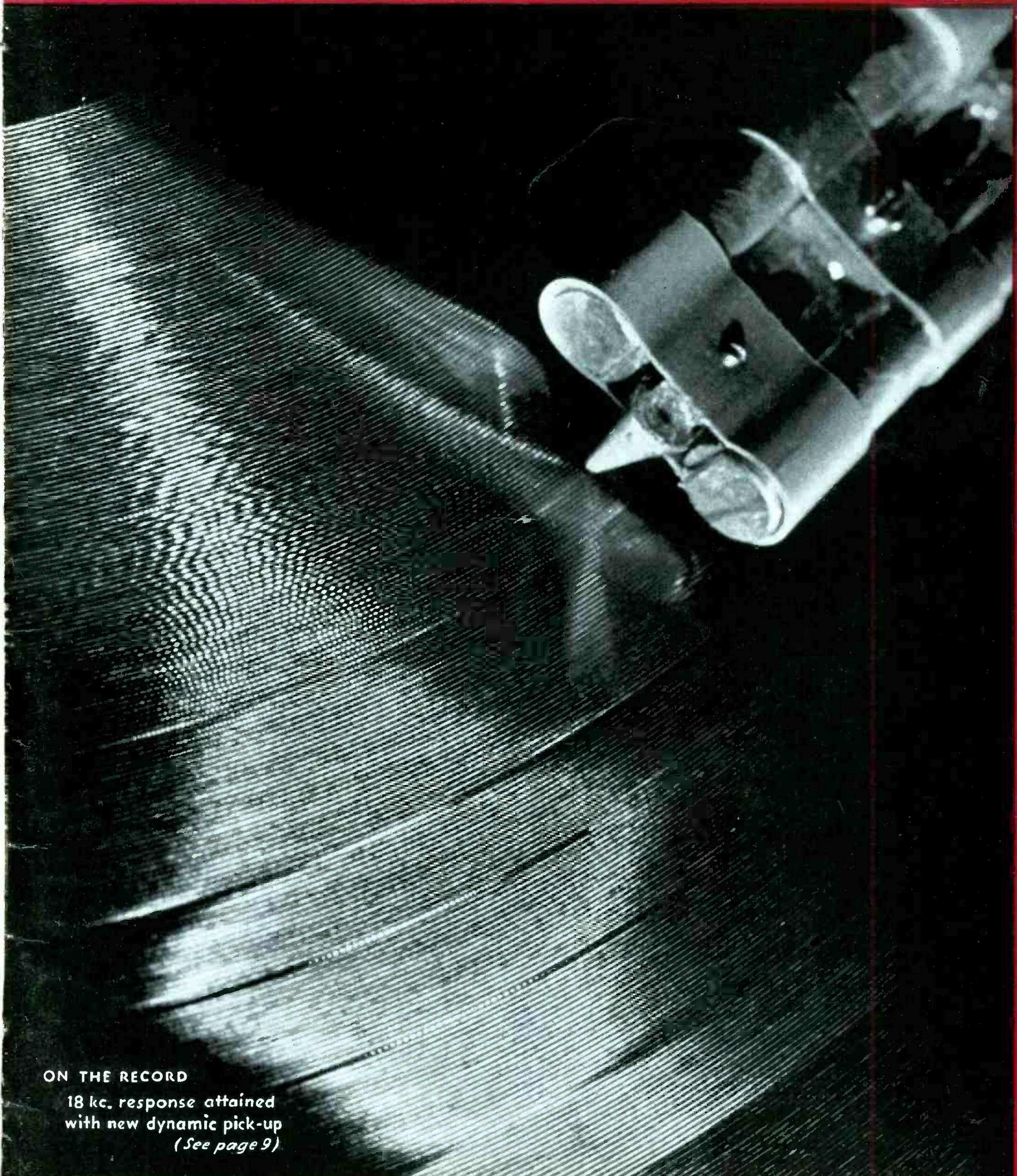
electronics

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



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(See page 9)

MARCH
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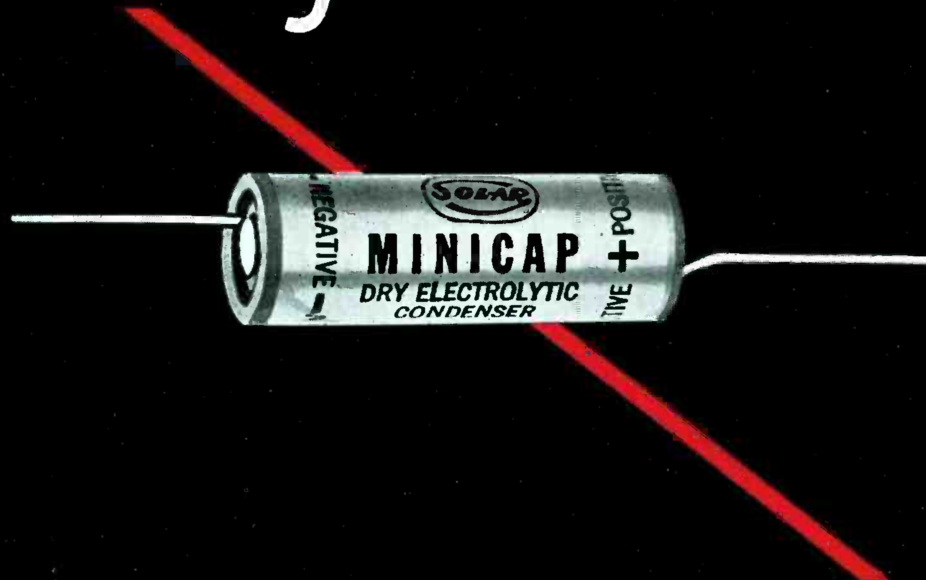

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CONTENTS, MARCH, 1938

DEPARTMENTS

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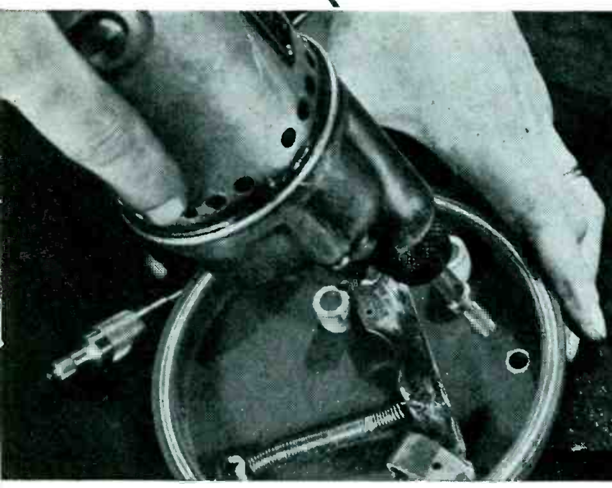
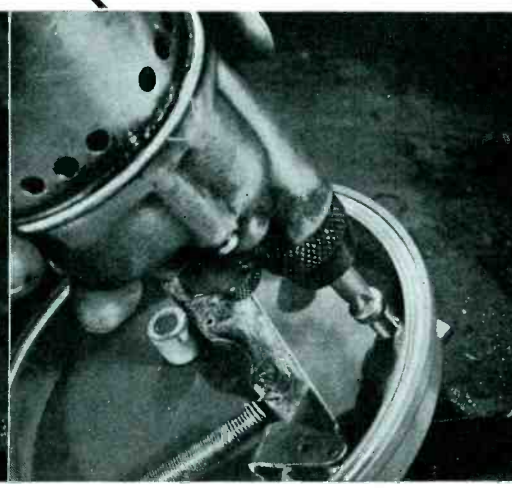
Guards Work



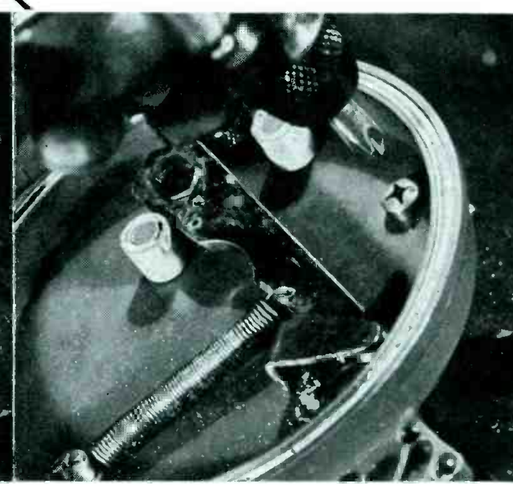
Faster work with half the pressure

One-hand starting and driving — other hand free to hold work. Three times the purchase of a slotted screw. Faster driving method cuts time to a fraction.



As easy as pointing your finger

The driver's point fits the screw's recessed head. Awkward places easy to reach—the screw won't drop off. Self-centering — straight or at an angle — no screws driven crooked.



Better work — and no spoilage

The driver can't slip out and scar costly material or the fingers. No broken heads — no burrs to remove. Better holding power — the screw sets up much tighter.

Given the acid test by certain key firms in the screw-using industries . . . plants where production costs are watched with an eagle eye — where quality is right and there's no excuse for waste —

The Phillips Screw *with the patented recessed head* has been okayed, after all sorts of time, motion and quality studies, by executives, engineers, purchasing managers, workers.

Now the production facilities of the screw manufacturers have been enlarged — and we're in a position to meet the demands of any plant that has use for screws.

Take the job the picture shows. There the Phillips Screw saves time — and screws — and strength — and spoilage — and money.

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Greater holding power — assemblies are more solid, and often fewer or smaller-diameter screws will do as well. No broken heads — no screws dropped. Greater driver and bit life — fewer sizes needed.

Easier work. The screw helps out. No push and turn — just turn. Maximum contact — minimum muscles. Men are fresher toward the end of day.

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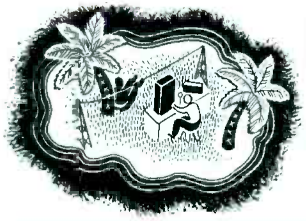
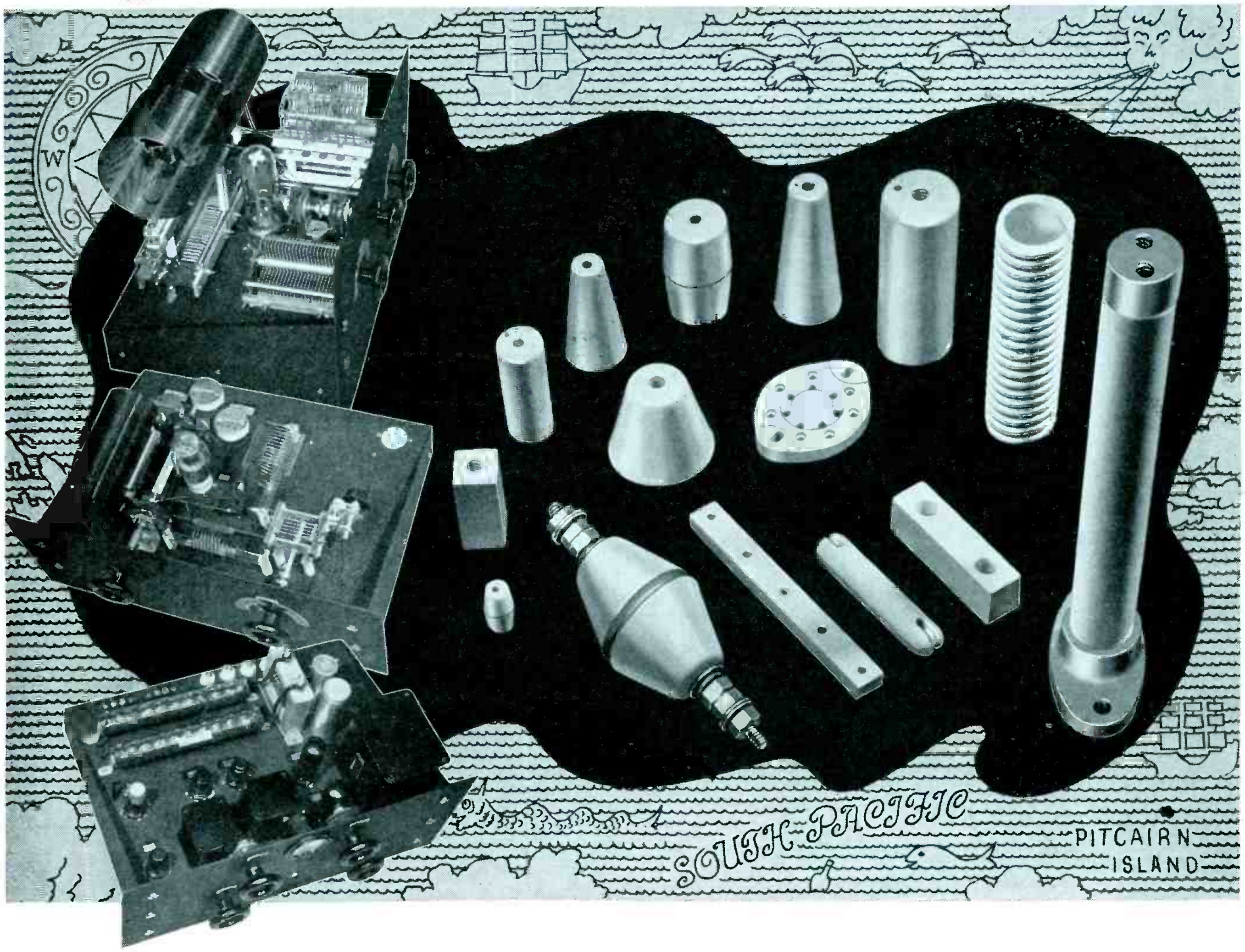
Note the tapered slot — its angle was worked out after months of tests to learn how to utilize the driver's maximum turning power. Note the flat surfaces — no curves except at the rim. That prevents the driver from burring the screw. Machined to tolerances of plus or minus .001" — to guarantee a perfect fit. Hand, spiral, or power drivers may be used — available from leading manufacturers and distributors.



AlSiMag insulation for the new "PITC" *Pitcairn Island*



Isolated in the middle of the South Pacific Ocean, without dependable communication for nearly 150 years—descendents of the H.M.S. Bounty mutineers now have a new radio transmitter that will span the gap of space and time at will. ¶Dependable insulation will safeguard this lonely "PITC" transmitter from disastrous breakdowns . . . insulation that must stand up indefinitely under the hot, humid, salt-laden tropical winds that sweep across the South Seas. ¶AlSiMag 196* is used at vital points in the radio frequency and high voltage circuits of the new Pitcairn Transmitter, both in standard insulator form and as an important component of parts furnished by Aerovox Corporation, The Allen D. Cardwell Mfg. Corporation, Coto-Coils, Inc., Ohmite Manufacturing Company, The Triplett Electrical Instrument Company, etc. ¶ In the wide range of AlSiMag and Lava Ceramics for all types of applications, you will find *better* insulation for *your* products. Recommendations and quotations on your requirements furnished promptly, without obligation. ¶ A Revised Table of Characteristics, with useful facts about AlSiMag and Lava is yours for the asking—send for it today.

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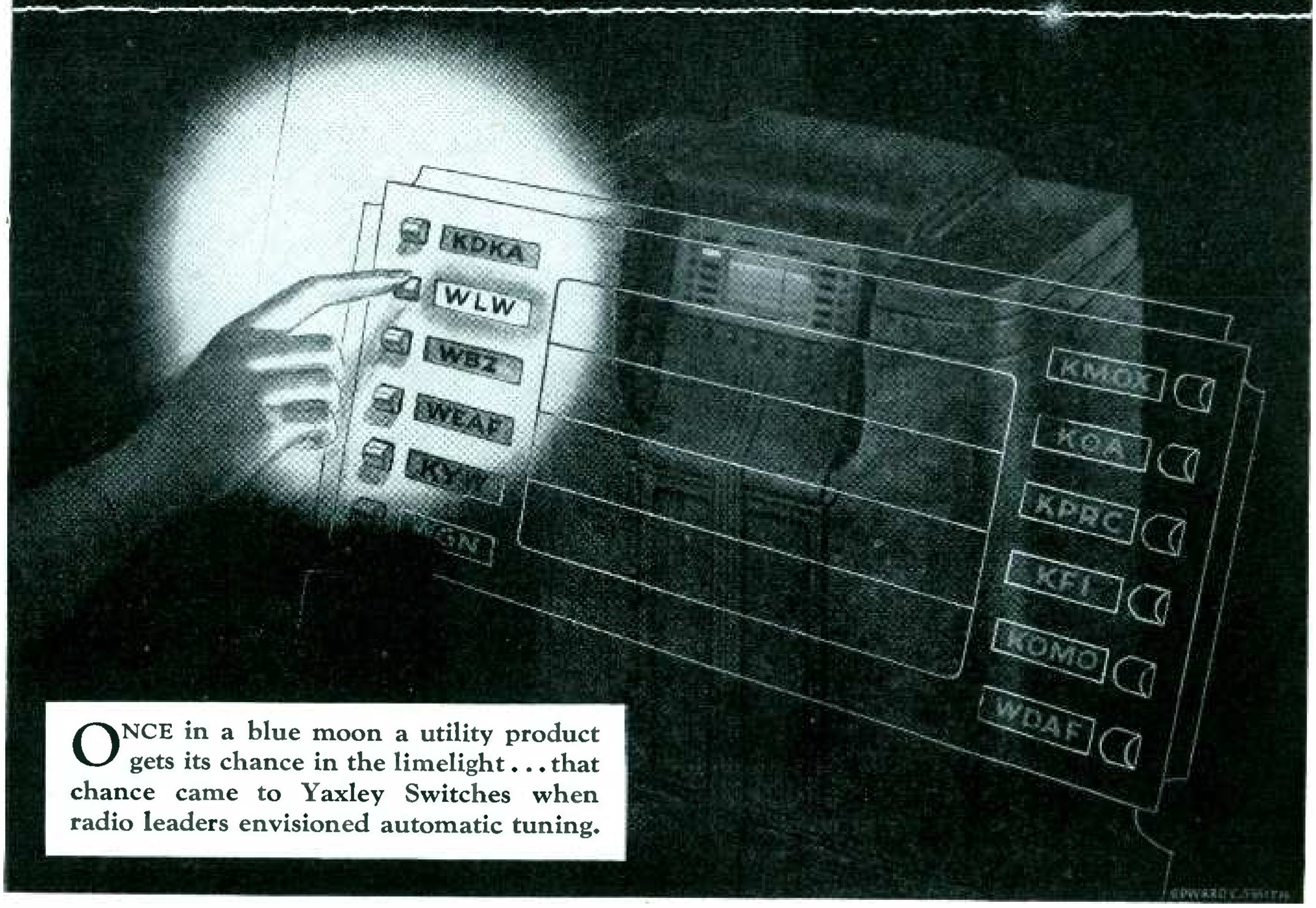

ONCE in a blue moon a utility product gets its chance in the limelight... that chance came to Yaxley Switches when radio leaders envisioned automatic tuning.

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ELECTRONICS

MARCH
1938

KEITH HENNEY
Editor

Crosstalk

NOISE . . . It has been pointed out that freedom from noise in a frequency modulated system is not due solely to the use of a balanced detector (page 60, February *Electronics*). The balanced detector gets rid of amplitude modulated noise. But the big virtue of the frequency modulation system is the fact that the desired modulation can be made as much stronger than the noise as desired by widening the band over which frequency modulation occurs. This was pointed out, correctly in the November 1935 *Electronics* where Major Armstrong's classic paper on frequency modulation was discussed, and again in May 1937 where Hans Roder's mathematical paper was given.

The tower for the Armstrong frequency modulation system is now high above the New Jersey Palisades and while rumors state that programs will soon be on the air, the rumors are slightly ahead of themselves. The transmitting equipment has not yet been installed. But summer will see this most interesting experiment begin.

► **COMPRESSORS** . . . In a recent item we questioned the advisability of amplitude compression produced by the volume limiters now going into so many broadcast stations. It looked like a pure case of limiting the volume range. There is no question about its ability to increase the station's signal. It will do that and is, in fact, equal to doubling the power output of the station.

A peak limiter, however, is not only a means of raising signal level but can be operated actually to increase the effective volume range. If peaks up to about 6 db are cut off, the ear seems not to know the difference. Therefore the average level of modulation can be raised, elevating the lower levels of modulation 6 db above the noise, which means that 6 db more volume range can be used. This figure of 6 db is the limit, however, and cannot be approached with safety. Manufacturers recommend that only 3 db compression be permitted.

► **SPIES** . . . Most individual and concerns representing foreign manufacturers in this country serve legitimate functions and are entirely respectable. They supply trade information, act as purchasing agents, etc. But competition among these purveyors of information has developed a somewhat dangerous situation.

Certain of these services are buying information on processes for sale abroad, and while most of them do not resell secret processes, there are others who do not seem to be so discreet. The more secret the process the higher the pay. "Operatives" in the employ of well known concerns are given annual retainers. Agents find it easiest to get information from men who are on payrolls subject to a big turnover. A man who feels insecure in his job seems to have less reluctance about selling his company's blueprints.

Much information is gathered at no outlay at all. Under guise of offering a man a job, the agency pumps him (and as many others as answer an ad) of all he knows about the process on which the foreign manufacturer wants data.

What to do about this business, we don't know.

► **INTRODUCTION** . . . A year ago *Electronics*' office boy and printer's devil, Kae Farrey, substituted the dictator rule of a husband for the autocratic rule of several editors. During this year the staff has been its own office boy and printer's devil in the mistaken assumption that it was a good idea. As someone has stated, the only thing that makes American business worth while is the secretaries.

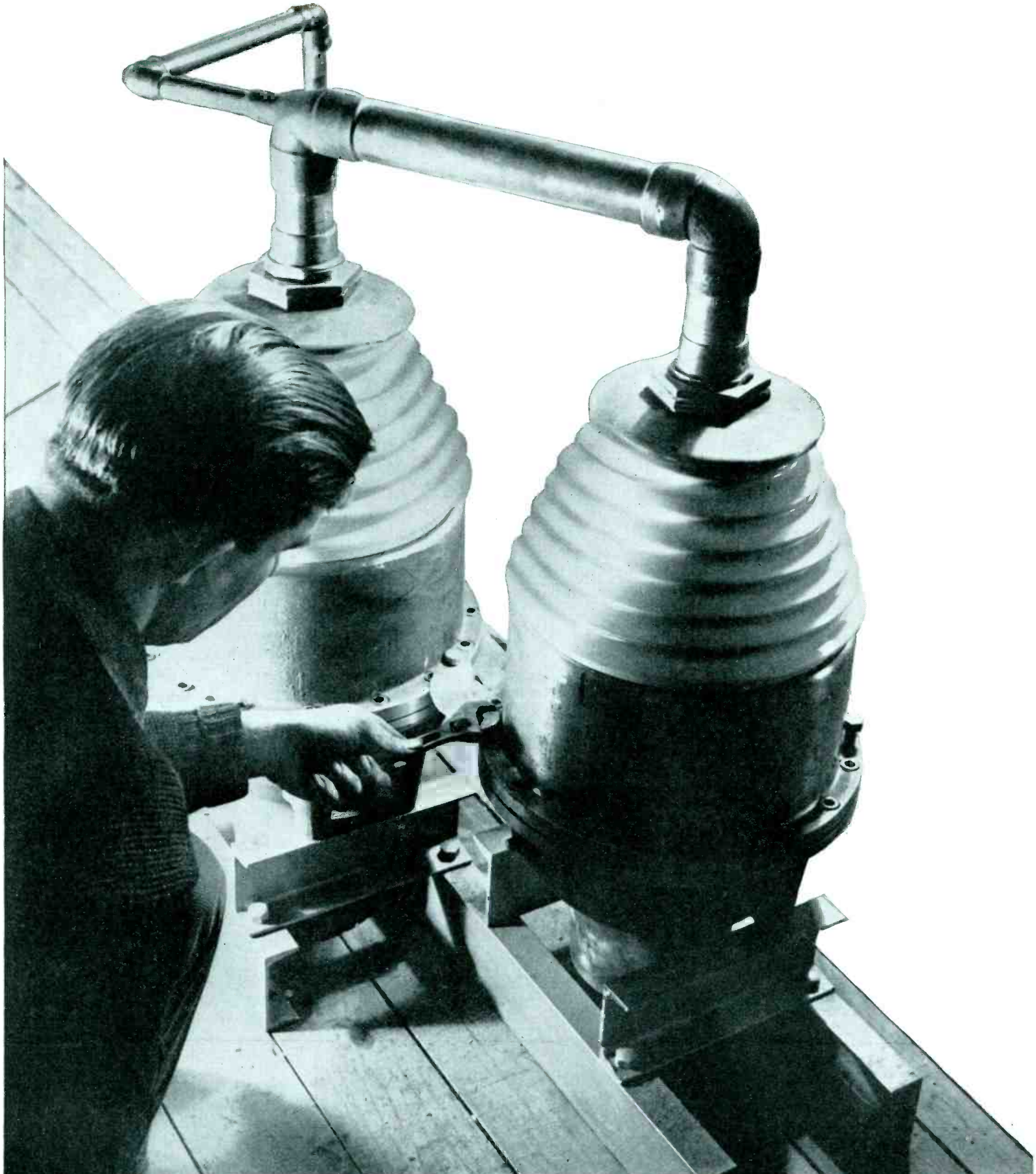
We are now happy to state that the great experiment is at an end; that Miss Marthe Mattey is now devil and boy and that our advice to anyone considering firing a secretary is not to do it. Miss Mattey was a member of the cast of The Bridal Crown, a Broadway production, which, fortunately for *Electronics* had a short run.

► **CANDOR** . . . After much scurrying around, a technical employment agency finally found a Ph.D. for a company who wanted a physicist who could write. His job was one of translation so the man in the street could understand what his company was doing. In conference with his prospective employer, everything went well. His technical qualifications were 100 percent. Finally he was asked "do you write?".

"Yes," he said, "but the editors send it all back."

Pleased with the young man's candor they promptly gave him a better job in another department, and at latest reports the company was still trying to find a physicist who can write.

► **Q FEVER** . . . In the New York *Times* we find that "a new fever has appeared in Queensland and doctors trying to discover its cause have named it Q". It seems that W. D. McLaughlin of Boonton Radio Corporation ought to look into this. The outstanding symptom, according to the *Times*, is headache.



