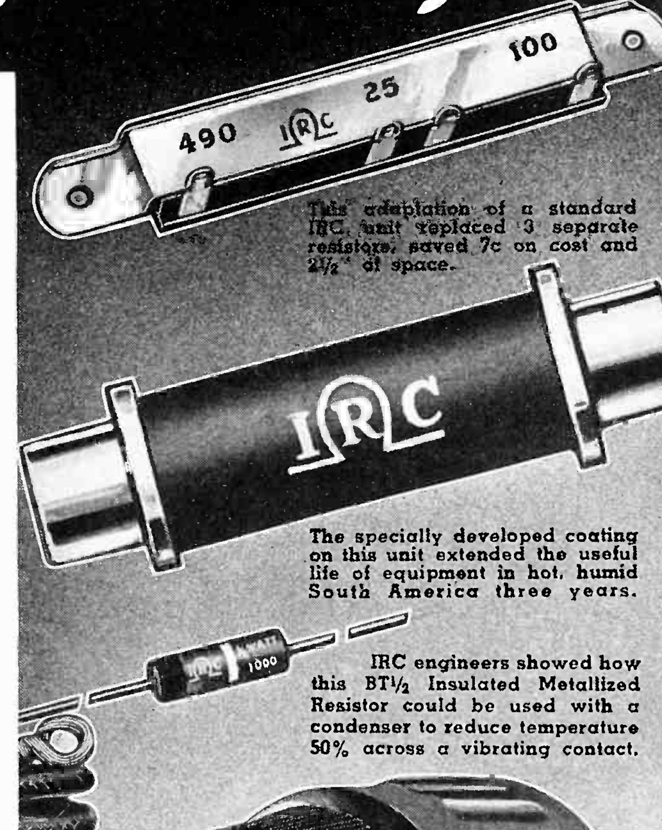

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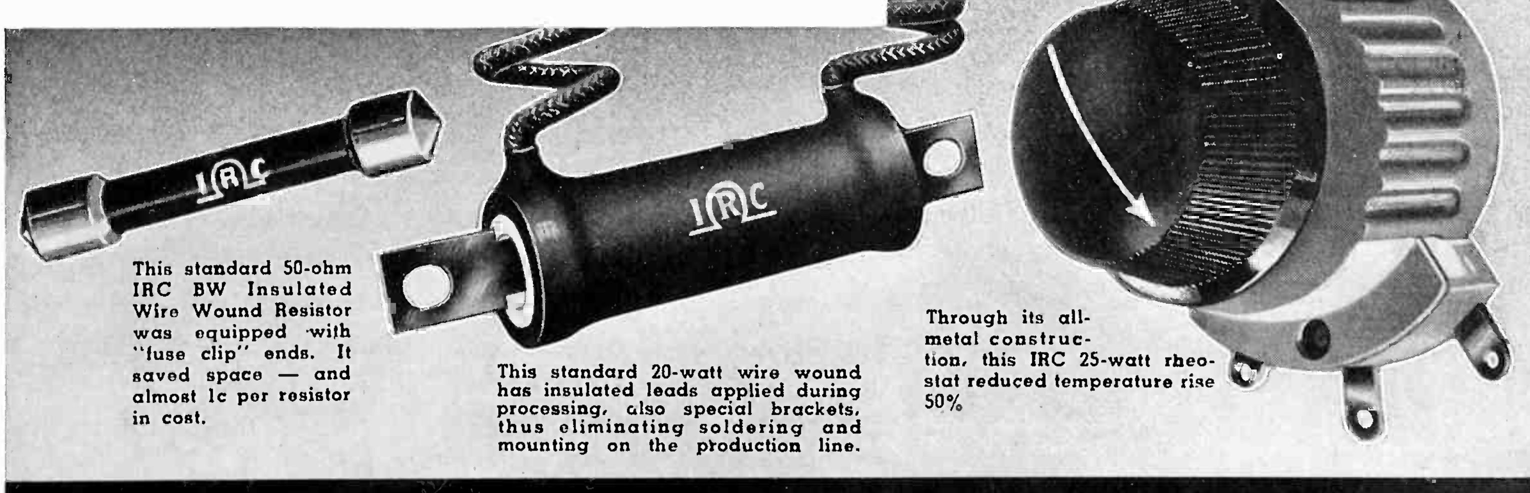

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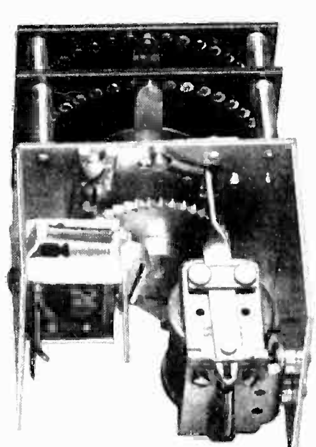

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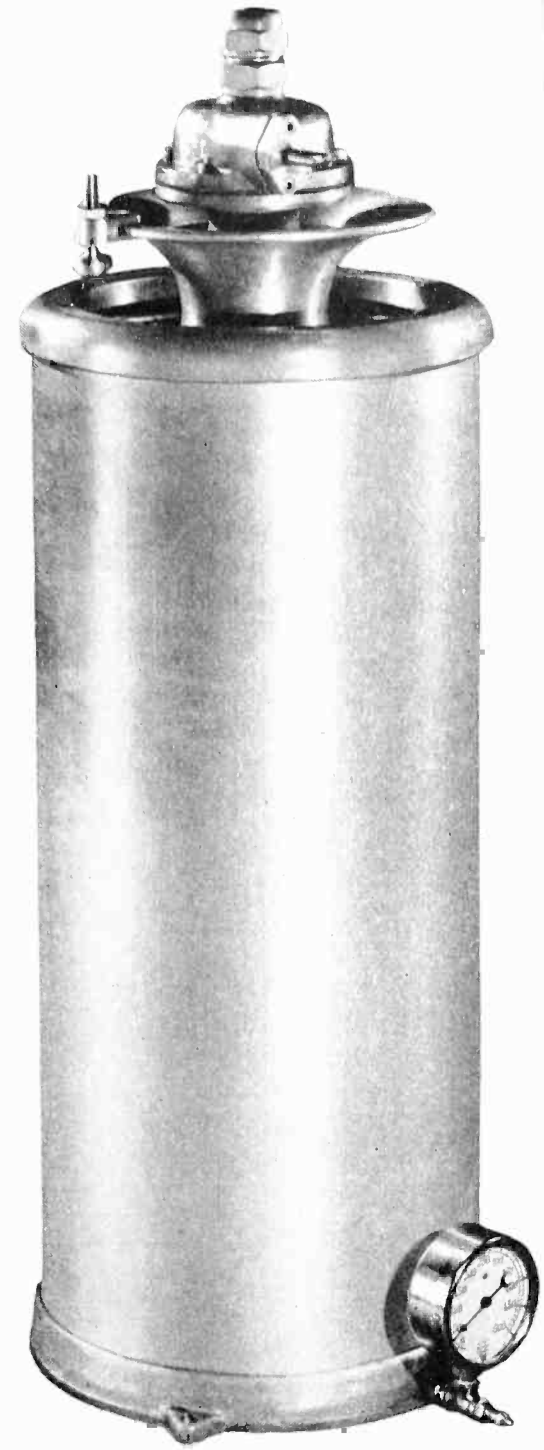

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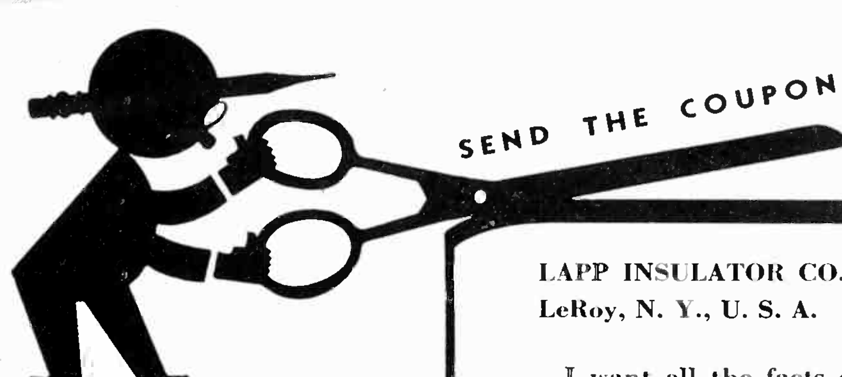

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ELECTRONICS

DECEMBER
1938

KEITH HENNEY
Editor

Crosstalk

▶ **TELEVISION** . . . Paramount, buying into DuMont, states that it will pipe programs (presumably by distributing film) from Hollywood into American homes by Christmas, or some such date. As in many things, "seeing is believing" and until at least the first of the year, our fingers are crossed.

Misguided dealers and manufacturers are offering radio receivers on the basis that they will receive, directly, the sound associated with television signals when they are available. These receivers must tune to frequencies at least as high as 50 megacycles; there are few, if any, receivers sold today which tune to any such frequency.

Therefore, if anyone wants to receive the sound channel of television only, it will be necessary to purchase a converter which will change the 50-odd Mc to the frequency accepted by the existing sound receiver. Any "vision only" receiver sold, however, will have a converter as an integral part. This converter will not only deliver the picture i.f. but will (or should) deliver the sound i.f. (8 Mc) which can be utilized by any existing sound receiver which will tune to 8 Mc.

There is always talk about television receivers becoming obsolete by the development of some—as yet unseen—radically new method of transmission and reception. All present thinking is to make the present standards do; and not to anticipate violent changes in basic principle. Within the structure of the present standards there is much opportunity for improved service which may tend to make the early receiver not so good as later models—but this is no different from the present sound system. Sets of 5 years ago still "play" but they don't have push buttons, shortwave, high selectivity or any of the other recent important improvements.

International Television Radio Corp., (a Delaware Corporation) offers one million shares of stock at $1.60 making 3,479,990 share outstanding. This company plans to build television centers consisting of a transmitter and sets for dealers; to develop infra-red fog piercing navigation equipment; and aircraft development. The Priess scanning mirror, vibrating in two planes, is the heart of the television system.

▶ **WELL MET** . . . By one of those happy circumstances which occasionally take place, Ken Andrews and F. J. Perillo, both interested in electronics, met each other in a restaurant—getting together because one was reading a copy of *Electronics*. The firm of Andrews and Perillo resulted. Animating displays for large industrial companies for such affairs as world's fairs is their forte; but they do a lot of electronic work too. Now John F. Dreyer, radio engineer with Atwater Kent and RCA Radiotron background joins the association—and his forte is electronics. Thus, three good fellows with good technical equipment join forces.

▶ **CONTRAST** . . . FCC spends a barrel of money investigating monopoly in communications; produces material which will be forgotten in a year or so; raises big rumpus, gets in the papers, etc., etc. The engineering work of the Commission, however, is largely buried, unappreciated, disregarded by politicians. Who knows of the long serious study of receiving conditions on shipboard where radio is of vital importance; of the investigation of tropical noise, static, engine room disturbances, all endeavoring for the first time to make a real approach to the problem of how much power a ship transmitter ought to have and of what signal strength it ought to receive? This work is of lasting benefit, and its effect will be felt long after the fuss and fury of the non-technical investigations have been forgotten.

▶ **RESEARCH** . . . In five parts of the country, *Electronics* has research men talking to subscribers, finding out their reading habits, what they like, what they read, what they don't like—in fact trying to discover at first hand the answer to all the questions an editor has about his readers. These editorial research men have nothing to sell, no axe to grind. They want facts; and it is to the advantage of the reader not to throw these fellows out when they appear. A successful technical paper must be a cooperative effort between publishers, editors and readers.

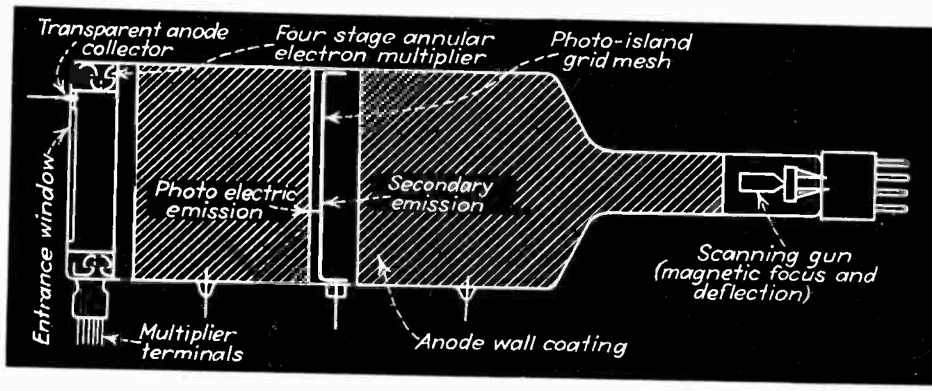
▶ **SORRY** . . . In the November issue, page 14, the statement was made that "the ratings of many transmitting tubes have been pushed to the limit, and beyond, under the false standard of 'more watts per dollar' whereas more watthours per dollar would indicate the true economics of the situation.

We take this opportunity to state that it was not our intention to impugn the motives of anyone using the above slogan or to imply that the use of the slogan indicates any unfair, dishonest or improper trade practices. Rather, it was the purpose of our statement to point out that in our opinion the life of a tube is more important than the amount of power that the tube could handle at any particular time.

▶ **REFUGEES** . . . America gains through the constant inpouring of highly trained men from Germany and Austria. Several have been in the editorial office recently, hunting jobs; their names and qualifications are on file. Physicists, mathematicians, chemists, engineers.

ROCHESTER 1938

TELEVISION advancement was the main item of interest at the IRE-RMA Rochester Fall Meeting, where several hundred engineers and about two dozen exhibitors congregated on November 14th to 16th for an informal discussion of engineering problems, to display new equipment, and to hold technical committee meetings. Papers were fewer in number than in past years, and a longer time was voted to the presentation of each paper. As usual, all papers were of high caliber. Nevertheless, special mention must be made of papers presented by Philo T. Farnsworth who described a new image tube of improved sensitivity and making use of electronic principles which, up to now, had not been applied to this type of tube; by Harold Wheeler of Hazeltine for his contribution to electric circuit theory in his discussion of "Interpretation of Amplitude and Phase Distortion in Terms of Paired Echoes"; and by Seeley and Foster for their demonstration of "Principles and Methods in Television Laboratory Practice".



The Farnsworth storage-type image-dissector tube, which displays no shading signal and has ten times the sensitivity of the ordinary iconoscope

Standardized Intermediate Frequency

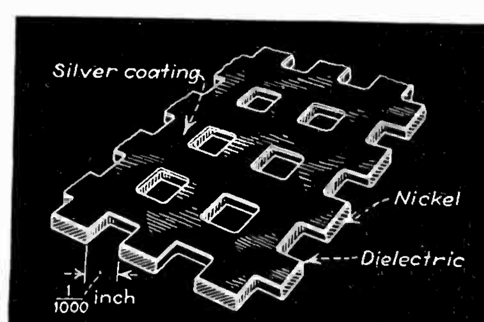
J. E. Brown of the Zenith Radio Corporation opened the technical sessions by delivering a paper on "Standardized Intermediate Frequency" which reviewed the past practice of manufacturers with respect to the selection of the difference beat or intermediate frequency for use in superheterodyne receivers. Requirements for suitable intermediate frequency are that: (1) the i-f pick-up should be a minimum, (2) interference from harmonics should be a minimum, and (3) the i-f selected should be such as will not result in interference from any radio services already assigned.

The extensive use of the band between 450 and 470 kc made it advisable to select a frequency in this range if possible. By considering the frequency assignments in this band, together with the three requirements given above, it became evident that 455 kc was the best possible frequency for use for superheterodyne purposes. The RMA requested that the channel between 450 and 460 kc be assigned exclusively for intermediate frequency use.

Farnsworth's New Tube

"Image Amplifier Pick-up Tubes" were revealed for the first time by P. T. Farnsworth in a paper of that name written by Mr. Farnsworth and B. C. Gardner. The new tubes combine several important features of the iconoscope and image-dissector, and in addition utilize the principle of a control grid, for amplifying the picture signal *before* the image is scanned, rather than after it is scanned as in all prior pick-up devices. The resulting tubes are free from the spurious "shading" signal, and one form has a sensitivity about 10 times as great as the conventional iconoscope.

The presentation of the paper followed the evolution of the new tube over a period of 12 years and many different forms of tube, embodying the same basic principle, were shown. All the tubes had the following in common: First a *steady* source of free electrons from a plane cathode surface or its equivalent. Second a plane grid structure, mounted parallel to and just in front of the cathode. This grid structure is made of a flat metal plate, perforated with fine holes to the extent of about 160,000 holes per square inch. The front surface of this plate is insulated with barium fluoride and coated with a sputtered silver-cesium-oxide layer on which the optical image is focussed. This grid, called by Mr. Farnsworth a "photo-island" grid is roughly analogous to the mosaic in the iconoscope. When the optical image is focussed upon it, it assumes a distribution of potential which has the same form as the distribution of light in the image, and the amplitude of the potential increases the longer the light is allowed to fall on it. The distribution of potential on this grid structure acts as the control potential over the electrons flowing from the cathode behind it. Consequently these electrons form an electron image which passes through the meshes of



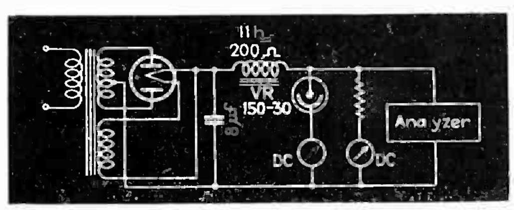
The "photo-island" structure used in the Farnsworth tube

Digest of technical papers delivered at the Rochester Fall Meeting, where an attendance of 500 gave evidence of an improved business outlook, and which proved once again that the laboratories have not been idle, business or no business

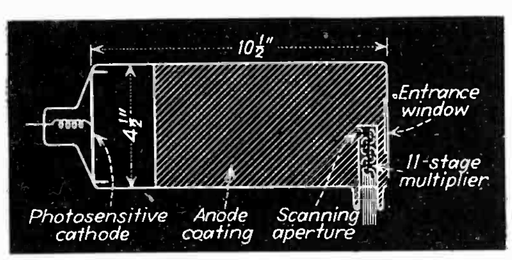
the grid, to be collected by an anode and conducted to the external signal circuit. In this case the scanning of the signal is obtained by moving the electron image, after passage through the control grid, bodily past a small aperture in the collecting anode, using magnetic deflection similar to that employed in the conventional image-dissector.

The most modern form of tube does not employ a plane cathode, but uses a beam of electrons from a gun, magnetically focussed and deflected. The electrons from this beam are directed, in the usual scanning motion, toward the back surface of the "photo-island" grid, which emits secondary electrons under the influence of the beam. These secondary electrons are drawn through the interstices of the control grid in an amount depending upon the potential existing at the point then scanned, the potential being determined by the degree of illumination at that point. The secondary electrons, after passing through the grid, are collected by an electron multiplier structure, built in the form of an annular ring, located at the circumference of the tube face and containing four stages. The output of this amplifier is conducted to an external coupling resistor of about 2000 ohms, and thence to the conventional video head amplifier. A signal of at least 10^{-4} volts is required to overcome the noise, in this arrangement. Actually under optimum conditions, the signal output is approximately 0.01 volt.

It was pointed out in the paper that the charge accumulation on the grid may be allowed to continue for very long periods, since the only paths for discharge are leakage and grid current resulting from the collection of primary or secondary electrons by the grid. Storage times of as long as 15 minutes have been observed. Obviously this is far too long a storage time if moving objects are to be televised. The ordinary storage interval employed in the iconoscope is the frame interval time of 1/30th of a second. Mr. Farnsworth states that storage times as long as 1/5th of a second might be tolerated, but that in any event, additional sensitivity may be obtained by employed storage at least as long as 1/15th of a second. The difficulty at present in the new tube is to limit the storage time to this amount.



Substitution of a voltage regulator tube for a filter capacitor (Acheson)



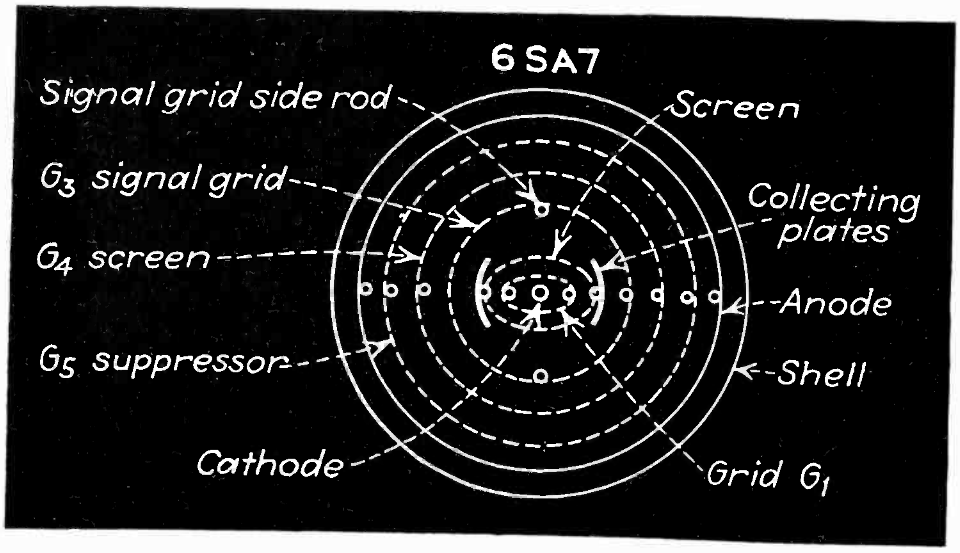
Non-storage image dissector used for television film pick-up

Since secondary electrons are generated, it was to be expected that these electrons might be redistributed on the control grid in such a way that a spurious shading signal would be generated, as in the case of the iconoscope. However, no such signal is observed, and the conclusion is that the secondary electrons are forced to proceed directly through the grid interstices by the high value of space charge existing at the back surface.

After Detail, What?

In the paper "Gamma and Range in Television" I. G. Maloff of RCA Victor pointed out that up to the present the attention of television engineers has been directed almost exclusively to the problem of obtaining adequate detail in the reproduced image. This problem has become correspondingly well understood, and the necessity of proper phase and frequency response is appreciated. However in picture reproduction three other factors are also of great importance: the average brightness of the scene, the range of brightness between the highlights and the shadows, and the linearity of reproduction between differences in brightness in the reproduced image. The purpose of Mr. Maloff's paper was primarily to draw attention to the latter two factors, which can be described in the corresponding photographic terms of range and gamma. Rough electrical analogs of these quantities are the usable gain and the harmonic distortion of the amplifiers or other transducers in the system. Unlike sound transmissions, television pictures may be improved by harmonic distortion.

The gamma of the television system may be described as the exponent of the curve (assumed logarithmic in form) relating the light level in the studio and the corresponding light level in the reproduced image. If the relationship between these quantities is linear, the exponent of the curve between them is unity, that is, the gamma of the system is unity and distinctions in brightness in the televised object are reproduced accurately in the reproduced image. That an overall gamma of unity is desirable seems likely, but it is true that the response curves of intermediate transducers may be far from linear, providing that there are compensating departures from linearity, so that the overall effect is linear. It is suggested, for example, that the response of the transmitter have a compressive characteristic corre-



The electrode structure of the new single-ended pentagrid converter employs some of the principles of the beam power tube in obtaining better performance with one less terminal

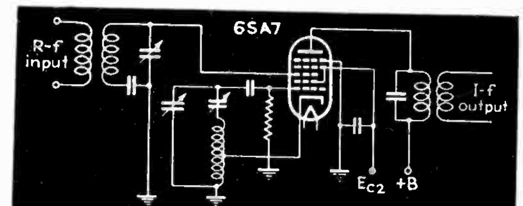
sponding to a gamma less than unity, and that the receiver have an expansion characteristic (gamma above unity), the product of the two gammas being equal to one. Such compression in the transmitter would allow more efficient use of the iconoscope, and could be used to emphasize the picture information relative to the noise.

Feedback Applied to Loudspeakers

Hugh Knowles of the Jensen Company presented an analysis of the application of inverse feedback to loudspeakers. By including the electro-acoustical system in the feedback path, distortion generated in this system is reduced by the feedback action. A very simple and direct method of accomplishing this result is to set up a microphone before the speaker and to feed the microphone voltage to the input of one of the amplifier stages. The difficulty here is that the phase velocity of the sound is so low, relative to the electrical propogation of the signal, that the phase relations cannot be accurately maintained and so the system becomes unstable.

A more practical solution consists in mounting a voltage pick-up coil on the voice-coil of the speaker, with its own magnetic field, and feeding the voltage generated in this coil back to the input of one of the amplifier stages. Any non-linearity in the mechanical system, but not that in the sound field itself, is thereby corrected to some degree.

The impedance looking into the speaker terminals changes with frequency and this effect must be taken into account if instability is to be avoided at the frequencies where the phase shift is great. One method is to derive the feedback voltage from a lumped-impedance network, in series with the speaker terminals having approximately the same impedance variation as the speaker itself. In addition the transfer characteristics inserted in the feedback path must be such that the proper phase and amplitude relations, required for stability, are preserved throughout the frequency range. Under these conditions it is possible to deliver power to the speaker in direct proportion to the square of the voltage input to the amplifier, which implies a linear system throughout.



Oscillator circuit for use with the 6SA7; no oscillator anode terminal is required

Pentagrid Converter

A paper by W. A. Harris, of the RCA Mfg. Co., Harrison, dealt with "A Single Ended Pentagrid Converter" in which were discussed circuits suitable for use with recently designed pentagrid converters in which the pins are all collected at one end of the tube.

Because of the large number of elements in a pentagrid converter, the octal base would not provide a separate pin for each element. Accordingly, if single ended construction was to be maintained, modification of the electrode leads was necessary. Accordingly, an examination was made of the use to which the various base pins were put and it was found that by not providing a separate pin for the plate of the oscillator section, the tube could be made a single ended device using a standard octal base. However, this change required the development of new and unusual oscillator circuits. A large portion of the paper was devoted to the development of new oscillator circuits, for use with this new tube, and the operating characteristics of the tube with the recommended circuits were given.

Single-Side Band Television

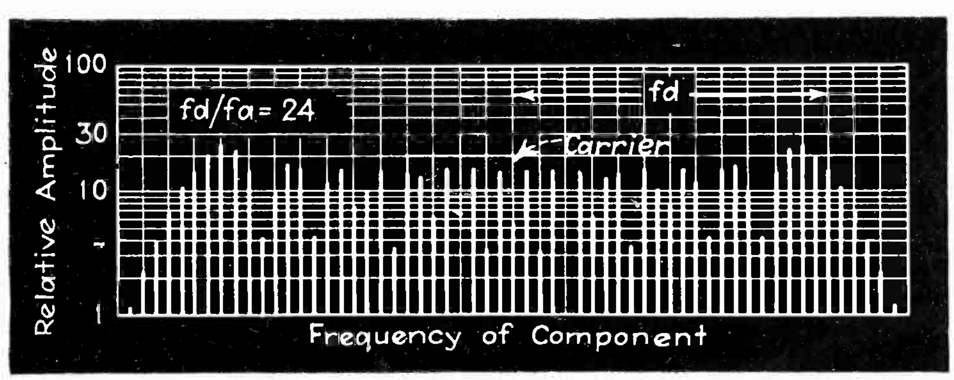
It became apparent at the convention that single side-band transmission of television images is to be the rule in this country, due to progress made in transmitting methods, and that as a result a bandwidth of about 4 Mc (as against about 2 Mc in double-sideband) is available for picture signal. That this doubling of the available picture frequency band would result in a corresponding doubling of the horizontal picture detail is certainly to be expected, but theoretical confirmation was not forthcoming until the presentation by Dr. Stanford Goldman of G.E. in Bridgeport, of the paper "Television Detail and Selective Sideband Transmission".

Dr. Goldman's paper assumed a type of picture detail represented by two square-wave pulses separated by a space of equal width. These pulses are used as the modulating envelope of a high frequency carrier, and this carrier and sidebands applied to a transmission system have a flat response over approximately 4 Mc with a linearly sloping cutoff at each end of this range. First the carrier frequency was placed in the middle of this range, corresponding to double sideband transmission with 2 Mc sidebands, and then the carrier was moved in succession to five other points in the pass band, closer and closer to the edge, the last two being on the cutoff slope itself. One of these positions, half way down the cutoff slope, corresponds to the tentative standard for the position of the carrier in single-sideband transmission, as recommended by the RMA. The investigation was carried out by means of the Fourier integral and involved much laborious calculation. The conclusion is that two square-top pulses are resolved in the double-sideband case only if their separation in time is twice as great as is required for resolution in the single-sideband case, which confirms the off-hand conclusion drawn from the fact that the frequency band is then twice as great. However in the case of a sudden rise in signal (so-called "unit function" impulse) not followed quickly by a corresponding fall, then the single-sideband transmission offers very little improvement over the double-sideband case. It appears, in other words, that single-sideband transmission does not aid in reproducing sharply the edge of an extended dark region on a white field (or bright region on a dark field) but that it does aid in the more important case of distinguishing edges between separate small details, such as isolated picture elements.

root of the bandwidth, and that the wide band width of the television system imposes interference roughly 20 to 30 times as great as those encountered in sound reception.

The arguments for and against automatic gain control in television receivers were reviewed. On the one hand fading is usually not severe on the ultrahigh frequencies, but changes in gain due to line voltage changes, etc., and the differences in signal strength in tuning from one stage to another are sufficient to require automatic compensation, especially since the eye is very sensitive to small changes in contrast.

The demonstration employed a television projection tube, and a screen about 4 by 6 feet in size. The projection tube was fed from a receiver, on which was impressed a standard RMA-type television signal, generated in an iconoscope located several floors below. An artificial transmission line, consisting of small lumped inductances and capacitances was inserted in the receiver circuit to show the effect of single and multiple reflections, and in addition phase distortion of the type which produces a white margin at the trailing edge of each black portion. The effect of reducing the picture bandwidth from 3 to 1.5 Mc was also shown. The above defects were shown on a standard pattern. Later the iconoscope was turned on L.C.F. Horle, Virgil Graham, and an unnamed member of the fair sex, as well as on the street scene below the hotel window. This was the first demonstration of moving projected television images in this country, to the best of the editor's knowledge. The paper was very well received by a capacity audience.