BEEHIVES . . . End seals on the nitrogen gas filled coaxial transmission line which connects the new Western Electric 50-kilowatt transmitter at station WHAS, Louisville, with the vertical radiator

HP6A: A Radical Departure in Phonograph Pick-up Design

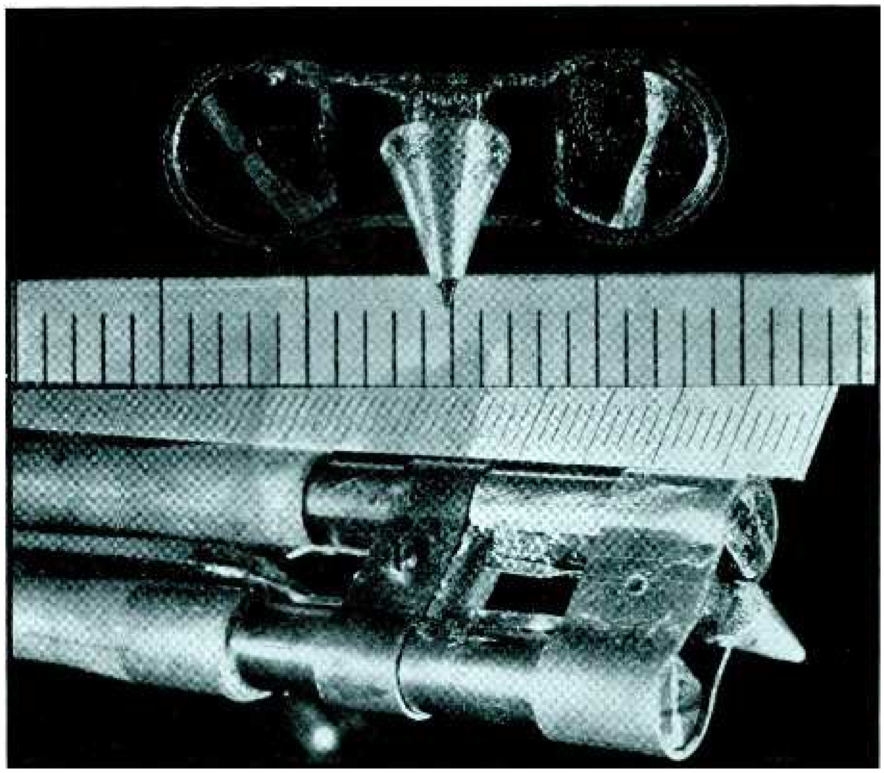
Unbelieveable response, flat within plus or minus 3 db. from 30 to 18,000 cycles, with a needle pressure of 0.17 ounces, has been achieved by applying velocity-microphone principles.

By F. V. HUNT
and J. A. PIERCE
*Cruft Laboratory, Harvard University
Cambridge, Mass.*

MUCH has been written in the technical literature during the past few years regarding the service and fidelity limitations of instantaneous recordings. It has been claimed, for example, that frequencies higher than 6,000 cycles cannot be recorded and that even if such frequencies could be engraved on the record they would be erased within the first few playings. In the field of commercial pressings intended for home consumption it is sometimes asserted that a wide frequency range would not be desirable, even if it could be secured, on account of the accompanying high noise level. This high noise level is in turn explained by the necessity of including an abrasive in the shellac pressing material so that the needle tip will be ground quickly to fit the groove contour. Even when so fitted the needle tip bearing pressure remains far above the elastic limit of the record material; both needle and record groove wear rapidly, and the initially high noise level steadily increases. It is the writers' belief that these limitations on fidelity and service life should be charged principally to the reproducers which have been available rather than to the recording and pressing materials. If a simple and rugged reproducer could be constructed which would have low needle-point impedance and operate with extremely low needle pressure, several advantages would immediately be gained. The abrasive could be omitted from commercial pressings and both these and the lacquer-coated instantaneous discs would offer high-fidelity, low-noise reproduction with long service life, either in the studio or in the home. Before describing a reproducer which meets these specifications we shall discuss the background which led to its design.

In preparation for the celebration of Harvard's Tercentenary the Cruft Laboratory was commissioned to make a phonographic transcription of the principal proceedings. We proceeded to acquire the best equipment we could afford and to make over-all frequency response measurements. By dint of heavy equalization, both in recording and in reproducing, we obtained good over-all performance up to 6,000 cycles and the Tercentenary proceedings were recorded under these conditions. A few months later our attention was

Fig. 1—Head-on and quartering views of the HP6A reproducer. The small-scale divisions are millimeters in each case



This material was presented at the Ann Arbor, Michigan, meeting of the Acoustical Society of America, November 29, 1937.

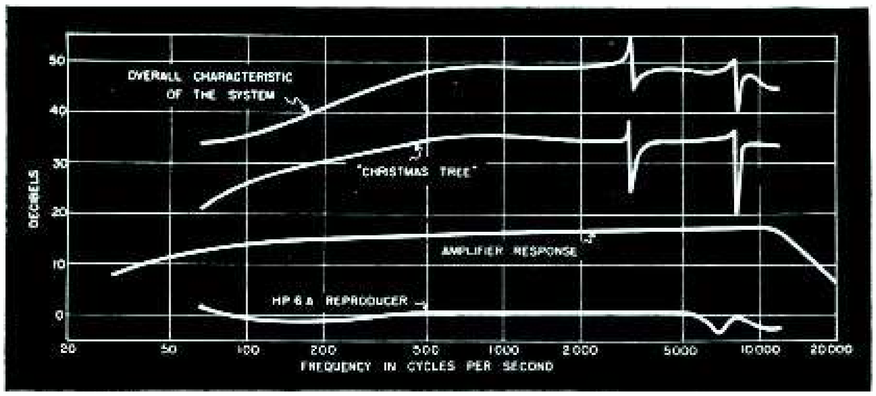


Fig. 2—Curves illustrating the method of calibrating the reproducer for frequency response. The lower curve is obtained by subtracting the two intermediate curves from the upper one

called to an optical method, first described by Buchmann and Meyer[1], whereby the recorded velocity amplitude can be measured by viewing the record under oblique illumination by parallel light. We immediately made test records under the same conditions obtaining for our recording of the Tercentenary proceedings and discovered to our surprise that we had recorded an essentially uniform response for frequencies at least as high as 10,000 cycles. Fortunately we had regarded these records as too valuable to play back with our conventional reproducer until effective steps could be taken for their ultimate preservation. We had, therefore, with one or two exceptions, given the reproducer no opportunity to erase these high frequencies from our records, so that if they had been recorded they were still there. Our problem, then, was to design a reproducer which not only would recover the high frequencies which we had engraved, but also would allow the records to be played frequently, for editing, without damage.

When one considers that a useful output can be obtained from a modern dynamic microphone when its mechanical circuit is merely exposed to an imponderable medium such as air, it becomes absurd to think that a weight of several ounces should be required to couple the mechanical system of a phonograph reproducer to the relatively rugged groove on a disc record. We began our investigation, therefore, by imposing the condition that the total unbalanced weight resting on the record should not exceed a few grams, and certainly should not be allowed to produce needle-point pressures in excess of the elastic limit of the record material. It follows, of course, that the moving system should be extremely light. In order to have as much output as possible most of the mass of the moving system should be active electromagnetically. Furthermore, if frequencies as high as 10,000 cycles are to be reproduced, with their correspondingly small amplitudes of motion, it seems advisable to avoid the use of ordinary pivots. If the foregoing conditions regarding lightness can be met the wear on the stylus tip will be extremely small, so that this may well be a permanent jewel.

[1] I. G. Buchmann and E. Meyer, *E.N.T.*, 147, 1930.

Details of the design

Our problem, therefore, became one of devising an extremely light inductor element which could at the same time serve as a pivotless mechanical system driven by a sapphire stylus. Several models were made incorporating these ideas and the results with Model 6 are so satisfactory that a description of its construction and performance characteristics forms the basis for this paper. It will be seen from the photographs of Fig. 1 that the moving system comprises a single-turn loop of thin phosphor bronze ribbon lying within a concentrated transverse magnetic field. To the outer, closed end of the loop is attached the base of a conical shell of aluminum whose apex bears a sapphire stylus. In the forward portion of the loop the ribbon is vertical and is bent into channel form to provide rigidity. A ninety-degree twist brings the ribbon into the horizontal plane in the rear portion of the loop where it is firmly clamped between insulating blocks. This yields a structure whose tip is quite rigid for lateral displacement in the plane of the loop but which is very flexible in torsion. Thus a lateral displacement of the stylus, which lies below the plane of the loop, is converted into a rotary motion of the stiffened front portion of the loop. Damping is provided by a membrane of pyralin connecting the closed, outer end of the loop to a small, stationary, soft-iron pole piece lying within the loop, and by two similar membranes bridging the spaces between the rear portions of the phosphor bronze loop and the adjacent magnetic structure. The impedance of the loop is quite low and is matched to 200 ohms by a small transformer mounted on the rear of the tone arm and acting as the counterbalance. Perfectly satisfactory tracking is obtained when the counterbalance is adjusted to produce a net weight on the stylus of approximately five grams. The needle-point impedance is so low that this weight is sufficient to keep the needle point firmly seated in the record groove with no observable distortion arising from chattering. The total mass of the moving system is approximately 50 milligrams (about one-fifth the mass of a standard steel needle) and most of this is concentrated close to the axis of rotation. In spite of the lightness of the moving parts the system is relatively rugged. For example, the reproducer head may be dropped from a height of an inch or more to the surface of a lacquer-coated record without damaging either the reproducer or the record.

Two testing methods were used to determine the frequency response characteristics of the reproducer. The first of these is illustrated in Fig. 2. The upper curve shows the over-all playback characteristics of a special test recording of a frequency sweep. The second curve, reading downward, is a calibration of the record, made by measuring the width of the optical "Christmas tree" pattern referred to above. It should be noticed that the two sharp resonances indicated in the first curve appear also in the "Christmas tree" pattern. These correspond to known resonances in the particular recording head used. The third curve, reading down, is the frequency response of the playback amplifier. By subtracting the second and third curves from the first we can eliminate from the over-all playback characteristics the recording system, the record material, and the playback amplifier, leaving the frequency response of the reproducer itself (including its step-up transformer). This is the fourth curve shown in Fig. 2. An alternative testing method consists in recording a frequency sweep at one speed, for instance at 33 rpm, and playing it back first at 33 rpm and then at 78 rpm. This yields the response of the reproducer at two frequencies bearing a known ratio and for stylus stimulations bearing a known ratio. By choosing different pairs of frequencies the relative response of the reproducer over a wide range can be obtained from a single recording. It was possible, for example, to calibrate the reproducer response for playback frequencies as high as 28 kilocycles. Using both of these testing methods on three different test records and collecting the results we have the curve shown in Fig. 3. The reproducer is seen to be uniform in frequency response within ± 3 db from 30 cycles to 18 kilocycles.

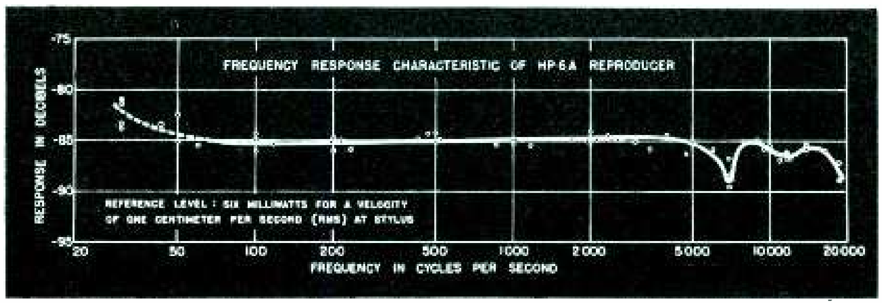


Fig. 3—Over-all frequency response of the reproducer and its impedance matching transformer

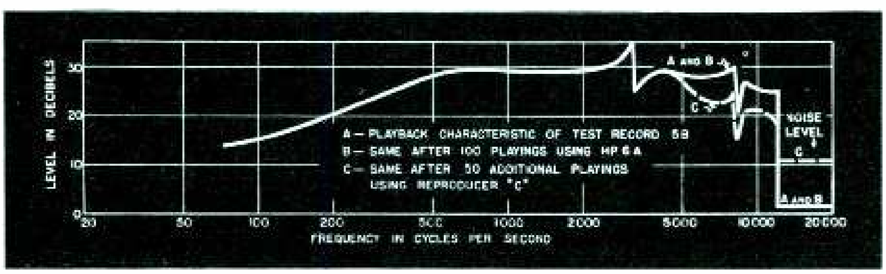


Fig. 4—Playback frequency response of a lacquer-coated test record before and after subjection to an endurance test

It is to be expected, of course, that a weight of only five grams on the sapphire stylus would produce very slight record wear, but we were not satisfied until we had tested the point. Fig. 4 shows the result of an endurance run. A lacquer-coated test record was made at 33 rpm with the frequency sweep adjusted to yield the frequencies shown on the abscissa scale of Fig. 4 when the record was played back at 78 rpm. Curve A of Fig. 4 shows the initial playback response. The sharp drop at 12,000 cycles represents turning off the recording amplifier so that the residual noise level on a blank cut could be observed. The record was then played 100 times with our 6A reproducer and after this treatment yielded the over-all playback response marked B. That is to say, no detectable change in noise level was apparent after 100 playings, nor were any recorded frequencies as high as 12,000 cycles erased by as much as 1 db. Following this test with our light-pressure reproducer we played the same test record 50 times with a standard broadcast transcription pick-up operating with its recommended needle bearing weight of approximately three ounces. After 50 playings with the transcription reproducer a check playing with our model 6A yielded the curve marked *C* in Fig. 4. While no significant changes are observed for frequencies below 4,000 cycles, there is a large and aurally objectionable increase in the background noise level. The noise level increases rapidly during the first few playings and rather slowly beyond that time, so that an increase of 9 db in background noise for 50 playings is not so encouraging as one would like to think. It is also interesting to note that the high frequencies which are erased by the transcription reproducer all lie above the cut-off frequency of this reproducer and in the range where the needle-point impedance undoubtedly becomes large.

For comparison purposes we carried out the calibration of three commercially available reproducers by the technique described above. These results are shown in Fig. 5. Curve *A* shows the response of the commercial reproducer used with our original equipment. We ought to be grateful, perhaps, that this curve is as smooth as it is, since it led us to the elaborate high-frequency equalization which we employed in making the Tercentenary records. Curve *B* shows the response of a standard oil-damped reproducer, while curve *C* shows the response of the transcription reproducer used for the endurance tests. This head was mounted upon an improvised tone arm and the low-frequency irregularity may be a spurious arm resonance. These response curves are made to match at 1,000 cycles for comparison purposes. The electrical output of our model 6A reproducer is approximately 50 db below the output of reproducer C and about 30 db below the output of reproducer A. An alternative comparison indicates that a typical vertical-cut reproducer, operating with approximately six times the needle bearing weight and somewhat less fidelity, has an output level about 40 db above that of our model 6A. It will be obvious from an inspection of the photograph of Fig. 1 that the output of our reproducer can be improved significantly by redesigning the magnetic circuit. This magnetic structure was prepared for model 4 and at that time we had more confidence in being able to build a sensitive amplifier than in being able to build a faithful reproducer! Model 7, which is under construction, will have an improved magnetic circuit. In spite of the present weak magnetic field no difficulty is experienced in keeping the hum pick-up well below the level of record surface noise, and the output of the reproducer on a normal recording is somewhat higher than the normal output of a velocity microphone.

Harmonic distortion and poor transient response in conventional reproducers usually arise from non-uniformity and non-linearity of the magnetic field, non-linear damping, and mechanical resonance and break-up of the moving parts. The design of our 6A reproducer is such as to minimize each of these difficulties. A mechanical step-down ratio exists between the motion of the stylus and the motion of the conductors in the magnetic field so that it is easy to confine the motion to the portion of the field which is essentially uniform. Since the magnetic field is constant no distortion arises from non-linearity of the B-H curve. The conical shell connecting the stylus and driven loop provides a very high ratio of stiffness to inertia and there is reason to believe that the electrically active portion of the system vibrates as a whole throughout the uniform response range, *i.e.*, to 18 kilocycles. Finally, the mass reactance of the moving system is so small that very little damping is required to secure resistance control of the motion and the damping material can be located almost on the axis of rotation. Here the amplitude of motion is least and any effect of non-uniform elasticity of the material is minimized. The use of a stiff conical member connecting the driving stylus to a loop whose motion is resistance controlled leads to small phase shift and correspondingly excellent transient response.

In measuring reproducer distortion it is difficult to separate out the portion of the over-all system distortion which is actually engraved on the record. We have obtained typical values of 3 to 4 per cent for the total distortion of the complete system from recording amplifier input to playback amplifier output and there is good reason to charge most of this to the recording head. In contrast, we have found that some commercial reproducers are good harmonic generators, one otherwise acceptable unit yielding 20 per cent total distortion at 400 cycles. It is well known that the effects of non-linear distortion become more objectionable the wider the transmitted frequency band. We have observed this effect in the case of some commercial symphonic releases. When such a record is played with a 5,000 cycle band width the reproduction sounds quite "clean"; when the reproduced band width is expanded to take advantage of the full recorded range the music takes on new naturalness and "life" but it is sometimes accompanied by slight cross-modulation "burrs" on the loud passages. We feel justified in ascribing this distortion to the original recording inasmuch as our own "choice" recordings referred to below do not exhibit the effect. We hope that the availability of the full audio-frequency range, free from distortion, through a reproducer of this type will furnish some incentive for the manufacturers to improve the distortion characteristics of recording cutters. Parenthetically, one may also hope that this reproducer will lend force to the request that commercial recording companies make available to the general public low-noise pressings from existing masters in some homogeneous material such as Vinylite or cellulose acetate.

Aside from the wide-range fidelity and the rugged simplicity of the new reproducer head, its most significant feature is the extremely low operating needle pressure. It is hard to realize the virtues of needle pressures as low as this without trying the experiment of allowing the needle of your favorite reproducer to drag across the uncut surface of a lacquer-coated record. With the 6A reproducer this leaves no visible scratch. In fact, it is possible to skid the reproducer stylus back and forth across the cut grooves of a lacquer-coated record without producing either a visible scratch or any blemish which is audible upon subsequent playing. We have not made extensive tests regarding the wear of the sapphire stylus produced by playing commercial shellac records with this reproducer, but at the low operating needle pressure such wear should be extremely slow. In any case, the reproducer head in our later model is detachable so that the sapphire stylus may easily be replaced.

The question is frequently raised whether the average listener really wants to have a band width of 12,000 to 15,000 cycles reproduced from phonograph records. Our experience indicates that such a preference is almost invariably indicated when the listener is given an opportunity to hear a low-noise, wide-range recording reproduced with various band widths. Of course the reproducer response should always be limited by electrical networks to the frequency range that is actually recorded. Prolonged conditioning of the "average listener" to home radio reproduction and the vulnerability of high-fidelity systems to all forms of distortion may make it desirable to restrict the frequency response still further. On the other hand, we have prepared records of symphonic music which are sufficiently free from noise and distortion and of such fidelity that the insertion of a low-pass filter cutting off at 11,000 cycles is distinctly recognized as an undesirable impairment in quality. Unfortunately, lacquer-coated records of this excellence are difficult to cut consistently on account of wide variations in the disc coatings. We hold it significant that those in our audiences who know best how orchestral instruments should sound have been most pleased with the reproduction from these wide-range records, and that the comparisons which have been evoked have usually been referred to the original performance rather than to other reproducing systems.

Fig. 5—Frequency response of HP6A compared with that of three commercially available reproducers. The curves are arbitrarily shifted vertically to coincide at 1000 cycles

A VERSATILE LEVEL METER

By FRED SCHUMANN

KMBC, Midland Broadcasting Co., Kansas City, Mo.

A MEANS for low level power measurements at audio frequencies is a great convenience and often a necessity in modern broadcasting operations. Typical examples of this are the determination of hum and noise levels, the equalization of plant and remote lines, measuring cross-talk between circuits, and the determination of frequency characteristics of low level amplifiers. Measurements of this sort can, of course, be made using various pieces of equipment generally found in a broadcasting station but in most cases such equipment is not flexible enough to perform adequately all the functions that are desirable. Often too, the set-up must be changed for different applications due to lack of sufficient range and seldom is the apparatus in portable form.

The level meter herein discussed was developed to overcome the apparent lack of commercially available equipment having all the features that were considered to be important.

One of the deficiencies of most existing power level measuring devices is the inability to read low levels. The instrument described here was theretofore designed to have a range of from —65 to +12 db. Zero level was chosen as 6 milliwatts.

Another desirable feature incorporated in this meter is that it will itself provide either a 50 ohm, 200 ohm or 500 ohm termination. This is accomplished by means of a rotary selector switch. A fourth position of this switch gives a high input impedance of 200,000 ohms.

A built-in regulated power supply for operation from 110 volt a-c lines is included. In addition a switch is provided so that external battery supply may be used under circumstances where no a-c line is available.

Circuit and Construction

Figure 1 is a complete diagram of the circuit used. The input signal goes through the input impedance selector switch into the primary of the transformer. The 500 ohm secondary feeds into a 500 ohm resistive load. By means of a switch, a 30 db 500-500 ohm T pad may be inserted between the transformers secondary and its load. A 200,000 ohm potential divider is placed across the 500 ohm load. This divider has 10 attenuation steps of 3 db each. A total loss of 60 db can therefore be inserted in the instrument when used on any of the three lower input impedances. When used with the 200,000 input impedance the transformer and T pad are eliminated and in this condition only 30 db total loss may be had in the instrument. It should

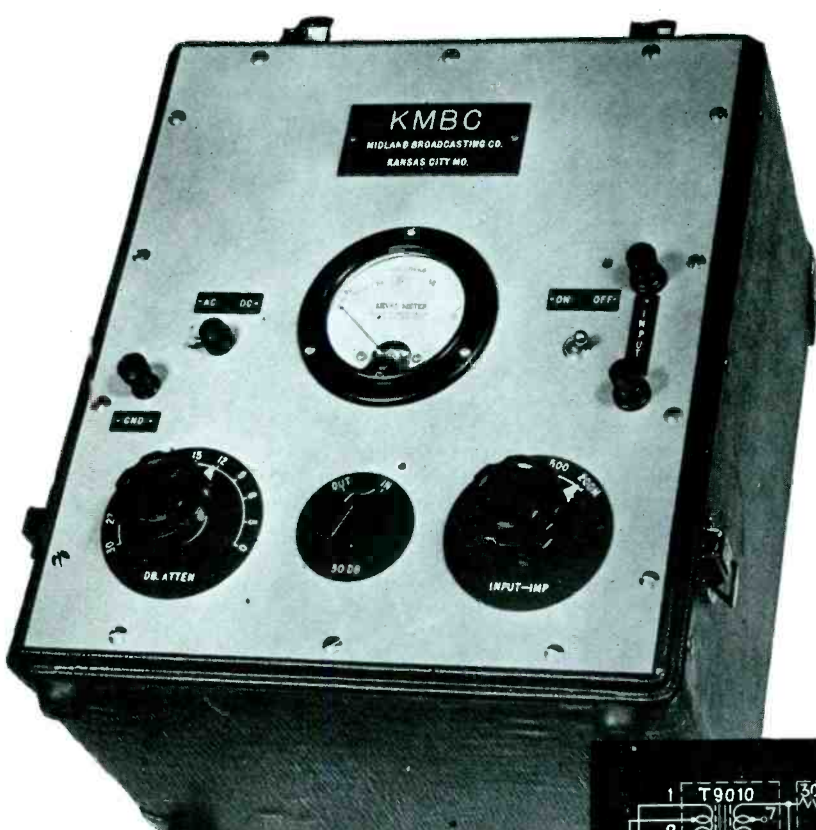


Fig. 2—Above, level indicating meter with a range from —65 db to 12 db, and with input impedances of 50, 200, 500, or 200,000 ohms

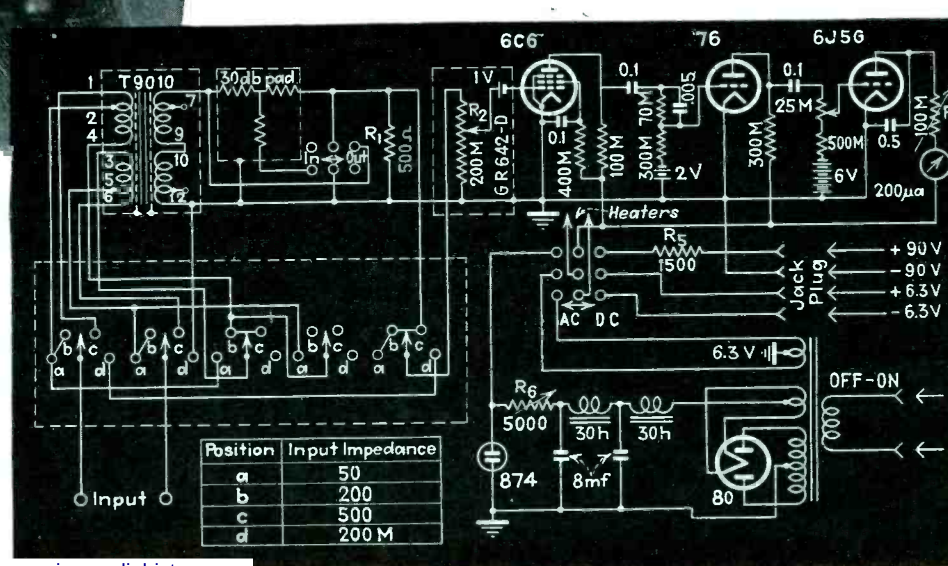


Fig. 1—Right, schematic wiring diagram of the complete level indicator with associated power supply

also be noted that the input is balanced on the three lower input impedance positions and unbalanced on the high impedance input.

The amplifier and detector circuits are fairly conventional and consist of a 6C6 pentode first amplifier, a 76 triode second amplifier and a 6J5G biased detector. The grid bias for each tube is obtained through the use of C-bias cells which have proved very satisfactory provided a mounting is used which assures good contact between cells. The use of these cells also obviates the necessity for cathode resistor and condenser combinations which might adversely affect the low frequency response.

High grade carbon resistors are used with the exception of those in the 30 db pad and those marked R_1, R_2, R_3 and R_6 which are wire wound. R_3 and R_4 are variable with screw driver adjustment and are discussed later.

The plate supply is a well filtered full wave rectifier and employs an 874 voltage regulator tube. This supply was adjusted to give slightly less than 90 volts and is free from the effects of line voltage fluctuation. When battery supply is to be used the a-c d-c switch is thrown to d-c. The resistor R_5 was inserted in the plus 90 volt battery lead to make the instrument give identical readings with battery supply as when using the built-in a-c rectifier.

Due to various stray and tube input capacitances the high frequency response of the instrument was bound to fall off and the necessary corrective equalization was placed in the grid circuit of the 76 stage. The constants of this network would no doubt require some readjustment in any individual instrument.

A 200 microampere meter was placed in the plate circuit of the detector stage. With no signal the current through this meter was adjusted to 5 microamperes by means of R_4. A blank scale was engraved to read directly in db below zero level. The range marked on the meter scale is from —65 db to —48 db.