Frequency spectrum of a frequency modulated wave whose deviation frequency is 24 times the audio modulating frequency. Note the low amplitude of the carrier

The Seeley-Foster Television Demonstration

A very impressive demonstration of the several important faults in television images was given by engineers of RCA in connection with the paper "Principles and Methods in Television Laboratory Technique" by Messrs Seeley and Foster. The preliminary part of the paper discussed some of the similarities between audio and video engineering, as well as the differences. Mr. Seeley pointed out that many interfering effects, such as hiss, increase as the square

Frequency Modulation

C. B. Fisher of the Northern Electric Company, whose reputation for presenting valuable summaries of radio advancement began at the 1937 Meeting when he presented a paper on negative feedback, gave the convention this year a similar treatment of the subject of frequency modulation. He began by pointing out that the frequency band occupied by a frequency modulated signal extends well beyond the limits of the frequency swing employed, and that the band width occupied depends on the ratio of the deviation (swing) frequency to the audio modulating frequency.

One very simple method of generating a frequency-modulated signal, described by Mr. Fisher, is based on the fundamental automatic frequency control circuit of Travis.

A Colpitts oscillator circuit, containing a small resistor in the tuned circuit, is connected to a source of audio voltage which is impressed across the resistance. The frequency of the oscillator is thereby varied by an amount directly proportional to the audio voltage. A similarly simple frequency-modulation detector circuit was described, employing a series resonant circuit, fed from a high impedance source. The circuit is tuned near the unmodulated carrier frequency. The diode detector is connected across the capacitance of the tuned circuit. A rectified output voltage of about 0.2 volt is obtained from a frequency swing of 100 kc when the input amplitude is 2 volts. The necessity of eliminating the response of the receiver to amplitude changes was emphasized.

Dissector Tubes for Motion Pictures

A second paper from the Farnsworth Laboratories was presented by C. Larson and B. C. Gardner on "Production of Image-Dissector Tubes for Motion Picture Pick-up". A typical tube of this type is shown in the accompanying illustration. It consists of a cylindrical glass envelope containing a flat metal photosensitive plate. The optical image, entering the envelope through a flat window at the opposite end of the tube, creates a corresponding electron image which is drawn from the cathode surface down the tube by the positive potential applied to the wall coating. Magnetic focussing coils are employed to bring the electron image into focus in the plane of the scanning aperture. Beyond the aperture, an eleven-stage electron multiplier of the d-c variety amplifies the signal current. Under ordinary conditions of illumination, the signal obtainable from the tube is too small, relative to the noise, to produce an acceptable picture. However, if the tube is employed for motion picture projection, where the light may be highly concentrated, signal-to-noise ratios of 30-to-1 or 40-to-1 may be obtained readily.

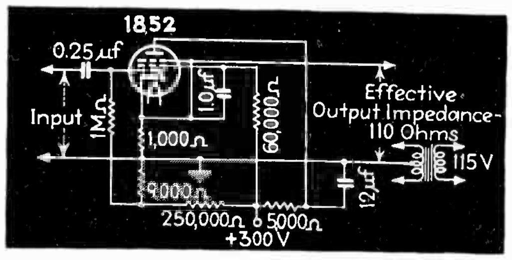
Since the tube is not a storage device, it is necessary to employ a continuous film projector. The mechanism of such a film projector developed especially for this purpose has recently been described in *Electronics*, in the July 1938 issue, page 25.

Input Circuits for Television Receivers

The important, and thus far rather neglected, subject of r-f input circuits for television receivers was discussed by H. T. Lyman of General Electric. It was pointed out that selectivity in the input circuits, in the r-f and converter sections is necessary to reduce image response and interchannel interference, as well as direct pick-up at frequencies within the i-f bandpass region. The effects of such interference, while inaudible in the audio channel, have a very serious effect on the reproduced picture. The problem is complicated both by the wide band to be accepted for each station (roughly 5.5 Mc assuming single-sideband reception) and by the extreme range of the television spectrum, from 44 Mc to 105 Mc. It was shown that an ordinary doublet antenna is capable of covering this range if tuned to the geometric center of the range (about 70 Mc) but that the response of such an antenna at 47 Mc would be roughly 60 per cent of the response at 70 Mc, and about 50 per cent at 105 Mc.

Tuning of the input and converter circuits, for maximum gain, should by accomplished by variable inductance, with fixed (and minimum) capacitance. In view of the need for simple controls ("push a button and there's your picture") switching is accomplished most readily by a push-button switch.

The relative merit of various tubes available for use in the input circuits was investigated, with the conclusion that the 1853 tube was best for the r-f stage, an 1852 for the converter, and a 6J5 for the oscillator (in the latter case a 955 would be preferred were it not for its higher price). The effect of tube noise was also investigated in the r-f stage, using an 1853 as the basis of computation. The signal-to-noise ratio in the plate circuit of this tube was calculated to be 57.2-to-1, on the basis of a 4 Mc bandwidth, with a signal field strength of 1000 microvolts per meter. Assuming that a signal-to-noise ratio of 20-to-1 is the minimum acceptable, this means that a satisfactory picture can be derived from a field strength of 350 microvolts per meter or higher.



Impedance transformer circuit employing high g_m tube

High g_m, U-H-F Tubes

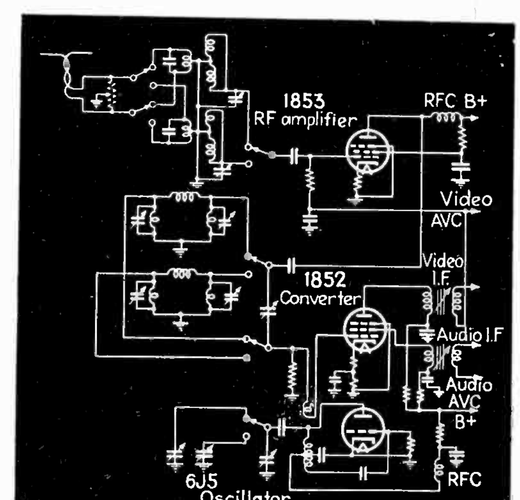
The design, construction, and characteristics of the 1851, 1852, and 1853 tubes developed for television use where discussed by A. P. Kauzmann in a paper, "New High Transconductance Ultra High Frequency Tubes".

The low loads required for the construction of wide band amplifiers which are required in television service behave in such a way that little or no gain is obtainable from standard radio tubes, and new tube structures were required for television use. An analysis of the circuit requirements showed that suitable tubes might be made by increasing the transconductance or by decreasing the interelectrode capacitances of the tube. Further analysis showed that the first of these two alternatives was the more desirable.

Reduction of interelectrode dimensions and spacings resulted in a number of manufacturing difficulties which had to be overcome. In order to produce a fairly uniform field at the cathode as a result of potential on the grid and obtain high transconductance at the same time, it was found that the grid-cathode spacing would be of the order of 0.005 inch, the grid pitch would be 250 turns per inch and the grid wires would have to be 0.0015 inch in diameter. Because of manufacturing difficulties, grid 0.002 inch in diameter with a pitch of 140 to 150 turns per inch were used and proved satisfactory. Flat, rather than cylindrical grids were employed to produce stable grid structures. The screen grid was removed as far from the cathode as practical and was operated at high screen voltage. Since the tube directed the electron stream into a beam, certain sections of the plate were not used to collect the electron stream. Accordingly these unused sections were cut away to reduce interelectrode capacitance. With this construction, emission from the grid became serious, but this difficulty was remedied by conducting the heat away from the grid by means of large side rods. The final design employed the single ended tube construction mentioned on page 26 of *Electronics* for September, 1938.

Overvoltage Timer

For purposes of making quick analyses of voltage variations, graphical recordings are unsatisfactory



Two channels of the 7-channel television r-f switching system (Lyman)

because they are too complicated and require so much time to analyze that the tape usually accumulates more rapidly than it can be analyzed. It is frequently satisfactory to know only for what percentage of time voltage fluctuations exceed some predetermined value. A paper by C. M.

Burrill and E. T. Dickey, and presented by the first author, described an instrument which measures the percentage of time for which a voltage exceed a certain value of specified magnitude. Essentially this overvoltage timer consists of a rectifier and two stage d-c amplifier which feeds a slow acting d-c d'Arsonval movement. A quiescent voltage which may be applied to the rectifier determines the voltage magnitude for which the rectifier becomes conductive, and therefore determines the reference voltage beyond which the instrument registers. The slow acting d-c meter integrates the rectified and amplified pulses.

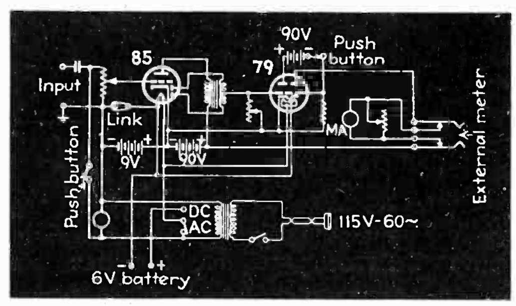
The particular instrument described is arbitrarily calibrated to indicate those voltages which are exceeded 85%, 50%, and 5% of the time. While these quasi-minimum, median, and quasi-maximum values are arbitrarily selected by the authors, they have been found to be useful in providing quick and rough specifications of voltage fluctuations, such as might be encountered in making noise measurements. While the authors do not recommend the instrument as a "noise meter" they feel that because it provides a simple, quick, and quantitative measurement of voltage fluctuations, the instrument would be useful in noise measurements. Familiarity with the instrument and its use are required to obtain greatest use from the device.

Engineers Discuss Economics of Television

An important extemporaneous talk by W. R. G. Baker directed the attention of engineers to the economic and business aspects of television. As head of the Engineering Department of the RMA, Mr. Baker spoke on recent RMA policies in order better to acquaint engineers with policies and trends of the manufacturing organization. While some of the points brought up were personal opinions of Mr. Baker, they are also being given consideration by various RMA boards and committees.

The desirability of having all radio receivers bear the approval of the Underwriters' Laboratories was discussed. It was pointed out that whereas practically all a-c receivers selling at more than $20, had the approval of the Laboratories, very few sets selling at less than this figure, and practically none of the a-c/d-c receivers had such approval.

It was realized that the inauguration of a new television industry next spring would bring about many new and unanticipated problems which would require engineering analysis. By thinking as much as possible about these problems, by aiming at an engineering approach to their solution, and by deferring immediate gains, if necessary, in order to build up a sound substantial industry, it was hoped that the television industry might avoid much of the prostitution which has occurred in the radio manufacturing industry. Accordingly engineers were urged to take active participation, together with their executives, in providing solutions to many of the problems of the incipient industry.



Overvoltage timer circuit useful in noise measurements

Among the problems which will face the television industry, Mr. Baker enumerated six of the most important. The first of these had to do with a standardized term for a picture tube. At present these are called kinescopes, cathode ray television tubes, picture tubes, and a variety of other names. Standardization of one recognized term would eliminate many difficulties and misunderstandings.

Along with the standardization of the term for a picture tube is one of the standardization of the tube itself. Tubes of several sizes and characteristics may be required to meet the various demands, but it is felt that it is highly desirable that the types of tubes be kept to some fairly small number.

The third item which was mentioned is one of standardization of the size of the picture. Undoubtedly various picture sizes will be available, depending upon the size of the tube employed. But for each size tube it might be possible to specify a definite, maximum picture size which could be used for advertising receivers. Such standardization would tend to prevent "gyp" advertising by which the size of the image might be increased at the expense of cutting the corners off of the picture.

The fourth question dealt with the operation of the receiver, and it was recommended that the operation of television receivers be reduced to the minimum number of controls. Questions as to whether or not the manufacturer should guarantee the operation of the receiver, and if so, for how long a time were brought up. Who should service receivers, and how should service men be trained to service television receivers were also placed before the engineers for their consideration.

The installation of television sets was briefly discussed as the fifth point. Should the set be installed complete with the antenna? If so, who should erect the antenna and bring in the antenna leads? Should the location in which a television receiver is to be used be surveyed in order to ascertain that adequate signal strength will be obtained? Who should conduct such a survey? If the survey indicates inadequacy of signal strength, what should be the policy toward selling a television receiver?

Finally, the desirability of defining a television receiver was stressed. Is a television receiver one providing only visible images, or pictures together with sound? What are we to call those sets which provide only sight or sound channels? What are we to call those receivers which bring in the normal broadcast stations as well as the audio and video channels of television systems? What shall we call all wave sets which include television services? What does the industry expect to do about attachments, such as a separate video and picture system for a radio set capable of picking up the audio channel?

Distortion Analyzed by "Paired Echoes"

One of the most significant papers of the convention was that presented by H. A. Wheeler of Hazeltine on "The Interpretation of Amplitude and Phase Distortion in Terms of

(Continued on page 33)

Remote Tuning of

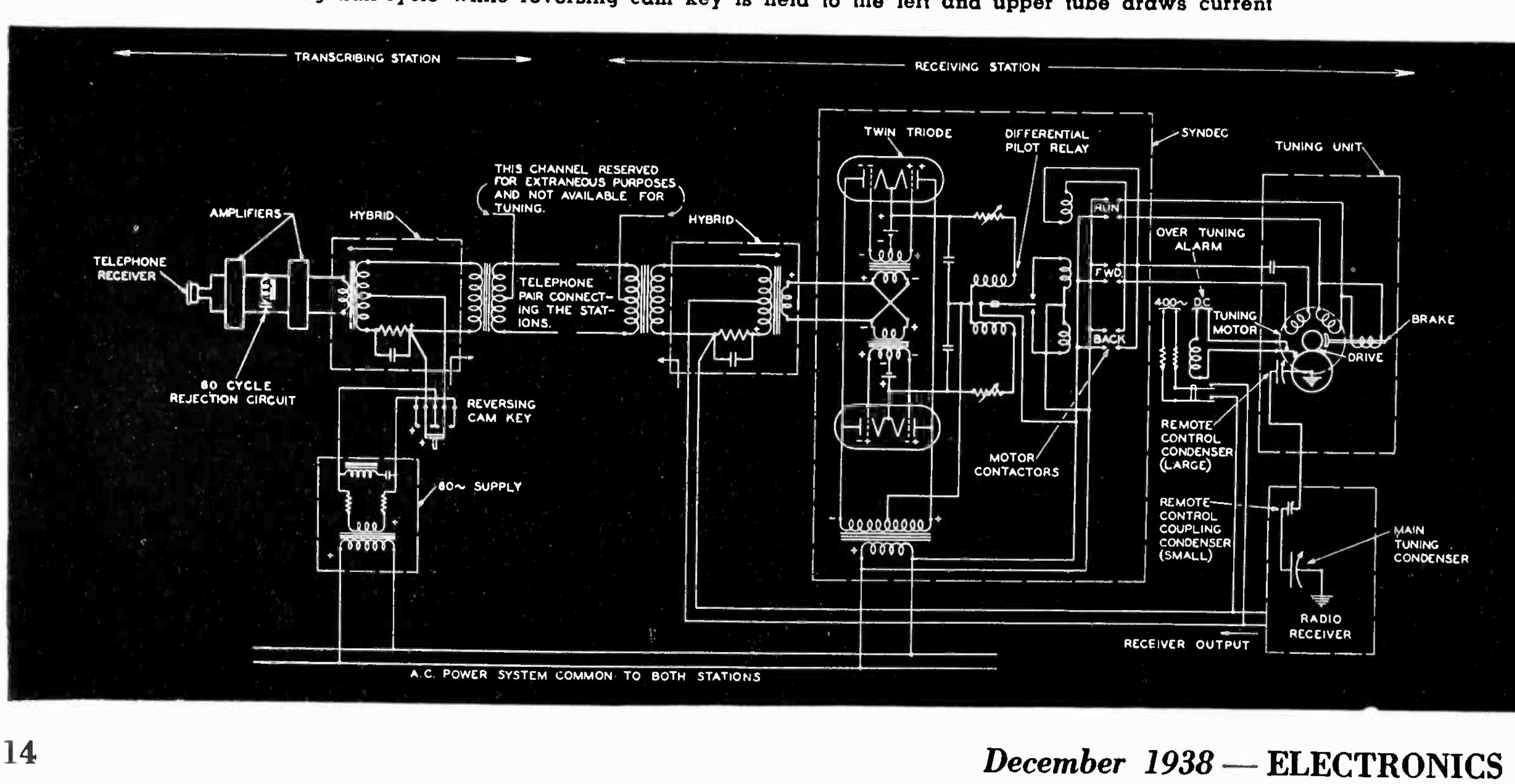
WHEN Globe Wireless went into remote reception of telegraph signals, control of the fine tuning of distant receivers was required for telegraph operators located in the city offices. Audio signals were run into the city office from the receiving station on standard telephone pairs in cable, and for reasons of line economy it was not desired to use any channels for tuning which could by the ordinary devices of telephone line practice be made available for any other purpose. "Simplex" or phantom circuits are thereby eliminated as well as super-audio frequencies, the latter because the telephone lines cut off at about 2500 cycles. There remained for tuning control only the use of frequencies distinctly within the audible spectrum.

60 cycle energy taken from the city office lighting mains was accordingly adopted as a source of energy for receiver tuning signal control. This is reduced to a suitable voltage and applied to the telephone pair on which the signals come in. Now the incoming signal must still be audible during the tuning operation and as during corrective tuning the signal is likely to be weak, the amount of interference must be even less than that which can be tolerated during normal reception. Conventional hybrid networks are used at each end of the line to give a directional discrimination as between incoming telegraph signal and outgoing tuning control. Such networks are not perfect over a range of frequencies, and some further precautions are taken against side-tone. The harmonics of the 60 cycle tuning energy are first filtered out by a series resonant circuit before the energy is applied to the hybrid network. The small amount of purified 60 cycles which leaks through the hybrid network is then blocked off by a similar 60 cycle filter between the stages of the final amplifier, which results in practically silent tuning.

The arrangement so far described gives a single-sense control for operating tuning relays at the receiving station, and can be converted into a double-sense control for operating the motor forwards and backwards by the use of a second circuit for phase comparison. Such a second circuit is actually available in the form of the public power supply common to the two stations. Phase comparison, amplifying, and rectifying are all accomplished at the receiving station in a device called the *syndec* (synchronous detector.) The syndec employs two 6A6 duplex triodes of which the plate voltage is supplied at 60 cycles from the power mains and the grid voltage from the tone channel through the hybrid network. The four plates and grids are cross-connected relatively to each other in such a way that when 60 cycle energy is sent out from the controlling station the plate and grid voltages in one tube will be in phase and current will flow each positive half-cycle, while those in the other tube will be out of phase and the tube continuously blocked. Turning the phase over at the control station reverses the grid phase and leaves the plate unchanged, shifting the rectified output to the other tube. The d-c component of the cathode currents is put through the two coils of a differential polar relay which makes no contact in the balanced state, but when unbalanced operates the contactors of the tuning motor for right-handed or left-handed rotation as desired.

In the typical case the band covered by remote tuning is narrow, but a very close control is called for. The initial stages of the receiver are accordingly set up by an attendant at the receiving station and only the detector-oscillator stage is tuned from the control point. As is well known, the use of a small condenser for fine tuning directly in parallel

Diagram (minus tell-tale wiring) of the remote tuning system. Polarity marks indicate instantaneous values during half-cycle while reversing cam key is held to the left and upper tube draws current



Communication Receivers

By
By HANS OTTO STORM
Globe Wireless, Ltd.

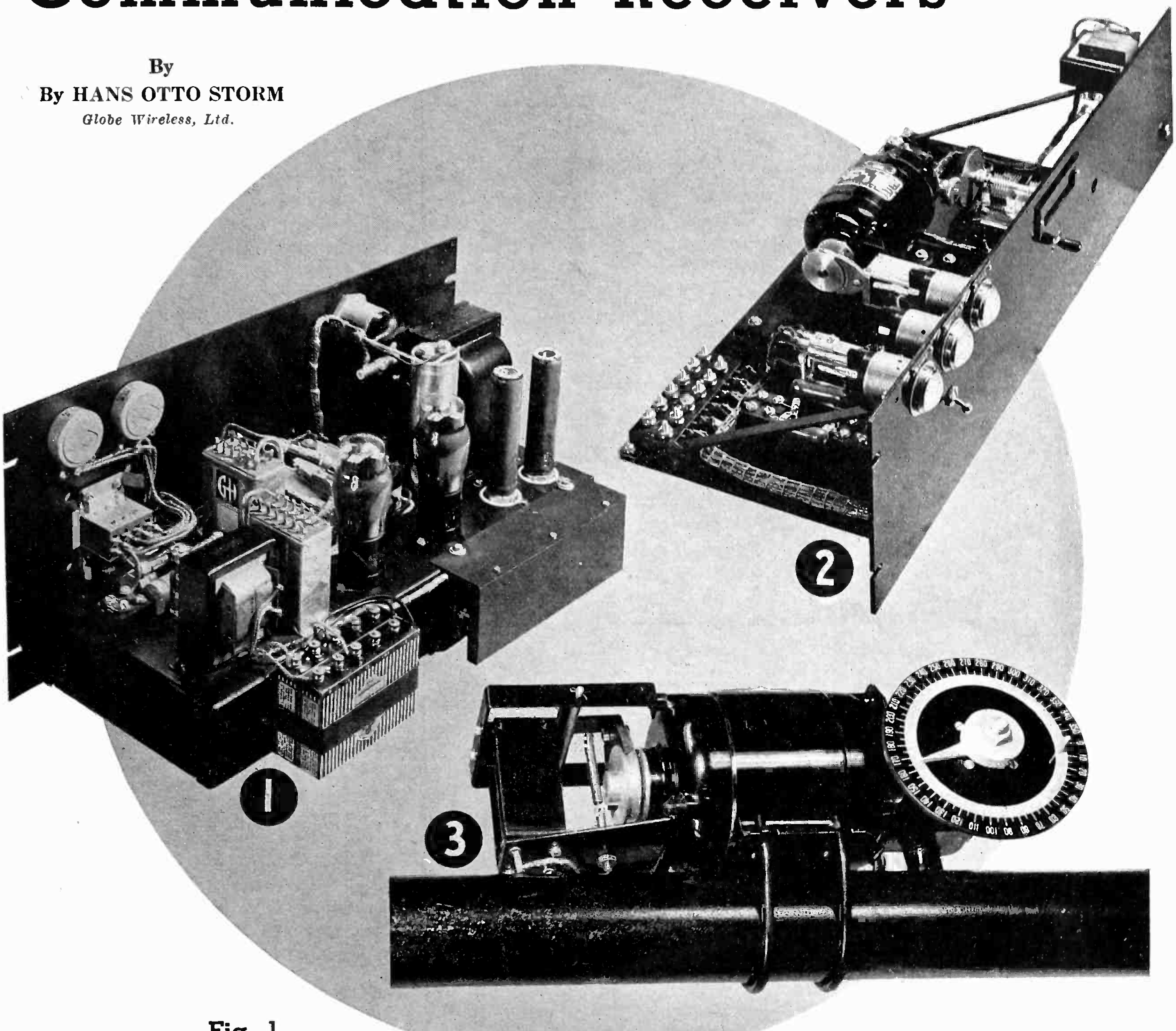


Fig. 1
The Syndec, or synchronous detector

Fig. 2
The tuning unit on its relay rack mount

Fig. 3
The tell-tale enabling receiving operator to see as well as hear the remote tuning

with a larger one introduces fixed capacitance which lessens the overall tuning range; for this reason a special arrangement was adopted. An extremely small trimming condenser is connected in parallel with the main tuning condenser but the low voltage side of this trimmer, instead of being returned in the usual way is joined by a connecting wire to a relatively very large condenser turned by the tuning motor. The connecting wire, being at nearly ground potential for radio frequencies, does not constitute an undesired encumbrance on the main tuning condenser, with the result that the motor-driven condenser can be put as far as 18 inches away from the receiver even with the highest radio frequencies used. Problems of motor noise, microphonics, and conversion of existing receivers are thereby simplified. By varying the capacitance of the small coupling trimmer, the band over which the remote tuning condenser swings the signal, can furthermore be made wider or narrower as desired.

The motors used are synchronous self-starting induction motors with 900/1 reduction gears built in, and run the tuning condenser through a 2/1 brass-to-rubber friction drive, moving the condenser at 1 rpm, or 30 seconds from end to end of the 180 degree tuning range. An electric brake is provided so that after the signal is tuned in and the control switch released, the motor does not coast. When the condenser comes to the end of its travel in either direction, a cam on the condenser shaft

(Continued on page 32)

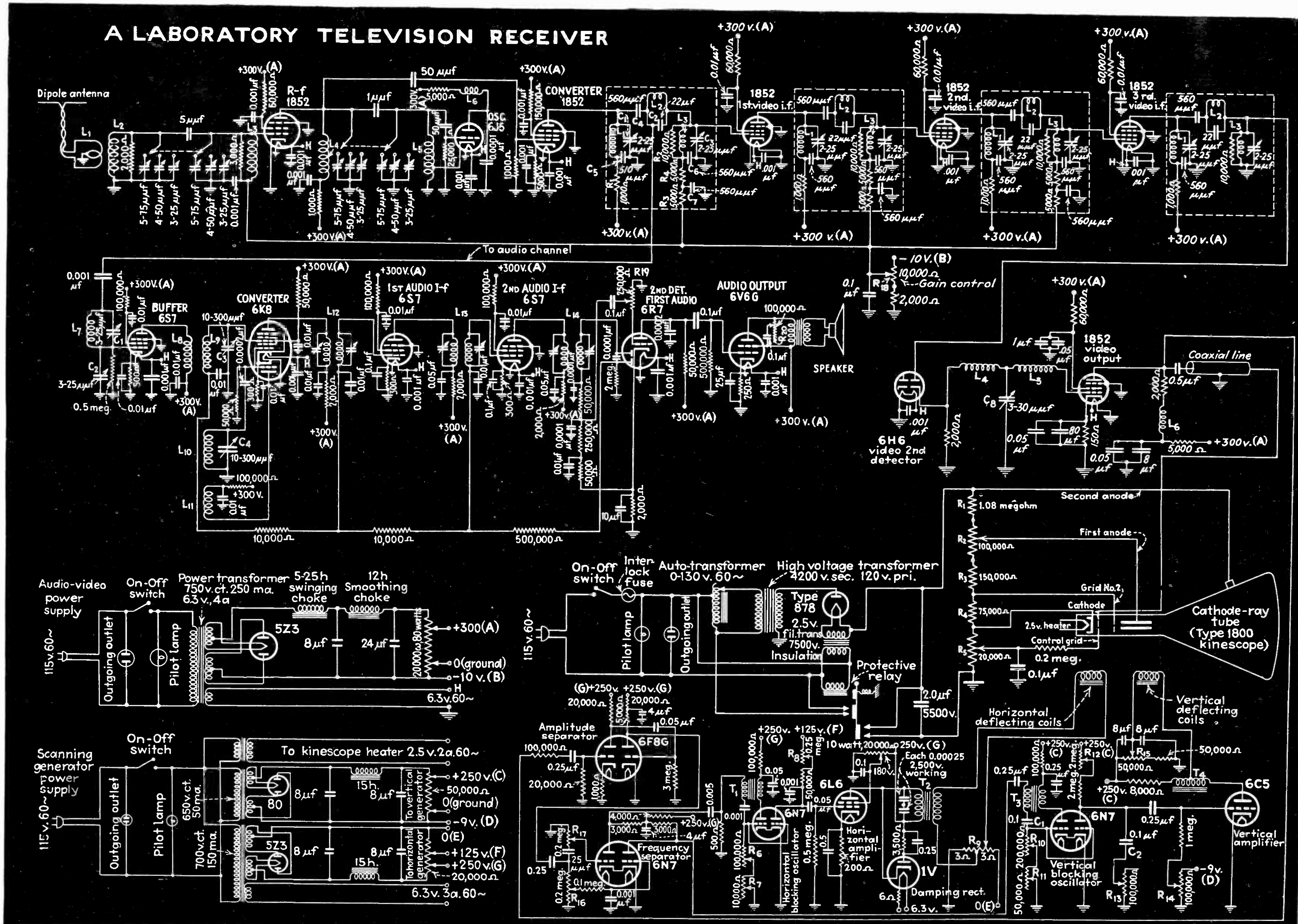


Fig. 1—Complete circuit diagram of the receiver, labelled to correspond with the sectional diagrams given in the preceding installments

A Laboratory Television Receiver—VI

Adjustment of circuits for selective side-band transmissions, antenna installation. complete circuit diagram, cost estimates, and examples of received images make up the concluding installment of this series

By DONALD G. FINK
Managing Editor, Electronics

IN the latter stages of the construction of *Electronics'* receiver it became apparent that double-side-band transmissions were rapidly becoming things of the past. Experiments with the NBC transmitter, and in other instances, have demonstrated that selective side-band transmissions are entirely feasible. At the Rochester Fall Meeting the R.M.A. Television Committee tentatively adopted selective-sideband transmissions as a recommended standard. According to this standard, the audio carrier remains at a position 0.25 Mc. below the upper limit of each 6 Mc. channel (at 49.75 Mc for the 44-50 Mc channel, for example). The vision carrier is placed 4.5 Mc lower in frequency than the sound carrier, that is 4.75 Mc below the upper limit of the channel, or 1.25 Mc above the lower frequency limit. This means, in the 44-50 Mc channel for example, that the vision carrier is located at 45.25 Mc.