The entire instrument was fitted into a black leatherette carrying case measuring 13"x 11"x 8" and is shown in Fig. 2. A chassis type of construction was used. The usual precautions as to shielding and placement of parts were observed and no difficulties were experienced with respect to feedback or undesired pickup.

Frequency Characteristics and Calibration

The frequency characteristic for the 50 ohm input is shown in Fig. 3. It may be seen that the total variation is 0.5 db for frequencies between 30 and 10,000 c.p.s. The frequency characteristics for the other input impedances are all more ideal within the same frequency limits than the curve shown and were therefore not included. For broadcast purposes the frequency characteristics of the instrument are very satisfactory.

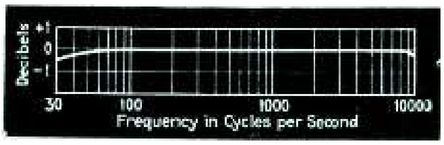


Fig. 3.—Frequency response of the level meter used at KMBC for 50 ohm input

The calibration was made using a vacuum thermocouple and associated equipment in a manner familiar to all communication engineers. At first, high levels around 0 db were fed into the instrument and the attenuators in the level meter itself were used to drop the level to within the range of the indicating meter. Then, as a check, the instrument was fed with low levels and with no attenuation inside the meter. The two methods of calibration agreed with no discernible difference.

Since the calibration was engraved on a blank scale, means were provided to insure that this same calibration could be obtained when a change of tubes became necessary. This is accomplished by first adjusting R_4 so that 5 microamperes will flow in the plate circuit of the 6J5G with no signal and then adjusting the gain of the amplifier by means of the 6J5G grid resistor.

Operation

When the input impedance selector switch is in positions a, b or c the instrument itself provides impedance terminations of 50, 200 or 500 ohms respectively. Thus, equipment designed to work into any of the above mentioned impedances may be correctly terminated by the input impedance of the level meter itself and output power level measurements made.

In reading levels it is advisable to first throw in the full 60 db attenuation in the instrument and then to gradually cut out some of this attenuation until an easily readable indication is obtained on the meter. Since the calibration of the meter scale is from —65 to —48 db in 1.0 db steps, and since 60 db of attenuation is provided within the case in 3 db steps the total range of the device is from +12 to —65 db. The actual level is then simply the algebraic sum of the scale reading and the attenuation setting of the instrument. The meter scale can easily be read to 0.5 db.

Another condition often encountered is that in which an amplifier, line or other piece of equipment is already properly terminated and it is desired to measure power levels in this terminating load. For this purpose the 200,000 ohm input of the meter is used to bridge across the load. An examination of the circuit of Fig. 1 shows that the instrument

(*Continued on page* 65)

Fig. 4—Table showing the corrections to be added and the level range over which the meter operates for various impedances across the 200,000 ohm termination

Impedance across which the 200,000 ohm input is bridged	db correction to be added algebraically	db range
50 ohms	10	—8 to —55
200 ohms	4	—14 to —61
500 ohms	0	—18 to —65
1000 ohms	—3	—21 to —68
4000 ohms	—9	—27 to —74

Photocell Experience in the Factory

By ABRAHAM EDELMAN
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New York City

ENGINEERING of photocell applications is of two kinds; first, the invention and experiment, ending in a laboratory model; and second, the development, incorporating performance experience, and ending in acceptable industrial equipment. The first kind of engineering is much publicized in the photocell field, because of the marked interest in each new application—the novelty of new tools with which to work. The second kind of engineering has not yet become popular; but if the "bugs" are to come out of new designs, if performance is to match promise, then there is much to be done.

An analysis of several years' service reports brings to light several important causes of servicing, and a few elusive faults. In the following, only the use of photocells in the more standardized applications, such as counting, conveyor control, machine control, alarms and signals, are considered.

Looking over the accumulated reports, it soon becomes apparent that the photocell itself, after correct installation, is one of the most stable, least troublesome of the components. Occasionally, a cell is smashed or cracked, or the base becomes loose; but rarely does it "go bad" without sufficient cause, even after five years of service. The more common ailments of the photocell are traced to improper installation, and include several varieties of stray light, current leakage, physical displacement, and dirt.

Stray Light Troubles

Stray light would be considerably less of a nuisance if it were not for the uninformed factory worker who finds it hard to appreciate that the photocell responds to "ordinary" light. It is commonly his opinion that the necessary light has some special character vaguely associated with radio. The records show that the electrician who installed the photocell system will unconcernedly install a drop light nearby, so that the light enters the photocell. He will become careless with his flashlight, and will not consider a window as a source of light capable of causing interference with the operation of a photocell.

Sometimes, stray light is difficult to locate. In one installation of a counting machine, cartons of merchandise travel on a conveyor, parallel to an outside wall which has a large, factory type window. After two months of perfect operation, we received the report that the counter was missing several hundred counts per day. For several days, each afternoon, our service engineer examined the equipment, watched it operate, and reported no trouble. Nevertheless, the errors increased slowly, and with regularity. After five days, the conveyor was watched in the morning, instead of in the afternoon. Instantly, the source of the error was revealed. The sun, reaching in between two buildings, illuminated the window and the cartons of merchandise as they passed, and was reflected from the light colored cartons, into the photocell. In spite of a long tube over the opening in the photocell housing, the reflected light was strong enough to cause this trouble, for a short period each day. Due to the changing seasonal angle of the sun, this had not occurred previously. The remedy for this condition was very simple, and consisted of a screen which prevented the sunlight from reaching the side of the carton, when the carton was close to the photocell.

Insulation Troubles

Insulation troubles affect the photocell and its connecting wires more than they do any other part of the equipment, because of the very slight currents that pass through the photocell circuit. The selection of a proper wire for the photocell connection is a large part of the problem. Any wire, nearly, will work well when first installed; but after water has condensed in the conduit which houses the wire, or perhaps, after the grease and oil that are in the conduit have softened the rubber insulation, trouble will develop. In the keg house of a large brewery, we discovered that the photocell wire as well as some of the other wires that lay in a short length of conduit were giving trouble. After disconnecting both ends of the wire, it was found to have an ohmmeter reading of less than 5,000 ohms between the conduit and the copper. On pulling the wires out, it was found that they were covered with a fungus which had eaten up the insulation. On other installations of a similar type, this fungus would cover the prongs of the photocell, the socket, and the surface of the glass as well. The proper remedy is to leave no exposed metal connections, and to wipe all grease and fingermarks from the equipment, especially from the light path. If this is not done, the mould will accumulate on the grease, and obscure the light.

Conduit which runs between two rooms is quite likely to produce condensate, if there is a difference of temperature between the rooms. In such cases, the conduit must be so designed that it cannot have a circulation of air through it, or else it must be arranged so that the condensate may drop off without reaching any vital spot. With the proper precautions, photocells may be installed permanently in the wettest locations, without special maintenance.

Several conditions affecting the photocell current have no connection with insulation. If the photocell wires are long and heavy, they may pick up interferences due to motors and other electrical equipment. Also the natural capacity between the photocell wires and from them to ground may slow down the responses to the point of improper operation.

Light wires, thick insulation, shorter distances, and encasement in conduit, usually remedy such faults.

The light source also has its peculiar troubles. It requires fairly regular maintenance, since bulbs deteriorate even if they do not burn out. For long life, a bulb may be operated at a yellow light, in which condition it will sometimes last for many years. But usually, after six months, the glass has blackened, the solder terminals have corroded and have deformed due to constant pressure from the socket, and the filament has weakened so much that it is quite unsafe. At such a time, a surge is quite likely to burn it out, and so it must be replaced even though it still appears good. Socket deterioration occasionally occurs due to replacement of the bulb by inexperienced help; due to chemical fumes that may be present; and sometimes due to excessive temperatures which occur when the bulb wattage is too great. This latter condition may weaken the springs inside the socket, which produce the pressure against the bulb terminals. Displacement of the socket while changing a bulb, so that the beam of light no longer shines into the photocell, is a common fault. In the same way, grease and dirt will be left on the bulb that is installed, causing the bulb to overheat as well as to give out insufficient light.

Improper installation of a bulb may frequently permit excessive vibration to shake the filament apart, or to displace the beam momentarily so that it does not reach the photocell. Rigidly fastened housings, bolted strongly to vibration-less surroundings, with sufficient space for bulb changing, will prevent this.

In damp locations, the light source may exhibit a condensation of moisture on the inside surface of the lens. This occurs shortly after turning the bulb on, because the housing warms up quickly, while the lens does not. Moisture inside the lamp housing evaporates, and this condenses on the cold lens, dispersing the light. To avoid such effects, the bulb may be kept burning continuously, or heating coils may be employed, near the lens.

The amplifier and its associated equipment also require regular attention. Tubes require replacement every six months; vermin which have entered the box must be cleaned out. Less often, contacts show pitting and corrosion which may be traced to initial dust particles; loose hanging pigtail resistors corrode loose or break off due to vibration; excessive heat inside the housing causes the deterioration of electrolytic condensers and of rubber insulation. Acid soldering flux begins to corrode the terminals it was used on, and tiny iron and steel particles from the air cling to the relay core, and prevent the armature from closing properly.

Tubes have been known to be forced into the wrong sockets, or into the rights sockets in the wrong way. These are minor troubles, occurring but rarely; however, they serve to show the designing engineer some new necessities.

Power Troubles

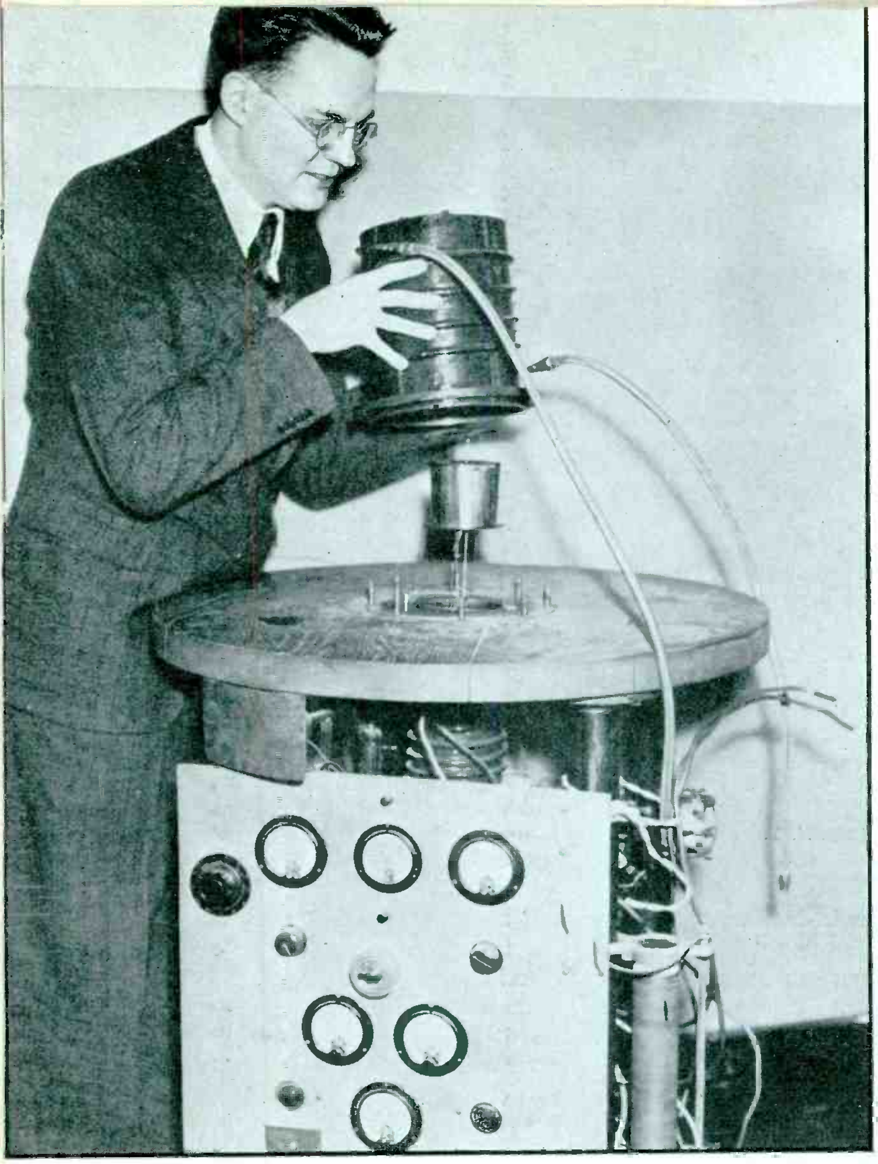
In many factories, power is generated on the premises, and this power must be used for all equipment. It is generally direct current; occasionally alternating current. Very often, the entire output is left ungrounded, so that minor shorts and grounds will shift the potential of the entire system, but will not blow out a fuse. The effect of such a system on a photocell circuit is to change the voltage on the photocell through wide ranges, while other conditions are apparently constant. Thus, an intermittent ground, such as has occurred when a commutator segment sparks to ground, may easily cause intermittent relay action in time with the offending motor. Complete shielding of the grid circuit, with an insulated shield connected to a fixed potential, is a certain remedy. Photocells with higher output may be used where shielding is inconvenient, as this will decrease the effect of the changing ground potential.

In such ungrounded installations, unusual effects may be discovered occasionally. In one plant, the intermittent operation of the photocell counting machine, noticeably operating at a steady, uniform rate when there was nothing passing through the beam of light, reminded the plant electrician that the large generator in the powerhouse revolved at just about that rate of speed. Prompt investigation disclosed that the generator was grounding a coil with each revolution, and would soon have broken down.

Quite recently, in another plant of similar type, there were noticeable variations in the brightness of our light source bulbs, and these variations appeared to be related to the changes in the potential of the electrical system with respect to ground. The investigation of this unusual effect disclosed that the bulbs were defective in a peculiar way, and also that most of the bulbs put out by this very large incandescent bulb manufacturer had the same defect. The defect consisted of a leakage inside the base of the bulb, probably due to a soldering flux, so that current could pass from the normally insulated shell to one of the solder terminals. Since the base of the bulb was of the double-contact bayonet type, with the base shell grounded, a varying amount of leakage current was passing through the filament together with the normal current.

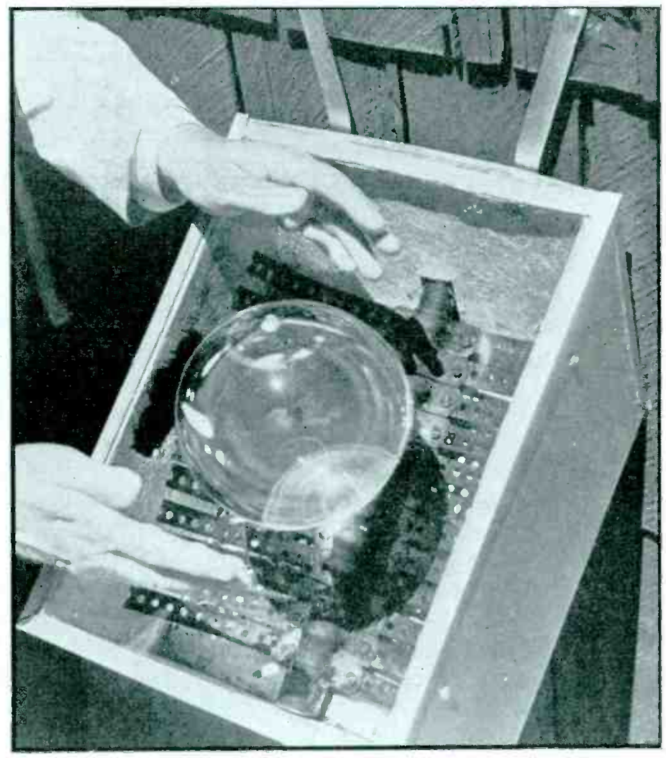
Voltage fluctuation has been another important source of service calls. Unusual line surges have caused bulbs and tubes to burn out; excessively long and overloaded power lines have caused large sustained voltage drops which change the conditions of operation of the equipment; and occasionally, high frequency effects are encountered where they were not expected and designed for, and have caused improper operation of the equipment. Such interferences are usually due to motor brush sparking, when the motor is on the same line; similarly, to solenoid coils and small relay coils, when they are on a direct-current line, especially. The remedy in each case is filtering, of a type sufficient to absorb all of the offending frequencies. For instance, simple filtering by electrolytic condensers has proved to be insufficient because these condensers change their high-frequency capacity with age. Also, filtering at the source is desirable as well. Relay coils that have a tendency to oscillate with the power line must be shunted with a condenser; contacts that make and break an inductive load should be shunted with an absorbing filter; and nearby machines that produce electrostatic or electromagnetic interferences must be treated according to their requirements.

Consideration of the foregoing experience enables the designer to avoid a repetition of these faults and weaknesses, without the expenditure of considerable time and money such as these have cost.



Electronic Miscellany

These recent news photos illustrate the variety of uses to which electronic techniques are now applied

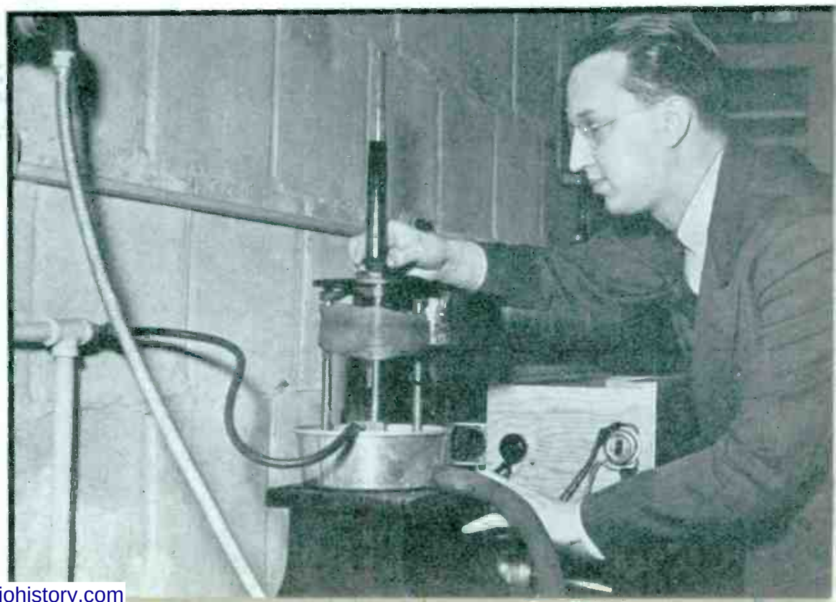


At Harvard University, Dr. Ralph R. Hultgen has developed a new form of electronic furnace, capable of attaining a temperature of 4500° Fahrenheit without contaminating the metal charge enclosed in it. The mechanical energy of electronic bombardment, similar to that which heats the plates of transmitting tubes, heats the crucible containing the charge

In Concord, California, Otto Mohr has perfected a device, energized solely by the heat of the sun, which ionizes water vapor, collects the hydrogen ions in one chamber, and the oxygen in another. The hydrogen is used as a fuel. At right is the ionization chamber

At the Bartol Research Laboratories, Dr. A. J. Allen, of the Franklin Institute Biochemical Foundation, takes a drink of water containing artificially produced radioactive sodium. He holds in his hand a ionization chamber, connected to an electronic counter, which will register the arrival of the radio-sodium at his finger tips, thus indicating the time it takes the blood-stream to assimilate it and carry it to all parts of the body

At the University of Pennsylvania, Dr. Leslie A. Chambers generates a super-sonic note, about two octaves above the piano range, in a electronic oscillating circuit. The "noise" is capable of separating typhoid bacilli into two parts one harmful, the other relatively harmless



Measurement of Minute Changes of Capacitance and Inductance

Determining changes in L and C of the order of 0.0005%, and temperature coefficients of the order of 0.0001% by beat frequency methods. Suitable for measuring effect of temperature changes on radio components

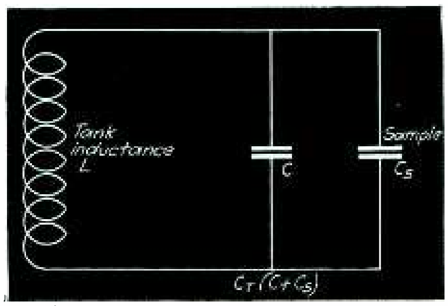


Fig. 1. LC circuit used in mathematical analysis

By S. C. LEONARD

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THE development of a portable radio transmitter having zero frequency variation under all conditions has been the goal of the radio design engineer ever since portable radio equipment has come to play such an important part in aircraft and police car service.

A thorough knowledge of the effect of temperature, vibration, and pressure upon the component parts of a transmitter is essential before a transmitter having zero frequency variation can be intelligently designed. Former study has shown that change in temperature is the predominant factor that causes a change in the frequency of radio transmitters.

There is an increasing demand for transmitters for air service that are flexible over wide frequency bands, and that have a frequency variation of less than 0.001 per cent per degree Centigrade.

Quartz crystals have been developed within the last year that have temperature coefficients as low as 0.0001 per cent per degree Centigrade. This development, although it is a great advance in the art of transmitter control, does not solve the problem of covering the wide frequency bands used in portable radio equipment, since separate crystals must be supplied for each specific frequency. Therefore, until the advent of the as yet, mythical "rubber crystal", the development of a self-excited oscillator having a temperature coefficient of less than 0.001 per cent per degree Centigrade seems imperative.

The critical part of any self-excited oscillator as regards its frequency characteristic is the tank circuit, which usually consists of an adjustable tuning capacitor and a fixed inductor. Changes of the value of either of these affect the frequency of the oscillator in direct proportion to the magnitude of such changes. Therefore, the first step in the development of a transmitter having zero frequency variation resolves itself into making precise measurements of the minute changes of tank inductance and capacitance incurred by changes of temperature, in order to determine the magnitude of such changes and to develop methods of reducing them to a minimum value.

Various attempts have been made previously to use bridge methods for measuring changes of inductance or capacitance produced by changes in temperature. The magnitude of the smallest change that could be accurately measured on a bridge was found to be greater than the largest change in inductance or capacitance

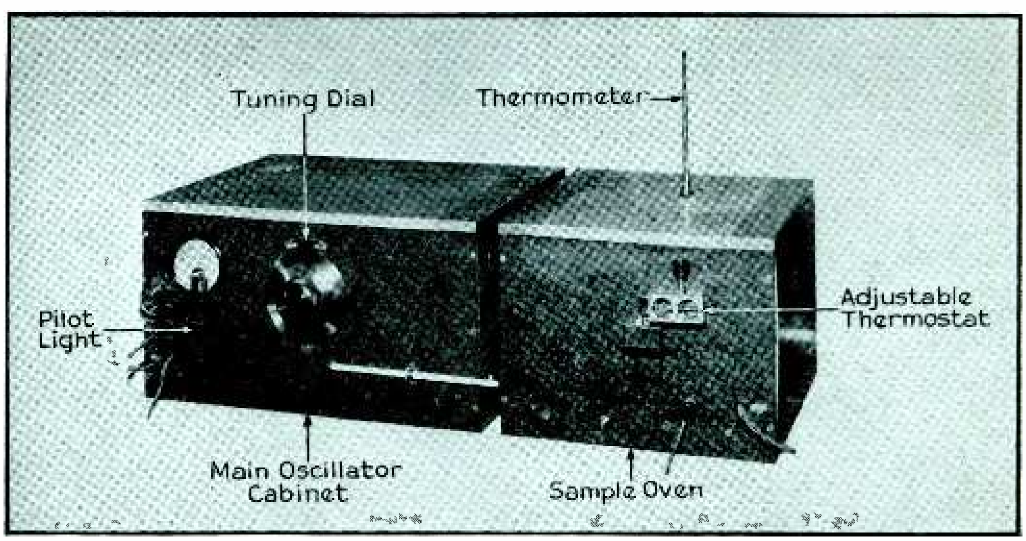


Fig. 2. Test oscillator and sample oven used in measuring small changes in L and C

that could be tolerated in actual transmitter design. For this reason the method described below was developed.

Description of Apparatus

The test oscillator is of the tuned-plate, tuned-grid type having a two terminal tank circuit so essential when samples of either inductance or capacitance are to be inserted external to the main tank circuit. Fig. 3 is a wiring diagram of the oscillator and heat control circuits. Fig. 2 is a photograph of the test oscillator assembly.

The main oscillator unit is mounted in a heavy duralumin shield, which is housed in a heat-insulated temperature controlled cabinet. The temperature of the main oscillator compartment is controlled to better than 0.1° C. by means of a heater wound on the inner duralumin shield; the amount of heat being controlled by a precision type thermostat imbedded in this shield. Uniform heating is assured by a small air circulating fan located inside the main cabinet.

A vernier tuning dial (see Fig. 2) is connected to the tuning capacitor inside the main compartment by a heat insulated coupling, so constructed that the dial is totally disengaged from the tuning capacitor after the final adjustment of the oscillator is made. This feature eliminates any defect that the expansion or contraction of the front panel might have on the frequency of the oscillator.

The sample oven is a separate heat-insulated cabinet with an adjustable bimetallic type temperature control capable of covering the temperature range from room temperature to 100° C. The two leads connecting the sample in the sample oven with the main tank circuit of the oscillator are two copper wires six inches long and 0.010 in. in diameter.

The additional equipment used for measurement is the primary frequency standard[2,3,4,5,] a standard radio receiver, a precision audio oscillator, and a pair of headphones. (See schematic layout, Fig. 4.)