In the present receiver, the oscillator frequency is 13 Mc higher than the vision carrier, that is, 45.25 + 13 = 58.25 Mc. The audio carrier of 49.75 Mc, beating with this oscillator frequency, produces an intermediate frequency of 58.25 — 49.75 = 8.5 Mc. Consequently, the audio channel must be adjusted to receive an 8.5 Mc signal. Fortunately the component parts

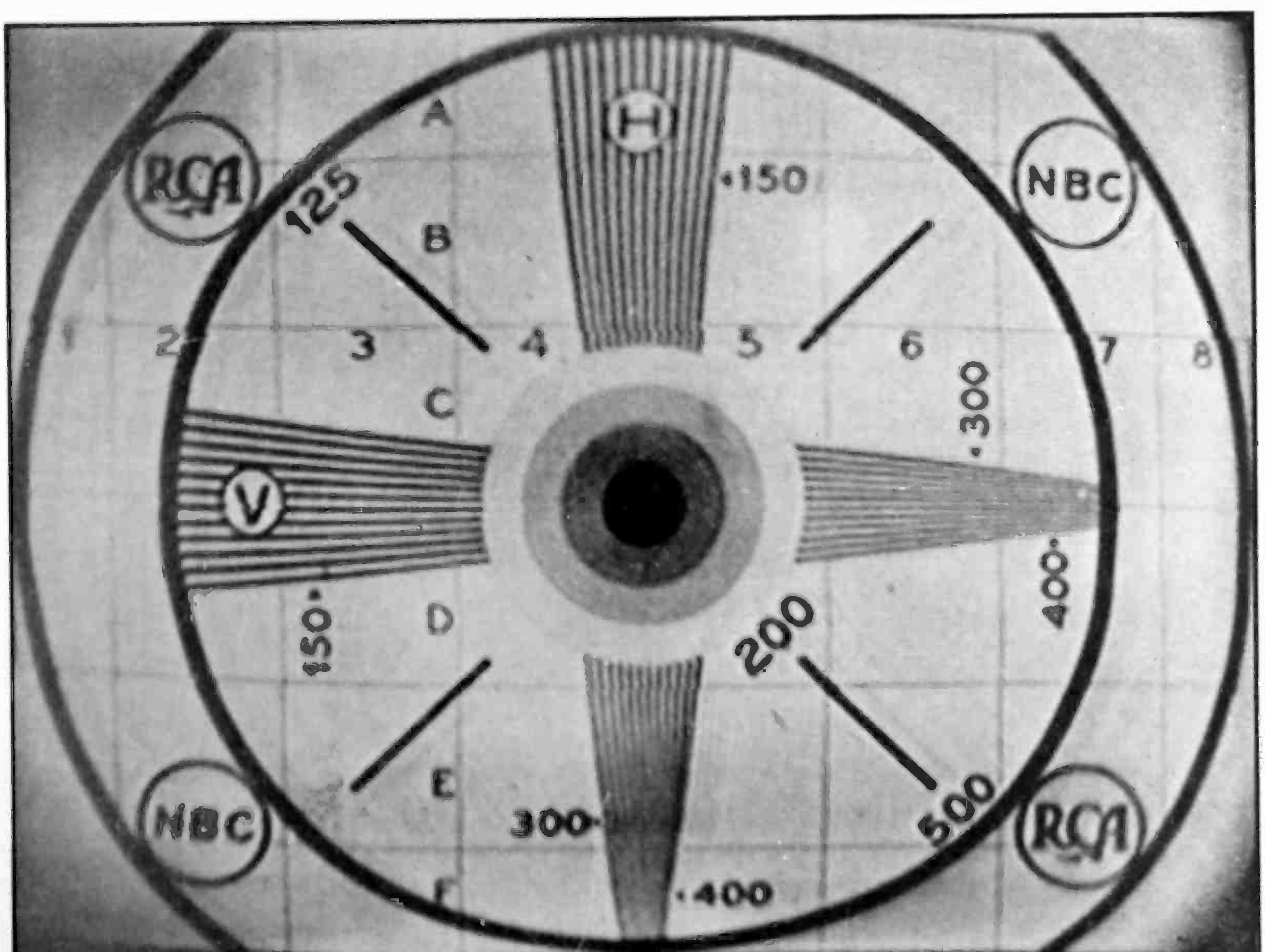


Fig. 2—Image of test pattern, actual size, as received from Empire State transmitter using complete receiver shown in Fig. 1

in the audio channel (shown in Fig. 4, Part IV, page 19, October issue) have sufficient range to make this change. In lining up the receiver for selective side-band reception, therefore, the instructions in Part IV may be followed, except that the oscillator frequency must be changed from 59.5 Mc to 58.25 Mc. The oscillator frequencies for the other channels must be reduced 1.25 Mc in each case. The audio channel is tuned to accept a signal of 8.5 Mc and this adjustment holds for all channels.

The bandpass of the video i-f amplifier must of course remain at the 2.5 Mc bandwidth for which the i-f coupling units were originally designed. The transmitter in the selective sideband system actually employs a modulating signal having components from 0 to 4 Mc, hence the receiver in its present form cannot make use of all the information transmitted. The remedy in this case is a complete redesign of the video i-f coupling units. While such a redesign is desirable, the fact remains that very acceptable performance may be obtained with the receiver limited to 2.5 Mc bandwidth, and that substantially equal picture resolution in the vertical and horizontal directions (see Fig. 2) is obtained. Increasing the bandwidth decreases the i-f amplifier gain, all other factors being equal, and lowers the signal-to-noise ratio. In view of these factors, the writer does not hesitate to recommend constructing the video amplifier on the basis of the 2.5 Mc bandwidth, as outlined in Part V, November issue. When satisfactory performance is obtained on the basis of this relatively simple requirement, new i-f coupling units, designed for 4 Mc bandwidth, may be inserted without major constructional or electrical changes.

The complete circuit diagram

In Fig. 1 is given the complete circuit diagram of the receiver, including 25 tubes, the cathode-ray tube, and all components for power supplies, sync separators, scanning generators, and video-audio superheterodyne. The labels of the parts have been made to correspond with the symbols used in the text, in the preceding installments, to describe each portion of the receiver. Certain slight changes have been made in the design, principally involving changes in the sizes of some fixed resistors. The diagram in Fig. 1 shows the final values in each case.

A word of caution should be given concerning the sizes of the coils in the u-h-f portion of the receiver. It is extremely difficult to design such circuits for reception above 70 Mc without a good source of signal energy. In the present instance, harmonics of a signal generator were the only source, and this fact, coupled with the double-conversion process used in the sound channel, produced a large number of spurious responses. Present indications are that the inductance values given in the preceding installments are somewhat too large for reception on the highest of the three frequency channels. The reader may find it necessary to reduce the inductance. The values stated give excellent results on the highest channel, that from 44–50 Mc, which is the only one on which a video signal is now available in the New York area. As further information on the higher channels is obtained, it will be published.

When the circuits have been lined up by signal generator as outlined above, slight residual adjustments must usually be made to bring the receiver into operating condition. The most critical adjustment is the tuning capacitor of the oscillator circuit. A slight readjustment will usually improve the definition of the received picture. It is necessary to make a corresponding change in the tuning of the audio channel to bring the audio circuits into tune with the 8.5 Mc intermediate frequency.

When the signal is tuned in, the scanning generators will in general be out of synchronism. First adjust the horizontal scanning generator frequency control (R_6), with the horizontal sync amplitude control (R_{17}) at the middle of its range. Synchronism will be readily apparent by the appearance of detail in the image. Two synchronized positions can usually be found, representing "free" scanning frequencies slightly above and below the sync frequency. In one case (the desired setting) the picture will be

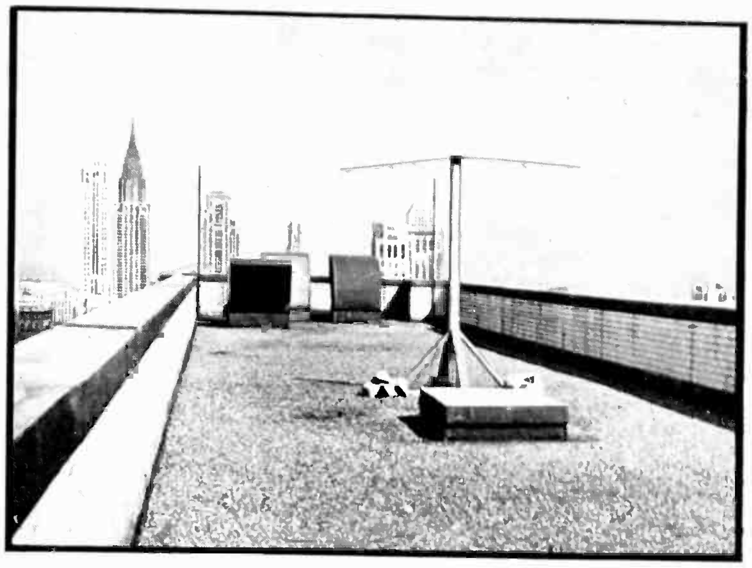


Fig. 3 — Antenna system. Two 4-foot brass rods insulated at the center feed a 50-foot twisted-pair transmission line. Reflections are minimized by placing antenna in middle of roof. Sandbags prevent structure from blowing over

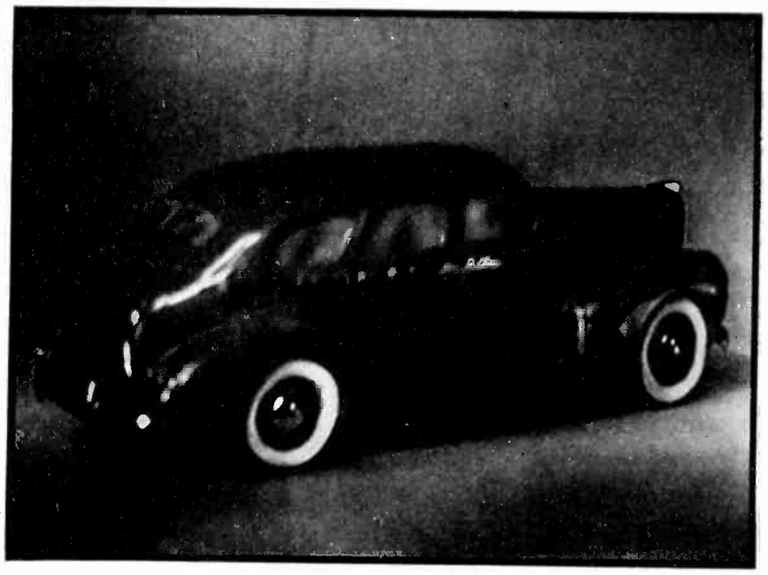


Fig. 4—"Ordinary subject matter". During the recent Auto Show, NBC broadcast. This image, received on the receiver as shown in Fig. 1, is a small model of the new Nash. The exposure was 1/10th second on panchro press film; chromium intensification of the negative before printing

properly centered. In the other, the picture will be divided in the middle by the horizontal blanking pulses.

When proper horizontal synchronization has been obtained, the vertical synchronization must be adjusted. Lack of vertical synchronization will produce a rapid upward or downward motion of the frames in the picture, but this is readily corrected by adjustment of the vertical scanning frequency control (R_{10}) and the vertical sync amplitude (R_{16}). When vertical synchronization is achieved, attention must be paid to the degree of interlace. To insure good interlace performance an adjustment of R_{16} and R_{10} should be made with the vertical scanning amplitude control (R_{12}) set at maximum, so that the lines in the image are spread well apart. Proper interlace is readily apparent by the evenly-spaced appearance of the lines. Usually it will be found that a fairly high setting of R_{16} is required.

When synchronism is established, attention must be paid to the focus, brightness, contrast, and picture amplitude (width and height) controls. The spot size and fineness of focus depend on the overall brightness setting. In general it is desirable to set the brightness at as low a setting as the room illumination will allow, adjust for maximum sharpness of focus, and adjust the contrast control until the most pleasing effect is obtained. If a test pattern is being televised, the contrast control should be adjusted until the center shaded circles appear to have approximately equal differences in tone (see Fig. 2). There is no real solution to the problem of circuit adjustment except practice. All circuit adjustments, except those made by means of knobs on the front panel, should be made with the high voltage supply *off* and *disconnected.*

A typical pattern received by the receiver is shown in Fig. 2. This pattern was received with the connections exactly as shown in Fig. 1. The pattern has several defects: spot defocussing at the edges of the pattern, slight pairing of the interlace, some white edges due to phase distortion, several faint ghost images probably arising in the transmission line, two slight tears due to faulty line sync, and a slight non-linearity of vertical scanning. Nearly all these defects can be improved by adjustment of the circuits, but no opportunity to correct them has been available, because the NBC transmitter has been on the air very infrequently since the receiver was completed. The degree of vertical and horizontal detail is very nearly the same, about 300 lines vertically and nearly 300 horizontally, the latter figure corresponding to the 2.5 Mc. bandwidth for which the video channel was designed. The pattern is a very critical test of the receiver performance. Viewed on ordinary subject matter (see Figs. 4 and 5) the defects are almost completely undetectable.

Cost Estimates for Various Sections of the Receiver

A complete cost record has been kept of the component parts of the receiver. The total cost of the complete receiver, including all parts, tubes, mountings is $324.27, at the usual mail-order house prices. At list prices the cost would be roughly $500. The cost is divided into the following sections: High voltage power supply, including tubes, $57.60; video-audio power supply, $15.88; scanning generator power supply, $19.41; cathode ray tube and mount, including the scanning generator circuits, bleeder controls, etc., $128.87; audio-video superheterodyne including all tubes, $91.81; panel rack, $10.70. The cost of tubes alone, including cathode-ray tube, is $87.88. The cost of tubes and components shown in Fig. 1, including no mounting parts except tube sockets, is $262.04.

The remaining problems are three: eliminating acoustic feedback from the loudspeaker to the 6J5 oscillator tube and its associated tuned circuit; reducing the interaction between the 6J5 oscillator tuning and the 1852 converter tuning; and shielding the video i-f circuits from direct pick-up from nearby code stations within the 10.5 to 13 Mc passband. None of these are difficult problems, but they do require time.

Signal generator tests indicate that any signal from 1 volt down to 1 millivolt, at the antenna terminals, will provide adequate performance with the contrast control (R_{18}) set well below maximum gain. A recognizable signal of nearly full amplitude can be obtained with about 50 microvolts, with the contrast control wide open, but the noise and tendency of the circuits to oscillate at this limit produce rather bad interference. Likewise the video i-f response characteristics under this condition are degraded by the change in tube input capacitance (Miller effect) with plate current in the 1852 i-f amplifier tubes. For signals within the design limits, 1 millivolt or higher, an acceptable picture may be obtained in any noise-free location.

The author wishes to acknowledge with gratitude the assistance rendered by the General Radio Company, the Allen B. DuMont Laboratories, and the RCA Victor Division for the loan of indispensable test equipment, to C. C. Shumard and Philip Richards of the RCA Radiotron Division for their invaluable help in the video i-f coupling-unit problem, to C. A. Nuebling, Technical Editor of *Radio Retailing* for advice and help on the u-h-f portions of the receiver, and to Beverly Dudley, of *Electronics*, for his untiring assistance in photographing the equipment and the received images.

Fig. 5—"Extraordinary subject matter." One of the young lady announcers during the auto show broadcast. The superimposed "veil" pattern is caused by interference from a press code station, WHD, which operates within two blocks of the receiver on a frequency in the video i-f pass band

Electronic Control Circuits for D-C Motors

By J. D. RYDER
Bailey Meter Co.
Cleveland, Ohio

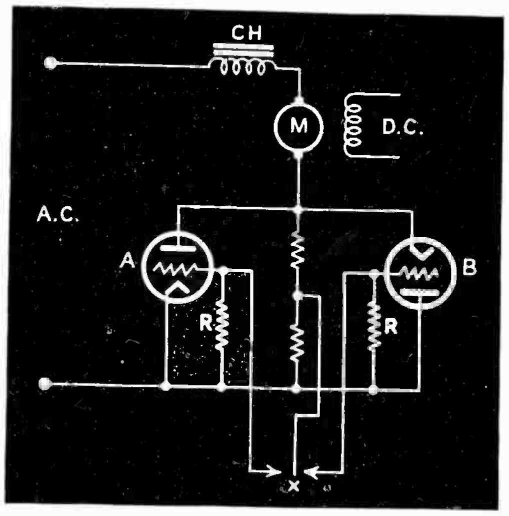


Fig. 1—Circuit for obtaining reversal and speed control of motors from thyratron tubes

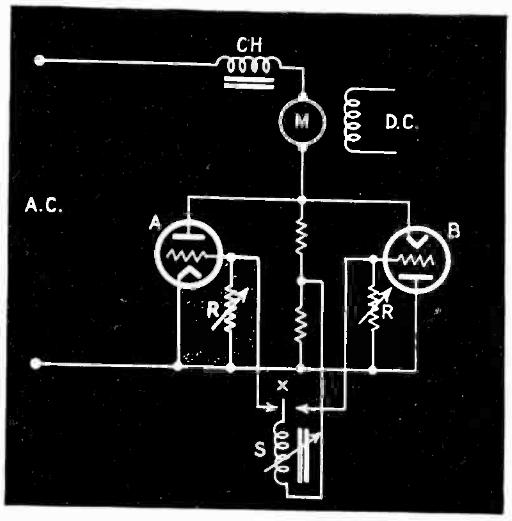


Fig. 2—Motor reversal and speed control of d-c motors are possible with this circuit

A CIRCUIT for obtaining reversal and speed control of ¼ or ½ hp motors directly from thyratron tubes, without intervening relays, is sometimes of interest to engineers. This paper describes simple circuits which were developed by the writer. In one of these circuits for motor reversing service, a very efficient and simple method of "plugging" or braking a motor is used.

Figure 1 shows a circuit for obtaining reversed rotation of a d-c motor by the now more or less familiar scheme of connecting two thyratrons "back to back" in series with a separately excited d-c motor. Due to the rectifying action of the thyratron tubes and their reversed connection, one tube will pass half waves of current of one polarity and the other tube, when conducting, will pass half waves of opposite polarity through the motor armature. This pulsating d-c will cause the motor to rotate in one direction if thyratron *A* is conducting, and in the opposite direction if thyratron *B* is conducting. The two resistors connected in series across the thyratrons provide a point at which the voltage is positive with respect to either thyratron cathode on the half cycle in which its plate is positive. By means of the contacts at *X* this positive voltage may be applied to the grid of either thyratron, causing it to conduct and produce rotation of the motor in the desired direction.

FG-33 or similar positive grid tubes are used simply because it is not then necessary to provide a source of negatve grid voltage to cut off the tube. Any failure of grid voltage or an open in the grid circuit will not cause rotation of the motor and will consequently be a "safe failure" in applications where safety is a factor. In many types of control, it is highly important that everything should be at a standstill in case of such a failure, rather than that a failure should run the motor to one extreme or the other.

The d-c field voltage can be supplied from a d-c line or by means of a small rectifier as field requirements of shunt wound ¼ or ½ hp motors are not large. The a-c voltage supplied to the circuit should be twice the rated voltage of the motor since due to the half wave rectification only 45 per cent of the voltage is effective. The voltage rating of the motor must also be high enough to limit the current requirements to the tube ratings if ½ hp motors are used. A ¼ hp motor rated at 120 volts d-c can be nicely operated from an a-c circuit of 220 volts with FG-33 tubes.

In the circuit of Fig. 1, the contacts at *X* are both shown normally open, and the tubes non-conducting. A very interesting result is obtained if these contacts are adjusted to be normally closed, that is both tubes normally conducting. In this state, the motor will be at a standstill since full wave a-c will be flowing through the armature and the inertia of the rotor is too great to allow any oscillation due to the successively reversed torques applied. If one contact at *X* is opened, one thyratron will stop conducting, only pulsating d-c will be applied to the motor and the motor will rotate in a direction determined by the closed contact. Now if the opened contact is closed, the motor will be plugged or almost instantaneously stopped due to connection of the armature across the a-c circuit. The plugging action obtained is as good as is normally obtained in conventional circuits.

To avoid heating of the motor armature by the alternating current flow during standstill periods, the choke coil *CH* is used in series with the motor. This is made with a closed core and should have sufficient inductance, usually a henry or so, that the standstill alternating current will be limited so as not to heat the motor seriously. When one contact *X* is opened and the motor rotates on the resulting pulsating d-c the core of the choke being without an airgap quickly saturates and has no effect on operation other than to produce a small voltage drop.

Life tests of a ¼ hp motor and FG-33 tubes were run to over 5,000,-000 reversals without failures except for brush replacements on the motor which are to be expected in any reversing and plugging service. The transient currents existing at the instant of motor stoppage are considerably limited by the choke and do not appear to have any bad effects either to motor or thyratrons.

This circuit has lead to considerable simplification in applications where accurate stopping of motors is of importance, since starting and plugging of the motor is handled by opening and closing a single grid circuit contact, with only very small currents on the contacts. No complicated switching is required, opening a contact starts the motor and closing of the same small contacts plugs the motor to a standstill.

Operation by Phase Shift

Figure 2 illustrates an adaptation of this circuit to provide rotation in either direction with control of motor speed. *S* may be any variable inductance, such as a standard movable core solenoid, or a clapper type solenoid. This solenoid produces a phase shift of thyratron grid voltage sufficient to stop conduction in the thyratron. The contacts *X* operate as before and then by decreasing the inductance of *S* by moving the core from the maximum inductance position, the grid voltage is brought more in phase with the plate voltage to allow the thyratron to conduct over longer periods and the speed of the motor may be brought up gradually and held at any point by locking the core in position. Adjustment of the grid resistance *R* varies the speed range obtainable with any particular solenoid *S*. Figure 3 shows typical speed curves obtained with a movable core solenoid and several grid resistances *R*. Considerable speed range is shown by these curves as well as the variation in solenoid operating position by changes in resistance *R*.

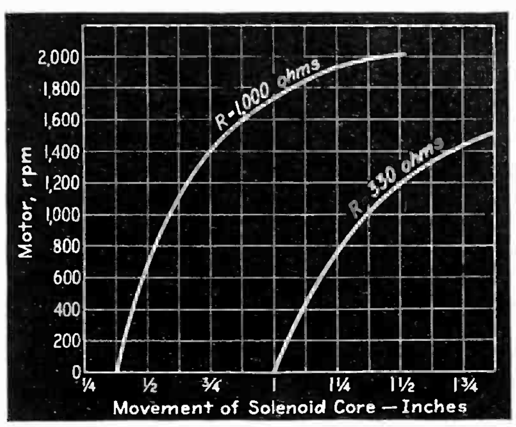


Fig. 3—Speed curves obtained with movable core solenoid and grid resistances shown in Fig. 2

At times it is not feasible to have the controlling devices provide torque enough to move a solenoid core in which case Fig. 4 using a phototube is of particular interest. The circuit is essentially that of Fig. 2 except that the value of the inductance *S* is controlled by the light intensity striking a photocell. Once the direction of rotation is selected by switch *X*, and this may be a switch requiring a very small torque, then the motor speed is controlled by the amount of light reaching the photocell. *S* is now a small medium-ratio transformer having low primary magnetizing current, similar in characteristics and design to some previously described.[1] When the contact at *X* is closed and there is no light on the phototube only the magnetizing current of the transformer flows through the primary winding, inducing a secondary voltage which serves as a plate voltage for the vacuum tube *T*. The primary inductance of the transformer is great enough to provide sufficient grid voltage phase shift to prevent conduction of a thyratron and no motor rotation or to cause only a very slow rotation, dependent on the value of the associated resistance *R*. As more light reaches the phototube, the tube *T* starts to conduct, drawing current through the transformer *S*, reducing the effective primary impedance and inductance and changing the phase of the voltage supplied to the thyratron grid, allowing the thyratron to pass more current and bringing up the motor to full speed.

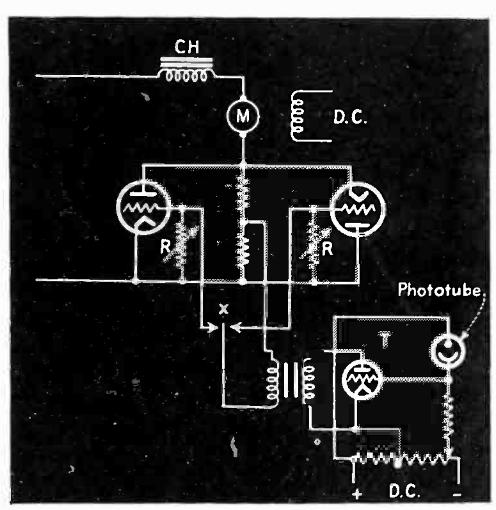


Fig. 4—Use of phototube to control value of inductance for speed control using circuit of Fig. 2

Figure 5 curve *A* shows the relation obtained between motor speed and position of a vane being rotated in a beam of light, to allow more or less light to reach the phototube. This curve is linear over only a portion of the vane travel and is therefore not satisfactory for some applications. However, by proper shaping of the opening through which the light passes to the phototube, thereby changing the light vs. motion of vane characteristics, it is possible to smooth out curve *A* to that of curve *B*, which is quite desirably linear, or to any other desired curve. The same flexibility can be obtained to some extent by shaping of the core used in the solenoid of Fig. 2. It is of importance only where some definite relationship is desired between the device producing the motion of the solenoid core or the vane or mirror, and the speed of the motor, as controlled by the thyratron current.

By duplicating the vacuum tube, transformer and phototube arrangement, and connecting the transformer primaries in place of the contacts, the contacts *X* can be eliminated and variable speed motor rotation secured in either direction as a function of the differential intensity of light on the two photocells. By adjustment of resistors *R*, it is possible to secure very smooth transfer of rotation from one direction to another and with uniform speed characteristics in each direction.

These circuits have all been used in automatic control equipment and have been found to be very adaptable to special applications. The number of parts used is just about reduced to a minimum and the cost is low. Using standard ¼ hp and ½ hp motors reasonable tube and motor life has been secured combined with extreme simplicity of operation.

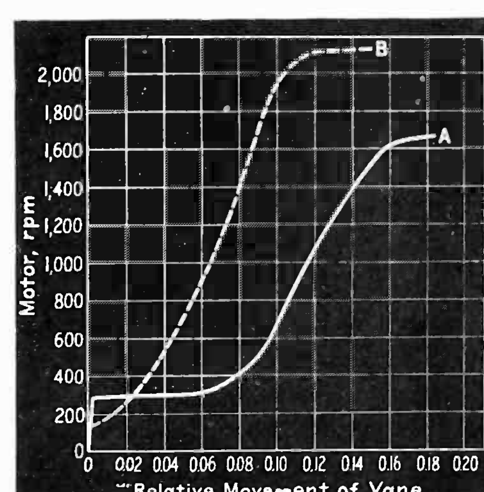


Fig. 5—Relation between motor speed and position of vane interrupting light beam

[1] Electronic Control of Small A.C. Motors, J. D. Ryder—April, 1936—*Electronics*.

Thermionic Emission in Transmitting Tubes

By CHARLES P. MARSDEN, JR.
Bloomfield, N. J.

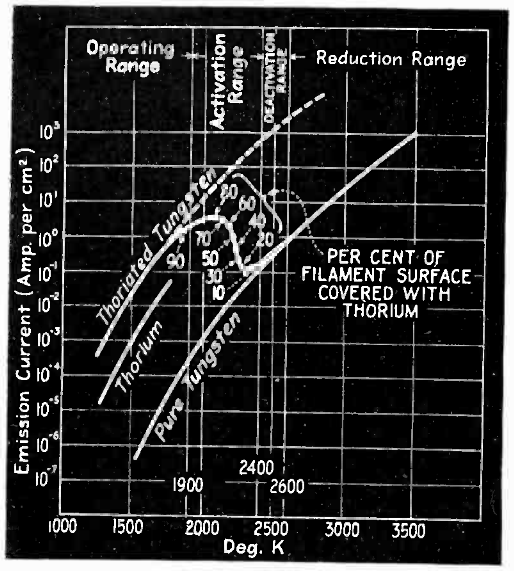


Fig. 1—Graphical plot showing relation between temperature and emission of a thoriated tungsten filament, together with the percentage of surface covered by thorium

To THE general user of vacuum tubes of the receiving type, the emission life of a tube is not usually an important factor, as this class of tubes is generously supplied with the requisites for long emission life and the ratings are quite conservative. Even in those few cases, where continuity of operation is imperative and assumes a vital, economic aspect, the replacement of tubes after a life period known to be conservative, is the logical economic solution. However, consumers of transmitting tubes have a prime interest in emission life because of the cost involved. If a very small broadcast station obtained only the guaranteed life on its tube investment, the tube cost would be the equivalent of buying a pack of cigarettes every operating hour. It is safe to say that this would put a crimp in the majority of personal budgets. On the other hand, when this same station obtains 4000 to 8000 hrs. tube life by observation of a few rules, the above figure then becomes the more nominal one of two or even one pack a day.

The manufacturers of this type of tube are of necessity interested in a quality product for this is their main sales argument. Further, one of the biggest bulk consumers of their product is the U. S. Government who are extremely explicit about what they consider a good tube.

Therefore it is safe to assume that the real meaning behind that 1000 hr. guarantee is to protect the consumer from those few duds that may go wrong due to no lack of engineering foresight. Moreover, one should safely assume that he has bought 3000 hrs. of useful tube life, and with care, perchance three to four times that figure.

Now in this class of tubes, we are interested primarily in thoriated tungsten filament emission, secondarily in oxide-coated filaments in their application in mercury-vapor rectifiers and perhaps thirdly in pure tungsten emission as found in water-cooled tubes. However, there are two other forms of emission which have an important bearing on the filament emission, namely the primary and secondary emission from the other elements of the tube and especially the grid.

In the case of pure tungsten emission, this is the simplest example of emission, i.e., from a pure uncontaminated hot metal surface. These filaments may be operated at or near their saturation or total emission current without harm to the filament or its life. Indeed, it is permissible to lower the filament voltage and therefore temperature if the tube is being operated under such conditions as do not require the full available emission. This reduction in filament temperature increases the useful life several fold. Also, little harm can come to the filament or its emission during operation with the exception

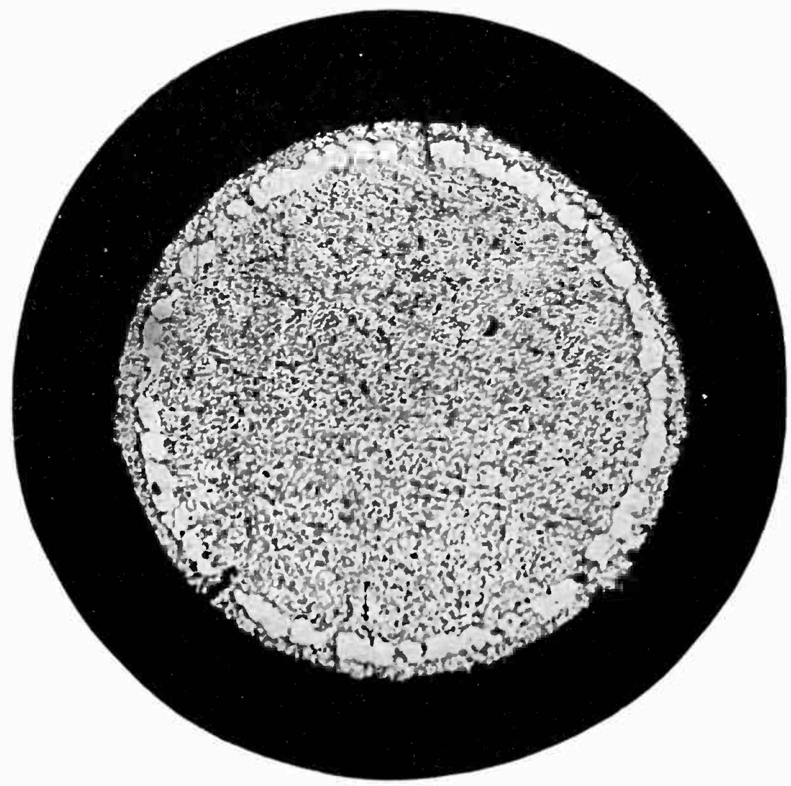


Fig. 2—Cross sectional diagram of carburized thoriated tungsten filament which has been partly decarburized. Magnification, approximately 300×

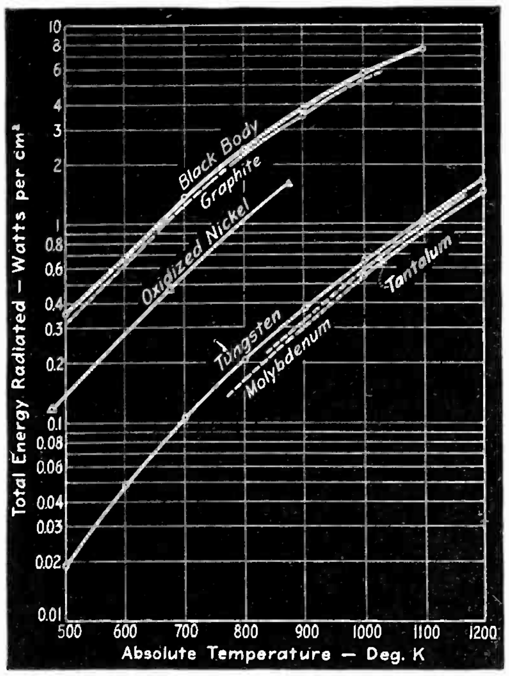


Fig. 3—Characteristics of suitable anode materials for electron power tubes

TABLE I — Plate Materials

	GRAPHITE	MOLYB-DENUM	TANTALUM
Melting-Point °K	3947*	2893	3123
Temperature of Operation Average °K.	600	750	900
Ease of Fabrication	Medium	Difficult	Readily
Cost of Finished Anode	Lowest	High	As high or slightly higher
Thermal Radiation Constant at 900°K in % Efficiency	94	8.3	8.8
Rigidity — Maintenance of Inter-electrode Spacing	Excellent	Both good depending on degree of reinforcement	
Tendency to warp with heat due to crystal strains	None	Slight	Little if any
Ease of Degasification†	Difficult	Hard	Slightly harder
Temperature of Degasification °K	1050	1200-1500	2000-2600
Gettering Action	Possibly some	None	Fairly good
Vapor Pressure at a given temperature	Very low or nil	Medium	Low

* Temperature of Sublimation.
† Attempted weighted averages which take into account the requirements of equipment, time and skill.

of a gaseous discharge. In severe cases such a discharge may pit the filament causing a local decrease in cross-section and resulting in a hot spot and ultimate burn out at this point before the useful life of the tube has been attained. However, small amounts of gas in these tubes have slight or no effect on emission and are quickly cleaned up.

In the case of thoriated tungsten emission we have a much more delicate mechanism of emission. In the first place, we must keep to a minimum the evaporation of the thorium from the hot tungsten filament and maintain, as nearly as possible, a uniform and complete coverage of the filament surface by the thorium. Secondly, we must operate the filament at a sufficiently high temperature to generate new thorium atoms to replace those lost by evaporation or ionic (gaseous) bombardment. The relation between temperature and emission of a thoriated tungsten filament together with the percentage coverage of the surface of the filament by thorium, is shown very completely in Fig. 1. The top curve represents the emission curve of a tungsten filament completely covered with thorium while the bottom curve represents pure tungsten and connecting the two is the emission of thorium coverages of various percentages. It is interesting to note that a pure thorium wire assumes an intermediate position between the two.[1]

After being mounted in its structure, the filament is carburized by heating it in an atmosphere of acetylene or benzene at reduced or atmospheric pressures. The carbon from these compounds combines chemically with the tungsten to produce tungsten carbide, W_2C. We now have a new surface of carbide rather than tungsten on the filament. This carbide layer has the very desirable property of retarding the evaporation of thorium by a factor of at least six-fold and also chemically aiding in the regeneration of the thorium supply. This layer might well be called the priceless ingredient, for when it has disappeared, so has the life of the tube. The simplest measure of its presence is the filament current at rated voltage for when this has increased 2%, one may assume that about 60% of its useful life has been reached, and at 4%, the life expectancy is but an additional 10%.

Now while this carbide layer has given us some very beneficial results, it has difficulties of a minor importance of its own. First of all as it chemically reacts with the thorium oxide, it is naturally consumed by this process. Further, due to different orientations of its crystals in the surface layer of the filament, some of these crystals are more active than others. The result is that these specific crystals are overworked to produce thorium for their neighbors and are reduced to pure tungsten crystals sooner. Lastly, as the most overworked crystals are on the surface, this part becomes decarburized first especially at the hot center portions of the filament, and this new tungsten surface permits increased evaporation of thorium though seemingly not to the high degree that the original uncarburized tungsten surface would have permitted it. In Fig. 2 there is shown a cross-section of a carburized thoriated tungsten filament which thru misuse was partially decarburized. This is shown in the photomicrograph as the outer ring of finely crystallized pure tungsten, and inside this ring are the crystals of carbide which are still remaining. The original structure of the wire is shown as the main or inner part of the figure.

For these reasons, the thoriated filament is always rated at about half its saturated emission value, and while it may be possible to carry a peak current above its rated plate value, it is not wise and may be disastrous to do so. Also, it is very critical of its operating temperature so that it is necessary to maintain the filament voltage at the rated voltage, otherwise the emission that you should expect to have available, will not be there. It might be mentioned that as this thorium layer rarely assumes a thickness of more than one molecule, the removal of those molecules is synonymous with the removal of emission. Thus while the rate of diffusion of the thorium to and over the surface of the filament is

[1] Bruche & Mahl—*Zeit. f. Tech. Phys.* 17 (1936), 3, p. 81.

rapid, it is not instantaneous. In summary, this extremely thin film emitting material is subject to the attacks of evaporation, ionic bombardment and even occasionally chemical attack on itself or rather on its subsurface.

With regard to oxide-coated filaments, particularly in mercury-vapor rectifiers, the barium metal film is the electron-emitting agent. This metal film is diffused thru the oxide coating and thus is not as vulnerable nor as sensitive to attack as the thorium layer. Nevertheless, it is susceptible to the same destructive forces and the maintenance of its filament voltage and therefore temperature is a matter of importance. Similarly, it is rated at less than 50% of its saturation current, and is thus capable of emitting much larger currents. However, if the emission is not there at the instant, and the voltage drop across the tube increases as a result, there is sure to be some gas available and ready to be ionized, which will result in the "hen-feet" marks that may be seen on these filaments. One other item of importance as regards filament temperature maintenance, is that most of these filaments are made with an alloy containing an element such as titanium, aluminum, silicon, etc. The purpose of this additional element (amounting usually to less than 1% and in some cases less than 0.05%) is to aid chemically in the formation of metallic barium. Now this percentage and the temperature of the filament are so regulated by the manufacturer, that a normal supply of barium is available in the filament and the evaporation of this element is not excessive.

In passing it is interesting to note that while the thermionic efficiencies of these emitters in millamperes plate current per watt of filament heating energy is a maximum for the oxide emitter, the applied plate voltage may actually reverse the order. Thus oxide emitters are limited to applications where the forward or positive peak voltage is less than 1000 volts because above this figure, it is necessary to decrease the maximum plate current and therefore the efficiency, in order to maintain an electron space charge adjacent to the filament which will be sufficient to neutralize any ions that may be formed and thus protect the emitting surface. Likewise the thoriated tungsten emitter, though more resistant than the former, is limited to voltages of less than 4000 volts, and above this figure the *practical* thermionic efficiency shows that the pure tungsten emitter is not only more satisfactory but more efficient. Thus each emitter has a definite range of applications of its own.

There is one other important part of the tube from which emission plays an important part, and that is the grid or grids. Of course, in this case, the emission is not desirable but nevertheless, it tends to be entirely too prominent. In fact, it may be safely said that the problem of grid emission is secondary only to gas as a manufacturing problem and indeed it may not even be second.

TABLE II

Amplifier Operation	Typical Value of I_{pk}/I_{dc}	Max. Value of I_{pk}/I_{dc}
Class B-AF or Unmodulated RF	3.14	3.14
Class B-RF Modulated 100%	6.28	6.28
Class C-RF Unmodulated	5	—*
Class C-RF Modulated 100%	8	—*

Relations between Peak and Direct Plate Current for Various Classes of Tube Operation

* Refer to Fig. 2, showing I_{pk}/I_{dc} versus Operating Angle

There are two forms of this emission known as primary and secondary emission. The former is quite similar in action to that of thoriated tungsten emission as it is essentially due to films of electron-emitting metals (as thorium, barium, alkalies, etc. from the filament, getter, etc.) being deposited on the grid wires. Further, the emission increases with temperature, and is subject to destruction by ionic bombardment and evaporation. It should be remembered that the temperature of the grid under operating conditions approaches that of the plate. Thus if we are running a molybdenum plate tube at a dull red, the grid is almost as hot, and may indeed be hotter than the cathode of some of the 2 volt line of receiving tubes.

The other variety of grid emission, namely secondary emission, is caused by the grid surface becoming sensitized, usually by the formation of oxides, which are capable of emitting electrons when bombarded by electrons and in extreme cases as many as ten electrons may be emitted for every bombarding one though usually the ratio is in the reverse order. The electron multiplier is a practical application of this effect. Temperature has little or no effect on the emission efficiency of the surface except by changing its constitution. The most important factor is the energy of the impinging electrons, the emission increasing as this energy increases from about 10 volts to a maximum at about 500 volts.

Of course, secondary emission is a characteristic of even pure metal surfaces although it is amplified by sensitizing the surface with gas and evaporated metals. Further, the effect apparently decreases with increase in atomic number, thus tantalum proves better than molybdenum.[2]

In both of these cases of grid emission, the cause is contamination of the grid surface by evaporated metal and gases. The supplier furnishes a tube in which both of these effects together with the gas current is only a few microamperes with the tube operating at higher than normal plate dissipation. He has accomplished this by bombardment of the grid at the end of his exhaust treatment, followed by proper seasoning treatment. However, while he has eliminated the effect, he cannot eliminate the possibility of these conditions appearing again, as all that is required is some evaporated metal and some gas. The origin of the former has been mentioned.

In addition, it may be mentioned that in high-power and multigrid tubes, the effect of secondary emission is ever present and even necessary and must be taken into account in the manufacture and utilization of these tubes.

Every part of a vacuum tube is a potential source of gas. This should not be understood as a theoretical or even a hypothetical statement. The filament is a constant producer of gas by the chemical reaction of

[2] R. Warneke—*J. de Physique,* No. 6, 1936, p. 270.

thorium oxide and tungsten carbide. The grid, perhaps the least offender, is rather difficult to raise to a sufficiently high temperature to insure proper degasification due to its small wire size. The plate, no matter what material, cannot be degasified sufficiently so that an excessive peak will not free some gas. The insulating supports, and the glass envelope itself due to electron bombardment and high-frequency losses may evolve gas very readily as local heating sets in and may readily heat the part to a higher temperature than it has ever reached since it has been in vacuum. This is especially so if secondary emission sets in at the same time. This gas, when evolved, attacks the filament to decrease emission, and the grid to increase its forms of emission.

Naturally, the plate is the most potential source of gas. For materials of construction, the manufacturer is limited to (a) carbonized or oxidized nickel, (b) graphite, (c) molybdenum or (d) tantalum. These materials are arranged in the order of decreasing potential gas content and their thermal emissivities are shown in Fig. 3. With the exception of nickel, which is limited to low power tubes due to its melting point, these materials are interchangeable in their use as anode materials. However, each has its merits and demerits as shown in Table I.

In the use of these various materials, it should be remembered that while a graphite plate cannot be harmed by peaks or over-wattage, there may be a molybdenum grid inside it which is more susceptible, and vulnerable. On the other hand, due to its high thermal emissivity, instantaneous peaks are easily dissipated and only continued operation above ratings will permit the temperature of the elements to reach a harmful point. Color in the plate is a definite indication of over-wattage, except in some high-power, air-cooled tubes in which the manufacturer has definitely designed the tube to operate with color-temperature on the plate. In any case, when the plates show color, it is an indication that the limit is being approached and circuit constants should be checked if it is not definitely known that the tube is designed to operate with temperatures high enough to show color.

Molybdenum plates are and may be operated at color temperature without harm but the plate may be harmed by high peaks as a change in crystal structure may cause warping. To date the tantalum plate, due to its cost, is confined to use in tubes of low interelectrode capacity which usually means large interelectrode spacings and therefore grid temperature is considerably under plate temperature. Because of its high melting-point, tantalum is very rarely harmed by hot-spots or over temperature. Tantalum also has an active gettering action up to perhaps 1000° C but above this temperature, it begins to liberate this absorbed gas, slowly but surely. The high temperature of degasification given in the table is an indication of

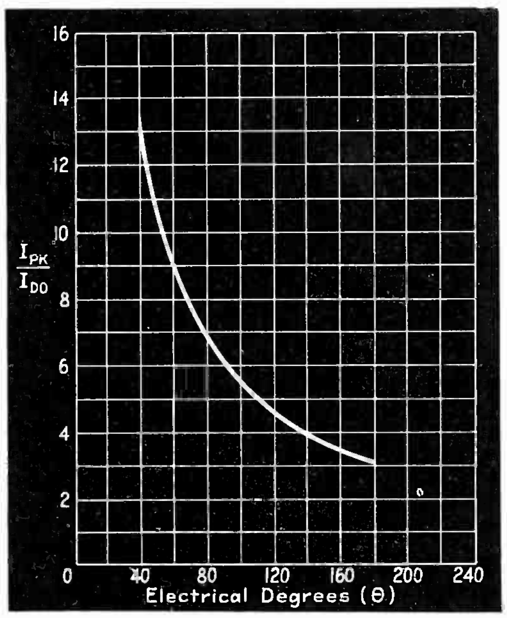


Fig. 4—Relation between peak and averaged d-c components of plate current for Class B or Class C operation

this fact. On the other hand, the author has observed a tantalum plate tube on test showing more than one milliampere of gas current; ten seconds later, this was reduced to several microamperes.

Operating Factors Affecting Emission

1. Filament voltage.

As voltage and temperature of operation of the filament are practically synonymous terms, the filament voltage should be maintained at its proper value. Voltage fluctuations, if not prolonged, have no effect on operation. Where the tube is operated under ratings, the filament temperature might be below normal but in no case is it desirable to operate the filament more than one or two per cent above its rated voltage.

2. Maximum D-C Plate Current.

The maximum d-c plate current is a limit established by the manufacturer to insure that the filament will have available at all times an emission sufficient to provide the peak currents required by the particular operation. This is especially true in the case of thoriated tungsten and oxide-coated filaments. A glance at Table II shows the relation between d-c and peak values of plate current. This relationship depends upon the operating angle (usually expressed in electrical degrees) or portion of the cycle during which plate current flows. In Class B service, the angle is fixed for all cases at approximately 180 electrical degrees but in Class C operation, it may vary from this value to only a few degrees in width. The curve in Fig. 4 shows the relation between peak conducted current and average d-c plate current for reference in analysis in Class B or C tube applications.

3. Maximum Plate Dissipation.

The maximum permissible operating temperature of the plate and other elements determines the maximum plate power dissipation. In calculating the value for a given condition, due consideration of the peak current and voltage values should be taken into account.

4. Maximum Plate Voltage.

This factor has little to do with the emissions in the tube except that it is a factor in plate dissipation. It is, however, a limit imposed by the design and the insulation of the tube. It might be well to mention that in multi-grid tubes, the peak voltage of the screen grid has much to do with its secondary emission characteristics.

5. Maximum D-C Grid Current.

The maximum d-c grid current establishes a limit on the grid dissipation, for grids are designed mainly from the point of view of the electrostatic fields they will produce and not as thermal radiators. The possibility of radiating any heat, except up or down, is nil, as the grid is necessarily interposed between the very hot filament and a plate which may be almost as hot. In this connection, therefore it must be re-

(*Continued on page 32*)

Fig. 2—Tanks partially disassembled
I $D_k = 10$ cm $D_f = 13$ cm $f = 1.3$
II $D_k = 5.8$ cm $D_f = 9.75$ cm $f = 1.68$

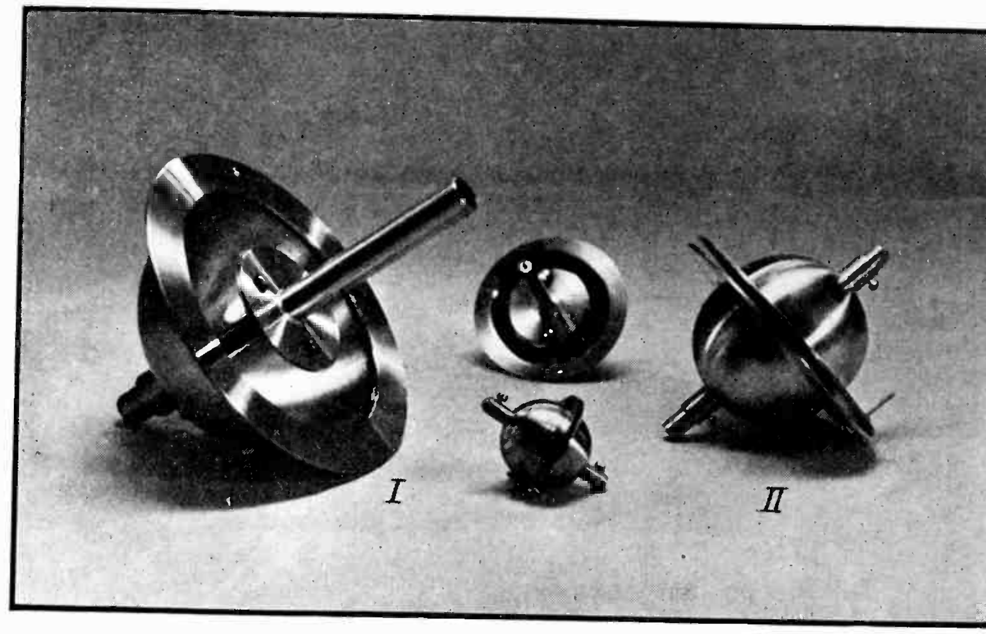
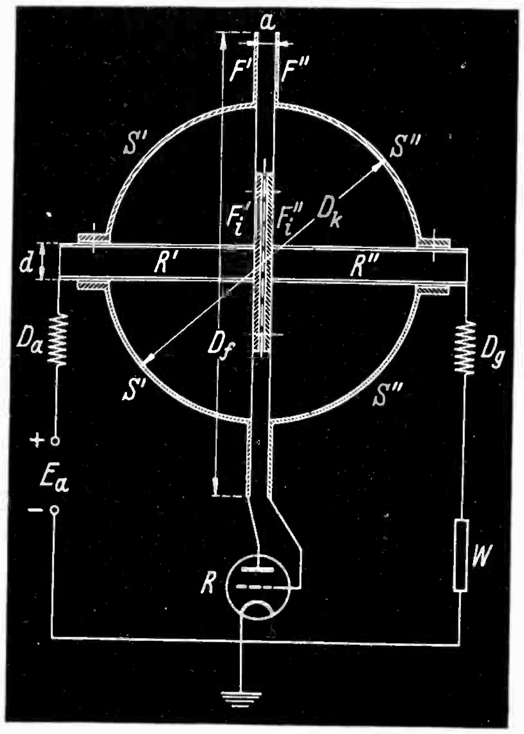


Fig. 1—A single tube spherical tank oscillator



SPHERICAL TANK

By H. E. HOLLMAN
Berlin, Germany

THE axially symmetrical tank circuit developed by Kolster is one of the outstanding methods of obtaining both a high Q resonant circuit and a suitable impedance match with the internal resistance of an oscillator tube even at ultra high frequencies. This tank circuit, the Kolster toroid[1], consists of two flanged metallic shells mounted on a common axial tube. The tube and the two shells provide the inductance while the spaced flanges form the capacitance. It has been shown that the high Q is due less to the L/C ratio than to the extraordinarily low damping resistance provided by the large metallic surfaces of the tube and the flanged shells. In addition, such tank circuits show a high degree of frequency stability because the thermal expansion of the tube which tends to separate the flanges is partially neutralized by the expansion of the shells.

Besides these advantages over other resonance systems, a third favorable property of this tank circuit is worthy of mention, namely the possibility of exciting it with a large number of tubes distributed around its circumference; in this way many tubes can be operated in parallel without requiring special connecting leads. This paper is devoted to a consideration of the practical construction of such multi-tube oscillators.

A spherical tank, that is, a tank circuit of the Kolster type with hemispherical metallic shells, will be considered first, and from this the multitube oscillators will be developed. In Fig. 1 the oscillatory system consists of an axial metallic tube $R'R''$ of diameter d on which are mounted two hemispherical shells S' and S'' of diameter D_k. Both shells are provided with equatorial capacity flanges F' and F'' of inner diameters D_k and of outside diameters of D_f. The flanges are separated by a distance a which can be adjusted by moving the shells on the central tube. The oscillating condition of the circuit is such that a potential node and a current anti-node are formed in the center while potential anti-nodes are formed on the flanges. These are consequently connected to grid and anode of the exciting tube R which excites the spherical tank as a simple Hartley circuit. To separate the grid and anode potentials, the axial tube has two central flanges F'_i and F''_i between which is placed a sheet of mica. The anode potential is connected to R' through choke D_a while the grid is connected to R'' through choke D_g and high resistance W. Figure 2 is a photograph of several such spherical tanks while Figs. 3a and 3b show two practical constructions

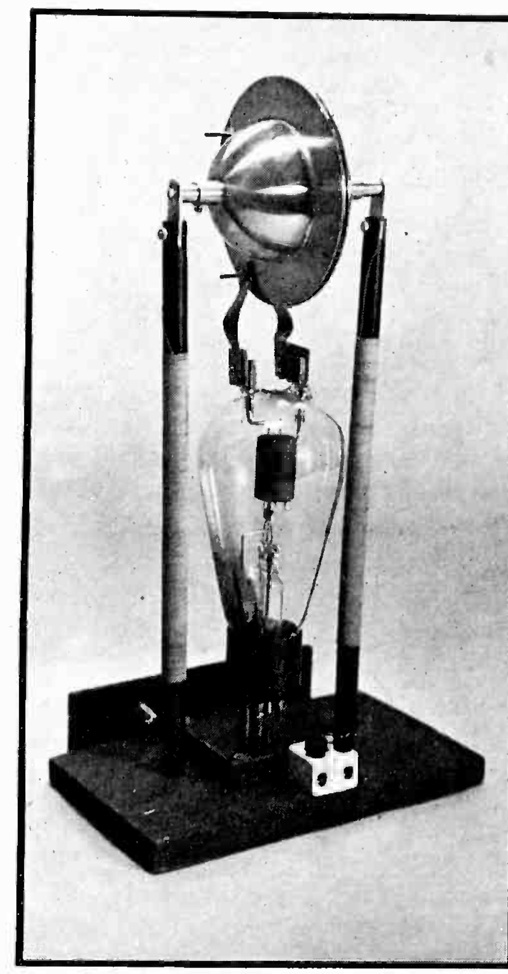


Fig. 3a—Single tube transmitter with RCA 834

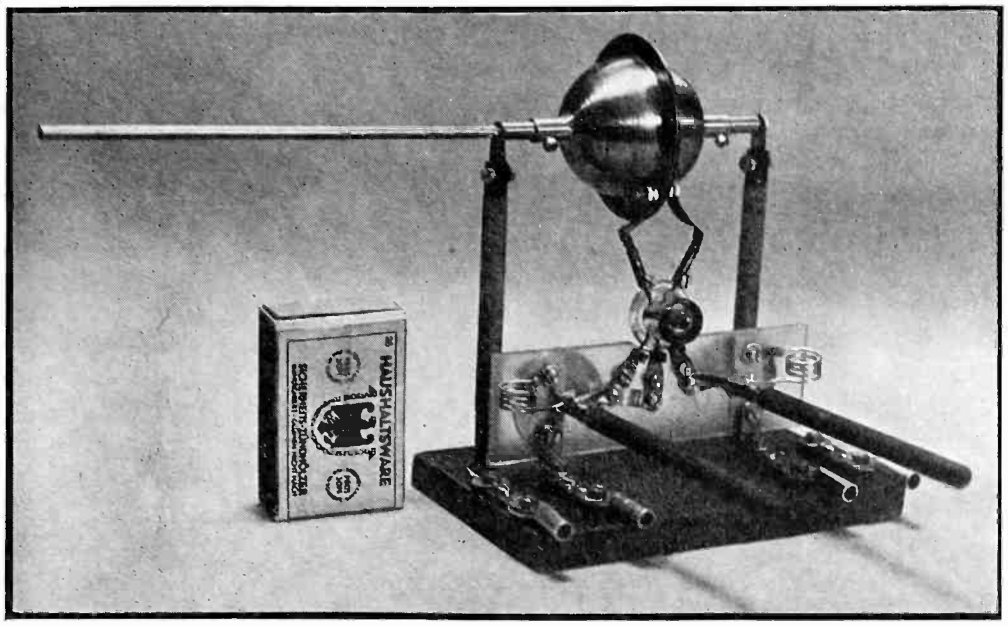


Fig. 3b—Single tube transmitter using an RCA 935 Acorn tube

UHF OSCILLATOR

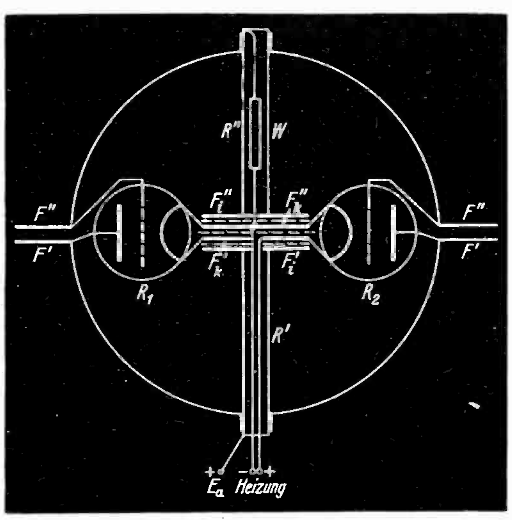
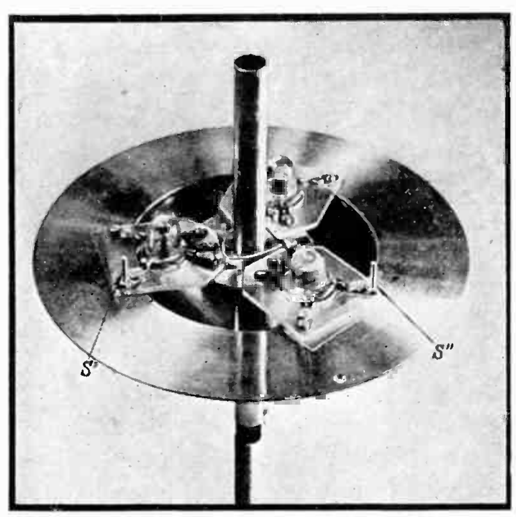


Fig. 4—Schematic circuit with two internally mounted tubes



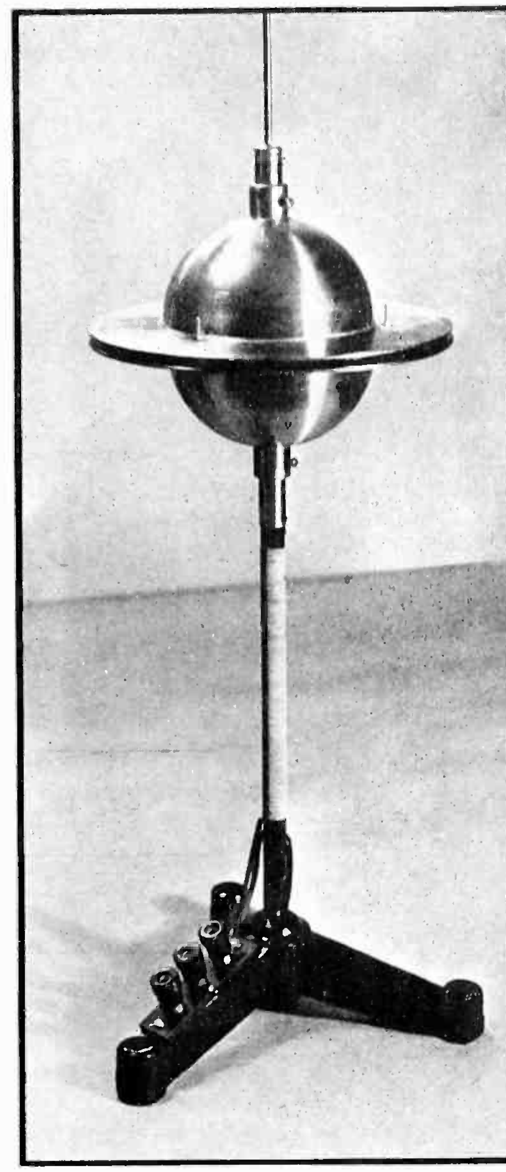


Fig. 5—Transmitter with three internal Acorn tubes. Above, (a) the internal arrangement. Right, (b) the external view

of single tube transmitters. The larger transmitter is equipped with an RCA 834 and has a power output of about 25 watts at 1.5 meters. The smaller spherical tank oscillator is excited by an acorn tube (RCA 955) in the region of 75-85 cms. An extension of the grid side of the central tube provides an antenna.