Method of Measurement

The primary frequency standard of the General Electric Company can be depended upon to one part in a

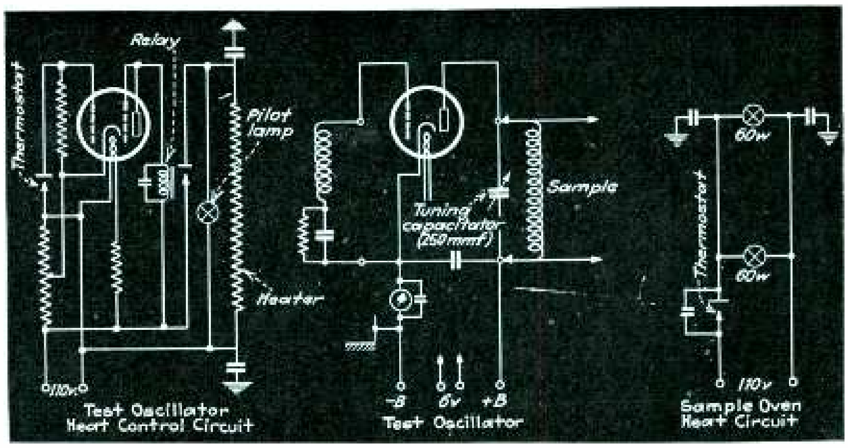


Fig. 3. Wiring diagram of test oscillator and heat control

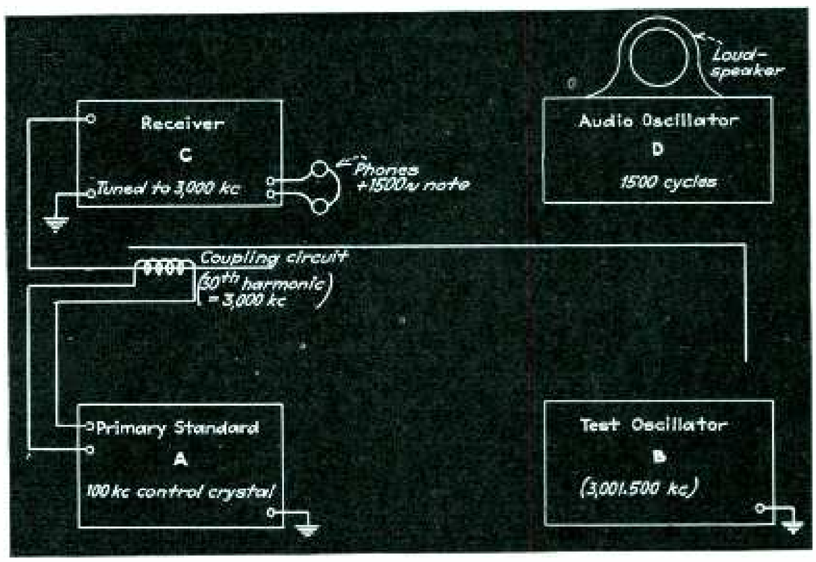


Fig. 4. Schematic diagram of measuring equipment

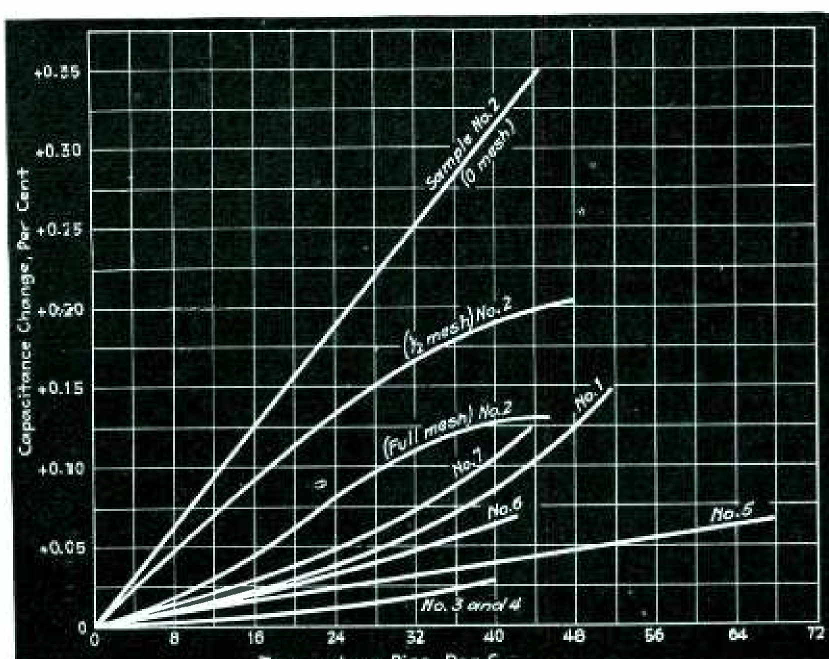


Fig. 5. Temperature characteristics of adjustable capacitors

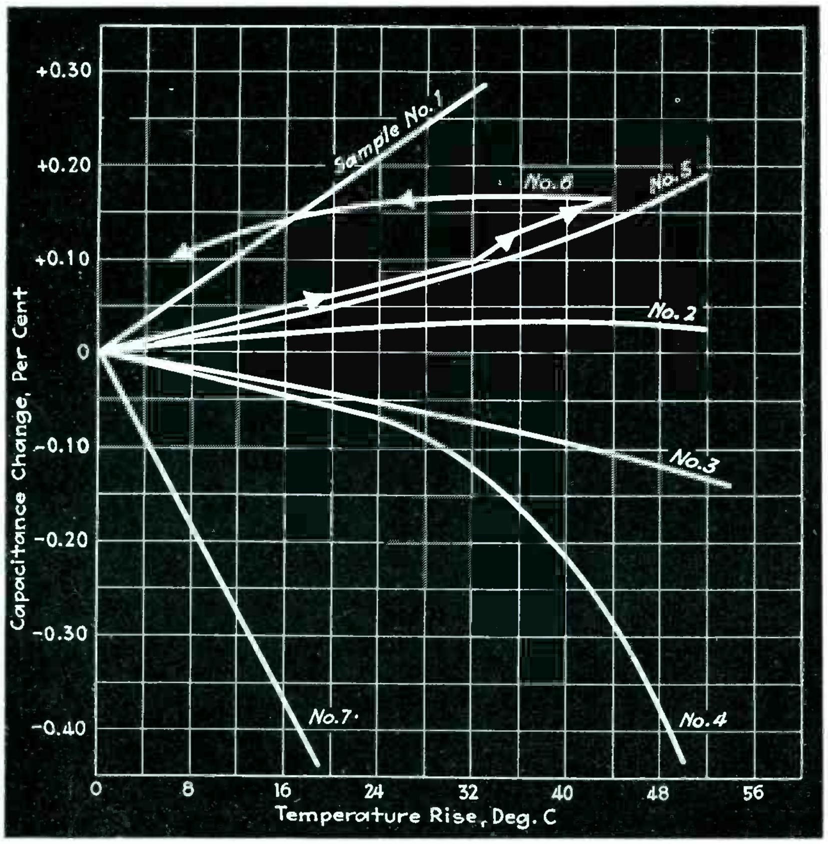


Fig. 6. Temperature characteristics of fixed capacitors

million without correction and to one or two parts in ten million (0.00002 per cent) with corrections as obtained by direct comparison with the Bureau of Standards at Washington through the medium of the Arlington time signals[2,3,4,5]. Measurement against such a primary standard is essential when attempting to detect changes in the order of 0.0001%. Direct comparison against the primary frequency standard of the Company is accomplished by making the sample of capacitance or inductance an integral part of the test oscillator described above whose frequency can be measured directly against the standard.

The schematic arrangement of the measuring equipment and the method of tuning is shown in Fig. 4. A rough calibration facilitates the accurate adjustment of the test oscillator (B) during the set-up and can be made by any of the standard methods of frequency measurement[6]. The frequency of the driving crystal in the primary standard (A) is 100 kilcycles[2]. The test oscillator (B) with the sample of capacitance or inductance in place is therefore tuned within an audible beat to some frequency that is a multiple of 100 kilocycles[2]. The frequency of 3,000 kilocycles was chosen in this particular case since it was convenient for the measurement of the samples of capacitance (0 to 200 $\mu\mu$f) and inductance (11 to 50 μh) being investigated. Through the medium of the non-oscillating receiver (C) the beat note between the test oscillator (B) and the standard (A) is measured with the audio oscillator (D). Any change in the audio beat is directly proportional to the change in the sample since the main tank circuit of the test oscillator is held constant. Thus by changing the temperature of the sample in the sample oven the corresponding change in inductance or capacitance of a sample can be calculated from the measured change in frequency.

Calculations

Let,

f = *Nominal frequency of oscillator at start of run.*

Δf = *Frequency change measured.*

$\%\Delta f$ = *Total per cent frequency change measured.*

$\%\Delta f_o$ = *Per cent frequency change caused by oven leads, etc.*

$\%\Delta f_s$ = *Per cent frequency change caused by the sample.*

$\%\Delta C$ = *Per cent capacitance change proportional to* $\%f_s$.

$\%\Delta C_s$ = *Per cent capacitance change of sample.*

ΔC_s = *Capacitance change in the sample.*

ΔL_s = *Inductance change in the sample.*

C_t = *Total capacitance to tune.*

C_s = *Sample capacitance.*

T = *Temperature rise in degrees Centigrade.*

$\%\ T_c$ = *Temperature coefficient expressed in per cent.*

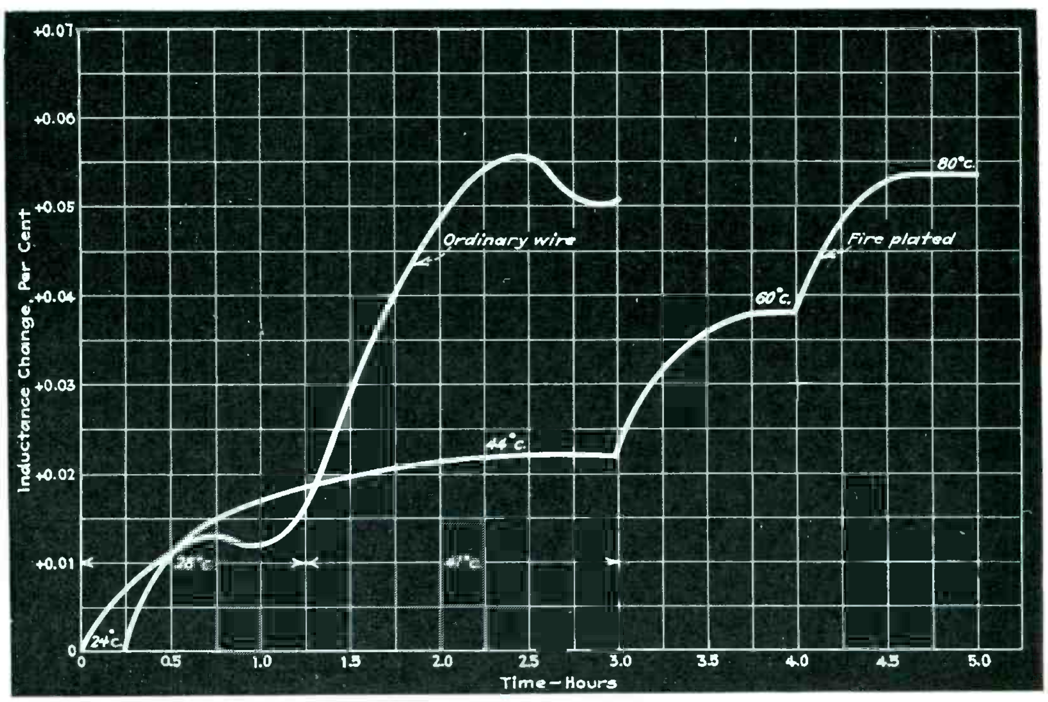


Fig. 7. Temperature-time characteristics of inductors

Then, $\%\Delta f = \dfrac{\Delta f \times 100}{f}$ (1)

$\%\Delta f_s = \%\Delta f - \%\Delta f_o$ (2)

$\%\Delta C = 2 \times \%\Delta f_s$ (3)

for small values up to 0.5 per cent. From Fig. 1 it follows that:

$\%\Delta C_s = \%\Delta C \times \dfrac{C_t}{C_s}$ (4),

as plotted in Fig. 5, 6, and 7.

C_t and C_s are determined by precision bridge methods. Then,

$\%\Delta T_c = \dfrac{\%\Delta C_s}{T}$ (5),

as tabulated in the table.

The per cent change of inductance is calculated from the frequency change measured in the same manner as outlined for the capacitance calculations.

Absolute values of capacitance or inductance changes can readily be calculated from the following equations:

$\Delta C_s = \% \Delta C_s \times C_s$ (6)

$\Delta L_s = \% \Delta L_s \times L_s$ (7)

Results of Measurements

The table lists the various samples measured and the average temperature coefficients determined from a 30°C change in temperature.

Fig. 6 shows the temperature characteristics of various fixed capacitors. These capacitors are experimental samples made especially to determine the effect of using various insulating materials as dielectrics, and the effect of various methods of construction (type of case, clamping etc.) upon the temperature coefficient. The curves drawn in Fig. 6 show the possibility of using combinations of two capacitors having equal opposite temperature characteristics to obtain a capacitance having practically a zero temperature coefficient.

In Fig. 5 the temperature characteristics of various adjustable air capacitors are plotted. Sample 1 is an ordinary midget type capacitor of light construction. Sample 2 is a two section capacitor of heavier construction than those ordinarily used in radio design. Three curves are plotted for sample 2 showing the difference in characteristic with plates at full, one-half, and zero mesh. A difference in the average temperature coefficient of two to one will be noted from zero to full mesh. (See Table). Measurements on samples 3, 4, and 5; (Fig. 5 Table).

(*Continued on page* 66)

Temperature Coefficients of Various Samples of Capacitance and Inductance Measured

SAMPLE	CAPACITORS MMF	*TEMP. COEFF. PER C. RISE PER CENT	REMARKS
FIXED CAPACITORS			
#1 Mica Insulation Aluminum Case	28.1	+0.0088	
#2 Special Type Insulation not designated. Aluminum Case.	60.6	+0.0011	Erratic while heating between 30° and 60° C.
#3 Special Capacitor as above...	48.7	−0.0024	
#4 Sulphur Insulation Bakelite Case.	47.0	−0.0032	Sharp decrease after 60° C. Erratic between 50° and 60° C.
#5 Fused Quartz Insulation. Mycalex clamps.	38.7	+0.0027	Erratic between 60° and 80° C.
#6 Fused Quartz Insulation. Mycalex clamps.	30.4	+0.0030	Became erratic at 60° C. Poor Retrace.
#7 German Tubular Type Karafar Insulation.	112.5	−0.0211	Large Temp. Coeff. but excellent retrace.
ADJUSTABLE AIR CAPACITORS			
#1 Midget Type Isolantite Supports.	25.0 (Full Mesh)	+0.0017	
#2 Special Two Section Type Heavy Aluminum Plates and Spacers, Mycalex Supports Rear Section.	132.7 (Full Mesh)	+0.0033	Good Retrace
#2 Special Two Section Type Heavy Aluminum Plates and Spacers, Mycalex Supports Rear Section.	69.1 (½ Mesh)	+0.0065	Good Retrace
#2 Special Two Section Type Heavy Aluminum Plates and Spacers, Mycalex Supports Rear Section.	9.7 (0 Mesh)	+0.0077	Good Retrace
#3 Special Type Invar Plates Brass Spacers Mycalex Supports.	66.4 (Full Mesh)	+0.0005	Good Retrace
#4 Special Type as above......	146.7 (Full Mesh)	+0.0007	Good Retrace
#5 Special Type as above.......	75.6 (Full Mesh)	+0.0010	Good Retrace
#6 Special Type Cadmium Plated Invar Plates with Mycalex Supports.	168.2 (Full Mesh)	+0.0016	Good Retrace
#7 Special Type Gold Plated Aluminum Plates Aluminum Frame Mycalex Supports.	126.5 (Full Mesh)	+0.0029	Fair Retrace

INDUCTANCES

SAMPLE	INDUCTANCE UH	TEMP. COEFF. PER C RISE PER CENT	REMARKS
#1 Fire Plated Coil on Grooved Calit Form.	11.8	+0.0013	Fair Retrace
#2 Ordinary Coil # 18 Cu. Wire wound on grooved porcelain form.	14.4	+0.0020	Erratic while heating

*Temperature Coefficients calculated on 30° C rise basis. The prefix (+) indicates a positive coefficient, and (−) indicates a negative coefficient. Ambient Temperature is 25° C

Direct Disc Recording

In producing "immediate playback" records, careful attention must be paid to turntable, cutter head, record blanks, and reproduction facilities. The second article in a series on practical recording problems.

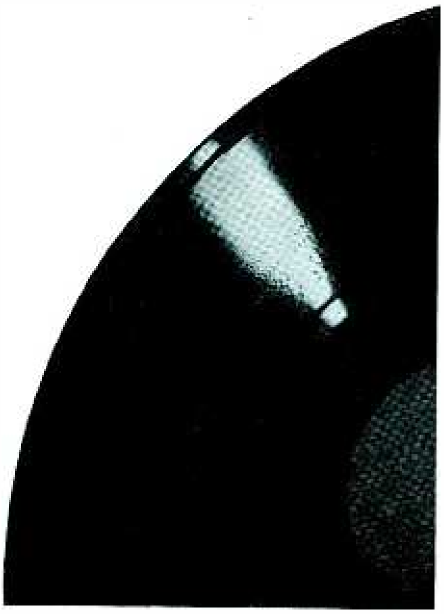


Fig. 1 — Ideal response pattern. Gradual increase in level from 25 to 300 cps, flat from 300 to 8500. (H.M.V. Record D.B. 4037, No. 10)

By C. J. LEBEL
Recording Consultant

IN the last few years a new branch of disc recording has become exceedingly important. It is the field of direct recording, which may be defined as the production of discs suitable for immediate playback without processing. They are used in many applications, perhaps, half of which are related to broadcasting and the other half to a variety of other purposes.

Before taking up the subject in detail it is necessary to distinguish between recording and reproduction. The latter is relatively easy. The sources of trouble are few and may be directly traced. But the production of records is another story. In broadcast transmitter practice, for example, an instant's overmodulation is quickly forgotten. It does no permanent harm to the station's reputation if not too often repeated. The equivalent in recording is a "cut-over"—only one of which will permanently ruin the record. Other sources of trouble are not so easy to locate. Distortion may be due to so many things—sounding quite alike to the average ear. Hence the good recording engineer is a very cautious man, continually checking his equipment. The broadcaster must emulate him before attempting disc work, otherwise he may be a failure.

High-fidelity recording

In considering the subject of direct recording, high fidelity may be broken down into four parts:

1. Stability of speed, i.e., steadiness of tone.
2. Frequency range.
3. Minimum harmonic distortion.
4. Minimum noise level, low hum level, scratch.

We come first to the driving mechanism. Stability of speed is the most important consideration. Gear drives and steel ball friction drives are at the present time the most perfect and most durable—when properly built. It is necessary to use a mechanical filter to iron out motor vibration and gear irregularity, and this must be properly designed and set up. Once adjusted, such as system is, however, quite stable. The one objection is cost.

An alternative method is the use of an endless woven cotton belt. This is successful if the proper tension is maintained. One objection is that sufficient reduction cannot be obtained with a commercial motor with one belt; two drives in series are needed for each machine. The space required may be inconvenient.

Another popular method is the use of one or more rubber faced rollers, driving the turntable rim by friction. One the whole, such machines have been satisfactory when handled carefully to avoid putting a "flat" on the rubber roller, maintaining proper pressure, etc. It is especially necessary to release roller pressure when not in use. The matter of speeds arises in connection with the question of drive. There is no question but that an installation handling the general run of work needs two-speed machines. Great speed of changeover is ordinarily not needed; however, the gear or steel ball friction drives are usually changeable at the throw of a lever; other types may take at least a few seconds.

The next question is one of feed mechanism which establishes the spacing of the grooves. This is not quite as important as the turntable drive; the worst defect is that of periodic "twinning" in the feed, i.e., periodic failure to feed exactly, causing two grooves to be closer together than the rest. This cuts down the level which can safely be recorded, which raises the relative level of the surface noise. Twinning is a fault of a particular machine or maker rather than of a design.

In some designs it is difficult to change the feed pitch; this is seldom objectionable because even at the worst the time required is not excessive. The overhead feed mechanism, where the feed screw is exposed, usually is poorest in this respect, for the whole feed screw must be removed. A built-in feed mechanism, where the pitch is changed by a slip gear or a movable belt, is much more convenient than this, but usually more expensive. The following approximate pitches are desirable: 110, 96, 120 grooves per inch. The last two are conveniences rather than necessities.

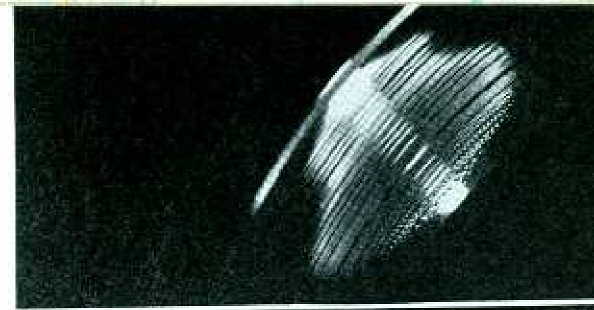
This brings us to the choice of a turntable and feed mechanism. Ordinarily both are secured together from the same manufacturer. The first step is to start the motor running. Touch the spindle at the top while it turns. There should be absolutely no vibration at 33⅓ or 78 rpm. Vibration is completely inexcusable; it will record as hum on the disc. Then fit a good wide range cutter head to the feed and make a record. Is it easy to maintain proper depth of groove? Are there any traces of wows in a piano recording? For this test be sure that the playback pickup is wide range and the playback turntable free from waver. Finally hold the disc in a good light and examine for traces of twinning. General inspection, when held two feet away, will usually show up irregularities in the regular pattern of the spiral. Some machines produce an irregular defect. Others—especially some of the overhead feed devices—tend to have twinning occur regularly. Often one with a removable screw will be all right with one screw and bad with another, evidence of a bad gear.

Cutter head characteristics

The cutter head governs frequency range. The importance of this is so little realized that one successful maker for several years put out a complete recorder with an amplifier with good response as high as 10,000 cycles, but a cutter head cutting off completely at 2,500 cycles!

The perfect cutter would cut a groove of constant velocity at all frequencies between 300 or 500 cycles and say 9,000 cycles. Below the lower cutoff frequency the velocity becomes proportional to frequency; this is the so-called constant amplitude range which is commercial standard. The reduced bass allows more volume on the record without overcutting.

The position and character of the high frequency cutoff is of considerable importance. A sharp cutoff definitely sets the upper frequency cutoff at f_c. For good results this should be above 5,000 cycles (5 db. down) and preferably over 6,500 cycles if possible. Note that such a sharp cutoff cannot be extended far by equalizing.



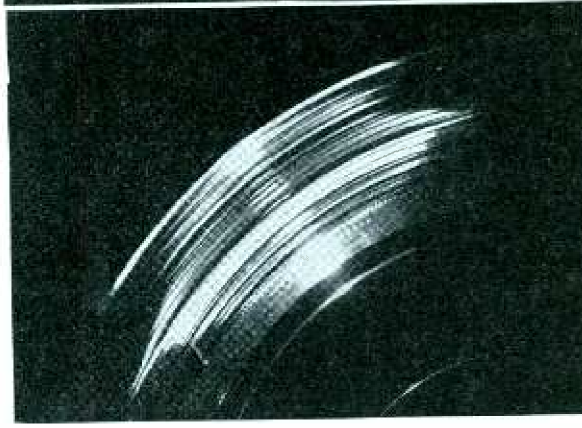
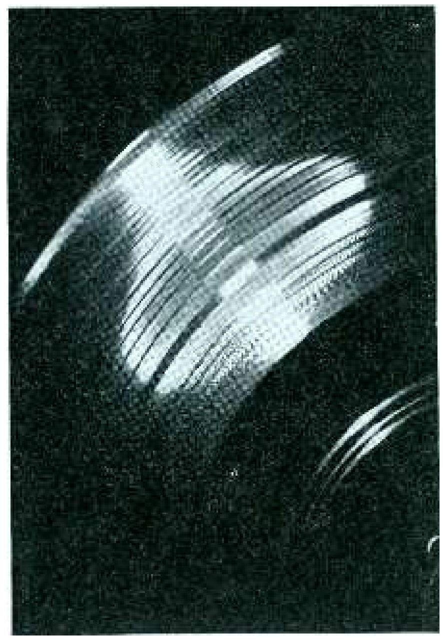


Fig. 2—Example of the use of response patterns. The cutter alone produced a pattern (below) having poor high frequency response. With some equalization (upper right) the highs were brought up. Attempts to introduce more equalization produced on objectionable peak (right) in the middle-frequency range, due to improper shape of the equalizer curve



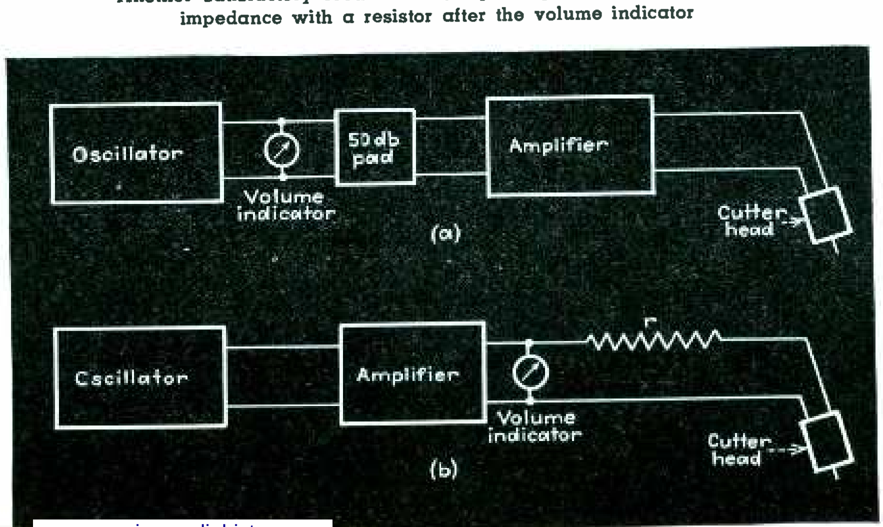
On the other hand, a curve having a less sharp cut-off can easily be equalized. Such a cutter might be 12 to 14 db. down at 6,000 cycles, perhaps even more, and would still be satisfactory. A cutter of this type sells for perhaps 20 per cent of the cost of the first mentioned type. A given wide frequency range may thus be obtained with the poorer cutter and an equalizer for much less than the cost of a wide range cutter.

A cutter accessory, which is not used as widely as it should be, is the advance ball, a small ball or shoe carried on an adjustable arm next to the stylus and riding on the uncut surface. Adjusting the advance ball regulates the depth of the cut. The easiest way of illustrating its value is to examine the ordinary record cut without such a device. Under the microscope or even to the naked eye there is unmistakable evidence of cutting light and heavy, that is the depth and width of cut are greater on one side of the record than the other. In practice few engineers realize the serious reduction of volume compelled by the over-heavy cut, or by any deviation from the equal width of groove and land. An advance ball is an absolute remedy for this.

Testing cutters

There are two simple methods of testing direct recording cutters: the playback and the pattern methods. In the playback method a series of

Fig. 3—(a) Proper method of feeding constant level to cutter head. An amplifier of known characteristics is required. (b) Another satisfactory feed method, replacing the amplifier output impedance with a resistor after the volume indicator



various frequencies, at constant level, are fed to the cutter. The cut record is then played back on a reproducing system of known, nearly flat characteristics and the output measured. Applying calibration data, the characteristics may be plotted. The only objection to this method is that very few people have a calibrated reproducing system of adequate quality. Some weird results have been secured by assuming a phonograph pickup to have a flat response.