When the separation of the flanges a is sufficiently small compared to the sphere diameter D_k, the wave length may be calculated from the following formula.[2]

$$\lambda_{cm} = \frac{5.7\, D_k}{0.0625\, D^2_k \sqrt{\left(\frac{f^2 - 1}{a}\right)} + 0.55\, D_k + C_r}$$

where f denotes the ratio of flange to sphere diameter, i.e., $f = D_f/D_k$ and C_r represents the tube capacity. For wide flanges having very small separation, resulting in a large flange capacitance, the last two terms under the root can be neglected and the formula simplified to

$$\lambda_{cm} = 1.425\, D^2_k \sqrt{\frac{(f^2 - 1)}{a}}$$

Experiment has shown that the greatest part of the tank inductance is in the axial tube. Consequently, to obtain the shortest possible wave lengths, without making the sphere dimensions excessively small, the use of a short central tube with spherical segments may be advantageously employed under certain circumstances.

In the excitation of an u.h.f. circuit, difficulty is usually encountered in making the cathode potential the same as that of the nodal point, i.e., to ground the cathode to r.f. because the inductance of a connecting lead cannot be neglected at these frequencies. Of course r-f chokes can be inserted or by-pass condensers employed. However, it is very difficult to wind a choke suitable for a wide frequency band in this region. Moreover, by-pass condensers are effective only when the potentials being by-passed lie between two points closely spaced, otherwise the inductance of the connecting leads becomes appreciable.

Of special interest, therefore, is

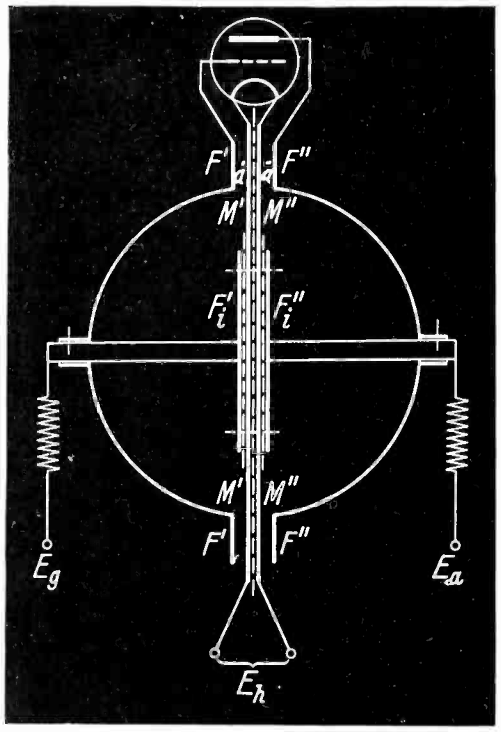


Fig. 6—Schematic circuit of oscillator with external tube

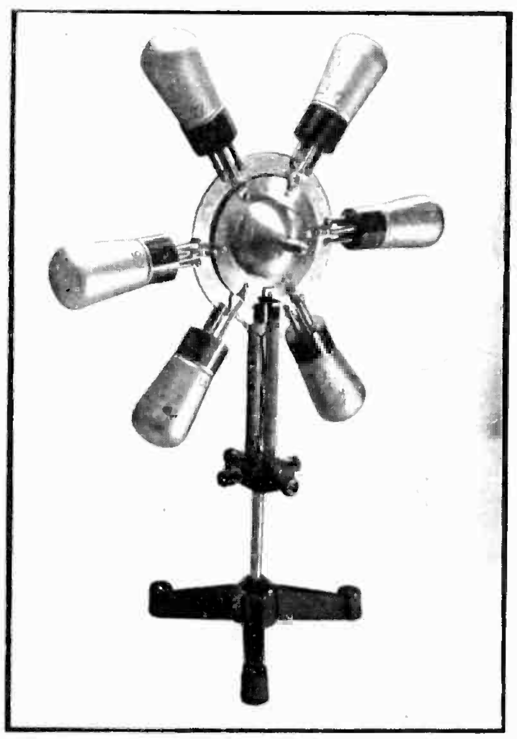


Fig. 7—Spherical tank transmitter with 6 external tubes

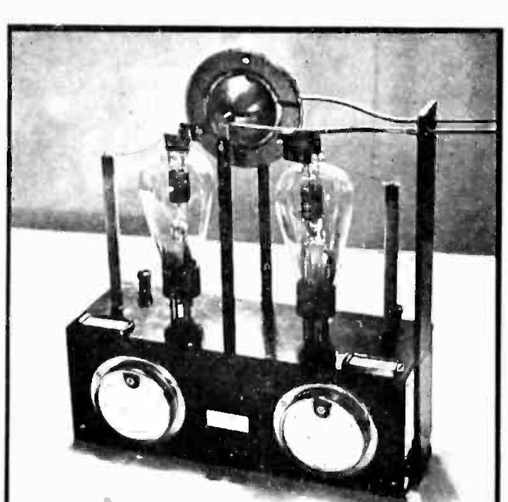


Fig. 8—Push-pull oscillator using RCA 834 tubes

the possibility of connecting the tube electrodes directly to the optimum points of the tank circuit and thus eliminating all special h-f leads. This may be achieved by mounting the tube inside of the sphere. Grid and anode then may be connected directly to the potential antinodes and the cathode to the node point. This is shown schematically in Fig. 4. Two additional insulated flanges F''_k and F'_k are provided in the central blocking condenser, which are connected to the heating battery. The filament leads are connected directly to these while the grid and anode leads are tied directly to the external flanges. Acorn tubes are particularly suited to this construction not only because of their small overall dimensions but also by virtue of the favorable disposition of the leads. Since it is entirely immaterial at which point of the circumference the tube is connected, the possibility arises of using several tubes, indeed as many as can be fitted into the tank and thus to operate the tubes in parallel with a minimum of connecting leads. Figure 5a shows the construction of such an oscillator with three internally mounted across tubes in a sphere 10 cm in diameter having a wavelength of around two meters and Fig. 5b shows the completed transmitter. The grids are connected to the screws $S'S''$ which pass through corresponding holes in the flange of the upper hemisphere, thus permitting the removal of the latter for inserting or replacing of tubes. The axial tube is extended upwards as an antenna wire.

Internal mounting, of course, is only possible with sufficiently large spheres, and therefore at relatively long waves or with correspondingly small tubes, which means low power. These limitations can be overcome with external excitation, several tubes being distributed uniformly around the circumference. For this purpose the central sheets F'_k and F''_k of Fig. 4 are extended beyond the flanges and thus one or several tubes can be externally mounted as shown in Fig. 6.

All of the described circuits with one or more tubes, whether internally or externally mounted, have the disadvantage of being highly unsymmetrical because one hemisphere is loaded by the grid-anode capacity while the other is loaded by the anode capacity. The difference in magnitude between the capacities causes the potential node to be displaced from the center towards the anode side. This is also checked by the fact that the r-f potential is greatest on the grid side because an antenna connected to it gives the best efficiency. Two methods of obtaining circuit symmetry, i.e., to excite the circuit so that the energy is equally distributed between the two hemispheres, are first to equalize the tube capacities by additional condensers in parallel and secondly by push-pull operation of two tubes or groups of tubes. The first method may be accomplished by suitably adjusting the central extended flange separations a' and a'' (Fig. 6) to equalize the anode-cathode and the anode-grid capacities.

While circuit symmetry must be attained by special adjustment in this arrangement, the push-pull operation of two or more tubes provides inherent circuit symmetry. By connecting each flange to the grid of a tube or group of tubes and simultaneously to the anodes of the other tubes or groups of tubes, each hemisphere is loaded with the same total capacity. Naturally, grid and anode potentials must be separated,, but stopping condensers may readily be incorporated with the external flange.

If both of the flanges are connected to the grids of the tube groups, the entire sphere is at grid potential and the axial stopping condenser becomes unnecessary. In this arrangement, the tubes are push-pull operated, in contrast to the parallel operation in all the previous circuits. A symmetrical transmitter of this type equipped with two RCA 834 tubes is shown in Fig. 8. This photograph also shows a Lecher wire system connected to the axial tube. If need be, the Lecher wires can be coupled through small variable condensers. Spherical segment shells placed over the spheres may be employed to provide such coupling condensers.

In conclusion it may be mentioned that the described circuits may advantageously be utilized also for multi-tube transmitters with "retarding-field tubes" and magnetrons.

1 Kolster, F. A.—*Proc. Inst. Radio Engineers*—22, p. 1335, 1934

2 *Hochfreq. u. Elektroak.* Vol. 50, p. 109 Oct. 1937.

RELAY CONTACTS .... their ailments

RELAYS go hand in hand with the vacuum tube in the application of electronics to industrial or other control problems. Relay contacts are, at times, temperamental, they must be treated with respect lest they rebel

By A. W. CLEMENT

Chicago, Ill.

THE increasing attention being given to relays in electronics prompts the writer to offer points concerning telephone and moving coil relays, the results of experiences over thirty years.

Contacts are the most vital part of relays. Their performance depends upon the material used, the shape, pressure, voltage, current, atmospheric and circuit conditions, maintenance methods.

Of primary interest is the pressure of a contact—or rather, two pressures, mechanical and electrical. A deficiency in one can be compensated by an increase in the other. The pressure serves mainly to penetrate film upon the contact surface and is also used to prevent microphonic action (chattering) and to adjust the relay.

Metals will form films due to chemical combination with gas (oxygen in the air being most common), but with the usual "contact metals" such films are easily penetrated by low voltages, under two. Platinum is outstandingly superior for minimum film formation, and is followed by gold and silver. Poor metals such as brass, tungsten, phosphor-bronze and as an extreme, lead, require higher voltages or mechanical pressure for penetration.

Films of the greatest seriousness are formed by deposits of grease from the atmosphere and by handling the contacts with files or in other manners. It may be said that over 90 per cent of contact troubles are due to grease. The metal used becomes a minor matter in view of the comparatively high pressure (electrical or mechanical) required to penetrate the grease.

Carbon is the next in order of contact surface troubles. It is the residue of burnt air and grease and forms in small rings about the actual point of contact, building up until the rings hold the contacts open. It is very instructive to examine contacts under a microscope of twenty or so diameters. A good contact pressure will aid in crushing the rings, keeping the contact usable.

Another surface condition is that of "cone and cratering", where the metal of one contact is transferred over to the other, leaving a hole or crater in one and a point or cone upon the other. The crater eventually clogs with carbon and is difficult to clean out. In some cases, with springs of light tension (10 grams or so) the cones can stick in the craters preventing natural opening. Occasional reversal of current will prevent this surface trouble. In some telephone plants using vibrator ringing generators clocks have been installed to reverse the driving current every half-hour: daily or more frequent contact cleaning became a matter of once a week or more.

Again, there is damage caused by the contact of two different metals due to the "contact potentials" of the particular metals used. This also forms a cone and crater effect. Different metals should never be used. A number of years ago a large number of strips of break-jacks were replaced throughout the country by a manufacturer whose assembly department had slipped up and used platinum and silver in the opposed springs.

For telephone relays the contact mechanical pressures may be rated as medium when between 20 and 40 grams. When under 15 grams they tend to be "microphonic", easily disturbed by jars from adjacent relays, etc. At low pressures they might also "sizzle" when currents of a few hundred milliamperes are passed.

Moving coil relays have almost zero mechanical pressure but they operate with reasonably high voltages and are almost always associated with telephone relays so the microphonic and sizzling effects are less disturbing.

Voltage pressures used with medium mechanical pressures and average "contact metals" ought to be over 20 volts for ordinary operations but for rapid and frequent use 40 or more volts is highly desirable. Manual telephone plants use 22 volts (called 24) where simple relay operations are involved, but automatic plants have used 48 volts for years.

Average good contact metals require only a couple of volts to penetrate their natural films or tarnish but grease will soon appear and demand the higher voltages mentioned, so actually the kind of metal used is a minor matter if it is not subject to heavy tarnish. Phosphor-bronze, for example, is a poor metal that needs about 28 volts to penetrate its tarnish (with almost zero mechanical pressure), though with over 32 volts or so it serves very well, with medium mechanical pressures. Tungsten is another poor metal, worked best with around 50 volts for medium pressures, though at high pressures, 100 grams or more, it can operate with only 3 volts or so.

What of Contact Shapes?

And now for contact shapes. They should be ball-faced and as small as practical alignment and reserve material for wear permits. Large contacts will not carry more current than small ones.

Two plane surfaces free to align with each other can only touch at three points unless there is sufficient pressure to distort the surfaces. If the surfaces are not free for alignment then they can touch at only one point—one molecule. Practical pressures encountered actually crush the molecules out of position slightly so several will be in contact, but this is still only a microscopic portion of the entire contact face. Therefore a ball contact can function as well as a flat one so far as the amount of metal in contact is concerned, the maximum current capacity being about one amp. at medium pressures: more current can be carried, at greatly less reliability, up to about two amps. Moving coil relays can carry about .25 amp. as a maximum and .10 amp. is safer.

The chance for dust to lodge between contacts is far greater for flat than for ball faces: also, a greater area of film is presented requiring more mechanical pressure for puncture.

Some contact pairs consist of a point and a flat: this type only halfway approaches the ideal with a disadvantage that craters develop in the flats.

Smooth, polished contacts are poor, there being less points to pierce the grease film and actually effect contact. A rough contact is essentially a multiple contact by virtue of the greater number of points crushed together. As a test, two sheets were chromium plated: one was highly polished, the other left with its natural granular surface. With about 5 grams pressure a blunt pointed copper contact upon the sheets showed the polished plate as having eight times the contact resistance of the granular plate.

Vertical or Horizontal Contacts?

The writer believes this to be immaterial. Theoretically, normally closed vertical contacts can form a rest for floating dust which might settle between the contacts when they open preventing their closing when released. With horizontal contacts the upper spring would catch the dust, sprinkling it over the sides by vibration as the relay operates. However, Brownian movements shoot dust in all directions and potential differences make attractive traps regardless of position. It is a different case with stepping switch bank contacts where the horizontal types are markedly worse.

Freely floating dust is of no consequence in relays. Blowers or vacuum cleaners are positively ruinous, forcing large chunks of dirt into contacts they could never reach by natural air currents. In the dust plagued industrial belt of India, from damp Bengal to hot and dry Punjab, the writer installed a number of all-relay automatic exchanges, each being *entirely* without dust protection from the moment of unpacking to several weeks after starting service. They were positively filthy yet gave no trouble from dust. On the other hand, one plant in the Jherria Coal Fields (surface mining largely) had abnormal grease trouble. A day would be bright and quiet when suddenly, in five minutes time, the whole plant would go bad from a gas wave. Filtering the air to this plant was of small benefit and it was left up to the maintenance men to do fast washing.

An interesting test was made concerning grease. A bay of 100 relays having three sets of break contacts and a like number of relays with three makes was unpacked, after about two years storage in Bombay. All contacts were ball shaped gold alloy with tensions of about 30 grams and worked with 40 volts. One would suppose the normally closed contacts to perform better than the open ones but they were worse. Grease had forced apart the normally closed contacts so the applied voltage could not penetrate. Of course there was grease upon the open contacts, but the mechanical force of operation aided the penetration. Further, while the closed contacts that failed would break through if flipped electrically, and repeat properly, yet after being idle for a day would be bad again—the grease had time to creep back.

Inductive Circuit Hints

Associated circuits have important effects upon contacts. It is highly desirable that contacts spark a little when opening as this burns the grease away quite well, the resulting carbon not being as troublesome. Thus inductive circuits are markedly better than non-inductive, up to the point where excessive sparking causes too much carbon. Useful sparks are such as can be fairly easily seen but not near a "spitting" condition.

Non-inductive circuits (slow relays and particularly lamps) are bad for contacts. Any contact will vibrate or chatter every time it closes, regardless of tension, and each vibration is a current interruption. In an inductive circuit the average transient current is low during the period of vibration whereas in a non-inductive circuit the current is practically full value for the entire period. There are several effects; the carbon-forming sparks are less but their grease burning is also less, so failures increase.

When any contacts carry current they are welded together—very minutely as a rule: in fact, no weld, no current. The non-inductive current welds at each vibration of the contacts, rapidly destroying the contacts. In one case observed, certain relays, operating almost continuously through the day, had two sets of make contacts—one driving a switch magnet, the other a lamp taking about one-fourth the current. The magnet contacts lasted over two years but the lamp contacts had to be replaced once about every three months.

Condensers when shunted directly across contacts are terrible, ruining the contacts quickly by excess welding. In some cases the weld prevents the contacts from opening. Assume that a condenser of any size is charged to 50 volts: a dead short upon it will produce an initial current limited by the resistance of the short. Assuming the short resistance is .02 ohm then there would be 2500 amps. at the first instant of closing. Just imagine the welding effect. A resistance should always be in series with the condenser and have a value of about one ohm per volt of power supply, limiting the maximum current to one ampere. For moving coil relays about 20 times this resistance is better.

A particular use of this welding was made in the case of about 75 valves used with pneumatic ticket carriers. Tickets and "cleaners" (dipped in powder) shot between the two German silver contact springs, opening a circuit supposed to close when the ticket was removed. A small narrow slot in one spring, aligned with a semi-penetrative embosure upon the other spring helped, but adding a 2.0 μfd condenser without resistance positively cured all contact troubles. The system operated with 22 volts. Of course, the weld was too small to interfere with ticket entries but it held the contacts electrically.

In many cases spark-killing can be

(Continued on page 54)

Characteristics of Phosphors for Cathode Ray Tubes

Characteristics of screen materials commonly used in cathode ray tubes summarized in convenient form. Spectral curves given for the most commonly used screen materials

THE TABLE below, as well as the set of curves at the right summarizes the more important characteristics of phosphors used as screen materials in cathode ray tubes for oscillography and television. All data applies to bombardment of the fluorescent screen by means of an electron beam.

For photographic purposes, the spectral distribution of screen images and the persistence of image are of considerable importance. Data on these characteristics are given graphically at the right and in tabular form below. The Reference Sheet in the April 1938 issue of *Electronics* may be used in conjunction with this one as an aid in determining the most suitable type of film for cathode ray tube photography.

The data given below was compiled by Dr. L. B. Headrick, of the RCA Mfg. Co., Harrison, N. J.

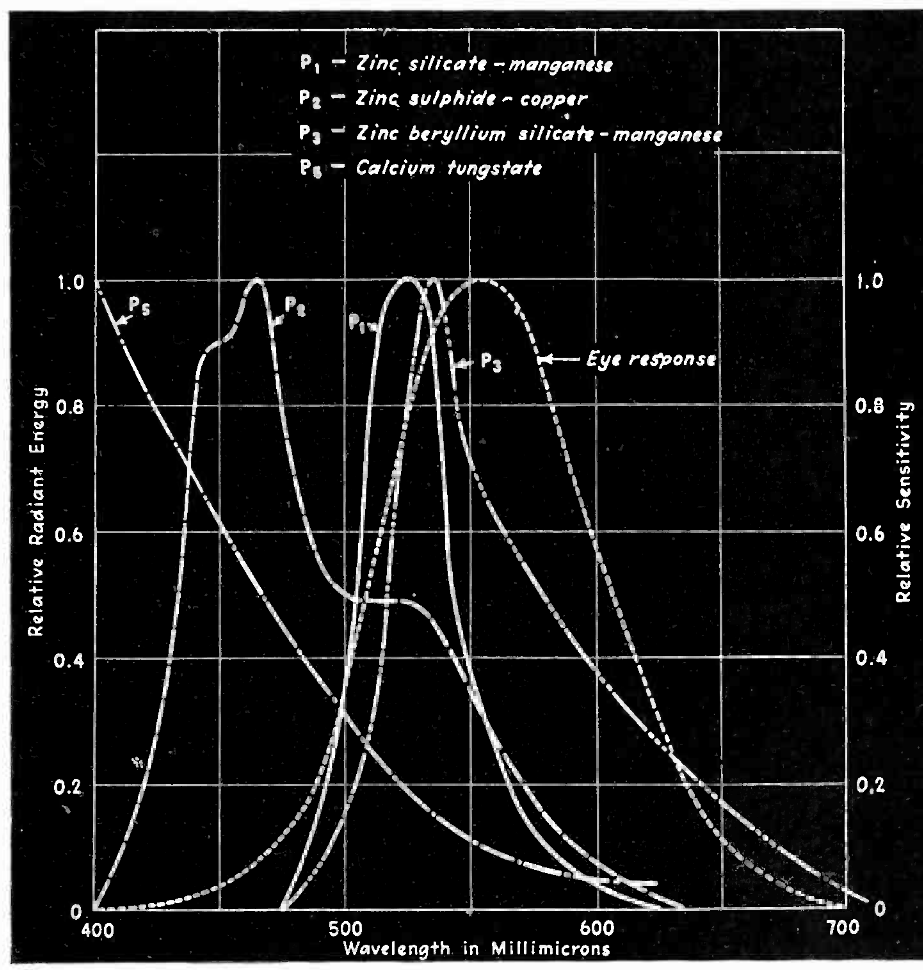


Diagram at the right shows spectral distribution of relative energy for various phosphors (left ordinates) and sensitivity response of the human eye (right ordinates)

DATA ON PHOSPHORS IN GENERAL USE
ELECTRON BOMBARDMENT

Material	Formula	Color	Spectral Maximum	Efficiency CP/Watt 1 to 6 kilovolts 1 μa/cm²	Persistence Time in Seconds for the Light to Fall to the Following Fractions of its Initial Value 10%	1%	0.1%	Principal Uses
			A°					
Zinc sulphide	ZnS	light blue	4700	1 to 3	—	$*10^{-3}$	—	Television
Zinc sulphide-silver	ZnS-Ag	blue violet	4500 to 4700	1 to 3	—	$*10^{-3}$	—	Television
Zinc sulphide-copper	ZnS-Cu	blue green	4700 to 5250	0.5 to 5	10^{-3}	$5x10^{-2}$	$5x10^{-1}$	Oscillograph
Zinc cadmium sulphide-silver	ZnS,CdS-Ag	blue to red	4600 to 7500	1 to 5	—	$*10^{-3}$	—	Television
Zinc silicate-maganese	$ZnO+SiO_2$-Mn	green	5230	1 to 3	$2x10^{-2}$	$5x10^{-2}$	10^{-1}	Television, Oscillograph Indicator and Illumination
Zinc beryllium silicate-manganese	ZnO+BeO $+SiO_2$-Mn	green to orange	5250 to 6000	0.5 to 3	$2x10^{-2}$	$5x10^{-2}$	10^{-1}	Television and Illumination
Magnesium tungstate	$MgWO_4$	light blue	4800	less than 1	—	$*10^{-5}$	—	Illumination
Calcium tungstate	$CaWO_4$	violet	4100	less than 1	—	$*10^{-5}$	—	Oscillograph
Cadmium tungstate	$CdWO_4$	blue white	4900	less than 1	—	$*10^{-5}$	—	Television

* Rough approximate values of persistence.

Remote Control

(*Continued from page 15*)

introduces a characteristic tone from a local oscillator into the signal wires to advise the controlling operator of the condition. Lamps on the receiver tuning unit advise the receiver attendant when the motor is running during tuning operations and when the condenser has been tuned out of bounds. An indicating dial is attached to the condenser shaft which shows the condenser position from the front of the panel. A cam key on the tuning unit permits the condenser to be rotated for line-up purposes from the receiver position, taking control away from the remote station during this operation.

To enable the control operator to "see" the tuning operation as well as hear it, a telltale device is provided at the control position. This is a dial with a pointer geared to a synchronous motor in the same way as the tuning condenser. While not absolutely necessary it is found to make the tuning more convenient, especially in cases where several signals in the same band are to be found one after the other and it is necessary to turn back quickly to a known receiver setting.

Although there is nothing to pull the telltale and the tuning condenser into a fixed angular relation, the two do in fact track together over long periods. Both motors are alike and both have electric brakes. They start and stop almost instantly, and while running they both turn at the same speed. Where absolutely positive angular relation is desired it can be insured as often as necessary by simply tuning past the end position. When this is done both telltale pointer and tuning condenser rest against their limit stops and the motors continue turning against the slippage of the connecting drives.

Emission

(*Continued from page 25*)

membered that the emissions of the grid are nearly as important as that of the filament and care must be taken to control them.

6. Maximum R-F Grid Current.

This value is limited mainly by the current carrying capacity of the grid lead, or I^2R loss in the lead itself. However, this lead cannot be degassed during manufacture above temperatures which the glass will stand (about 450°C) and so if heated during operation, the lead will evolve gas or crack the glass at its seal.

7. High Frequency Troubles.

Numerous observations have been made by tube engineers of r-f losses on the glass envelope and the insulators in the tube, in which the material was raised to a sufficient temperature to show color, or to actually suck in the bulbs. When the bulb becomes so hot as to soften, secondary emission from the glass usually occurs. In these cases, the output of the tube falls off undoubtedly due to increasing losses in the tube. Shortly thereafter the emission of the filament will be found to have decreased or disappeared.

The user should seldom observe such cases, for through careful design, they have been eliminated in the tubes designed for high frequency operation. The important thing therefore in the use of tubes at very high frequencies is to locate high-voltage leads, and the apparatus, so that the fields generated by these cannot have detrimental effects on the operation of the tube. For instance, in a two-tube 6 meter therapy outfit, it was found that continuous failure of the tubes resulted due to the proximity of the plate lead and the tubes. By relocating this lead, everything was satisfactory. Usually a discolored (brownish) spot will appear on the bulb showing the location of the effect.

It may be mentioned with regard to Class C operation, that in those cases where the d-c resistance of the grid circuit is low, the effect of primary emission from the grid is minimized as a current of a few microamperes can result in only a slight change in grid voltage.

8. Mercury Vapor Rectifiers.

There are really but two limiting items in the operation of mercury vapor tubes; namely, peak inverse plate voltage and peak current. The best indicators of the available life in the tubes are the d-c voltage drop across the tube and the color and volume of the glow. The smaller the volume of the glow for a given plate current and the deeper the blue color, the better the tube. One other caution to observe is to prevent the high-voltage leads from resting on the glass. An easily measurable current passes thru the glass on the inverse peak and may be destructive.

ACCURACY PLUS

Focus of electron beams in X-ray tubes depends upon placement of filament in slot in focussing cup. In these Westinghouse units the accuracy of measurement is one ten thousandth of an inch

Rochester 1938

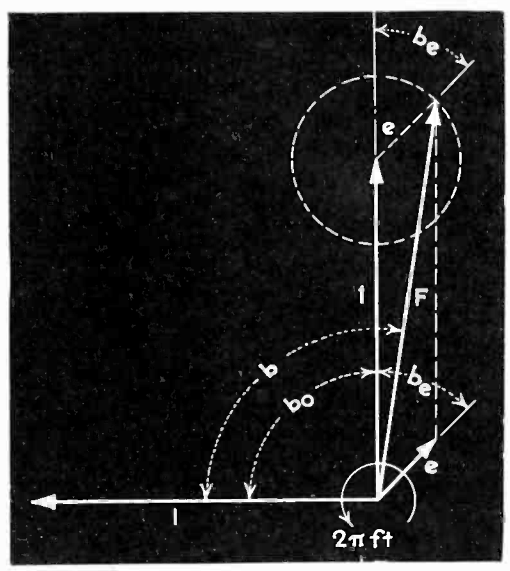
(*Continued from page 13*)

Paired Echoes". Essentially the method consists of separating the effects of phase and amplitude distortion by considering each signal component to be accompanied by a pair of "echoes", that is two small signals separated in time from the main signal by the same interval. In television transmission it often happens, for example, that the main image is accompanied by a ghost image, resulting from a signal which traveled from transmitter to receiver by a path longer or shorter than that taken by the main signal. Consider first the main signal accompanied by one such echo signal which lags it by a definite phase angle. The two signals, considered as vectors, may be combined with each other vectorially in polar coordinates. The resultant vector is the distorted version of the main signal. The amplitude distortion is the difference in amplitude between main signal and the resultant, while the phase distortion is the phase separation between the two. Now if another echo be added to the resultant, at the origin of the coordinates, such that it is equal in amplitude to the first echo but leads the main signal by the same phase angle then the phase distortion is cancelled, but the amplitude distortion remains. Similarly if the added echo signal is equal and opposite in amplitude to the original echo but leads the main signal by the same angle, then the amplitude distortion is removed, while the phase distortion remains. Thus by adding echo signals, the effects of phase and amplitude may be separated.

The addition of the echo signals may be conveniently made in a voltage vs time plot, and this representation is especially convenient in visualizing the effect of the distortion on a television image. Mr. Wheeler proceeded to illustrate the use of the method by assuming different types of amplitude response curves with variously placed cutoffs and corresponding distortion characteristics, the departure of the distortion characteristic from a straight line being limited to small amounts. For each amplitude curve, a paired echo is added above the time axis and spaced from the main signal on the opposite side by an amount equal to the spacing of the echo representing the original distortion. A response curve is then erected on each of these signal lines in the proper proportion, and the addition of curves gives the overall response. For each phase distortion an echo is added below the time axis, spaced equally from the main signal, and a similar addition of the response curves for all components performed.

Noise Measurements

In discussing the measurement of radio noise interference, C. J. Franks, of the Ferris Instrument Corp., pointed out that two important



Vector addition of main signal (one) and echo (e) to show effects of amplitude and phase distortion (Wheeler)

factors must be considered in determining the psychological factors involved in receiver noise. The first point is that no device whose indications are proportional to the noise energy output can give true readings of the ability of any radio frequency disturbance to cause interference with radio reception. The second point is that the characteristics of the radio receiving equipment should be carefully standardized and maintained in order that consistent and correct results may be obtained by different observers who, most probably, are working under widely different conditions.

In the design of an instrument which would give indications proportional to the psychological effect of radio interference it was decided to reduce the measuring equipment to three units: (a) the radio receiver for which the interference is to be determined, (b) a weighting network which operates on the output of the receiver in such a manner as to produce an output which is more or less proportional to the disturbing effect as judged by human observation, and (c) a meter for giving visual indications of the output of the weighting network. While such a system is simple in operation, a major difficulty is encountered in the design of a proper weighting network. Ideally, such a network should be "the equivalent circuit of a human being", but data and measurements which are available at present are not sufficiently extensive to assure the attainment of this ideal.

Complete specifications for instruments used in the measurement of noise have been established by the Special International Committee on Radio Disturbances and other standardizing bodies. It is recommended that the recording instrument be of the quasipeak reading variety, and the constants are so chosen that the peaks must be maintained for a specified length of time before an indication is obtained on the meter. A commercial noise meter has been built in which the weighting network and indicating meter have been constructed in accordance with the specifications of the C.I.S.P.R.

Cold Cathode Discharge Tubes

Mr. M. A. Acheson delivered "A Discussion of Cold Cathode Gas Discharge Tubes" in which was reviewed the essential general characteristics of tubes of this classification, and the detailed characteristic of several commercial and experimental tubes were given. The equivalent circuit for several types of gas tubes were derived, and by considering the equivalent circuit, various interesting applications of such tubes were developed.

It was shown that gas discharge tubes might be used not only as voltage regulators, but that, because of capacitive reactive effects occurring within the tube, such a voltage regulation tube would also serve as a smoothing condenser in filters for power packs. Calculations and measurements showed that commercial gas tubes were the equivalent, in their reduction of ripple voltage, to an 8 μf condenser when used as the second section of the filter.

TUBES AT WORK

APPLICATION of a practical voltage regulator, mercury-vapor detection, single-resistor attenuator sections, a mercury rectifier operating at 100 kilovolts, a 30,375 rpm motor for mechanical television, and a pin-hole detector—all contribute to the advance of electronic technique

The Voltage Regulator Applied to an Amplifier

By W. W. Waltz

Readers of *Electronics* may be interested in an application, which has been made of the voltage regulator as described by A. G. Bousquet in the July 1938 issue. With the few minor exceptions, noted on the accompanying drawing, the regulator is essentially as described originally. The load requirements (179 milliamperes at 325 volts) were largely responsible for the changes.

Two reasons dictated the use of a regulator—poor line-voltage regulation, and excessive hum, this latter being traceable entirely to the amplifier plate supply. Reports of earlier experiences with voltage regulators had indicated a possible improvement in hum conditions which might reduce the aggravation in this particular amplifier to below audibility. Such was found actually to be the case.

Of practical interest is the problem of mounting the ¼-watt neon bulbs so that good contact will be obtained. These bulbs are available generally in the candelabra-base type, but these must be changed somewhat before use in this circuit. As purchased, these bulbs have a resistor of about 27,000 ohms mounted inside the base; this resistor must be removed. However, on special order, these bulbs may be obtained without the resistor[1]; they are then furnished with a double-contact candelabra base (best known as the auto-type bulb). Sockets to hold these lamps were found to be unreliable, so the only solution was to solder leads directly to the contacts of the base itself. The sockets were cut down so that only the metal shell with the bayonet lock remained; these serve to hold the lamp, but, as mentioned, contact is made by soldering.

The changes shown in the circuit drawing are, with few exceptions, in accordance with data in the original article. That is, the number of neon lamps in the voltage-divider circuit was increased to four because of the higher output voltage desired; a variable resistance was placed in series with the voltage divider to provide exact adjustment of the output voltage; and the 1-megohm resistance was shunted across the neon lamp in the cathode circuit of the 6F5. This last was a suggestion of the G. E. Vapor Lamp Co., and is intended to prevent the lamp from dropping out and re-igniting at a rapid rate.

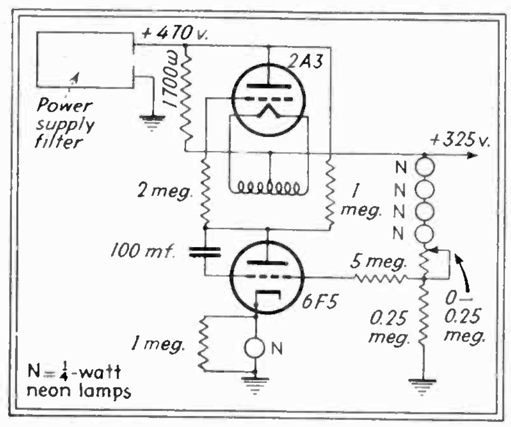


Diagram of voltage regulator based on Bousquet's design

Final results, once all adjustments had been made, were more than gratifying. Line voltage fluctuations over a range of 107-123 volts had no perceptible effect upon the plate voltage of the amplifier tubes; this, it is believed, exceeds expectations expressed in the Bousquet article. As anticipated, the hum dropped out entirely.

One point to mention is the inability of the regulator to function at a load current that is considerably lower than that for which the circuit is designed; this is in accordance with the Bousquet data, however, and the "headache" might have been avoided by a more careful examination of the curves given.

1 From General Electric Vapor Lamp Co., Hoboken, N. J. (Their code number, 2005-CL) Westinghouse also makes this type of lamp.

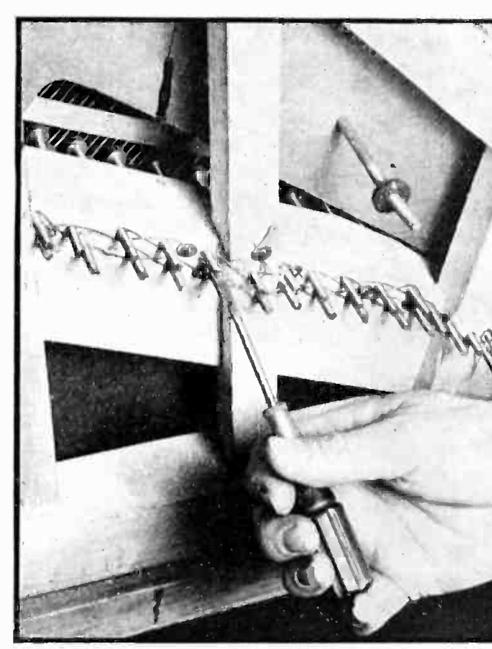
• • •

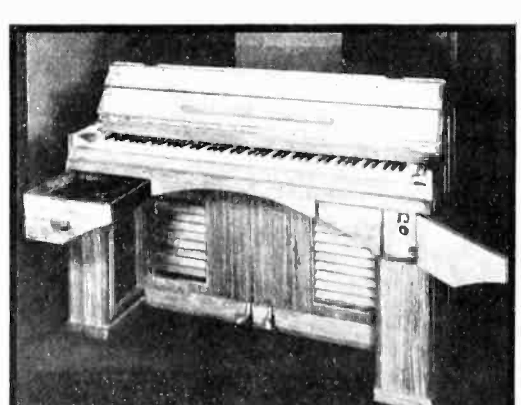
Spectral Absorption Used for Mercury-Vapor Detection

The detection of mercury vapor is becoming of increasing importance in industry pursuits, primarily because of the health hazard associated with it. T. T. Woodson of the General Electric Co., has recently devised a detector for observing as small an amount as one part of mercury vapor in a billion parts of air. The principle of the detector is based on the fact that any vapor will absorb light of the same color that it emits when excited. Using a lamp which produces the spectral colors of mercury, and a photo-tube which observes the lamp light, balance can be

(Continued on page 36)

THREE-IN-ONE ELECTRONIC MUSIC

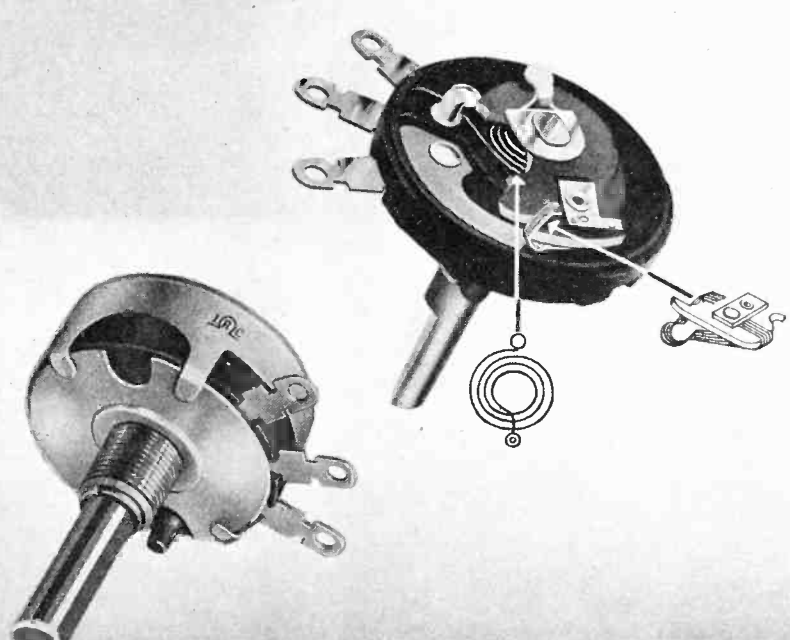




This piano is built without a sounding-board, but contains electrostatic pickup electrodes (above) near each string. The amplified output is applied to a speaker behind the louvers under the keyboard. The instrument contains also, at either side, an all-wave radio and a phonograph

IRC

IRC Type CS Controls combine the twin noise eliminating features of (1) Silent Spiral Connector and (2) 5-Finger "Knee Action" Silent Element Contactor—each equally important—each pioneered and perfected by IRC. The combination of these two features plus the inherent dependability of the Metallized element insures better performance under all conditions than any other known construction.



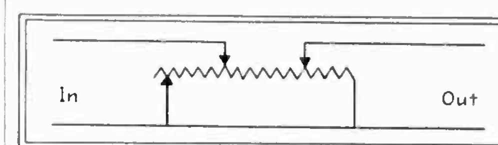
INTERNATIONAL RESISTANCE COMPANY, 401 N. BROAD STREET, PHILADELPHIA, PA.

obtained between the light emerging from the lamp and that impinging on the photo-tube. If, between the lamp and the photo-tube, a small quantity of mercury vapor is allowed to accumulate, the absorption of the light by the mercury vapor is sufficient to upset the phototube balance, and a warning light or similar device may thereby be actuated.

• • •

Simplified Resistor Pad

THE EDITORS ARE indebted to Earle Travis of Station KVEC for the following suggestion concerning the use of ordinary movable-clip resistors in attentuator construction, as outlined in "A Simply Constructed Attenuation Network" by Francis King, p. 48 Sept. issue of *Electronics*. Mr. Travis points out that a single resistor with movable clips may be used as a "pi" section of



Single-resistor attenuator element

an attenuator. In this arrangement 2,000 ohm resistor of sufficient length to allow spacing of the 3 clips will allow variation of from 1 to 35 db loss. The connections are shown in the accompanying sketch.

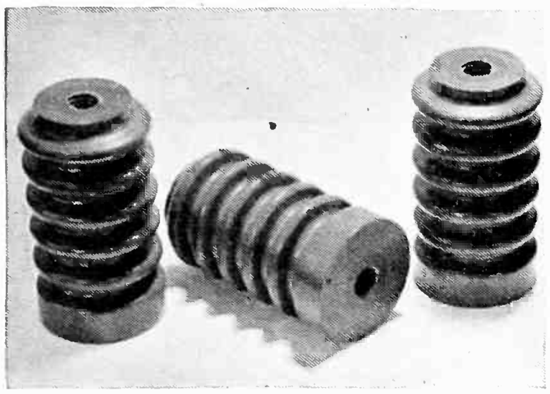
Since a pi-section can always be constructed equivalent to a T-section, the choice of using a pi or T depends upon the resistors on hand.

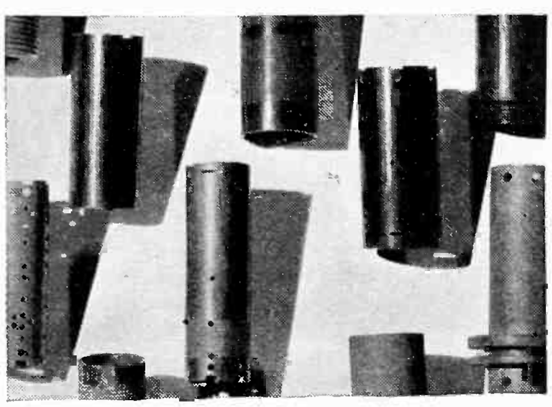
MOUNTAINEER RADIO

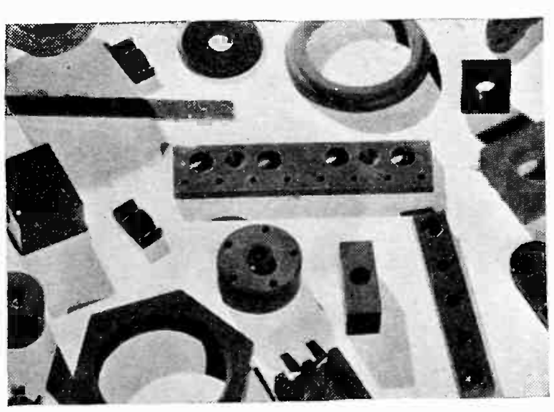
Alpine enthusiasts near Geneva, Switzerland, employ shortwave amateur equipment, with antennas woven into the climbing ropes, to maintain communication between parties and for rescue work

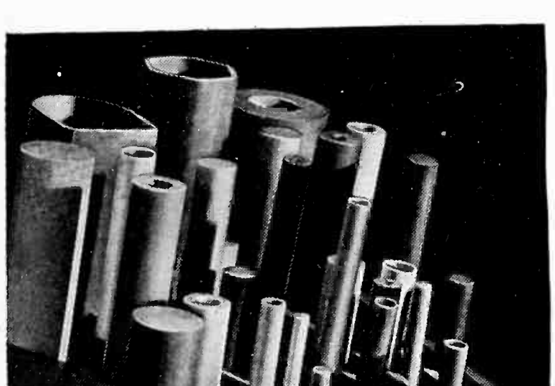
—a thousand new uses for DILECTO

A LAMINATED PHENOLIC MATERIAL


HIGH VOLTAGE INSULATORS


COIL FORMS


INSULATING PARTS


SHEETS — RODS — TUBES

The principal virtue of a good designer is his curiosity. If worth his salt, he is constantly on the look-out for ways and means to step up performance, improve the appearance or lower the production cost of his company's products. *Discoveries* along these lines mean something! And when designers are thinking in terms of new materials it is perfectly natural that they should consider DILECTO. For here is a material of almost unlimited possibilities. . . . This laminated plastic possesses high mechanical and dielectric strength, is half the weight of aluminum and machines like brass. It is chemically inert, insoluble and infusible. Add to these qualities a beautiful appearance and you have some idea of how DILECTO will fit into your plans for product development. . . . Your request for further information will receive a prompt and intelligent answer.

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CONTINENTAL-DIAMOND FIBRE COMPANY

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High-Speed Synchronous Motor Employed in British Television

By John H. Jupe

A motor has been developed by Scophony, Ltd., in England for driving the scanning mechanism in their television apparatus. It runs at a synchronous speed of 30,375 rpm and consists of two sections. This mode of construction is necessary because any normal synchronous motor has a slight residual phase variation with the supply frequency and further, all synchronous induction motors have a low efficiency and a widely varying impedance when running up, points of great importance where tubes are concerned.

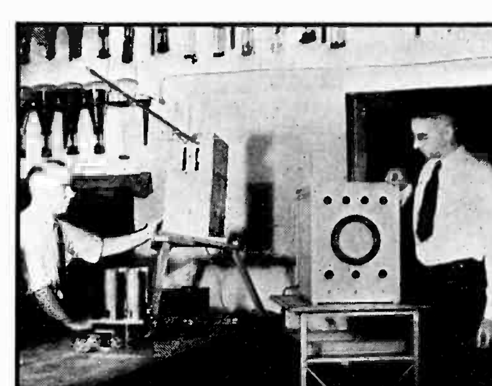
The two sections consist of an induction motor and a phonic wheel synchronous motor with a common spindle. The first is of the two pole, squirrel cage type, wound to work at 520 cycles, 3 phase. Its purpose is to overcome friction and windage and to maintain the motor at approximately correct speed. Section two is a 20 pole rotor running in a 10 pole stator, the winding of which is tuned to resonance at the television signal frequency. D.C. is passed through the winding, equal to the peak a-c current so that the magnetic flux remains unidirectional.

Now phonic wheel motors have a tendency to hunt and to increase the damping the induction section is designed to have a very rapidly falling torque/speed characteristic near synchronism. Tuning the stator to resonance also helps because any change in phase alters the inductance and detunes the winding, reducing the current and again dropping the torque.

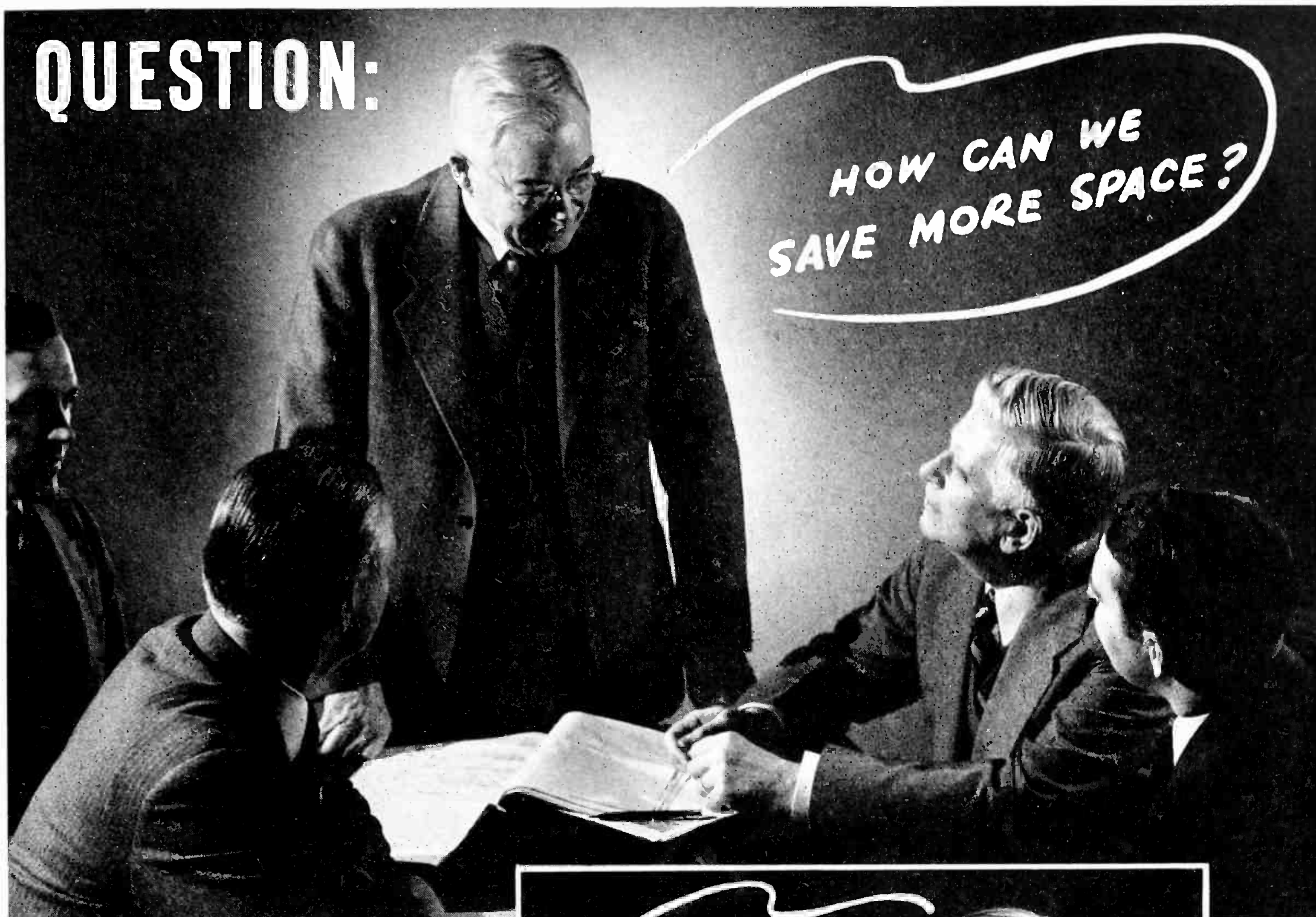
Ball bearings are mounted in rubber and all moving parts have smooth contours to reduce noise. Dynamic balancing is of course very important and the accuracy obtained is the order of 1 milligram-centimeter.

The life of the motor without servicing is equal to that of the average radio tube.

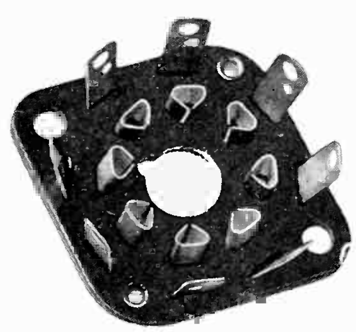
U-H-F FOR FOG BEACONS



Members of the staff of the Engineeering Experiment Station at Purdue are developing ultrahigh frequency directional transmitters to be used for establishing landing beams and markers for landing airplanes in fog



ANSWER:



SOCKET 6708—8 CONTACTS ACTUAL SIZE

save space with the new Cinch "Cub". For octal tubes 1-5/16" mounting centers . . . where set space is at a premium —this socket with *improved* individual features will find a ready use. Samples and further detail on request.

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Efficient design—contact spacing arranged so as to allow maximum mechanical and electrical efficiency: CINCH sockets in use have proved to be time—money—and *space savers.* Rigid, durable, compact and trim. Immediate delivery! Specify "CINCH" . . . and insure good performance.

Cinch and Oak Radio Sockets are licensed under H. H. Eby socket patents.

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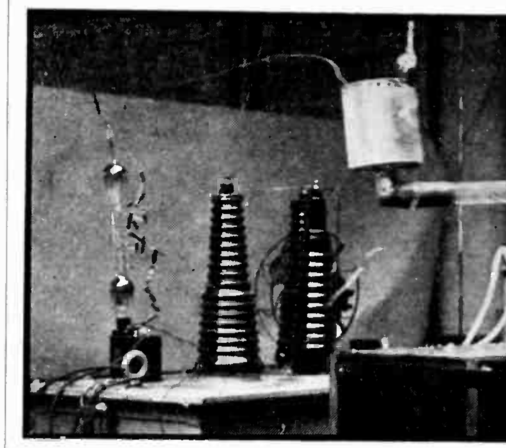
Unusual Mercury Rectifier Operates at 100 Kilovolts

In a recent demonstration before the Technical Service Dept. of the Consolidated Edison Co. in New York, Professor J. W. Dorsey of the University of Manitoba, showed how very simple rectifier tubes of the mercury vapor type may be modified to operate at extremely high voltages. In the demonstration, 35 kw. of rectified power was made available from a mercury vapor rectifying tube very similar to the ordinary 866 type, but employing an elongated glass tube between the cathode and anode. A special arrangement of grids and resistors is employed to control the potential gradient along the glass tube. In the demonstration the tube delivers 0.5 amp. peak at considerably above 70,000 volts. At voltages much higher than this the grid system sparked externally, but the tube itself showed no sign of deterioration. After several minutes of sustained operation, the tube was not perceptibly warm except around the hot cathode. Present plans are to build a tube of longer dimensions and with a more complex grid structure, with the expectation of operating circuit voltage as high as 150 kilovolts.

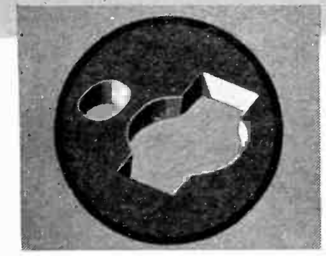


Rectifier (left) in 100 kilovolt set-up

ANIMAL X-RAY TECHNIC

One of the largest X-ray installations intending exclusively for animal patients has recently been installed at the veterinary hospital at the University of Pennsylvania

Third and Six to Go at 10:47 p.m.



HE'S OFF! He's loose! He's running for a touchdown! Night football is a popular game—and all credit to floodlighting. Synthane Bakelite-laminated helps keep the night sun burning.

The one big reason why Synthane is used by makers of floodlighting equipment may also interest *you*, regardless of what you make. And that is Synthane's unusually broad *combination* of physical, electrical, chemical and mechanical properties—properties you can use. Synthane is dense, tough, strong, and light in weight. It is an excellent insulator—with low power factor, low moisture absorption, high dielectric strength, low dielectric constant. It's chemically inert and corrosion resistant. It has a minimum cold flow; machines easily.

Synthane is often the most economical material to use because of lowered production costs, better product performance, dependable adherence to standards. Why not write for data on Synthane, giving us your requirements? We might help you make more money.

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Phototube Scans Steel for Pin-Hole Flaws

At the Sparrows Point, Md. plant of the Bethlehem Steel Corporation, a phototube scanning device has recently been installed by General Electric engineers to examine steel strips for minute perforations. The steel strip is 36 in. wide, and is taken from an "uncoiling," unit, passes the scanning unit to a trimmer. The speed of the strip is as high as 900 ft. per min.

Light is projected upward through a slot in the scanning head. The beam is very intense, and as a result any light which penetrates through pinholes or other perforations is capable of actuating the phototube section of the scanner, which is above the sheet. The tubes actuate a relay-operated diverter mechanism which causes any faulty sections of the strip to be removed later in the production line.

A simplified version of the scanning device was exhibited at the Iron and Steel Exposition, scanning a continuous steel strip running at a speed of about 600 ft. per min. When a pinhole enters the slot between light source and phototube, the relaying system stops the machine.

• • •


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OF 1939 AUTO RADIOS
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THE ELECTRON ART

Each month the world's technical literature is scanned to see what physicists and engineers are doing with tubes, for presentation in tabloid form to Electronics' readers

Acoustic Instruments for Routine Testing

ANOTHER INSTANCE of the application of scientific methods to replace subjective estimates in the factory is contained in an article by Blair Foulds, in the October issue of the *Journal of the Acoustical Society of America*, and entitled "Recent Advances in the Use of Acoustic Instruments for Routine Production Testing."

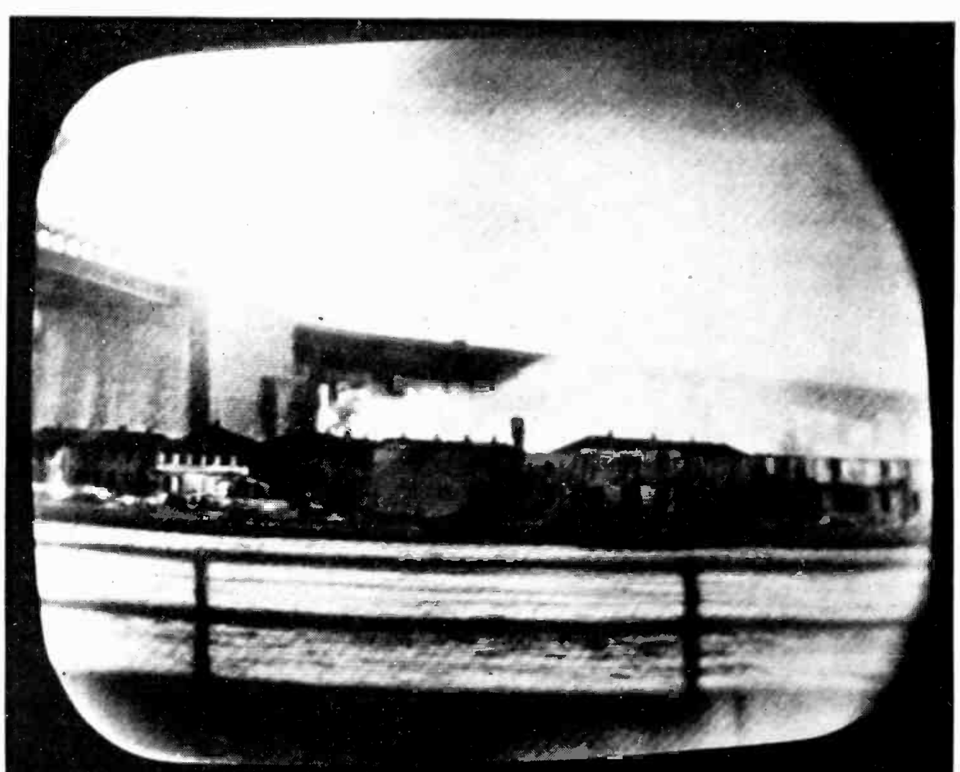
As a result of the author's experience that the usual types of noise meters were generally unsuccessful for routine testing of products, a new approach to the problem became necessary. Failure of the earlier attempts at the use of noise meters has been attributed to two principal causes; lack of frequency discriminating and lack of sufficient stability in the measuring instrument itself. Whereas the noise meter is intended to measure the level for loudness of a sound, the human observer not only gets the loudness of the entire sound but involuntarily analyzes the sound, fixes his attention on any components which stand out or which he believes to be abnormal in the product, and judges the loudness of them individually.

As a result of an examination of the methods used in the production and testing of rotating electrical equipment by acoustic methods, two important facts were discovered. The first of these is that the overall loudness of a motor is controlled largely by the low frequency component and does not reflect small changes in mid or high frequency ranges. The second fact to be discovered was that defects produce small changes in a portion of the frequency range, rather than pronounced peaks at definite frequencies. As a practical solution to the problem of routine production testing by acoustic methods, a filter system was designed for use with the noise measuring equipment which enables various portions of the audio spectrum to be measured or analyzed separately. The filters were so designed that cut-out frequencies at one-half octave intervals were provided. Through a switching arrangement it is possible to select a high pass, low pass, or octave width bandpass type of filter. Experience with this filter has indicated that the arrangement is sufficiently flexible to meet the requirements of most products, while at the same time the system is relatively easily constructed and operated. The filters employed were of the constant K type. Double sections were used on the high pass side and single sections on the low pass side, providing a suppression of approximately 40 db and 20 db, respectively at on octave away from the cut-off frequency.

To meet the requirements of extreme stability of calibration, an a-c operated feedback amplifier was used. The feedback of about 35 to 40 db was used with a net gain of 120 db. A variation in gain of less than 0.1 db occurs for line voltage variations of 10 per cent.

In use, a number of acceptable motors are tested by means of the variable filter, noise meter arrangement. The noise frequency response of these acceptable units is then plotted. A similar procedure is made for units which are barely acceptable as well as those which are rejected for one reason or another. Experience soon indicates the shape of a desirable frequency response curve for satisfactory and unsatisfactory units and in addition, gives some indication as to the type of trouble or defect which is present in the motor.