The optional pattern method has been used by wax recorders for several years. It was described by Buchmann and Meyer, who give a proof of its validity. In this method the record is cut as before, then is examined in parallel rays of light. Sunlight is parallel, as is the light from a small lamp bulb some distance away, or the beam from a spotlight. By tilting the record while looking at it from some distance, a position will be found in which a light pattern appears, shaped like a Christmas tree silhouette. The width of the pattern, measured at right angles to the radius, is directly proportional to the volume at that point. The ideal cutter pattern might appear as in Fig. 1. In the use of the pattern method it is possible to take advantage of the instantaneous optical method of reading to secure a continuous graph of the characteristics, rather than a point by point series. This is done by using a heterodyne type of oscillator. The oscillator is set for the highest frequency to be recorded and the recording machine is started, cutting from the outside of the disc in. As the cut proceeds the frequency is gradually and continuously decreased until at the end of the record the lowest test frequency is reached. At various reference frequencies the tone is interrupted for two revolutions of the turntable. This produces a distinct series of lines to mark the important points. The great advantage of a sweep or glide pattern is that there is no chance of missing large but sharp peaks, which might be skipped in cutting at only a few frequencies. The continuous change in frequency is best secured by using a vernier dial on the oscillator condenser shaft, and driving the slow motion shaft from a geared down miniature motor, preferably thru a flexible shaft.

The following point needs to be very strongly emphasized to recorders who are not transmission engineers. When cutting a pattern or a test record for playback, be sure that the cutter is properly fed. The word "matched" has not been used because matching cutter and amplifier in the classical sense is not customary. Proper feed does not mean the far too prevalent practice shown in Fig. 4.

As the oscillator frequency is varied the volume indicator reading is kept constant. This is completely wrong for it has the same effect as feeding the cutter from a source of zero impedance—which completely suppresses the effect of the cutter impedance. The proper circuit would be, with an amplifier of reasonably flat characteristic, that shown in Fig. 3-a. Here constant level is maintained at the input after a preliminary adjustment for normal output level at say 1,000 cycles.

If this method is not desired, due to doubt of the amplifier calibration, the best method is that of Fig. 3-b. In this case *r* is equal to the actual output impedance of the recording amplifier as presented to the cutter, not the nominal value. Constant level may then be maintained by the volume indicator.

The proper interpretation of a pattern is a subject in itself. No commercial unit is likely to produce a perfect pattern and the choice of the best value is a serious problem. Inspection of the sample patterns shown in Fig. 2 may be suggestive. In examining the characteristics, the possibility of the use of equalizing networks should be kept in mind. When using networks be sure that the equalizer and cutter curves match well enough to produce the desired effect.

In the diagrams in Fig. 5 we see the effect of an incorrect equalizer. In *a* the use of too broad a boosting curve builds up a hump in the middle register. In *b* an excessively sharp curve produces a valley in the overall curve. Either effect is equally undesirable; the goal is not wide range, but high fidelity. Irregularities in a response curve may be more objectionable to the ear than lack of overall range.

While we are on the subject of irregularities in response there is one thing which is overlooked by many newcomers to recording, and that is that the ear is the final judge of quality. If the measurements show a set-up to be good and the ear pronounces it bad, it is bad.

In purchasing styli it must be remembered that they are the most important single factor in the control of surface noise. An ordinary machine-made steel point is too rough for first-class results. Steel styli should be hand-lapped with diamond dust; the cost is not excessive. At the other extreme we have the sapphire—the finest technical product of the lapidary's art. If properly made, it will give an exceedingly smooth and quiet cut. With record blanks of modern commercial quality the life of a sapphire is long.

This brings us to the question of examining styli. Most recorders examine only the front surface under their microscopes. This is only one-third the job. The edge is formed by the intersection of two back surfaces with the front plane. Any flaw in any one of the three surfaces will give a ragged, noisy groove, hence all surfaces near the tip, must have no less than a mirror finish.

An interesting improvement has been the process of very slightly dulling the edge of the stylus. If carefully done, by one properly skilled, the result definitely improves the smoothness of the groove and hence quiets it. The unskilled usually overdo it and ruin the edge com-

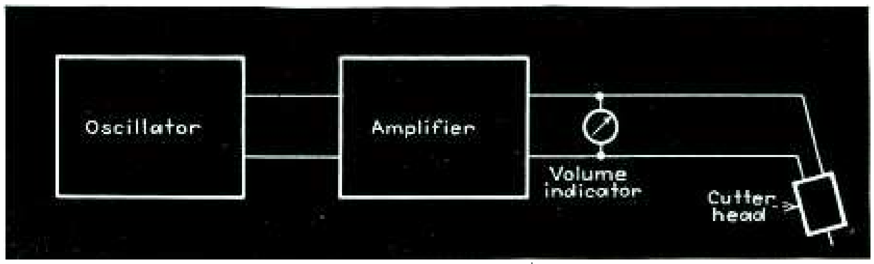


Fig. 4—Improper method of maintaining constant level at the cutter

pletely. That is why so few lapidaries—however skilled with jewelry—can make first-class recording jewels of any type.

Co-important with cutting points in reducing noise is the character of the material used. The first practical material used in this country was aluminum. It is still in use, though not for broadcasting. The objection has not been to its durability—which is excellent—but to the noise level, which is a bit high for many applications.

We come finally to cellulose nitrate, usually coated on metal. This is unquestionably the standard material. It is quiet, moderately durable, and can easily reproduce a high fidelity cut. In handling cellulose nitrate (usually miscalled "acetate") remember that the material is somewhat unstable chemically, and further that most makers use a rather volatile material to preserve plasticity. Open storage or heat will embrittle the coating, producing a very noisy groove.

One matter of safety is this: The metal base makes a nitrate coated blank quite safe, but the shavings are violently inflammable. They should be disposed of under water as soon as possible. A dry can full of shavings is not safe.

Auxiliary equipment

The well equipped recording channel includes a number of items not usually included in a radio installation of equal quality. First, the equalizers must be mounted where readily accessible, preferably on the mixing panel. Secondly, the monitor system input should not be so positioned as to produce an unnatural sound. This means that connecting the monitor speaker directly across the cutter may be unwise, particularly when the cutter is inductive or when the equalizing is great.

As a matter of fact a very good monitor system, according to many, is the use of a pickup and a separate amplifier, i.e., playback monitoring while recording. The advantage lies in the ease of detecting cutover, distortion, high surface noise, and other defects while the recording is in progress. This is satisfactory for a carefully monitored radio program recording, but for most work the ability to hear the program as well as read the volume indicator is essential. Combining the two systems we have, in Fig. 6, what the writer considers the most satisfactory arrangement.

Thirdly, it should be very easy to run a test. When it is necessary to pull half the control room apart to run a test—few tests are run. The oscillator should be permanently mounted and wired, and a system of jacks or clips should be provided to simplify connections. If, as should be the case, the optical pattern method is used, a small motor drive may be provided for the best frequency oscillator to assure uniform patterns. Hand operation by varying the proportions of the pattern tends to obscure the characteristic shape and to that extent make it hard to detect small changes in characteristics at a glance—which in turn makes it that much less likely that minor troubles would be detected before they become major.

This point is of more importance than many realize—it cannot be over-emphasized: A properly run studio will check the entire system quantitatively from preamplifier to cutter every morning. This means over-all gain runs from system input to output, plus patterns for every cutter to be used that day.

Finally, the reproduction facilities should be exceedingly good. In direct recording, dubbing is so often necessary that excellent reproduction facilities should be provided right in the control room, preferably within easy reach of the control engineer. The proper tonal balance in a pickup circuit used for dubbing is rather weaker on bass than when used for direct reproduction. Just enough bass compensation should be provided to neutralize the bass attentuation in recording.

On the other hand, much more bass compensation should be provided for audition purposes. It used to be said, with truth, that a record would sound better anywhere than at the studio which recorded it. The way to avoid this reproach is to provide a really good system for clients. The extra bass compensation is needed to compensate for the bass attenuation of the human ear at ordinary audition volume. By extending this compensation down to 40 cycles, and using equipment specially designed to produce little distortion at the lower frequencies, startling realism may be achieved. This greatly enhances the value of direct recordings for audition purposes.

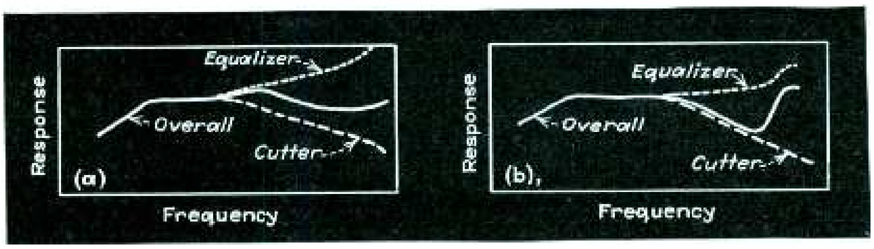


Fig. 5—Effect of incorrect equalization on response characteristic

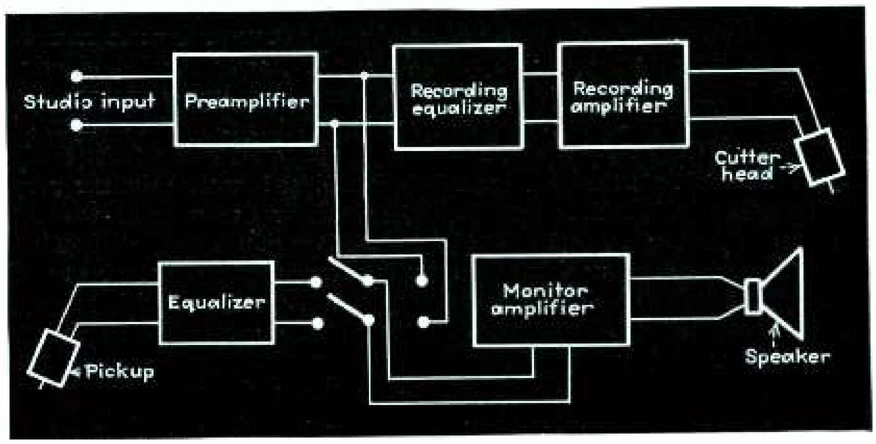


Fig. 6—Playback and monitoring set-up recommended for maximum flexibility

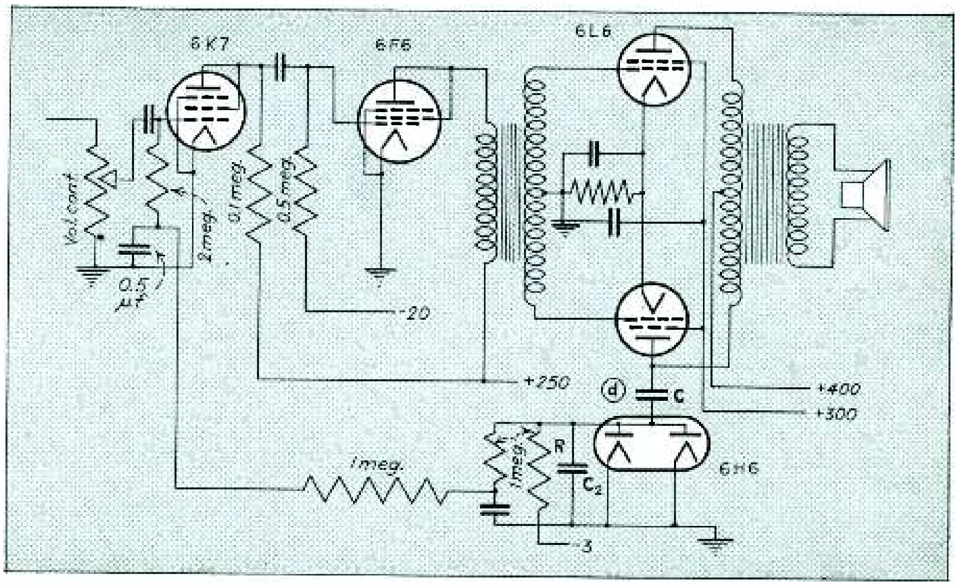


Fig. 1

Circuit for utilizing voltage at grid of power tube as distortion limiting potential

Distortion Limiter for Radio

Methods of preventing distortion arising from overload at first audio or power audio grids from appearing in the output of receivers at high volume levels

A VERY desirable feature of a radio receiver is to be able to turn the volume control up to maximum, increasing the audible signal without evidence of distortion resulting from amplifier overload. An amplifier may of course overload at two places ordinarily, at the output tube grids and the first audio tube grid. The method described here can be made to eliminate the distortion at both ends of the amplifier.

The circuits used to produce the desired results must employ as the first amplifier tube one whose characteristic is such as to produce no appreciable distortion over wide range of applied negative grid voltage. The 6K7 tube or equivalent used as a pentode in a resistance coupled audio amplifier does not produce the desired effect because of the high resistances necessary in the screen and plate circuits. The 6K7 or equivalent used as a triode, however, produces exactly what is desired, since the plate current vs. grid bias characteristic is very nearly exponential over the range desired. Measurements on the tube have shown that as much as 55 volts of bias can be applied, increasing the input signal to produce the same audio output as obtained with 3 or 4 volts of bias with a rise in distortion of approximately one percent.

The circuits described below in principle utilize the voltage of the output tubes (either plate or control grid), rectify that voltage and feed it back to the first amplifier tube as negative d.c. to control gain. The rectifier is delayed in some cases and effectively loosely coupled in others. The circuit feeding from the diode rectifier to the input tube must be a filter to prevent audio from feeding back and also must have the proper time constant to prevent too rapid an action which might result in "chopping" off peaks valuable to good reproduction. Thus, with the negative voltage increasing on the first amplifier tube, it does not overload and prevents the output tubes from overloading by limiting the power outputs to a predetermined setting dependent upon the amount of distortion allowable.

The simple circuit of Fig. 1 shows an amplifier consisting of three stages. The signal for the volume control feeding the system may be the usual rectified audio signal from the radio receiver. It will be noted that the signal from the plate of the one output tube is fed to the diode (d) through a small capacitor (c). This in conjunction with C_2 forms a voltage divider which puts a small percentage of the audio voltage across the diode where it is converted to d.c. and causes a voltage drop across R, which is fed back to the first audio tube which causes the amplification to be reduced. At the same time the grid bias of the first tube is increasing so that more signal may be admitted to the grid from the volume control without over-shooting the grid which causes more voltage across the diode and so limits the amplification of the whole system to prevent the output tube

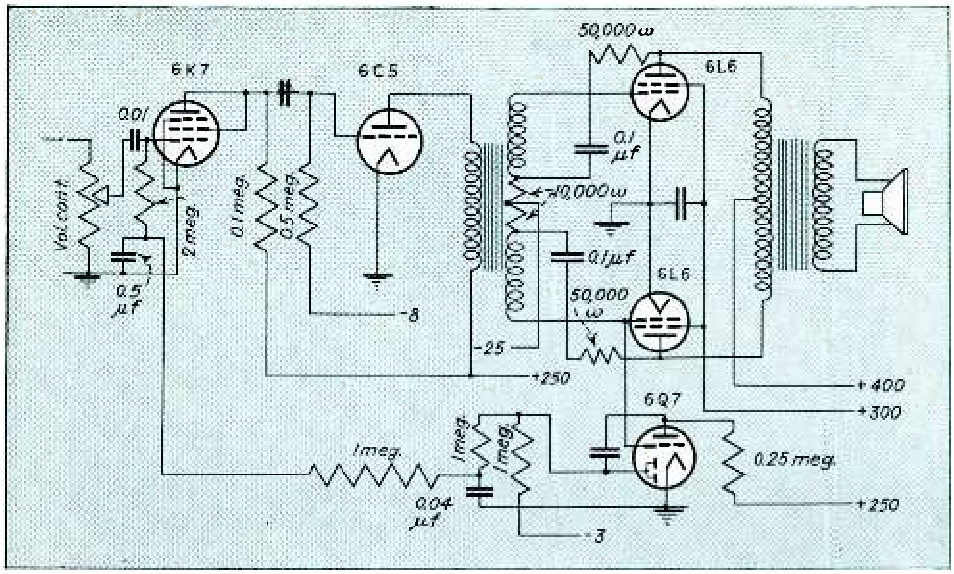


Fig. 2

Use of a 6Q7 tube to reduce distortion occurring when voltage signals at output tubes reach 21 to 25 volts

Receivers

By M. L. LEVY
Radio Development Laboratory
Stromberg-Carlson Telephone Mfg. Co.

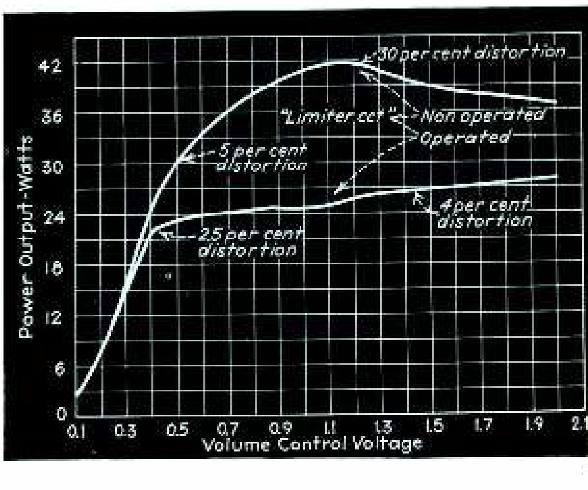
and the input tube from overloading. It is true that a small percentage of maximum power available ordinarily is sacrificed but this can be reduced to a very small amount. It will be noted that the network feeding the bias from the diode to the first tube is composed of resistors and capacitors. These are so proportioned as to prevent low audio frequencies from feeding back to the first audio tube (i.e. low frequency filter) and also the values are so chosen as to create a time constant long enough to prevent "peaks" from being chopped off. Thus, the circuit shown limits distortion without cutting off peaks. This circuit can be well applied to 6L6 output tubes where high powers are available. It will be noted further that the first tube in the amplifier is shown as a pentode connected as a triode.

Figure 2 shows another method of applying the same principle in the grid circuit of the output tubes. Here an amplifier is used, biased from the grid of the output tube where the audio signal is also applied. The amplifier tube used is a 6Q7 which has a cut-off point of about 7 volts. The output system used is a pair of 6L6 tubes operated with inverse feed-back and produces approximately 30 watts. The output tubes are driven by a 6C5 tube and the input tube is a 6K7 tube operated as a triode. The 6Q7 tube starts to operate at about 4 volts peak which means that at 21 peak volts across the grid of the output tubes, the 6Q7 begins to operate. Grid current begins to appear in the output tubes at a peak voltage of 25 volts which is its operating bias. Therefore, within the range of about four or five volts, the 6Q7 tube must "trigger" off and produce enough bias to reduce the gain in the amplifier and limit distortion. A slight delay is also applied to the diodes to prevent residual current from reducing the gain of the amplifier prematurely. The four-volt peak occurs at about 25 watts output, so that from 25 to 30 watts, (which is the maximum the limiting tube will allow under normal operating conditions) is the operating range. With reversed feed-back on 6L6 tubes the power sensitivity is less than that obtained in Fig. 1, so that the limits between 25 and 30 watts can be maintained satisfactorily. Here again peaks will not be chopped off because of the chosen constants in the filter circuit.

The attached curves show the results in a radio receiver of this circuit. Further work was done with this method of "distortion limiting" using the 6L7 tube. The limitation of the 6L7 tube is that any great difference of potential between the two control grids produces distortion. Unless the bias is fed back to both grids the deviation will cause distortion. Since one grid is sharp cut-off and the other is more or less remote cut-off, the change of bias on the sharp cut-off grid will cause bad distortion, although this grid is not the signal grid. Also, a certain amount of motor boating entered into the scheme probably because of cut-off on this grid.

Tubes other than the 6K7 type as a triode will operate successfully if a shorter range of control is satisfactory. The 55 and even the 6C5 will not produce undue amounts of distortion for short ranges of control. There is no reason why this method cannot be adapted to simpler systems and produce good results except that overload signals are sometimes necessary in low power amplifiers for commercial reasons.

Fig. 3 Effect of distortion limiter in production receiver



By REINHARD K. HELLMANN
Transatlantic Research and Information Service, Inc.

The MODULATOR

DURING the last few years, the circuit shown in Fig. 1 has attracted much interest in the field of communication engineering, because some important modulation problems can be solved by it in a simple manner. It comprises two generators of any frequency, Ω_1 and Ω_2, and a bridge-like arrangement of non-linear resistances into which the currents are fed by means of transformers tapped at their centers and a choke. There is, moreover, a third pair of terminals, which are connected to a load resistance R. The effect of the circuit is that across this load a voltage is developed which consists essentially of the modulation sideband of the two original frequencies, these original frequencies themselves being suppressed in the output.

Working Principle

In order to explain how this circuit works, let us first consider the circuit shown in Fig. 2, which under certain assumptions is equivalent to that in Fig. 1, as we shall show later. The generator of frequency Ω_2 is connected to a load, R, through a device acting as a reversing switch free of inertia. This switch is operated by the generator of frequency Ω_1 in such a way that the polarity of e_2 is reversed after each half period of Ω_1.

The effect of such a treatment is shown in Fig. 3a and 3b. The frequencies Ω_1 and Ω_2 are shown in the upper lines. For the sake of simplicity it is assumed that Ω_1 is of rectangular shape. In Fig. 3a Ω_2 has nearly the same value as Ω_1, while in Fig. 3b the ratio is high, as in the case of an r-f carrier (Ω_1) modulated by an a-f signal (Ω_2).

From the reversed output voltages shown in the lower lines, it can easily be seen that the main components present are the sum and difference frequency $\omega = \Omega_1 - \Omega_2$ and $\omega = \Omega_1 + \Omega_2$ and that there is no component either of frequency Ω_1 or Ω_2. But it seems as if the output voltage, which somehow resembles the familiar picture of a modulated wave, shows considerable distortion. In order to investigate this we may analyze the output voltage by putting $e_3 = \cos \Omega_2 t . f(\Omega_1 t)$, where $f(\Omega_1 t)$ is a function with period 2π, the value of which jumps from -1 to $+1$ and vice-versa after every half-period. The Fourier analysis gives the following expression:

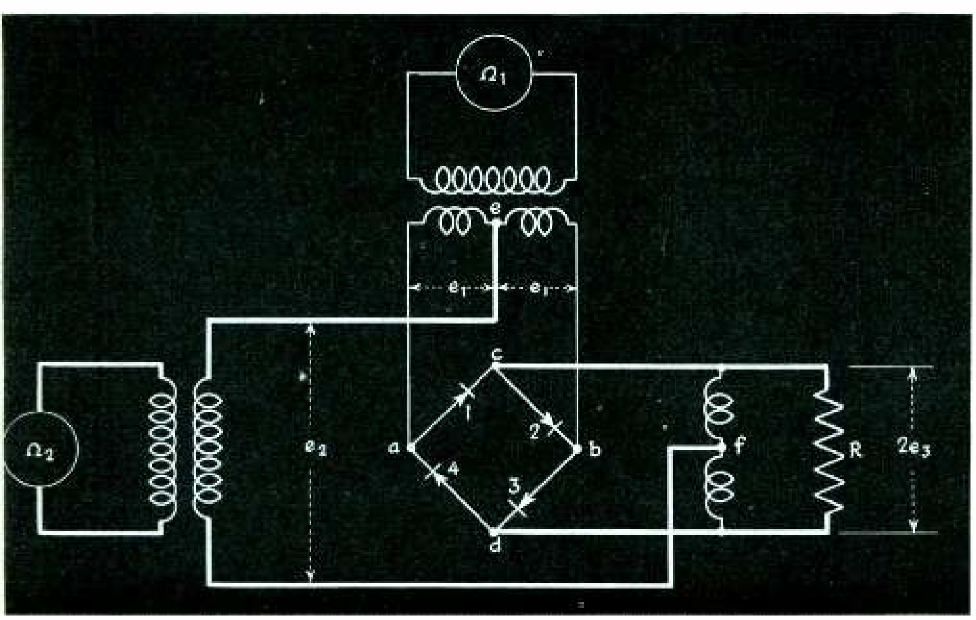
$$e_3 = \frac{2}{\pi} e_2 \left[\cos (\Omega_1 \pm \Omega_2)t - \frac{1}{3} \cos (3\Omega_1 \pm \Omega_2)t + .. \right]$$

When this formula is applied to the case of Fig. 3a where the term with $\Omega_1 - \Omega_2$ is the only "desired" modulation product, it is seen that there are no harmonics whatsoever of the desired frequency. The only "undesired" components present in the output are $\Omega_1 + \Omega_2$ and those in the neighborhood of 3Ω, 5Ω, etc., so that they can easily be eliminated by means of filters if necessary.

The question is how to design a reversing switch which, according to our assumption, is free of inertia. It is obvious that only an electronic device is suitable for this purpose, as soon as audio or even higher frequencies are being considered. A device which meets these requirements is incorporated in the circuit shown in Fig. 1. Four electronic rectifiers are connected so as to form a ring, the direction of the flow currents being the same for all branches. Let us assume that e_1 is much greater than e_2, as in most practical cases, and that the rectifiers are ideal ones, so that a small positive voltage will make their conductivity infinite, while a small negative voltage will make it zero. Thus, during the half period of Ω_1 where point a (Fig. 1) is positive in respect to b, rectifiers 1 and 2 will become conductive and thus connect e with c, so that e_2 is across f and c. During the next half period, 3 and 4 are conductive so that e_2 is across f and d, the polarity thus being reversed. In this way, the desired effect is accomplished, and the same conclusions apply as in the case of Fig. 2.

Though tubes have been found to do the job, metal rectifiers are pre-

Fig. 1. Schematic wiring diagram of the modulator bridge



BRIDGE

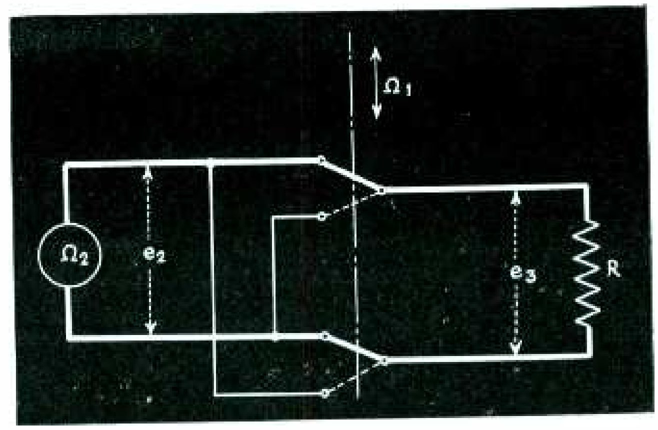


Fig. 2. Simplified diagram illustrating modulator bridge operation

ferred for low and medium frequencies, chiefly because of their nearly exponential *i-e* characteristic. The relation between the resistance $r = e/i$ and the voltage e is shown for a copper oxide rectifier in Fig. 4. Within a large range this relation may be represented by $r = r_0 \varepsilon^{-ke}$, the value of k being as great as 18. A similar curve is valid for the differential resistance de/di, the resistance presented to the e_2-current which flows to the load resistance R. Since the value of r is changed by several orders if the voltage is changed from zero to a few tenths of a volt, the ideal characteristic assumed above is approximated very closely.