Mobile Unit Telecasts A Fire

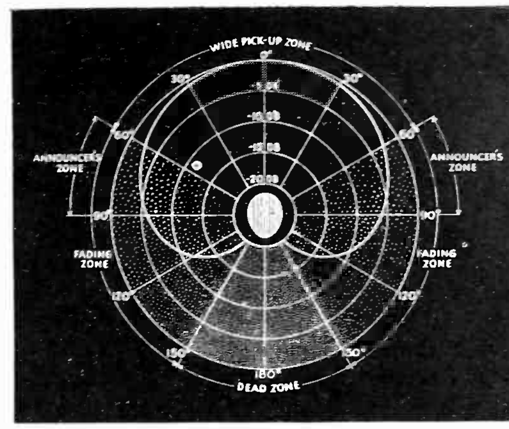


A fire which broke out on Ward's Island in New York's East River was picked up by the NBC mobile television unit recently while in Astoria. The photograph shows smoke rising from burning buildings, with the Triborough Bridge in the background. The diagonal line pattern are caused by interference from a local high frequency transmitter

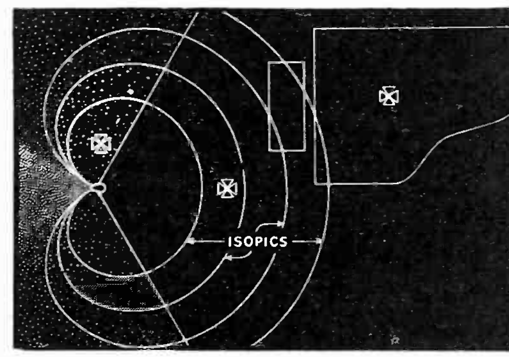
Bibliography on Electron Tubes

AS AN ANSWER to those who sometimes come to us with the request for information on electron tubes and their application as a basis of becoming familiar with current practice, or to become acquainted with the relatively new field of electronics, we may now make reference to quite a good sized bibliography on the subject which appears in the October 1938 issue of the *General Electric Review*. The bibliography, occupying six pages, is indexed as well as being grouped into various related subjects. The bibliography has been prepared by E. D. McArthur, whose book, "Electronics and Electron Tubes" is not omitted from the list.

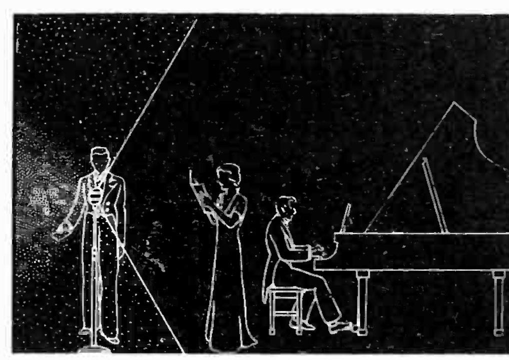
Although the bibliography is, in no sense of the word, a complete compilation of the numerous articles which have been published, it does include many of the most important ones, and should provide an excellent "starting point" for one who has occasion to make reference to the literature on electronics.



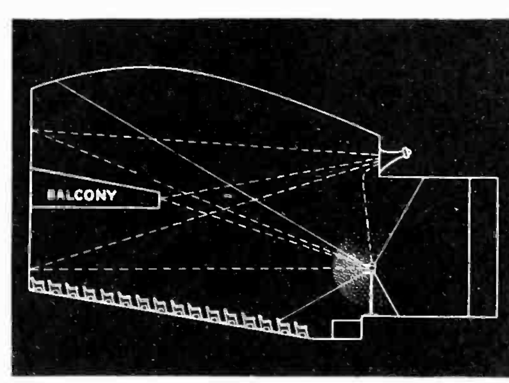
1. Cardioid directional response of 639A.



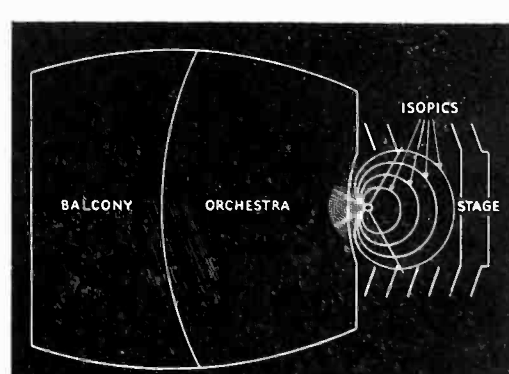
2. Showing isopics, or lines of equal pick-up.



3. 120° pick-up angle lessens need for tilting.



4. No feedback from rear of playhouse.



5. Ideal for dividing stage and audience.

It's the answer to a sound-transmission engineer's prayer! — The new Western Electric Cardioid Directional — the microphone that gives you pick-up control never approached by even the best dynamic or ribbon mikes!

The key to this control is cardioid directivity — for all ranges from the lowest bass to the highest overtone. Bell Telephone Laboratories achieved this by combining dynamic and ribbon units in one mike and electrically equalizing and combining their outputs.

In addition to this realization of true cardioid pick-up, a 3-way switch enables you to use either unit independently. This makes the 639A either a dynamic or a ribbon mike at your will. One way or another, it can handle *any* situation!

Small, sturdy, beautifully streamlined, the 639A is interchangeable with the 8-Ball and Salt-Shaker on stands using the 442A Jack. It greatly simplifies pick-up technique — assures balance, clarity and fidelity of pick-up that will give you a new conception of what broadcast quality can now be!

For booklet giving full details, write to Graybar. Better still, order one mike — put it "over the jumps" — and tell us how many more you want!

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New I. R. E. Standards

A NEW SET of radio standards, supplementing those contained in the report of five years ago, is being published by the Institute of Radio Engineers. Separate pamphlets have already been issued on standards on electronics, on electro acoustics, on radio receivers, and on transmitters and antennas. Copies of these standards are mailed to all members of the Institute of Radio Engineers. Others interested in obtaining copies should communicate with Harold P. Westman, Secretary, Institute of Radio Engineers, 330 West 42nd Street, New York City.

• • •

Push-Pull Stabilized Voltmeter

A PUSH-PULL VACUUM TUBE voltmeter in which the effective values of amplification factor, transconductance and plate resistance of two similar tubes selected at random may be equalized, is described by Charles Williamson and John Nagy in an article, "A Push-Pull Stabilized Triode Voltmeter," in the September issue of the *Review of Scientific Instruments*. Since the circuit is provided with adjustment by which the electrical characteristics of the two tubes themselves are adjusted to equality, a highly stable form of voltmeter results without using elaborate or auxiliary voltage stabilizers.

Fig. 1 shows a schematic wiring diagram which illustrates the essential circuit and mode of operation. The inequality of characteristics of the two tubes are balanced up by means of auxiliary resistors in Fig. 1. For example,

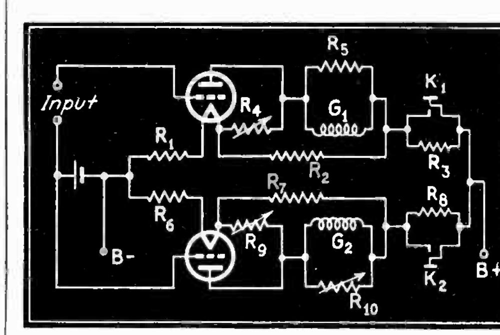


Fig. 1—Schematic wiring diagram of push-pull voltmeter

a series resistance in a plate circuit of one of the tubes will increase the effective values of the a-c and d-c resistance, but will diminish the transconductance and thus tend to leave the amplification factor unchanged. A shunt resistance, on the other hand, will decrease the effective value of the a-c and d-c plate resistance without effecting the transconductance, thus providing a means of changing the amplification factor.

The circuit of Fig. 1 provides means for equalizing the effective values of the amplification factor, transconductance and a-c and d-c plate resistance of both tubes. The adjustments are made as follows: First R_4 and R_9 are set to

maximum resistance. Then the power sources are connected and R_{10} is adjusted until the galvanometer reads zero. Now K_1 is depressed. In general the galvanometer will be flexed, showing that the μ of the tube is too high to give μ balance in the circuit. A decrease in R_4 will, however, reduce the plate resistance without affecting the current conductance, since the current in R_4 is not controlled by the grid of the tube. This adjustment will therefore reduce the effective value of μ. The resistor R_9 must simultaneously be decreased in order to preserve galvanometer balance. When μ balance has been obtained for the first tube, no deflection will occur if K_1 is depressed.

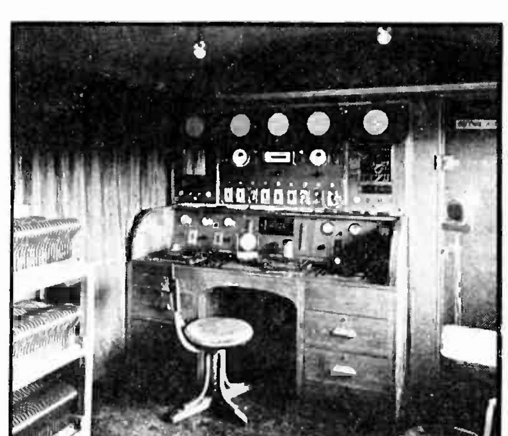
Now K_2 is depressed. Any unbalance observed is corrected by the simultaneous adjustment of R_9 and R_{10}. As in the case of the first tube, R_9 changes the plate resistance without affecting the transconductance; but R_{10} changes the value of both of these quantities for it affects plate current increments no matter what their source may be. Hence the prescribed adjustment of R_9 and R_{10} tends to leave the plate resistance unchanged, but alters the current conductance and therefore the amplification factor of the tubes.

The authors describe a practical embodiment of the circuit, in which two type 85 triodes are used. With this circuit, and the differential galvanometer connected at G_1 and G_2, it has been found that the electrical zero of the galvanometer is unaffected by changes of ±20% in the power supply voltage, when the circuit has a sensitivity of 40,000 mm. per volt.

An advantage of this circuit is that the tubes need not be specially selected, and the balancing principle enumerated in the original article may be adapted for use in any circuit requiring tubes having identical electrical characteristics.

• • •

FRENCH "RADIO TRAIN"

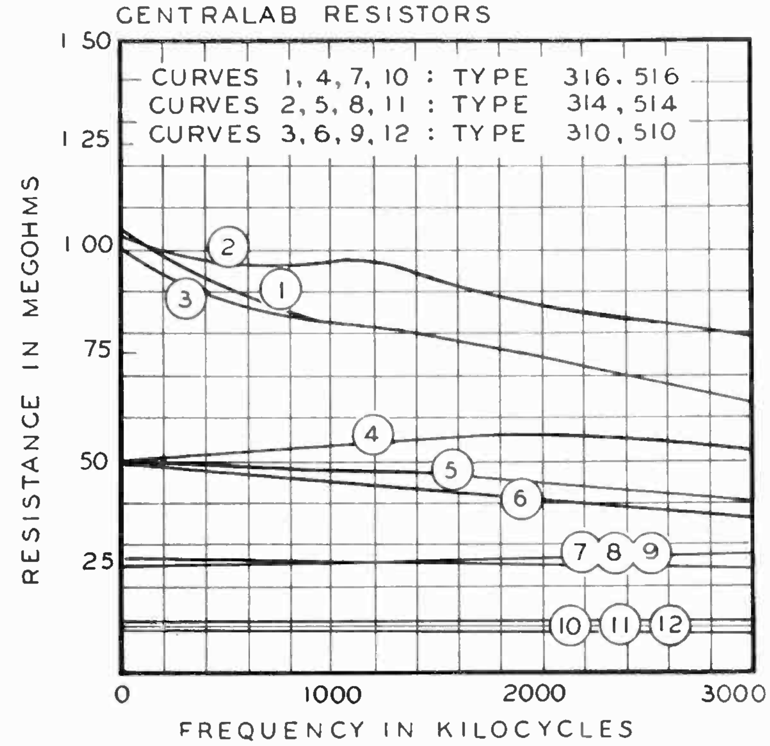


The pleasure-loving Frenchman can now travel on a train equipped with a "dancing car." Loudspeakers are fed from the control point, above, with phonograph music and radio programs

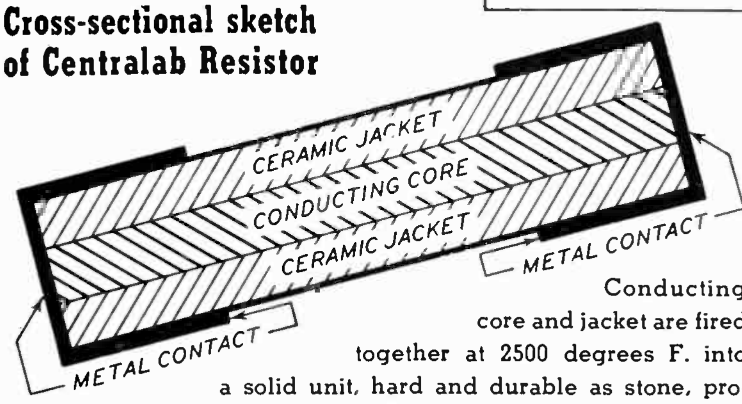
Charting a future course

RADIO FREQUENCY CHARACTERISTICS

CENTRALAB RESISTORS



Cross-sectional sketch of Centralab Resistor



Conducting core and jacket are fired together at 2500 degrees F. into a solid unit, hard and durable as stone, providing mechanical strength and protection against humidity.

Copper contact to the resistance material at the extreme ends only provides uniform resistance and load distribution over ENTIRE length. End contacts do not short circuit part of the resistance as in other types.

Because resistance is small in diameter and uniformly distributed for entire length, Centralab's specific resistance per unit length is low. The result is low noise level and constant value over a wide range of frequency and voltage.

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TELEVISION CIRCUITS

frequently require fixed resistors whose values remain uniform at high frequencies.

Centralab Fixed Resistors because of their relatively small cross section conductor area plot a comparatively flat resistance-frequency curve . . . as shown in the graph above.

In charting the future — in Television broadcast and reception, Centralab will continue to give satisfactory service . . . just as it is now doing with its performance record of more than 80,000,000 units in all parts of the world.

Engineers send for Resistor Data Bulletin 647.

SPECIFY CENTRALAB

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★ FIXED RESISTORS ★

Tube Problems at Ultra-High Frequency

SOME OF the more important problems confronting the designer of vacuum tubes for use of ultra-high frequencies are covered in the October issue of the *R.C.A. Review* in an article "Review of Ultra-High Frequency Vacuum Tube Problems," by B. J. Thompson. At ultra-high frequencies, the simplified description of the operation of electron tube physics, which appears in most current textbooks, no longer holds and refinements must be made to take account of the electron transit time, the inter-electrode capacitances, the inductances of the leads in the tube and other factors.

The author begins with some fundamental considerations in which is pointed out the fallacy of considering the current flowing to an electrode in a vacuum tube as resulting from the arrival of electrons at the electrodes, and thereby considering the current to be proportional to the instantaneous rate of arrival of electrons. Whereas this view of the problem is reasonably satisfactory at frequencies sufficiently low so that the electron transit time may be neglected, this view point is totally inadequate at the higher frequencies.

A much more satisfactory view of conduction within the tube, especially at high frequencies, where transit time is important, may be obtained by considering the current flow as the result of the motion of charges in the inter-electrode space. If, as shown in Fig. 1, we have

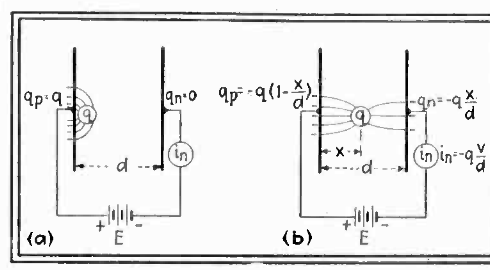
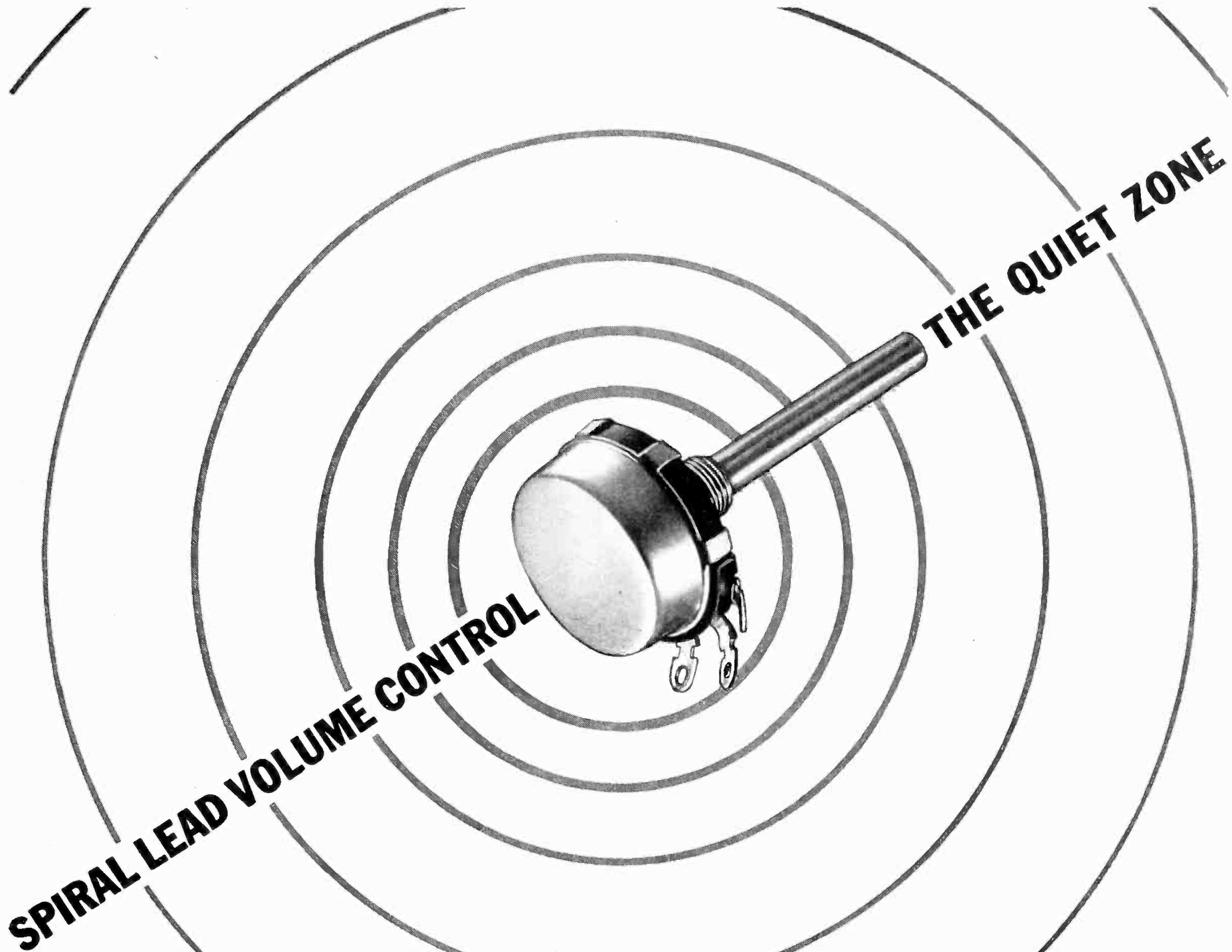


Fig. 1—Diagram illustrating flow of current in tubes operated at high frequencies

two infinitely large parallel plane electrodes, whose distance apart is d and whose difference of potential is E, the electric field is uniform and equal to E/d. If now, a small positive electric charge, q, is placed between the plate but very close to the positive plate, an increase in the charge of the positive plate by an amount—q will result, but there will be no increase in the charge of the negative plate. Because this charge is in a uniform field whose magnitude is F, the positive charge will tend to move toward the negative plate. In moving, work is done on it by the field, equal in magnitude to Fqx, where x is the distance the charge has moved from the positive plate. The work done on the charge, supplied by the battery, is equal to the voltage E, and the change in charge induced on one of the plates. If the charge induced on the negative plate is represented by q_n the equation of work may be written as

$$-Eq_n = Fqx = Eqx/d$$



STACKPOLE has the answer to noises originating in volume controls. In place of the friction contact between center terminal and collector ring is a non-corrosive spiral spring rigidly attached at each end — insuring positive and silent control for the life of the set . . . Write us for a testing sample today.

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FIXED RESISTORS
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VOLUME CONTROLS
TONE CONTROLS

These products are sold only to manufacturers of original equipment

OUR INDUSTRIAL PRODUCTS INCLUDE: CARBON, CARBON GRAPHITE, ELECTRO GRAPHITIC, GRAPHITE, SILVER GRAPHITE, AND METAL COMPOSITION BRUSHES . . . CARBON, CARBON GRAPHITE, ELECTRO GRAPHITIC, GRAPHITE, SILVER GRAPHITE, SILVER LEAD OXIDE, SILVER NICKEL AND SILVER COMPOSITION CONTACTS . . . WELDING RODS AND ELECTRODES . . . FURNACE ELECTRODES . . . ANODES FOR ELECTROLYTIC CELLS . . . CARBON PIPE . . . BRAZING BLOCKS . . . PACKING RINGS . . . GRAPHITE PISTON RINGS . . . METAL GRAPHITE AND CARBON BEARINGS . . . FLASHLIGHT AND DRY CELL CARBONS . . . GRAPHITE ANODES FOR POWER TUBES . . . CARBON RHEOSTAT PLATES AND DISCS.

from which we may determine that

$$q_n = -qx/d$$

Thus the charge induced on the negative plate is proportional to the charge in the space as well as to the fraction of the total distance between the plate which it has traveled. It is thus seen that q_n is a continuously varying quantity while in the space between the plates is not represented by a fixed unit of charge as is frequently considered to be the case with the less refined theory.

This fact may be further borne out by establishing the equation for the current. The current of an elementary charge flowing to the negative plate is equal to the rate of change of the charge, so that we have

$$i_n = dq_n / dt = -\left(\frac{q}{d}\right)\frac{dx}{dt} = -qv/d$$

The total current, of course, is the sum of all the individual currents resulting from the unit charges between the two plates.

For the steady state conditions or for frequencies for which the transit time may be neglected, the current as derived above, is equal to the rate of arrival of electrons at the electrodes. But when the current is varying rapidly with time, as in the case of an amplifier operating at ultra-high frequency, the rate of arrival of electrons at the electrodes may be greater or less than the actual current flowing because of the transit time of the electron. If the current is momentarily increasing the rate of arrival of electrons is less at any instance than corresponds to the flow of electrons in the space. From this it is evident that the current flowing to an electrode, especially at high frequency, may be different from the rate of arrival of the electron at that electrode, and it is pointed out that it is possible to have a current flowing to an electrode at which no electron arrives. The effect of the transit time upon the flow of current is consequently indicated, at least in a qualitative manner.

Transit time effects may be observed in either the grid or in the plate circuit of the tube. The effect of transit

• • •

COMPACT TELEVISION CHASSIS

A compact chassis (left) recently exhibited in London sells for 22 guineas, or about 115 dollars time in the grid circuit is to produce, in effect, a component of grid capacitance which is proportional to the transconductance and to the transit time. This capacitance is the increase in capacitance between that observed when the tube is heated, and that measured when the tube is cold. Another effect of electron transit time is to decrease the shunt resistance between the grid and the cathode. Whereas this grid-cathode resistance may be high at frequencies as high as 1 megacycle, it may become as low as several thousand ohms at frequencies of 50 megacycles when conventional receiving type tubes are employed.

Transit time effects in the plate circuit account for three important factors. One of these is the lag in phase between the plate current and the grid voltage; this lag is proportional to the frequency of operation as well as to the transit time. A second effect is that the magnitude of the transadmittance decreases slightly as the frequency is increased although this effect is observed small. A third effect which is observed is the decrease in the internal resistance of the tube with an increase in frequency. This effect also is usually small.

The author shows that in receiving equipment for wide band amplification, the inter-electrode capacitances of the tubes may become the limiting factors to determine the maximum applification obtainable where only moderately high frequencies are involved. In the case in which the tubes are operated at ultra-high frequencies, however, the increase of input conductance with frequency may become the limiting factor for wide band amplification. When such is the case, the width of the frequency band for which a given amplification is obtainable, may be obtained by increasing the ratio of the transadmittance to the input conductance of the tube. In practice, this means that the inter-electrode spacing must be reduced, or the voltages at which the tubes operate must be increased.

For several years, tubes have been commercially available in which the inter-electrode spacings have been reduced considerably beyond that which is found desirable for receiving and transmitting tubes operating at only moderately high frequency.

In the case of transmitting tubes, the limitation in power output at a given frequency is limited by cathode emission density and the anode and grid dissipation capabilites which are dependent upon the construction of the tube as well as upon the materials of which the elements are made. The limitation in frequencies for a given power output is set by the transit time which results from the operating voltages, anode area, and spacings determined by the permissible anode dissipation per unit area and inter-electrode capacitance. The limitation in the highest operating frequency without regard for power output is set by how small and how closely spaced it is considered feasible to make the tubes.

Relay Contacts

(Continued from page 30)

better and more cheaply accomplished by shunting the inductive load (not the contact) with a non-inductive resistance. The value is better found by cut-and-try, depending upon permissible sluggish release of the coil involved. For average apparatus a good starting value to try is around 10 times the resistance of the coil.

Condensers in series with contacts cause much failure but do not damage the contact. In such circuits there is always some appreciable resistance so welding effects are not troublesome. It is really a lack of weld that gives trouble, for by the time a contact has ceased vibrating the condenser voltage will have risen to that of the power supply so the last "make" of the contact finds no current flow to weld it. Shunting the condenser with a few thousand ohms (the less the better) or otherwise maintaining a potential difference across the contacts cures the fault.

Another trouble is the contact that closes when there is no voltage across the pair (no current flow). This is particularly aggravated if the contact remains closed for any number of hours (sometimes minutes) before a potential is applied, allowing time for the grease, displaced by mechanical pressure when the contact closed, to creep back and separate the pair. Such "non-potential" contacts were found by a test in a new plant to give about ten times the trouble found in live contacts. This test was at 40 volts with gold alloy contacts.

Moving coil relays are annoying due to the light mechanical pressures and to the long period of vibration fouling the contacts. Sticking or welding is another nuisance. Further, when operated or released the hair-springs may vibrate excessively since they carry a circular current of several turns in a magnetic field—near a neutral point, but never really neutral. This vibration is carried to the contacts.

Moving coil contacts should always be of platinum-iridium, the iridium supplying a useful degree of stiffness. They should be mounted as close to the axis of coil rotation as possible so that the greatest pressure may be obtained.

How to Clean Contacts

As for cleaning contacts the writer is still puzzled. A number of definite comments that can be made. Never use a piece of paper: there is always some fuzz that usually stays upon the contact. Filing a contact often fixes it but frequently the trouble will soon return: the grease that was pushed away returns and the contact shape and mass has been changed. Theoretically, washed files should be used, but who goes to that trouble? Files sometimes put more grease upon the contact.

Having tried it upon thousands of relays, the best but not perfect method is a double operation—washing and wiping. Chamois cemented over the end of a thin strip of bakelite, dipped into carbon tetrachloride, washes the contact (one quick jab is enough) and another dry chamois "stick" wipes off the residue. Most carbon tetrachloride is old enough so it leaves a residue. Thus wiping is quite necessary. Carbon deposits may need a touch with a file followed by washing and wiping.

The argument that filing is bad because it leaves a roughened surface is based upon a wrong premise: rough contacts perform better than smooth ones, unless the roughness is so coarse that slivers or points protrude altering the desired air-gap and subjecting it to change by crushing.

Rubber should never be near contacts, especially if of silver. This applies to the insulating pips that operate the contact springs, rubber insulated wire connecting to the relays, etc. The idea that rubber must be used for wires carrying one or two hundred volts (in fixed wire groups) is not practical. Very slight heating of rubber increases the gas emission greatly, so wiring near power transformers, resistors and warm tubes may easily affect relay contacts a couple of feet away, in open air. Open flames in the same room with relays are bad, particularly some kinds of illuminating gas and oil stoves.

Vitally important relay contacts may be double—in fact, should be. One spring, but better both, is bifurcated, with a contact point in each tine. With only one split spring there is more difficulty in equalizing the contact pressures. Experience shows that most contacts will continue acting after a failure if given a chance: by having double contacts there is very little probability for both to fail at the same instant. Of course, bifurcation reduces the pressure for each contact but this is more than balanced by the gain in general performance.

An interesting application of contacts was made when telephone relays were used to operate 48 volt motors pulling a 4 amp. starting current. The relays worked hundreds of times a day and often with a flipping action, opening the full starting current before the motors started. Solenoids with laminated copper contactors had been furnished with the plant but would burn up in a few days. The telephone relays had been operating about two years when last heard of. One relay per motor was equipped with three sets of make contacts, silver alloy. The widely moving armature gave about .080 in. spring movement. The make springs were staggered in sequence of opening, the first to open being directly connected to the motor, the next spring joined to it through about two ohms and the last spring through an additional four ohms. The resulting current decay characteristic made practically sparkless breaking of the full current which was flowing in a highly inductive circuit.

THE INDUSTRY IN REVIEW

A New Limiting Amplifier . . . *By Frank M. Davis*

Eng. Dept. Collins Radio Co.

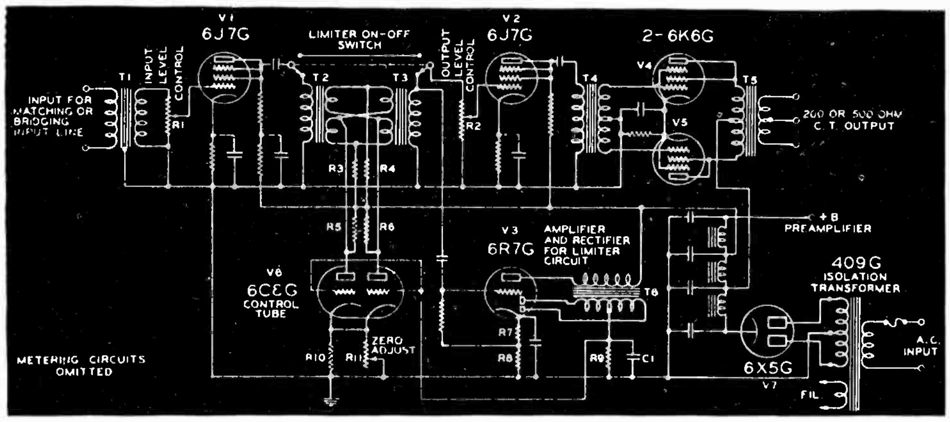


Fig. 1—Circuit diagram of program amplifier with automatic gain control

PRESENT demand for "compression" or output limiting in a-f equipment has resulted in the development and use of many different types of signal operated gain adjusting circuits. Some of these represent modifications of well-known circuits, while others have been developed expressly for the purpose.

In one common type of circuit the gain is varied by changing the operating potential on one or more elements of an amplifying tube. Other circuits have been devised with the variable resistance characteristics of heated filaments, diodes, triodes and dry contact devices used as part of a bridge, voltage divider, or attenuation net work. Many such circuits have been used, but all can cause serious distortion due to nonlinearity of the control device unless the signal level at the control point is low.

The control voltage or current is generally obtained by rectification of a portion of the output signal. The amount of filtering following the signal rectifier is limited when small time constants are desired so that special precautions are necessary to prevent re-introduction of rectified signal components which would cause instability and distortion. Push-pull connection of the control device is helpful and it is often necessary to select the original and replacement parts on the basis of matched dynamic characteristics to obtain satisfactory performance if the gain is high following the control point.

The circuit developed by Collins Radio Company is an adaptation for gain control service of a little-known form of bridge circuit having several advantages which are not all shared by previously used circuits.

1. The circuit is balanced to ground with respect to audio frequency voltages.

2. The circuit is symmetrical with respect to d-c voltage, so that no audio frequency decoupling is required.

3. One variable element serves to vary the signal transmission through the circuit from zero to unity.

4. One side of the control voltage source can be connected to ground.

5. The circuit can be used at a higher level than can most of the usual circuits, so that the requirements for exact balance to avoid re-introduction of signal components is relaxed.

6. The circuit is inherently quite stable with respect to supply voltage.

7. The component parts required in the circuit can be made impervious to the effects of moisture, heat, or age.

8. The operate time and the release time can be controlled independently.

A simplified schematic diagram of a complete program amplifier incorporating this bridge circuit for automatic gain control is shown in Fig. 1. One stage of amplification precedes the limiter circuit and two stages follow. A separate triode amplifier tube, V_3, is provided for the control circuit to avoid modulation of the program output due to the non-linear characteristics of the diode rectifiers.

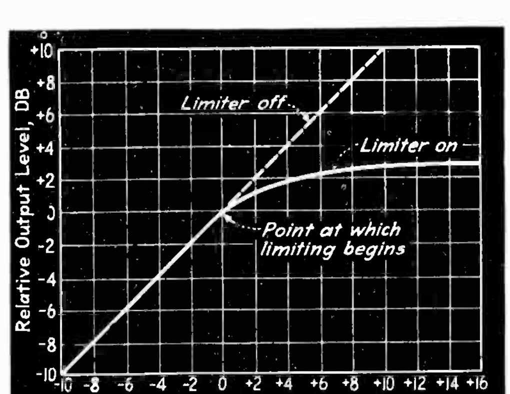


Fig. 2—Input-output characteristics of limiter circuit

The triode plate current of V_3 flowing through resistors R_7 and R_8 forms a voltage drop or delay bias which the signal voltage applied to the diodes in V_3 must exceed before rectified current can flow in the rectifier circuit. Thus the amplifier functions normally (linear input-output relation) until a certain pre-determined level is reached. When this input level is exceeded the gain is reduced to maintain a substantially constant output level. The amount of delay bias determines the point at which limiting begins and has some effect on the shape of the input-output curve.

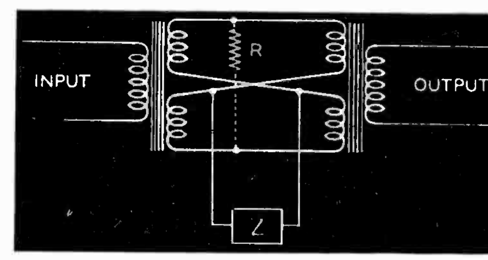


Fig. 3—Adaptation of circuit for distortion measurement

A typical input-output characteristic curve obtained with an amplifier using the circuit is shown in Fig. 2. The amount of control which such a circuit can provide is determined largely by the distortion characteristics of the input tube, V_1. The output level remains substantially constant as the input signal is increased above the point at which limiting begins, and as the input level continues to be increased V_1 is the first tube to become overloaded. In general, an input stage of conventional design will accommodate an adequate range of input levels; with the circuit shown, distortion in the input stage becomes apparent at an input level 15 db above that required to initiate automatic control.

This bridge circuit is used as a gain control in this limiter, but the fact that a single control element can be used to vary the attenuation from zero to infinity (assuming perfect transformers) makes the circuit useful for many other applications as well.

For example, the control tube, V_6, can be replaced with an impedance as in Fig. 3, and the frequency response through the system will be determined by the characteristics of the impedance.

If a circuit parallel resonant at a frequency f is used at Z and a resistance $R = Z_f$ connected as shown, there will be no component of frequency f in the output. This arrangement is useful in remote control work for separating single frequency control tones from the voice amplifying channel. The control voltage is developed across Z. Two or more control tones can be used by providing a resonant circuit for each frequency with the tuned circuits connected in series at Z.

The circuit of Fig. 3 has been used successfully in a distortion measuring instrument. With a series resonant circuit at Z the bridge serves as a filter, passing only the fundamental frequency and providing a high order of attenuation to all harmonics. With a parallel resonant circuit at Z the circuit rejects the fundamental frequency, passing harmonic frequencies with negligible attenuation.

A full description of the working of the circuit is to be found in Collins bulletin 26C.

News

✦ In recognition of his pioneer work on wave antennas and his continued work in this and other phases of the radio art, the award of the Armstrong Medal was made to Harold Henry Beverage by the Radio Club of America, New York City. The citation of the medal stated: "Mr. Beverage has been actively interested in all phases of radio, his first amateur station having been built in 1910. To both the amateur and the professional his name is well known because of the Beverage antenna, the precursor of wave antennas of all types. His late work in the development of spaced diversity antenna systems is of outstanding importance in present day radio communication, and his knowledge of the phenomena involved in the operation of antennas of all types is profound. The successful use of long distance short wave signals through all types of interference is basically due to his work in the optimum utilization of space power." . . . Canadian Marconi Company announced the appointment of J. H. Thompson, former Chief Engineer of this Company, to the position of Technical Counsellor. L. S. Payne, Assistant Chief Engineer becomes Chief Engineer, and J. M. Conroy, Works Engineer, becomes Deputy Chief Engineer. . . . Owens-Illinois Glass Company and Corning Glass Works announced the formation of Owens-Corning Fiberglass Corporation which will be an independent structure, and will not operate as a subsidiary of either parent company. About $5,000,000 has been spent in extensive research for the production of a variety of products made from fiber glass. Among the new developments are: fiber glass separator plates for batteries, insulation purposes, pipe coverings for high temperature and refrigeration lines, sound insulation for aeroplanes and other structures, and air filters. . . . A high speed printing telegraph system, on a pay-as-you-use-basis enabling commercial services, particularly news services, to type a story directly to an office through the use of a specially designed typewriter keyboard inductively coupled to a telephone, is described in patent 2,133,811 issued recently to W. G. H. Finch, President of Finch Telecommunications Laboratories, Inc., in New York City. . . . International Standard Electric Corporation, a subsidiary of the International Telephone & Telegraph Company, has taken out a license under the Finch Facsimile patents. . . . Gano Dunn, president of J. G. White Engineering Corporation, and Henry C. Bonfig, Commercial Vice-President of RCA Mfg., Co., have been elected Directors of RCA Mfg. Co., to fill the vacancies of the late Messrs. J. R. Sheffield and J. C. Warner. . . . For the third quarter of 1938 and the first nine months of the year Radio Corporation of America showed a net profit of approximately $1,600,000 and $4,140,000 respectively compared to $1,950,000 and $6,600,000 for last year.

Literature

Precision Products. Illustrated and described in "39" catalog. Hammarlund Mfg. Co., Inc., 424 West 33d St., New York City.

Plastics. 304-page handbook-catalog-directory number of *Modern Plastics* includes survey of the advancement of plastics production in foreign countries as well as the United States, a properties chart, and a trade directory with complete listings. Price $2.00. Modern Plastics, 425 Fourth Ave., New York City.

Characteristic Sheet. A completely revised list of radio tubes. Hygrade Sylvania Corp., Emporium, Pa.

Converter Catalog. Includes electronic converter Valugraph and also illustrations and description of converters and polarity changers. Electronic Laboratories, Indianapolis.

Rectifier Manual. Bulletin No. R-38 describes and illustrates recent developments in dry metallic rectifiers and contains information on construction, application and performance. B-L Electric Mfg. Co., 19th & Washington Ave., St. Louis, Mo.

Specifications. For revised standard electrical characteristics for two-way reproducing systems in theatres. Supercedes previous specifications. Research Council of the Academy of Motion Picture Arts and Sciences, Suite 1217 Taft Bldg., Hollywood, Cal.

Record Playing Equipment. Described and illustrated in 8-page booklet. Garrard Sales Corp., 17 Warren St., New York City.

Tube Charts. Form Act 7138 is for owners of electrometers Models 500, 500A, 600 and 700. Precision Apparatus Co., 821 E. New York Ave., Brooklyn, N. Y.

Radio Foto Log. Log of American and Canadian stations denotes call letters, locations, frequencies and power assignments and includes latest available corrections from official sources. National Union Radio Corp., Newark, N. J.

Nickel Cast Iron Data. Revised data sheet for "Guide to the Selection of Engineering Specifications for Gray Cast Iron". International Nickel Co., 67 Wall St., New York City.

Sound and PA Catalog. Described in catalog No. W-38. Atlas Sound Corp., 1447 39th St., Brooklyn, N. Y.

Recorder. Bulletin No. 1178 announces new line of 9 in. pressure and temperature recorders and recorder-controllers with full size 9 in. charts with 3 1/16 in. pen travel. C. J. Tagliabue Mfg. Co., Park & Nostrand Aves., Brooklyn, N. Y.

Sound Amplifier Guide. Practical and theoretical information on amplifiers ranging from 8 to 120 watts output; Guide No. 346-D, 15 cents. Thodarson Electric Mfg. Co., 500 W. Huron, Chicago, Ill.

New Products

Chimes

UTILIZING 21 STANDARD tubular chimes played from a small keyboard attached to an organ console, a synthetic set of bells for churches has been developed by Transformer Corp. of America, 69 Wooster St., New York City. The sound from the chimes is picked up by two microphones amplified by a 250 watt booster and radiated from 4 heavy duty horn type loud speakers in the belfry.

Portable Telephone

THE WESTERN ELECTRIC 10-A magnetic telephone is a sound powered unit which functions both in the transmission and reception of speech and signals without the use of batteries or other external source of power or excitation. It is intended primarily for portable use or semi-permanent installation. All parts of the unit are protected from mechanical injury and weather by a semi-hard rubber housing. As a speech transmitter and receiver, the telephone is a highly efficient receiver structure of the balanced armature type.

New Tubes

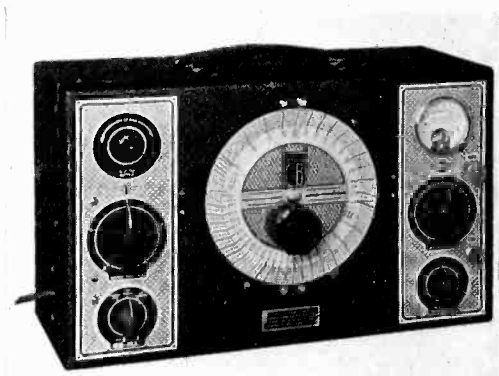
Raytheon Production, Newton, Mass. Gas triode detector thyratron, Type RK62, and a triode power amplifier oscillator tube Type RK63.

RCA Mfg. Co., Harrison, N. J. Announce three new transmitting types as follows: A power amplifier modulator, Type 810; half-wave high-vacuum rectifier, Type 1616; and Type 1623 an oscillator, r-f power amplifier, modulator.

For experimental television equipment RCA has announced the following cathode-ray tubes: 906-P4 kinescope (electrostatic-deflection type with medium-persistence white phosphor 3 in. screen); 1802-P1 kinescope (electrostatic-deflection type with medium-persistence green phosphor 5 in. screen); 1802-P4 kinescope (electrostatic-deflection type with medium-persistence white phosphor 5 in. screen); and 1899 monoscope (electromagnetic-deflection type).

Microvolter

Model No. 199 of Clough-Brengle Co., Chicago, Ill., includes special lattice-wound, non-inductive attenuator resistors, and solid copper internal shielding. This new microvolter has a 7 in. jumbo



Verni Vider dial. With its accurately calibrated output of 1/2 to 100,000 microvolts at frequencies from 100 kc to 30 Mc, it provides an accurate yardstick of receiver over-all performance.

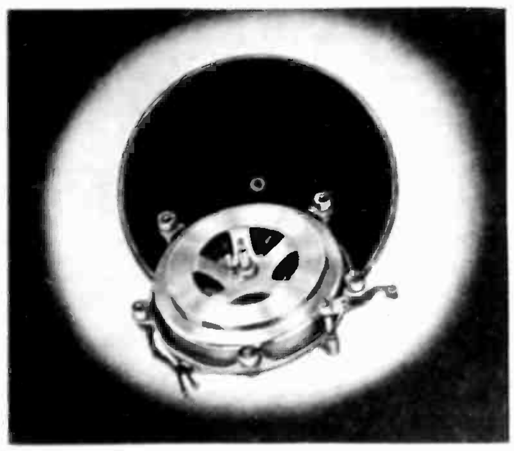
Pregwood

A new product consisting of thin laminations of wood impregnated with phenolic resins and vulcanized into a hard homogeneous sheet developed by The Formica Insulation Co., Cincinnati. It is called "Pregwood" and is offered for various mechanical and electrical uses.

The product is lighter than aluminum (specific gravity 1.35), and has a flexural strength of 25,000 to 30,000 lbs. per sq. in. Tested parallel to the laminations it will stand 60 vpm. The material is highly resistant to moisture absorption; shows a minimum of dimensional change due to moisture and humidity; has low co-efficient of thermal expansion; and is applicable to small machined parts where maintenance of dimensions is required.

Transcription Motor

Model 201-A motor of Garrard Sales Corp., 17 Warren St., New York City, (officially used by British Broadcasting Company for all transcription work) is silent because of its extra heavy slow running rotor. The rotor is 7½ ins. in diameter and weighs approximately 5½ lbs, and revolves at the same speed to which the turntable is set, resulting in a reduction of wear on bearings and reduction of wobbling.



The motor is self-starting with stepless, smooth variation of speed over a wide range. One-shot lubrication through the shaft makes it unnecessary to remove the turntable when oiling. The motor is five-position rubber mounted, available in either 33 1/3 or 78 rpm, and is 4 in. high x 9½ in. in diameter furnished with a 12 in. Florentine bronze turntable.

Socket

No. 237 Socket of E. F. Johnson Co., Waseca, Minn., is designed especially for the new RCA beam power tube type 813. This socket is made of steatite with cadmium plated phosphor bronze contacts recessed to prevent turning, and is of square design with four mounting holes, all bossed, permitting panel mounting.

Moving Coil Pickup

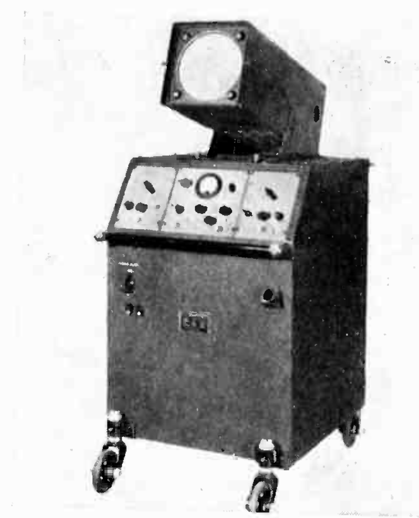
For lateral recordings Model 100 LR of Lansing Mfg. Co., 6900 McKinley Ave., Los Angeles, Cal. Generated voltage is directly proportional to needle

point velocity from 30 to 10,000 cycles without distortion. Low needle point impedance and light weight (6 to 30 grams) on a record permit 500 playings without damage to the record.

Television Equipment

RCA MFG. Co., Camden, N. J., announced that it will make available television transmitting equipment for sale to stations desiring to enter this field of service. This apparatus includes studio equipment, transmitters and television test equipment. The 1-KW transmitter is believed to be sufficient to enable experimental stations to render a service over a reasonable area without too great an initial expense in starting television service. The transmitter conforms with recently established RMA standards and is designed for d-c transmission with negative modulation. The video response extends beyond the 441 line picture range providing future requirements as to frequency response. A long line controlled oscillator uses an invar rod (which is unaffected by changes in temperature) to maintain the carrier frequency at a stable value. The transmitter includes provision for inserting the d-c components during picture transmission providing for variable carrier output.

RCA ALSO HAS available several pieces of television test equipment. A



special cathode-ray oscillograph, Model 136-B, makes it possible to examine the wave form of minute impulses and to produce a large image on the tube for photographic purposes.

A video sweep oscillator which enables adjustment of amplifiers to provide the necessary wide-band response has been announced; also a square-wave generator to test an amplifier for hf response and for phase-shifting; and a uhf field intensity meter for checking the range of television and other uhf transmitters.

Ceramic Tube Bases

THESE BASES, made from a Steatite material, are available in all pin combinations, with and without side-locking pins and for metal tubes. American Lava Corp., Chattanooga, Tenn., are equipped to supply them from stock.

Capacitance Bridges

Two NEW CAPACITANCE bridges have been brought out by the General Radio Co., Cambridge, Mass. By the 740-B the accuracy and the speed of routine measurements are improved. By it the capacitance and power factor of paper, mica and electrolytic condensers, inter-conductor capacitance in cables and inter-winding capacitance in transformers may be measured. It may be used as well for production testing of condensers.

The bridge is direct reading in capacitance and power factor. Power (15 watts) is obtained from a 115-volt 60-cycle a-c line. A visual null indicator is included, and no accessories are necessary. It is small in size and light in weight (19 pounds).

The range of capacitance measurement is 5 $\mu\mu f$ to 1100 μf. The accuracy over most of this range is $\pm 1\%$. The power factor range is 0 to 50%.

The second bridge (671-A) is used to measure the dielectric properties of insulating material at power-line frequencies. Among its applications are the testing of materials used as dielectrics in capacitors and as insulation in transformers, cables and electrical machinery, tests on ceramic, fabric, paper and plastic products to determine such properties as composition and moisture content, as well as the change in these characteristics with temperature, humidity and voltage gradient.

Index to electronics—Volume XI

January to December issues, inclusive, 1938

McGraw-Hill Publishing Company

330 West 42nd Street, New York City

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with good connections radio tube and lamp factories to represent manufacturers of Molybdenum Wire and other promising products. Good remuneration to responsible party. Write details also previous connections confidential. Our employees were notified of this advertisement. Write

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Earn $56.00 per unit, selling nationally advertised short-wave diathermy unit to physicians. Reliable firm. Estab. 60 years. Valuable territories now open.
McIntosh Electrical Corp., 223 N. California Ave., Chicago

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If YOU have not already placed your order, do so NOW because sets will be printed for only the number of orders on hand.

Electronics Yearly Service was inaugurated at the request of subscribers for an opportunity to secure an extra set of the Reference Sheets that had appeared in all the issues during the current year. These will be printed on heavy stock, punched and ready for insertion in the notebook.

The cost is only $1.00 plus a small delivery charge. If you send payment with your order—eliminating bookkeeping and collection expense—we will pay delivery charge.

This is the ONLY opportunity you will have to obtain a complete set of 1938 charts. We will not be able to fill orders after publication date.

Don't delay—Send your order in NOW—the closing date is—

DECEMBER 20th

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Experienced **auto radio engineers;** also **draftsmen** with instrument and small mechanism experience. Apply by letter stating experience and salary desired, etc.

P-166, Electronics
520 No. Michigan Ave., Chicago, Ill.

POSITIONS VACANT

RADIO BROADCAST RECEIVER ENGINEER wanted having formal technical education and several years practical experience in all phases of receiver design. Large Chicago manufacturer. P-173, Electronics, 520 N. Michigan Ave., Chicago, Ill.

COIL WINDING MACHINE DESIGNER experienced with all types radio coil winding equipment wanted by Eastern radio manufacturer. Also experienced "Radio Coil Design Engineer" and "Radio Coil Production Superintendent". Give full particulars in reply. P-174, Electronics, 330 W. 42nd St., New York, N. Y.

POSITIONS WANTED

RADIO ENGINEER; filter design experience wants opportunity with antenna design manufacturing company; salary inconsequential, 24, married. PW-176, Electronics, 330 W. 42nd St., New York, N. Y.

RADIO OPERATOR Radiotelegraph 2nd class Radiotelephone first class license three years experience. Recently discharged U. S. Army seeking employment radio operator. Reference on request. PW-171, Electronics, 330 W. 42nd St., New York, N. Y.

B.S. IN PHYSICS, North Carolina '38 holding Radiotelephone. First Class license, desires position with future looking to research in electronics. Age 22, single, available immediately, any location. PW-172, Electronics, 330 W. 42nd St., New York, N. Y.

INTELLIGENT, electro-mechanically inclined graduate of Radio, Television, Talking Picture School desires position. Also High School graduate; expert typist; experienced in general office practice and traffic management. PW-175, Electronics, 330 W. 42nd St., New York, N. Y.

ELECTRONIC ENGINEER, college graduate, age 32, twelve years extensive experience in design, development and production of industrial and electron tubes. PW-168, Electronics, 330 W. 42nd St., New York, N. Y.

RADIO ENGINEER. A.B.; RCA Inst., Electronic courses Columbia U. Three years experience New York Times wirephoto; filter design; patent studies, operating; first class radiophone license; wants position electronic, radio laboratory; 24, married. PW-177, Electronics, 330 W. 42nd St., New York, N. Y.

COLLEGE GRADUATE. B.S. Mathematics and Physics. Excellent scholastic record. Radio Telephone First Class License. Four years experience in Amateur Radio Telephone. Age 23, available immediately at any location. Would consider either communications field or research laboratory. PW-179, Electronics, 330 W. 42nd St., New York, N. Y.

SPECIALTIES

NAMEPLATES. White Core Bakelite, engraved to order. Prices reasonable; list upon request. A. L. Woody, 189-K West Madison St., Chicago.

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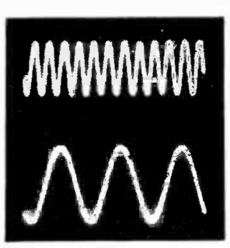
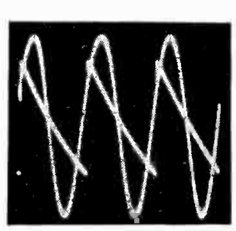
New DU MONT ELECTRONIC SWITCH *and* SQUARE WAVE GENERATOR

Allows Simultaneous Comparison of Two Phenomena on One Oscillograph

The Type 185 Electronic Switch incorporates many features not found in previous instruments. The switching rate is approximately 6 to 2000 times per second which range permits observation of either extremely low or high frequencies. The switching impulses or "tails" have been reduced to a point where they are no longer objectionable. In this new device the patterns may be displaced at will to facilitate close observation of each pattern. In addition to its value as an electronic switch this instrument may be used as a square-wave generator between frequencies of 60 and 400 cycles per second.



This photograph illustrates a comparison of two harmonically related signals on one oscillograph obtained by using the New Du Mont Type 185 Electronic Switch. The patterns have been displaced in order to allow individual observation.



The independence and freedom from interaction of the two channels of the Type 185 Electronic Switch is shown in the photograph at the right. This photograph illustrates the ability of the unit to handle a sawtooth and a sinusoid at the same time and to make them appear as one on the screen of the cathode ray oscillograph.

Write for Bulletin D12

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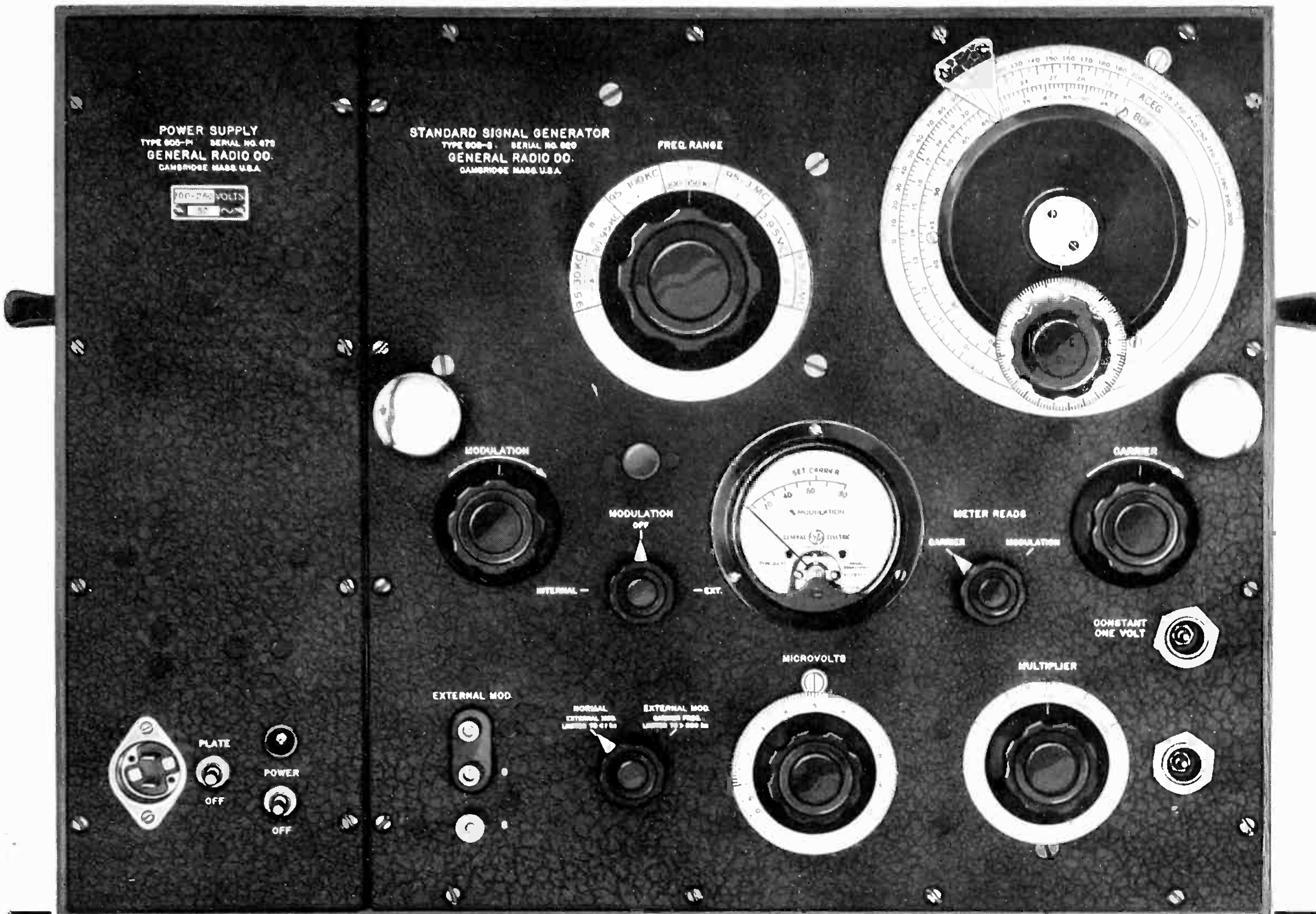
in the field of Electronic devices may be found through enlisting the services of the Consultants whose cards appear on this page.

This is a highly specialized field and specialists are therefore better able to undertake the rapid developments necessary to keep in step with modern manufacturing progress.



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To increase further the general utility of the G-R Type 605-B Standard-Signal Generator, internal modulation is now provided at 400 cycles *up to 80 per cent.*

This generator owes its wide acceptance to the following features, many of them exclusive:

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- EXCELLENT SHIELDING WITH NEGLIGIBLE LEAKAGE
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Another IMPORTANT Development in Radio Tube Design...by RCA

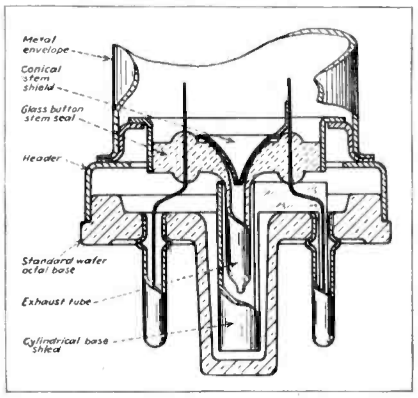
Radio set manufacturers will like the advantages offered by this new Pentagrid Converter! Study them.

- Complete wiring below set panel
- No grid lead to connect
- Cleaner, neater chassis
- No loose or broken grid leads
- Higher conversion gain
- Small frequency shift at high frequencies
- Economy
- Simplification of tube renewal

RCA's new Pentagrid Converter, the RCA-6SA7, features single-ended construction. The use of a special structure gives this fine tube excellent oscillator frequency stability. The magnitude of input capacitance of the oscillator grid is not appreciably affected by signal-grid bias. Changes in cathode current and in oscillator transconductance with AVC voltage are small.

Another RCA tube development is the twin triode amplifier, RCA-6SC7. This is a new single-ended twin triode metal amplifier designed primarily for phase-inverter service. Each triode unit offers a high mu-factor for high gain. Hum voltage picked up by the grid lead from the heater leads is greatly reduced because of interlead shielding between grid and heater within the base. This permits operation with satisfactory hum level.

For complete details about either of the above tubes, write to the address below.



Base construction of the new RCA single-ended Twin Triode Amplifier is shown in this cross section diagram. It also shows shield cone and cylinders for reducing inter-electrode capacitance.

Over 325 million RCA radio tubes have been purchased by radio users ... in tubes, as in parts and test equipment, it pays to go RCA All the Way.

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