A more complete analysis confirms that in spite of these deviations from an ideal reversing switch, the features of the device taken as a modulator can be summarized as follows:

(1) A suppressed carrier modulation is obtained with practically no distortion of the desired modulation product.

(2) By means of proper design, the amplitude of this modulation product can, within broad limits, be made independent of the amplitude of the "carrier" frequency and strictly proportional to the other voltage e_2.

(3) The attenuation of the energy transferred from the signal to the side-band is practically zero.

(4) The circuits connected with the three pairs of terminals do not interact with one another, as the device operates as a balanced bridge.

Application in Communication Systems

Due to these features, the modulator bridge, equipped with metal rectifiers, is adaptable for many purposes when high quality modulation is required with a small and light unit. So it has found wide application, especially in the European countries. In Fig. 5, a modulator is shown which may be adapted to a 500-ohm line in order to transfer the a-f message to a higher frequency band. Such a bridge can be used either as a modulator or as a demodulator, if only the transformers and the filters at the output are matched according to the special purpose. Thus, similar arrangements can be used in suppressed carrier systems both at the transmitting and at the receiving station. Its range is, moreover, not confined to audio frequencies. Though the capacities of the metal rectifiers cannot be neglected at higher frequencies, circuits have been found to work satisfactorily at frequencies as high as several hundred kilocycles.

The modulator bridge has found one of its most modern applications in concentric cable circuits, where several hundred carriers are each loaded with a telephone message. In such systems, the filter requirements are very critical. They can be reduced materially by transferring every 0-3000 cycle message to a higher frequency band by means of premodulating it with an intermediate carrier of, say, 6 kc. For, if the lower side-band (3 to 6 kc.) is selected and applied to a carrier of 50 kc. for example, the new side-bands of 44 to 47 kc. and 53 to 56 kc. can be separated by means of simple filters. Since the modulator bridge unit, as described above, takes very little space and also does not draw any current from batteries, it will not be difficult to place some hundred of such premodulators in a single booth.

It is specially interesting that the device will work even if one of the currents involved is d.c. If both input frequencies, Ω_1 and Ω_2, are equal, a steady voltage is set up across the load resistance, the value depending on the amplitude of e_2 and the phase relations. Thus, the modulator can be used as a phase meter or monitor.

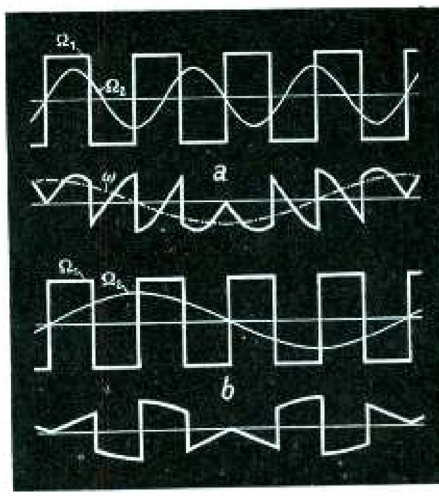


Fig. 3. Effect of operating on the sine wave with circuit of Fig. 2

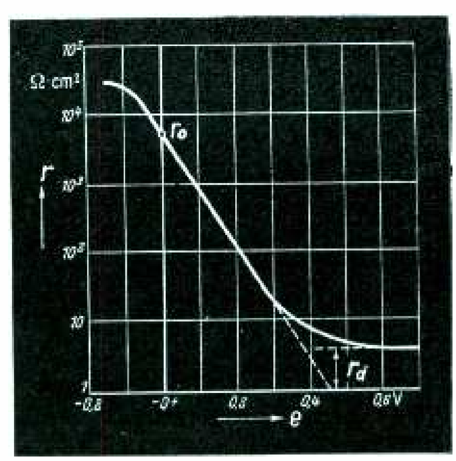


Fig. 4. Characteristics of copper oxide rectifier

Industrial Applications

Industrial applications have been made with a circuit like that in Fig. 5 for such purposes as measuring the humidity of paper in paper-mills. A generator of 5000 cycles feeds a modulator bridge (I) as well as a second bridge (II), one capacity branch of which is designed as a measuring condenser. A part of its dielectric consists of the material to be tested in mass production, such as paper. Thus, humidity changes in the latter will cause changes in capacity and will disturb the balance of bridge (II). The alternating voltage established is fed through an amplifier

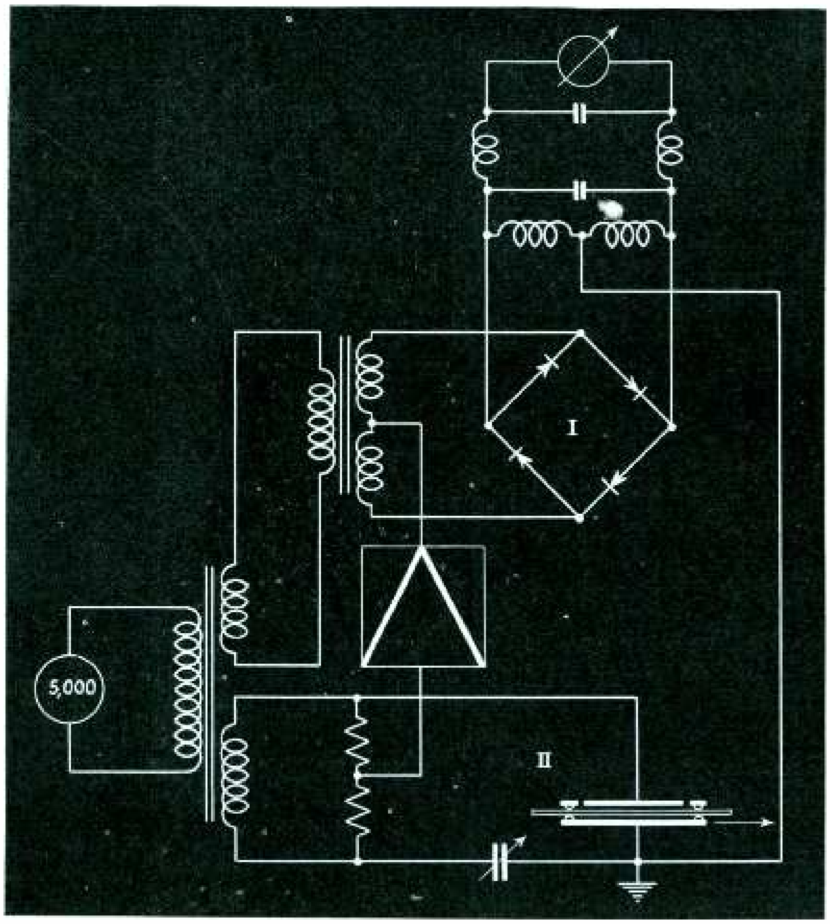


Fig. 5. Application of modulator bridge to measurement of humidity

into the modulator bridge (I), where a deflection of the instrument will result. The bridge (II) can be set in such a way that positive and negative deviations from a medium humidity can be read directly in per cent. It is especially convenient that the arrangement can be adjusted to indicate changes in capacity only, no matter how the loss-angle changes. On the other hand, special loss-angle measurements can be made for continuously testing the uniformity of insulating material, such as tape etc. The device has been installed in rubber plants to control the thickness of the rubber band produced.

Most frequently, a measuring condenser is used the capacity of which is varied with pressure. If the instrument is replaced by an oscillograph, the pressure occurring in the cylinder of an engine, for instance, can be recorded without distortion.

The modulator bridge is of no less importance in the designing of portable equipment for testing floors and laboratories. Beat frequency generators are the most frequently used source of a-f voltage, but the full advantage of testing arrangements based on it is only obtained if the generator is practically constant over the entire audio range. As the frequency of one of the high frequency oscillators used in such a generator has to be varied, its voltage will have to change too as a rule, unless the percentage of the frequency change is very small. Such small changes mean high oscillator frequency and hence reduced stability. The modulator bridge is the type of modulator in which the output amplitude can be made independent of the control frequency amplitude. Thus, if the variable frequency oscillator is taken as the voltage source e_1 and the fixed one as e_2, a theoretically constant and undistorted output voltage of the difference frequency will be developed throughout the whole frequency band. The sum frequency can be eliminated by a properly designed low-pass filter.

There are some limitations to this ideal performance, which are essentially set by the fact that the reversing switch is not an ideal one. Possible non-uniformity of the rectifier characteristics is another point which must be considered carefully. If the bridge is not exactly balanced the circuits become coupled to some extent. In the case of the beat frequency generator, spurious h-f voltages will appear across the output. Moreover, a coupling of both oscillators will occur resulting in increased distortion towards the lower end of the a-f scale. But after all these subtleties have been investigated, remedies have been found for most of them, so that rather intricate problems of measurement have been solved.

One of them is the amplification of frequency bands starting with frequency zero. Designing stable d-c amplifiers, as is well known, presents difficulties which could be overcome only by rather complicated means. This task has also been materially simplified if the modulator bridge circuit is altered in such a way that it can handle a steady voltage too instead of an alternating voltage only. Then, an output voltage of frequency Ω_1 will be produced across the output terminals, the amplitude being strictly proportional to the fluctuations of the d.c. Stable amplification of this voltage can easily be secured by means of an ordinary resonance or band amplifier. At the output of the device an amplified d.c. is produced by a similar bridge circuit operated as a demodulator.

A complete account of the possibilities involved in the modulator bridge could not, of course, be given in this article, nor was an attempt made to deal with the theoretical side which also presents some interesting problems. More applications and more complete information on the problems mentioned will be found in the papers listed in the attached bibliography.

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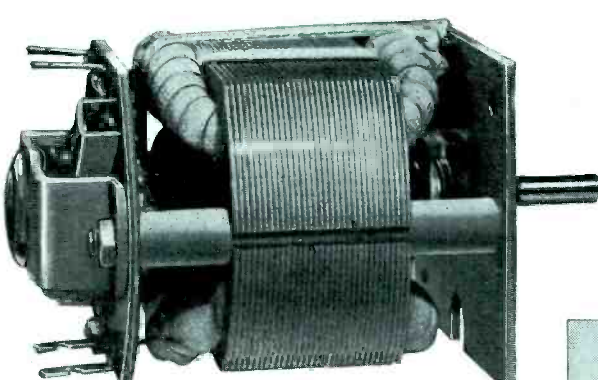
Another "tuning" problem solved by

DELCO APPLIANCE



Built to the specifications of a manufacturer for a particular radio application, this husky little tuning motor now enters volume production.

Here are the requirements—conservation of space, reserve power and ample speed for quick action, reversibility, dependable connections and simplified mounting.

The illustration gives you an idea of the fine design, shows the mounting, self-aligning bearings, taped coils and simple connections. But to really appreciate this motor you should have one right on your desk.

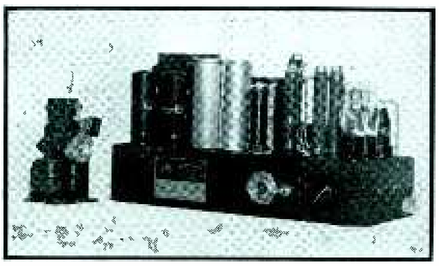
Why not send data on your requirements and let our engineers make their recommendations?

Product of General Motors

TUBES AT WORK

High Speed Counting Made Possible by Ratio Control

THE MAXIMUM COUNTING speed of electrically driven mechanical counters ranges from 400 to 700 per minute. In many photoelectric counting applications, the desired speed of counting exceeds this by as much as five times. Consequently, it is necessary to introduce a division factor, which delivers one impulse to the counter for a given number of impulses received from the phototube. The division factor introduced is usually in units of two, that is, the counter responds for every two, every four, every eight, or every sixteen impulses received from the phototube. A ratio introducing device, called a "ratio differential control," has been developed by the United Cinephone Corp.



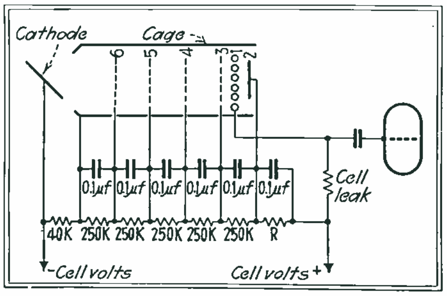
Ratio control for high speed electronic counting

In order to insure accurate counting, it is desirable that the mechanical counters receive a definite control impulse regardless of the length of time the light beam is interrupted. In the ratio differential control, the counter is energized exactly 50 per cent of the control time, regardless of the length of time the beam is interrupted. Using the device with a Veeder-Root reset counter, counts as fast as 5,000 per minute have been successfully accomplished.

• • •

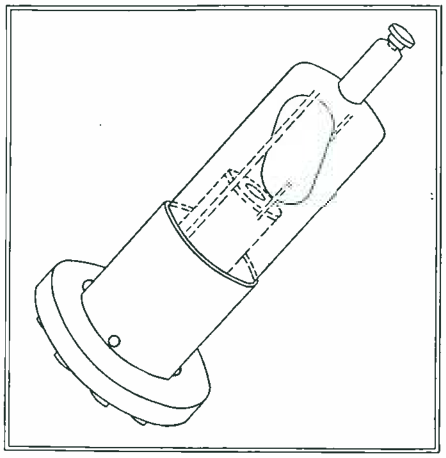
Grid-Type Multiplier Phototube Introduced in England

THE BAIRD TELEVISION CO. of London have recently developed two multiplier phototubes of unusual design. Type ML has a large photo-sensitive cathode (250 sq. centimeters), while the type MS has a smaller cathode of 15 sq. centimeters area, the latter tube being intended for concentrated light beams. The initial sensitivity of these cathodes is about 30 microamperes per lumen, the sensitive material being caesium-oxide, and having sensitivity throughout the visible range, and in the infra-red as far as 10,000 angstrom units. The photoelectric current derived from the cathode circuit is caused to pass successively through several wire grids, the surfaces of which have been prepared to produce a high ratio of secondary electrons when bombarded by high voltage primary electrons. Each grid thereon acts as a multiplying stage, the secondary electrons from one grid passing on to the next, and there exciting the emission of still other secondary electrons, and so on. At the end of the tube a flat plate receives the multiplied electron stream, and provides an additional secondary amplification of about eight times. The final current is collected by a wire screen just forward of the flat surface.



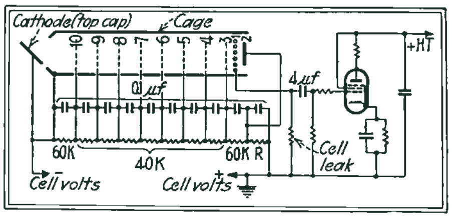
Five-stage connection diagram

The multiplying grids, metal screens of circular shape, are arranged in parallel planes, the whole being surrounded by a cylindrical tube. This method of construction avoids the necessity of an external magnetic field, such as is used in the Zworykin type multiplier. An amplification of as high as four times is obtained at each multiplying grid. By avoiding the use of coupling resistors, such as would be necessary if a thermionic amplifier were used, the signal to noise ratio of this photocell device is approximately 200 times better than that of a thermionic amplifier of the same gain.



Type MS multiplier phototube

The overall amplification obtainable depends on the number of stages and on the overall voltages applied. A nine-stage multiplier with a 1,500-volt overall applied voltage will produce multiplication up to 20,000 times. But by using higher voltages, as shown in the diagram, multiplications up to 200,000 times can be obtained. The final output should not exceed 1 milliampere, otherwise instability may result. The life of the cell is said to be very long. Frequency response of the device is about the same as that of an ordinary vacuum type phototube, that is, it is determined only by the interelectrode capacities, and at very high frequencies, by the transit time of the electrons.



Nine-stage multiplier (type MS)

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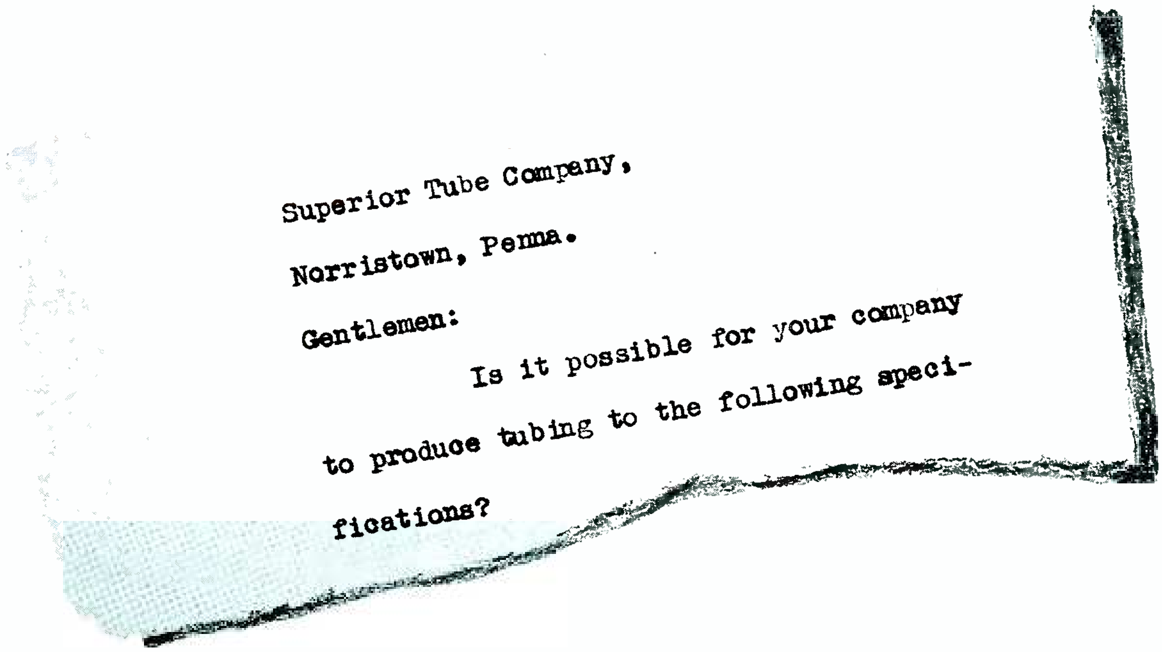
Vibration Pick-up Used to Balance Motor Rotors

AN INTERESTING APPLICATION of the vibration pick-up has been made by Westinghouse in a portable rotor-balancing device which can be used to correct vibration in large rotating machinery. On the shaft of the machine to be corrected is attached a sine wave alternator, the stator of which can be shifted about the axis of the machine, thus controlling the phase relation between the sine wave output and the vibration of the larger machine. The vibration pick-up is held against the vibrating machine. The output of the pickup is amplified and fed to the voltage coil of a wattmeter, while the output of the auxiliary sine wave alternator goes to the current coil of the same meter. The stator of the alternator is then shifted to obtain minimum and maximum readings of the wattmeter, and with these readings the correct position of balancing weight on the large machines may be calculated. The device has been used on generators of as high power as 165,000 kw., which had resisted all previous attempts at balancing.

(*Continued on page* 40)

SUPERIOR TUBING


Superior Tube Company,

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MANUFACTURERS OF
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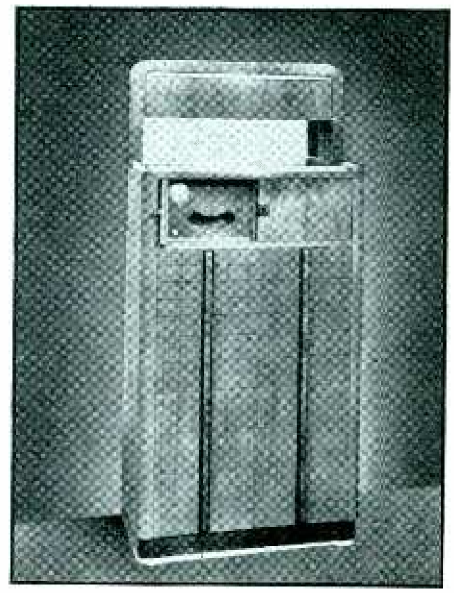
25 MILES FROM PHILADELPHIA — 100 MILES FROM NEW YORK

Phototube Drawer Opener Used to Safeguard Dental Patients

A DENTAL CABINET has recently been designed with photoelectric control of the drawer compartments, the purpose



Phototube-controlled dental cabinet

being to permit the dentist to open the drawers without actually touching the cabinet. Eight instrument drawers can be operated individually by passing a finger over beams of light directed at a photo-electric cell. By this means the possibility of transferring disease from the mouth of one patient to another through the medium of the cabinet drawers is overcome. The cabinet is designed by Glenn W. Cammen, and manufactured by the American Cabinet Company.

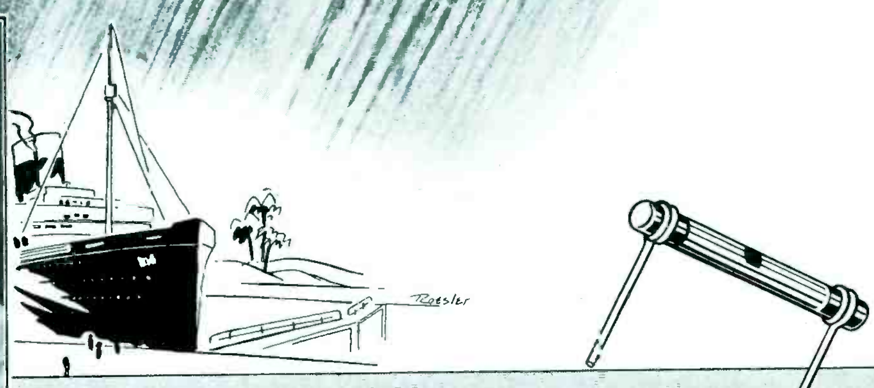
• • •

Phototube Color Analyzer Used in Chemical Research

THE AUTOMATIC SPECTROPHOTOMETER, developed by Prof A. C. Hardy of

Spectrophotometer measures color of complexion

M. I. T. and the General Electric Laboratories, has recently been applied to chemical analysis. The development



"Since using Centralab Controls... we have not replaced more than three. Centralab has remedied our troubles due to 'comebacks' of noisy controls, and we are proud to recommend them 100%."

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was originally intended, and has found wide use, for analyzing the color content of any material or sample. The new application involves the detection of color in compounds when the unknown chemical element is mixed with a reagent. Among the organic compounds studied are sugars, with copper as the reagent, and chlorophyll with magnesium as a reagent.

Even when two compounds give essentially the same color, the two may be separated by the color analyzing device. For example, when titanium is present in iron, the percentage of titanium may be estimated even when the ratio is only one part of 4,000, despite the fact that both titanium and iron give yellow colors in solution.

• • •

Direct-Current Amplifiers: A Review

A Contribution of the Engineering Staff Aerovox Corporation

It is one of the most difficult tasks to build an amplifier for the measurement of small d-c voltages or to make a small d-c voltage control a relay or solenoid. The simplest form, usually shown in textbooks, employs a voltage divider to supply the required voltages to the different plates and grids. An example is shown in Fig. 1 where the directions of the currents is indicated by arrows.

Of all the possible arrangements of direct coupled amplifiers, this is the

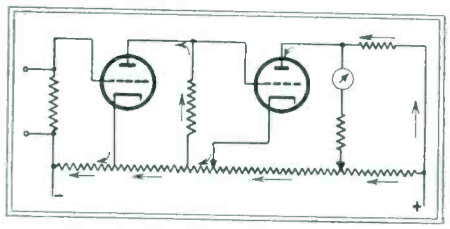

Fig. 1—Simplest direct coupled amplifier

poorest. Any change of plate current in the last tube must also cause a change of current in the lower sections of the voltage divider and thus change the bias on the first tube. The circuit then becomes regenerative or degenerative depending on whether the number of stages is even or odd. An odd number of stages becomes degenerative and is therefore easier to construct. The feedback effect could be minimized by employing large bleeder currents but this is obviously undesirable.

If all the voltages must be taken from a single source it is better to employ the self-biasing arrangement shown in Fig. 2. This circuit is subject to slow drifts of plate current due to the usual causes which will be discussed presently. Since the drift can be made very slow and a two-stage amplifier of this type is degenerative, it is usable if not too sensitive an indicator is employed.

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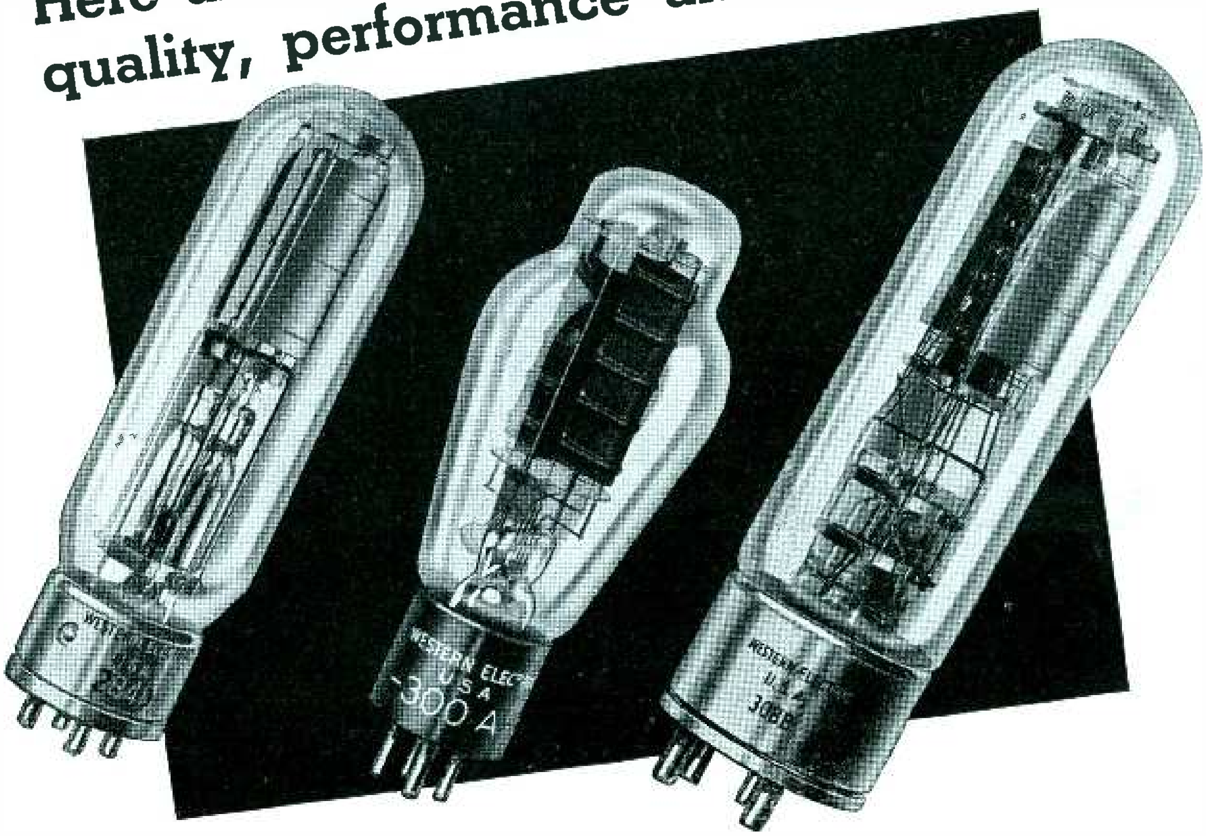

The 284D is the tube that will meet your needs if you have 50 watt or high powered equipment. These tubes are standard in one of the most popular Western Electric audio amplifiers.

The 300A is designed for high quality Class A service at comparatively low plate voltage. These tubes are used extensively in Western Electric speech input amplifiers with less than 2% distortion.

The 308B was developed for use in Western Electric's high powered *public address* system. Four 308B's deliver 1000 watts of audio power with less than 2% distortion for average speech input levels.

	284D	300A	308B	
Filament Voltage	10	5	14	volts
Filament Current	3.25	1.2	6.0	amperes
Plate Voltage (Max. DC)	1250	450	2250	volts
Plate Current DC	175	70	300	ma.
Mutual Conductance	2500	5200	7500	micromhos
Class A Output (2 Tubes)	50	25	100	watts
Class B Output (2 Tubes)	165		500	watts

For full details write to the distributors: Graybar Electric Co., Graybar Building, New York; *In Canada and Newfoundland:* Northern Electric Co., Ltd.; *In other countries:* International Standard Electric Corp.

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RADIO TELEPHONE BROADCASTING EQUIPMENT

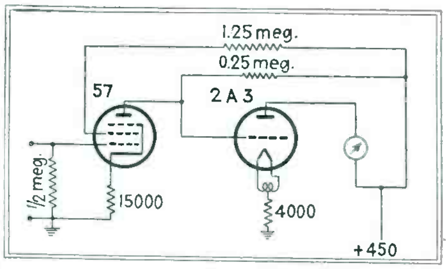


Fig. 2—Self-biased amplifier circuit

Another type of d-c amplifier is made by employing two independent power supplies in series. Voltage doubling may be employed for this purpose. Figure 3 shows a circuit which was due to Otto Greenberg who employed it for an automatic engraving process. With the constants given a 0.1

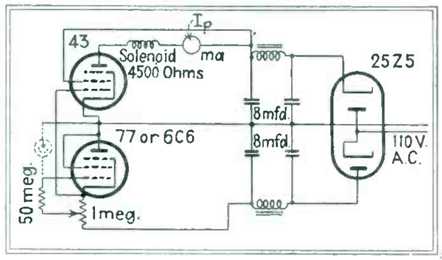


Fig. 3—Voltage-doubler d-c amplifier

volt signal will cause a change in plate current of 1.25 ma. in the plate circuit of the 43.

A very interesting and useful amplifier can be operated directly from the a-c line and does away with the necessity of cascaded power supplies. This circuit (Fig. 4) was developed by Shepard. The first tube is connected directly across the line in a self-rectified arrangement while the second tube is also placed across the line but "upside down." Suppose that during the

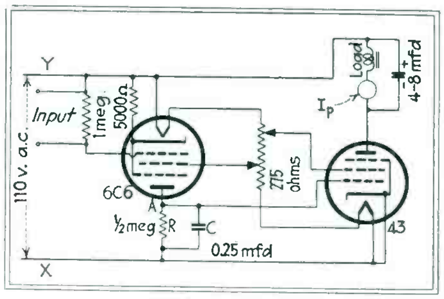
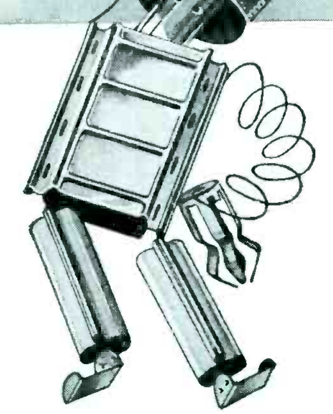


Fig. 4—A-c operated "back-to-back" circuit

first half cycle under consideration the first tube conducts, the plate being positive with respect to its cathode. At the same time the other tube is non-conductive. Plate current will then flow through the plate load resistor R making the point A negative with respect to the side of the line marked X. This negative voltage across R charges the condenser C to the same potential. During the next half cycle of the power supply line the first tube becomes non-



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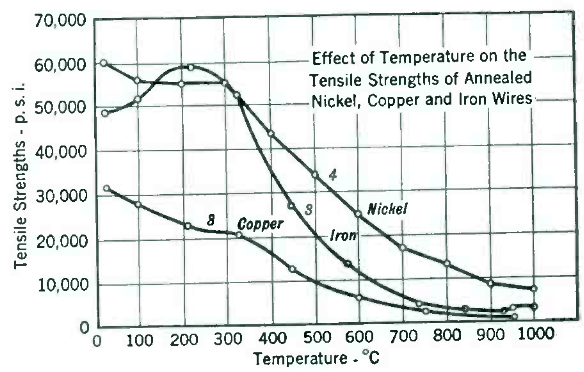

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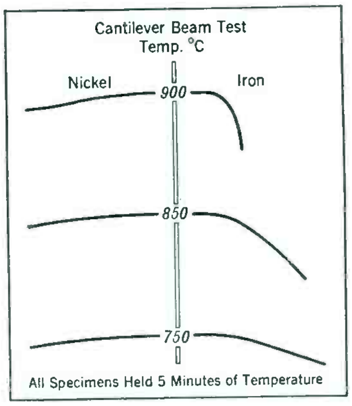

NICKEL

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conductive while the second tube is now operating. However, the charge of C cannot leak off fast enough due to the time constant of C and R so it provides a bias to the grid of the 43. The magnitude of this bias depends of course on the amount of plate current which was flowing in the 6C6 plate circuit and this in turn depends on the input signal voltage. This process of placing tubes "upside down" alternatively could be repeated but the circuit soon becomes subject to erratic changes of plate current due to amplified small fluctuations in the first stage.

Causes of instability

Variations in the power line voltage will affect all of these amplifiers and is one cause of erratic changes in the indicating needle as well as slow drifts. Employing a regulated B supply alone will not eliminate all of this trouble because the filament current will still be subject to variations which cause slow fluctuations of the emission in the tubes. Different heaters respond to these influences at different speeds. Supposing that all these objections have been eliminated there are still the following sources of trouble.

Each joint in the circuit usually brings two metals together and forms a thermo-couple. These junctions develop small d-c voltages depending on the temperature of the circuit which is usually fluctuating. Although these voltages are small, those in the input stage will be amplified enough to cause motions of the indicating instrument. Leakage across resistors, tubes, condensers, etc., may also vary the resistance of these parts and the voltage drops across them.

Photo sensitivity as a cause of instability

Most tubes are photo-sensitive to some degree and if sufficient amplification is provided the effect shows up. The lighted cigar of the experimenter has proven to cause variations in plate current which were hard to track down. Variations in the power supply can be reduced by one of the

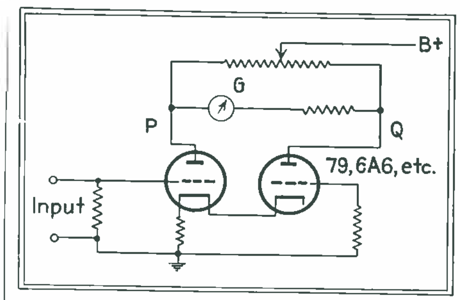

Fig. 5—Balanced bridge amplifier

systems of regulating them and the remaining small variations in filament and plate supply may be balanced out. The balancing out process consists in

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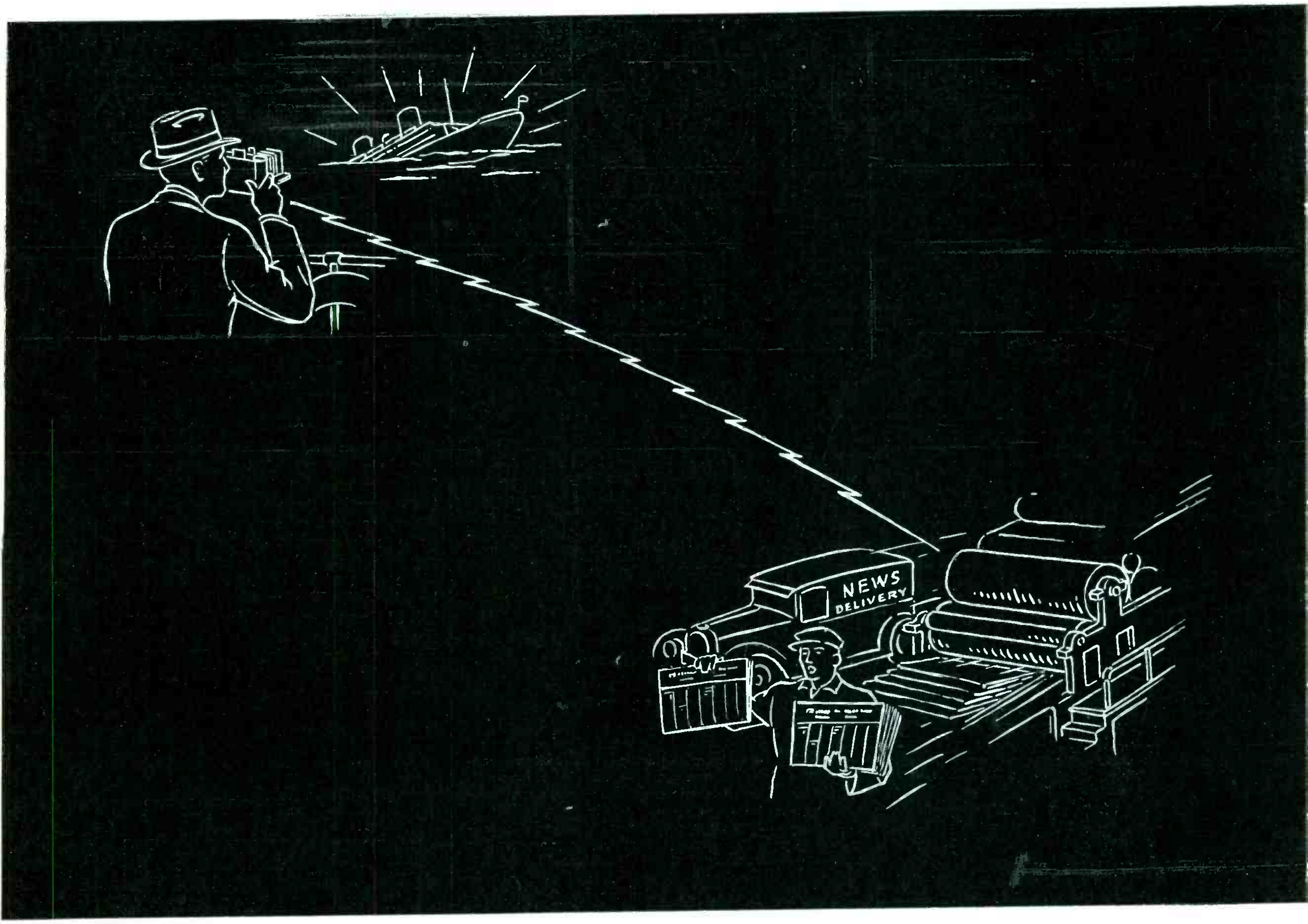

THE reporter and the camera-man join hands in bringing to the public the news of the day. And as telegraph wires and radio flash the reporter's story from city to city with the speed of light, the camera-man's pictures travel at the same speed, ready to make the same deadline—ready to appear in the same edition with the story.

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stage in a light-tight compartment

Regeneration

Some workers have made use of a regenerative d-c amplifier but it requires patience. One form, developed by Turner, is shown in Fig. 6. An increase in plate current of the first

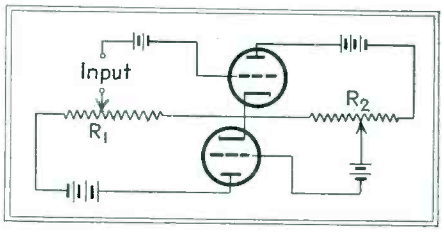

Fig. 6—Regenerative d-c amplifier circuit

tube, decreases the plate current in the second tube and this in turn increases the plate current of the first tube, etc. The regeneration is adjusted by the two potentiometers R_1 and R_2. The condition corresponding to oscillation results in the smallest input voltage causing the first tube to show saturation plate current and the second tube to be blocked. The removal of the tiny initial impulse then does not return the circuit to its original condition. However, the originator of the circuit claims it can be made stable if not too high amplification is desired from it.

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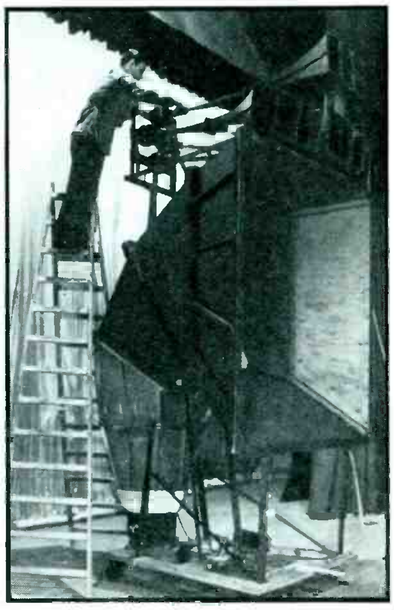
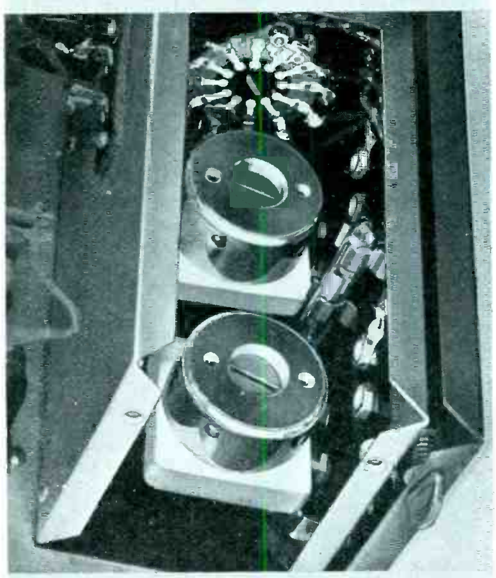
KILOWATT SPEAKER



A Berlin movie house has recently installed this loudspeaking unit, capable of handling 1000 watts with fidelity from 40 to 10,000 cps. Four tweeters are used, three for the range 5,000 to 8,000, and one from 8000 to 10,000 cps

When the transmitter deviates from the assigned frequency by a predetermined amount, one of the warning lamps on the panel lights and indicates direction of deviation.



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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.

Gaseous Discharge Lamps

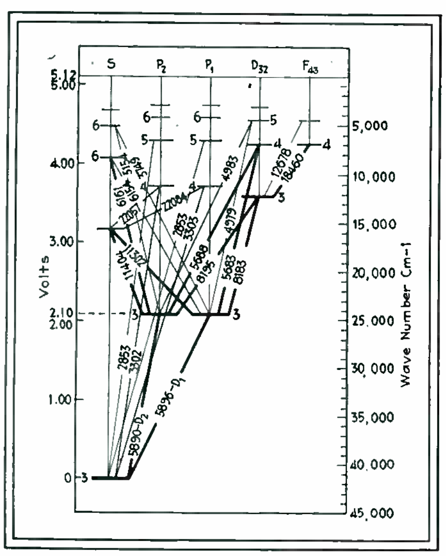
ONE FIELD in which theoretical electronics and atomic physics have been playing an increasingly important role of recent years, is that concerned with the design and manufacture of gaseous discharge lamps. Recent advances in this field are discussed by S. Dushman in the January issue of the *Journal of the Society of Motion Picture Engineers*, under the title "Recent Developments in Gaseous Discharge Lamps."

The mechanism of the production of light in gaseous discharge lamps is discussed, and the reasons are given why one type of gaseous discharge lamp is more efficient than another. The mechanism of light production is ably described, using a sodium tube as an example. Suppose we had a diode in which a copious supply of electrons is provided by an incandescent cathode or filament. If a pellet of metallic sodium is inserted into this diode and the temperature of the walls is increased so that the vapor pressure of the sodium reaches a value of about one millionth of an atmosphere, the characteristic of the sodium lamp can be studied. For zero voltage between the cathode and the plate, no light is produced. As the plate voltage is increased, no visible effects are produced until the voltage is at least 2.1 volts. At this voltage, the two D lines of sodium are emitted. These are the most prominent lines of sodium having wave lengths of 5890 and 5896 Å.

As the voltage is increased still further, a new series of lines becomes visible with a plate voltage of about 3.3 volts and still more lines of the spectrum appear, until with a plate voltage of 5.12 volts or higher the entire sodium spectrum is emitted.

Each line of the spectrum of sodium corresponds to a transition between a higher and a lower energy state of the sodium atom and each of these states requires a definite electron energy (corresponding to a so-called critical potential) for its excitation. The relation between the spectrum lines and the voltages which it is required to produce these lines are shown in energy level diagrams, of which a diagram for the arc spectrum of sodium is shown. The wave length of the light produced is a function of the excitation voltage and this fact accounts for the differences in the quality of light as well as in the efficiency of sodium vapor, mercury vapor, neon, and other gaseous discharge tubes.

Considerable space is devoted to a discussion of the importance and practical forms of gaseous discharge tubes and their applications, as well as to visible light sources which make use of the transformation of ultra-violet radiation into visible light, through the action of fluorescent material.



Energy level diagram for the lines in the arc spectrum of sodium

Time and Speed Measurements

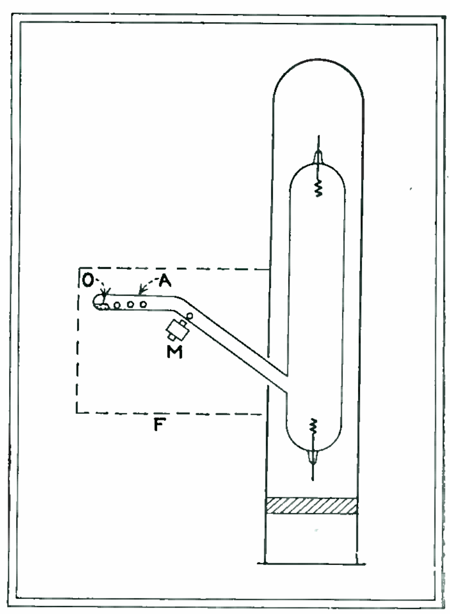
DEVELOPED AT the request of the Illinois State Highway Department for the measurement of car speeds two electron tube circuits are described by Herbert J. Reich and Hershel Toomin under the title "Electronic Circuits for the Measurement of Time and Speed," in the December issue of the *Review of Scientific Instruments*. In one of these the total output current of the device is approximately linearly proportional to the time of operation in seconds. A modification of the original circuit gives a relatively uniform calibration between the plate current of the output tube and speed in miles per hour as determined by the successive closing of two switches.

Convection Currents in Mercury Arcs

THE EFFECTS OF convection currents on the heat losses and on the form of the arcs must necessarily be taken into account in formulating any rigorous and complete theory of an electric discharge at high pressure. The experimental and theoretical results recorded by Carl Kenty in "On Convection Current in High Pressure Mercury Arcs," in the January issue of the *Journal of Applied Physics* provides additional information on the subject which has for the most part been treated purely from theoretical considerations.

In order to test the results which theory predicts, the vapor velocities existing in high pressure mercury vapor tubes were measured. The principal method adopted was to photograph the motion of incandescent particles on a motion picture film. In order to make these photographs, incandescent particles of oxide such as CaO were introduced into the mercury vapor tube. The movement of such incandescent particles of oxide may be determined visually through the use of a red filter, and by photographing these visual effects, a permanent record is obtained.

The illustration shows the experimental method used for introducing the oxide particles into the high pressure mercury vapor lamps which were studied. Into the side arm A, of the lamp, is inserted a small amount of carefully dried and baked oxide powder. The side arm also contains a number of small ball bearings which, having come in contact with the oxide powder, contain small deposits of oxide on their surfaces. The bearings were kept in the horizontal portion of the side arm until it is desired to make motion pictures of the convection current. One of the ball bearings is held in the inclined portion of the side arm by means of an electromagnet M, and is released



Method of introducing oxide particles for studying convection currents

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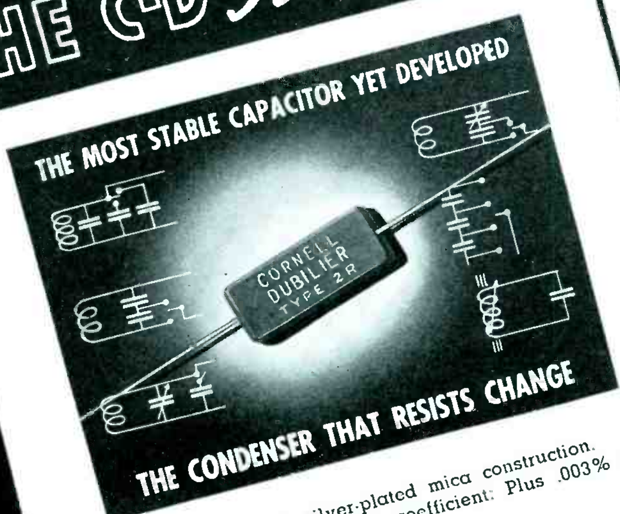

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at the proper moment. When released, this ball bearing carries a minute amount of the oxide powder into the tube. A number of incandescent particles can then usually be seen rising in the arc stream. By properly synchronizing the electromagnetic release with the shutter of the camera motion pictures showing very distinct tracks of incandescent particles were obtained. In making such motion picture records, a deep red filter was used in conjunction with panchromatic film.

From the photographs thus obtained convection currents of about 40 centimeters per second are found at the axis in the mid-section of a 400-watt lamp having approximately atmospheric pressure. The speed of convection currents is somewhat greater near the bottom of the tube and are found to increase somewhat less rapidly than in proportion to the mass of mercury per centimeter length of tubing. It is also found that the arc blows up against the wall of a tube and softens it when the lamp is operated in horizontal position.

Photographs of particle tracks show in a striking manner the migration of ions in the electric field. Ca and Mg vapors from the evaporating particles are strongly ionized and excited at the higher temperatures and progress rapidly in the field.

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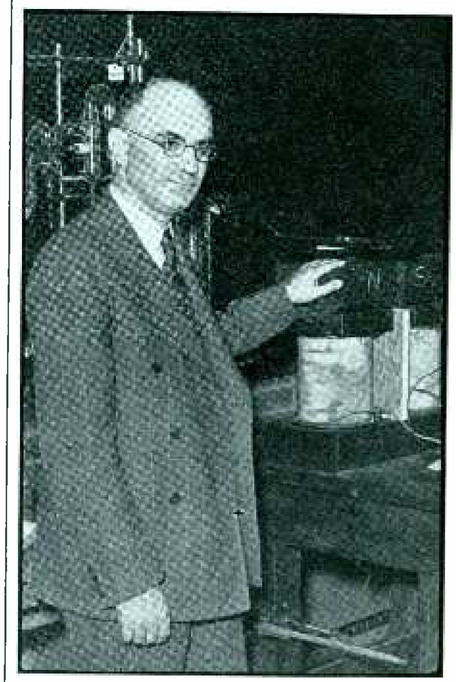
DETECTS INCONSTANCY OF ELECTRONIC CHARGE



Dr. G. E. M. Jauncey, Professor of Physics at Washington University, St. Louis, with the apparatus he used in detecting that the mass and charge of the electron are not invariable constants

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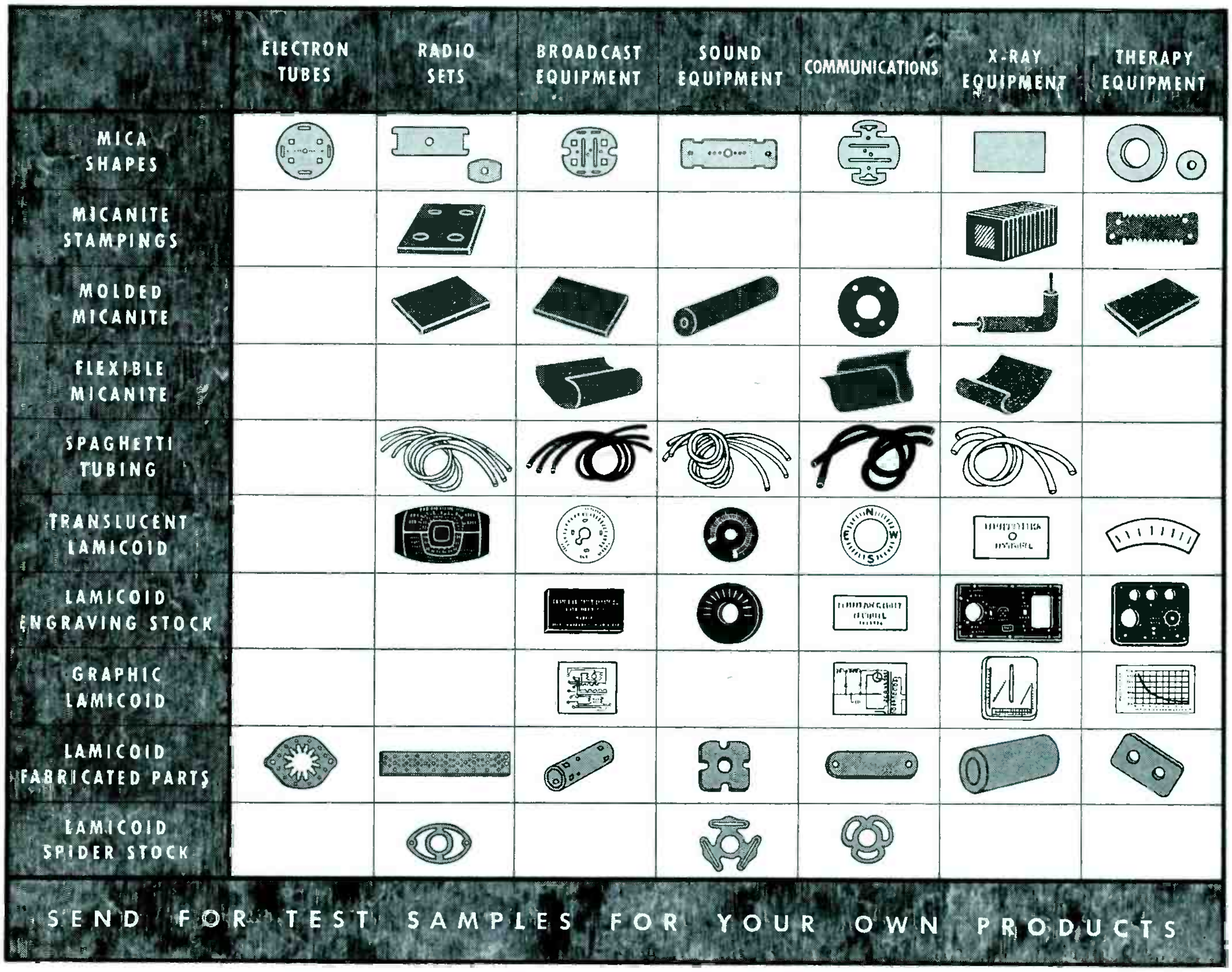

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London Annual Exhibition of Scientific Equipment

By John H. Jupe
London, England

Electronic devices held quite a high place in the exhibits at the Physical Society's Exhibition held in London early in January.

In the field of cathode ray oscillography several new units were shown. A double beam oscillograph with two electron beams which enables two sets of phenomena to be observed at once was one of these. Another unit shown was the 12½ in., high vacuum tube, developed for television purposes. Shields to avoid interference and magnetic deflector coils are fixed round the neck of the tube. Beam trigger and modulation facilities and a 50 cycle a-c calibration voltage are all provided. The tube, controls and power pack are self-contained.

Automatic brilliancy control is also new. This is a special value for obtaining uniform photographic records.

There was also a new ganging oscillator and oscilloscope for visual alignment of the tuned circuits in radio sets. The oscillator makes use of the Miller valve effect, in which the varying grid anode capacity of the tube produces a frequency sweep above and below the radio frequency applied to the set for test purposes. The frequency sweep is controlled by the saw tooth base voltage applied to the cathode ray tube in the oscilloscope, which simultaneously shows the voltage output from the radio set detector. The screen image therefore shows the response of the tuned circuits for a 15 kc. band above and below the carrier frequency. Tuned circuits can thus be quickly aligned by observing the shape and symmetry of the response curve.

Photoelectric cells were fairly well represented, a particularly interesting exhibit being a photoelectric high speed recording pyrometer for temperatures over 800° C. This apparatus has been designed for mains operation with voltage variations up to ±25 volts, at room temperatures up to 50° C. It can maintain an accuracy of ± 5° C. over the entire scale.

Another interesting photocell instrument was a counter capable of counting objects up to a speed of 5000 per minute.

A shield grid thyratron was shown for the first time. In the usual hot cathode thyratron the discharge is controlled by the grid voltage and the lower limit of control circuit power is determined by the grid current.

In high impedance circuits, such as are used with photocells, it is generally necessary that the controlling impulses be amplified before being applied to the grid. With the shield grid thyratron, the control grid is partially screened from arc stream, thus reducing the grid current to a very low value and enabling the tube to be controlled directly from the photocell.

A thyratron shown was suitable for

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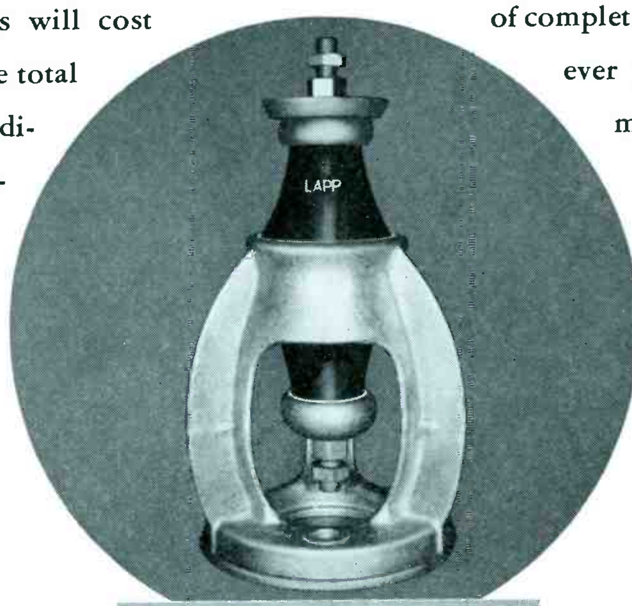
And if you are planning such a structure, it is because you expect to achieve finer transmission quality. Is it not a wise investment, then, to give your radiator the security of insulation by Lapp? For then, and only then, would you have the assurance of complete electrical insulation, whatever your transmission equipment, whatever your antenna feeding circuit.



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peak currents of 75 amperes and peak voltages of 2000 and was controlled directly from a cell without amplification.

Two medical instruments were on view, intended for raising the body temperature of patients. One of these employs a tube oscillator of 160 watts output and operating at 15 megacycles per second. The oscillatory inductance takes the form of a flexible cable to be wound around a limb, looped over or under the body or applied in the form of a pancake coil. The other may also be used for electro surgery, cutting, coagulating, disscating or cutting under a liquid.

Electron Tubes in the Motion Picture Field

THE PROBLEMS of vacuum tube engineering as applied to motion pictures are discussed by L. C. Hollands and A. M. Glover, in an article, "Vacuum Tube Engineering for Motion Pictures," appearing in the January issue of the *Journal of the Society of Motion Picture Engineers*. The manufacturing and development technics of vacuum tubes are described with particular reference to the motion picture equipment. A brief discussion is given of how application requirements effect the choice of materials, the structural design, and electrical characteristics of phototubes and amplifiers of both power and voltage type is included. Methods which manufacturers use to reduce microphonics are mentioned as well as are methods of reducing hum.

The article is concluded with a brief description of the electron multiplier, consisting of a photo-sensitive circuit and a number of secondary emitting surfaces so arranged that the primary photoelectron current may be amplified by large factors depending upon the the number of secondary surfaces used. While these tubes are still in the developmental stage, gains of from 20,000 to 65,000 may be obtained in an 8-stage electron multiplier.

RADIO CONTROLLED PLANE

This model airplane, built in California, will take off, maneuver in the air, and land, in accordance with radio signals emitted from a portable transmitter

tained beyond 1000 km provided that the transmitters are sufficiently powerful.

While the Standard-Adcock series of radio direction-finders has a large field of use at coast stations for marine navigation, and also for military purposes, its most valuable application is clearly to aircraft navigation. This has been recognized by the aviation authorities, and equipment of this type will shortly be in use at many important aerodromes.

The normal method of use for two or three such equipments to operate as a group. When a pilot wishing to know his position asks for it by means of the radio transmitter on board his aircraft, his request is picked up by the direction-finding stations, each of which immediately observes the bearing of the signals. At the station in charge all the observed bearings are transferred to a special chart by means of a system of stretched threads, the intersection of the threads giving the position of the aircraft by triangulation; the bearing so found is then transmitted to the aircraft in some such form as "20 km southwest of Abbeville." All communication is by telegraph code, and the whole process takes remarkably little time; with skilled operators a position can be given to a pilot within 20 seconds of his request.

Another application described in *Electrical Communication* is that known as "homing on bearings." In this case the pilot is kept informed at short intervals of his bearing on an aerodrome, and continually adjusts his course to fly on this bearing; usually the process commences when he is still distant by 30 km or 50 km. When by this means the machine has been guided over the aerodrome, which may be obscured by clouds, a special signal is transmitted to the pilot, and he descends through the clouds knowing that the aerodrome must be beneath him, and completes his landing in the usual way. The Standard-Adcock equipment is particularly useful for this method of navigation owing to its complete immunity from aeroplane effect and consequent ability to give accurate bearings even when the aircraft is close in and the transmitted wave arrives with a large angle of tilt. If a frame aerial system is used it is true that the aeroplane effect is at its minimum because the aircraft is flying towards the system (assuming the latter to be close to the aerodrome) but even so, better accuracy is obtainable with an Adcock aerial system of quite low height, 9 m to 10 m at the most.

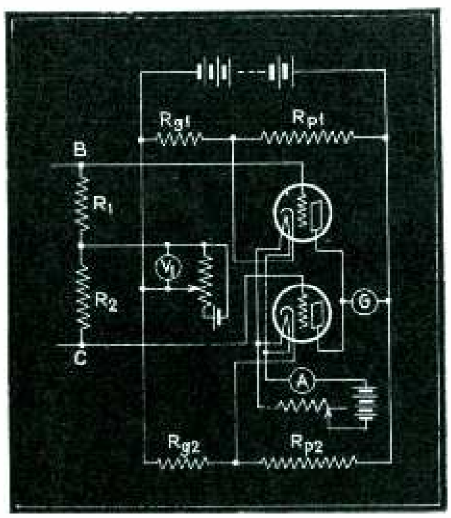
It is the opinion of the author of the article that for maximum efficiency aerodrome equipment should include two direction-finders, one for long range work with its aerial system well away from the landing ground, and another for short range work with a low aerial system erected at the boundary of the landing ground and on the normal line of approach. By the use of transmission line connections the goniometer and receiver units for both systems can be installed together in the same office quite conveniently.

In conclusion the author points out that fitting an aircraft with a radio compass does not make the aerodrome direction-finder any less necessary, and vice versa. Two safety measures are better than one. If the aircraft transmitter breaks down the aerodrome direction-finder cannot provide either a position or a bearing, but both can be obtained on the aircraft itself if a radio compass is carried, and disaster may thereby be avoided.

R-M-S Vacuum Tube Voltmeter

A DOUBLE TUBE vacuum tube voltmeter which gives root-mean-square readings is described by Walter B. Michels in the January issue of the *Review of Scientific Instruments.*

The schematic wiring diagram for the double tube voltmeter is shown and consists of two type 37 tubes with associated batteries and resistors. It was found that the type 37 tubes gave a plate current response which was proportional to the square of the grid voltage, within 5 per cent, when the plate voltage was 75, and the grid was — 11.8 volts. This square relation is



Schematic wiring diagram of Michels two-tube voltmeter

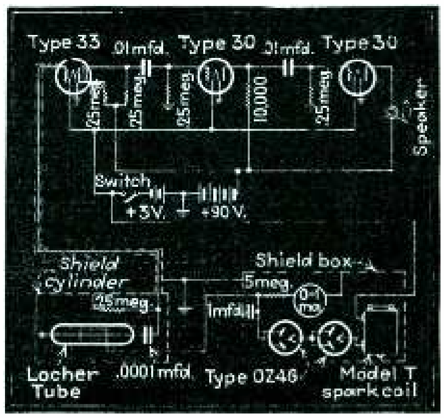
essential in order that the device may indicate r-m-s values. In this circuit $R_p = 7.40\ R_g$ and $E_a = -1.66$ volts. The input resistance, composed of R_1 and R_2 in series may be chosen at will provided that the total resistance is not sufficiently high as to produce instability of operation. In order further to increase the stability of operation, the heater current for the two tubes in parallel was maintained at 0.5 ampere rather than the rated value of 0.6 ampere.

The article gives the mathematical treatment which is necessary for the proper design of all of the resistances and voltages of the circuit, on the basis of experience with a number of type 37 triodes.

Battery-Operated Device for the Recovery of Lost Radium

A BATTERY-OPERATED Geiger-Muller counter which is suitable for the detection of lost radium is described by Robert B. Camp in the December issue of the *Review of Scientific Instruments.* The unit described combines ruggedness with simplicity and uses standard radio parts wherever possible.

Essentially the radium detector consists of a Geiger-Müller counter tube, a three-stage resistance coupled amplifier feeding a loudspeaker, and the necessary power supply unit. The wiring diagram of the complete unit is shown in the accompanying drawing. Standard size radio batteries are used to operate the amplifier. The high voltage supply necessary for the counter tube is provided by means of a Ford spark coil, a condenser, and cold cathode tube, the combination giving a source of reasonably smooth direct current of practically any desired voltage. The voltage of the high voltage supply depends upon the adjustment of the vibrator. Objectionable hum in the loudspeaker is eliminated by properly shielding and bonding the circuit as indicated in the diagram. Cold cathode tubes of the type OD4G connected in series are used as the rectifier.



Schematic wiring diagram of simple, portable device for detecting lost raidum. The unit is battery operated and so far as is possible, uses standard radio parts throughout in its construction. Presence of radium is indicated by the number of clicks emanating from the lour speaker

In use the instrument may be carried about until a greater number of pulses greater than normally due to cosmic radiation is heard from the loudspeaker, or a count of the impulses for several minutes in each location may be made to determine the rapidity in which the radium is lost. According to the author, Doubling of the count normally gotten from cosmic radiation is regarded as the criterion of detection of radium. It is stated that 20 milligrams is detectable at about 135 ft. with no obstruction intervening.

The advantages of this simple application of the Geiger-Müller counter are its portability, low cost, relatively good sensitivity, and the availability of all parts, except the counter tube.

Versatile Level Meter Used at KMBC

(*Continued from page* 14)

will read correctly when the 200,000 ohm input is bridged across a 500 ohm load. The range of the meter in this condition is —18 to —65 db. When bridged across loads different from 500 ohms, a correction factor must be applied. This factor is,

$$F = 10 \log_{10} (500/R_t)$$

where R_t is the impedance of the load across which the 200,000 ohm input is bridged. It is of course, assumed that the effect of the high input impedance of the meter in shunt with the load impedance is negligible. Hence, when bridged across 50 ohms, the correction is plus 10 db and consequently this amount should be added to all readings. The table of Fig. 4 gives correction to be added and the range of the instrument for a few typical bridging conditions. If desired, the table of Fig. 4 can be extended, through the use of the equation above, for other shunting impedances.

The case of the instrument should always be grounded at the terminal provided to insure proper operation when measuring very low levels.

Calibration and Performance Characteristics

Checks were made over a considerable period of time to determine how well the instrument retained its calibration. The results indicate, that provided a warming up period of about 15 minutes is allowed for, the instrument will always maintain its calibration within a total error of 0.4 db. Considering that quite a few carbon resistors were used this variation is to be expected. An error of this magnitude is not very serious in the applications for which this instrument was designed. If, however, extreme accuracy is desired it is a simple matter to check the instrument and bring it back to its calibration by the adjustment of R_3 and R_4. In actual use over a long period of time the device has performed extremely well and proved very useful and dependable.

Measurements of L and C

(Continued from page 21)

show the results obtained by using two materials having compensating coefficients of expansion in the construction of the plates, and spacers between the plates. The two materials, invar and brass, were chosen with the hope of obtaining a low negative temperature coefficient. Actual measurements show positive but the low order of magnitude of these results indicate that capacitors can be compensated in this manner to give negative coefficients provided that the mechanical difficulties involved in obtaining proper bearing surfaces, and insulating supports can be overcome. Measurements on samples 6 and 7, (Table 1 and Fig. 6) show the difference between the use of a plate material with a very low coefficient of expansion such as invar and a material with a relatively high coefficient of expansion such as aluminum. Again improper bearing and support design probably accounts for the lack of a greater difference in these two samples.

Measurements were made on two types of coils (See Table 1, and Fig. 7). The curves in Fig. 7 were plotted as percent inductance change as a function of time in order to point out the erratic behavior of the ordinary coil in general use as compared with the fireplated type. The fireplated inductor should have a change of inductance proportional to the coefficient of expansion of the form on which it is wound. Measurements were made on only one sample of this type and therefore are not conclusive, but the curve (sample 1 Fig. 7) shows uniform change with temperature and time, and indicates that the use of a material such as fused quartz for the form would result in an extremely low temperature coefficient.

Accuracy and Observations

The calculation of the probable error of measurement is based on a temperature coefficient of 0.0001 per cent per degree Centigrade and a

MANUFACTURING REVIEW

News

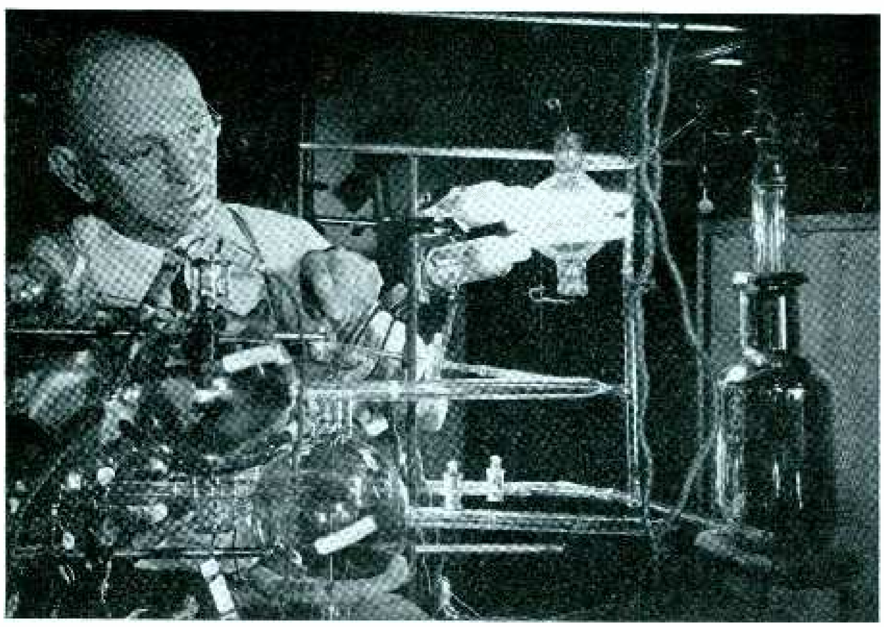
✦ The Thomas A. Edison medal of American Institute of Electrical Engineers, highest honor in electrical engineering, was presented to Gano Dunn, president of the J. G. White Engineering Corp. and head of Copper Union, on Wednesday, Jan. 26. The award was made at a ceremony featuring the Institute's winter convention. Mr. Dunn received the award "for distinguished contribution in extending the science and art of electrical engineering, in the development of great engineering work, and for inspiring leadership in the profession."

✦ Foreseeing an enlarging field of usefulness for electronic tubes, the Westinghouse Electric & Manufacturing Co. has reorganized its manufacturing facilities at Bloomfield, N. J., to form the special product division, under the management of H. J. Hoffman. According to an announcement by D. S. Youngholms, vice-president, the new division will embrace the design, manufacture and sale of electronic tubes. It will also continue the manufacture of a complete line of radio transmitting tubes as well as X-ray tubes, rectifiers, and other electronic devices for industrial purposes.

✦ A non-exclusive license was recently granted to Heinz & Kaufman, Ltd., of San Francisco, Calif., by the Radio Corporation of America. The license extends to various commercial radio apparatus for use on ships and aircraft, and by the government.

✦ General Charles G. Dawes and Gano Dunn, were elected to the board of directors of the Radio Corporation of America at the regular meeting of the board held on Jan. 28. They fill the vacancies due to the recent deaths of Frederick Strauss and Newton D. Baker. At the same time it was announced that Dr. James Rowland Angell, former president of Yale University and now in charge of educational programs and development for the N.B.C., was elected a director of that company.

✦ Leon Podolsky, has resigned his position as research engineer of the Wirt Co., Philadelphia, to become associated as research and sales engineer of the Sprague Products Co., North Adams, Mass.



Thorough evacuation in which the tubes are freed from contaminating gases is an essential operation in the manufacture of gas filled as well as vacuum tubes. Mr. W. A. Ruggles is shown operating the gas purification system used in conjunction with exhaust equipment in the Research Laboratory of the General Electric Co.

✦ Although admitting unsatisfactory business in the last quarter of 1937 due to the effects of the business recession which began late in September, the annual report of the Hygrade Sylvania Corp., announces that 1937 was the 21st consecutive year in which a profit has been shown. Net income amounted to $868,064, a decrease of 16 per cent from 1936 after all charges and taxes. The number of tubes sold in 1937 decreased 7 per cent from those sold in 1936 as a result of the business recession. During 1937 an increased amount of research work has been done on tubes for television and substantial progress has been made in the development of cathode ray tubes.

✦ Dr. Chauncey Guy Suits has been chosen as America's outstanding young electrical engineer for 1937 by Eta Kappa Nu, Honorary Electrical Engineering Association. Dr. Suits was selected from a list of sixty candidates of less than 35 years of age, nominated by leading industrialists and educators.

✦ In an advance statement made to the stockholders of the Radio Corporation of America, an estimated profit for 1937 of $9,000,000 was reported. While the final audit is not yet completed, the preliminary estimate indicates an increase of approximately $2,844,100 over the net profit of the previous year.

✦ Speech input equipment of new and unusual design for broadcast station WJR, Detroit, is being built on special order by the Western Electric Co. The new equipment has been designed by Bell Laboratories Engineers to meet the specifications of Mr. A. Friedenthal, in charge of studio facilities for WJR.

✦ Robert L. Barr, for several years an executive with Clough-Brengle Co., announces the formation of the firm of Lund & Barr, sales engineers, with headquarters at 2815 W. 19th St., Chicago. The new firm will engage in sales and consulting engineering, and at the same time will represent Clough-Brengle's test equipment and Vocagraph sound system.

electronics

Catalog & Literature Service

Manufacturers' literature constitutes a useful source of information. To make it easy to keep up to date, "Electronics" will request manufacturers to send readers literature in which they are interested.

1. Cutting Blade. A 4-page folder issued by the Musto-Keenan Co., 1801 South Soto St., Los Angeles, outlines the advantages of a new blade devised for cutting non-metallic products.

2. Pyranol Condensers. Two bulletins of the General Electric Co., Schenectady, N. Y., describe pyranol condensers. One of these is Bulletin GEA-2021A dealing with condensers for radio transmitters. The other is Bulletin GEA-2621 giving characteristics of pyranol condensers for radio and x-ray equipment and other d-c applications up to 75,000 volts.

3. Marine Radiophone. An 8-page bulletin issued by the Western Electric Co., 195 Broadway, New York, deals with their type 224A, 50-watt, two-way marine radio telephone system.

4. Machining Aluminum. A 32-page illustrated booklet published by the Aluminum Company of America, Pittsburgh, Pa., deals with machining aluminum and aluminum alloys.

5. Rotary Switches. Single and multiple point, multipoint rotary switches suitable for instrument use are described in Bulletin No. 500 of the Shallcross Manufacturing Co., Collingdale, Pa.

6. Radio Hardware. Bulletin No. 50 of the Federal Sales Co., 26 So. Jefferson St., Chicago, lists a complete line of radio hardware for manufacturers, parts jobbers, servicemen, etc.

7. Switchgear. Bulletin 66 gives catalog information on metal enclosed switch gear manufactured by the Delta-Star Electric Co., 2400 Block Fulton St., Chicago.

8. Raytheon Tubes. Tentative data sheets have been issued by the Raytheon Production Corp., 55 Chapel St., Newton, Mass., on their type 6K8 triode-hexode frequency converter and their type 6W7G pentode amplifier.

9. Transmitting Condensers. A single page folder giving the characteristics of transmitting condensers is available from Bud Radio, Inc., 5205 Cedar Ave., Cleveland, Ohio.

10. Hardness Meter. A folder describing their Brinnell hardness meter is available from Louis C. Eitzen Co., 280 Broadway, New York.

11. Antenna Coupling Units. A single page folder issued by Victor J. Andrew, Chicago, Ill., and known as Bulletin 816 describes coupling units for shunt excited radiators. Bulletin 72 describes coaxial cable.

12. Condenser Manual. A new edition of the Industrial Capacitor Manual is now offered by the Aerovox Corp., 70 Washington St., Brooklyn, N. Y.

13. Auto Radios. The 1938 catalog of automobile radio receivers and accessory equipment has been released by the Galvin Manufacturing Corp., 4545 Augusta Blvd., Chicago.

ELECTRONICS **March**

330 W. 42nd Street, New York, N. Y.

Please request manufacturers to send me, without obligation, literature identified by numbers circled below.

1	2	3	4	5	6	7	8	9	10	11	12	13	14
15	16	17	18	19	20	21	22	23	24	25	26	27	28
29	30												

NAME .... TITLE ....

COMPANY ....

ADDRESS ....

CITY .... STATE ....

14. Motor Starting Condensers. A 4-page folder from P. R. Mallory & Co., Inc., Indianapolis, Ind., announces a complete line of motor starting capacitors designed to service replacement needs. More than 160 replacement units are listed.

15. Phototubes. Bulletins recently received from the Continental Electric Co., Geneva, Ill., and available for distribution includes a single page folder on Cetron mercury rectifiers: form PT3 a general bulletin on photoelectric devices; form PC-2, giving the characteristics of a wide variety of Cetron phototubes; and form TV-2 dealing with a vacuum gage suitable for use in tube manufacture.

16. Wire Cable. "U. S. Royal Cords and Cables", an illustrated wire manual designed to provide electrical engineers and others with wire and cable data and specifications, has been announced by the Wire Division, United States Rubber Products, Inc., 1790 Broadway, New York.

17. Screws, Bolt, Nuts. The 1938 catalog of 108 pages recently released by the Pheoll Manufacturing Co., 5700 Roosevelt Rd., Chicago, gives complete specifications on their standard threaded products.

18. Insulator Data Book. The 1938 engineering data book issued by the Spaulding Fibre Co., 310 Wheeler St., Tonowanda, N. Y., gives electrical and mechanical specifications of the wide range of Spaulding insulation products which are available.

19. Resistance Devices. Bulletin No. 835 issued by the Shallcross Manufacturing Co., Collingdale, Pa., describes decade potentiometers and resistance boxes covering a wide range of resistance values.

20. Light Dimmers. A new light dimmer for use in theatres and similar installations, is described in bulletin 76 of the Ward Leonard Electric Co., Mount Vernon, N. Y.

21. Electronic Welding Control. Ways of increasing profits with improved welding qualities are suggested in a 12-page booklet, "New Profits from Resistance Welding with Ignitron Split-Second Control," issued by the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

22. Graph Sheets. An 88-page booklet, illustrated in color, describes graph sheets, and various types of coordinate paper and cloth. A fairly large part of the book is devoted to the proper use of various types of coordinate ruling. The book is published by Keuffel & Esser Co., 127 Fulton St., New York.

23. Push-Button Switches. The new line of multiple push-button switches manufactured by the P. R. Mallory & Co., Inc., Indianapolis, is described in Form Y-606. Mallory condensers are described in another publication, Form M-801.

(Continued on page 71)

Literature

24. **Electric Cable.** "Anaconda Crossway Cable" is the title of the 16-page booklet, No. C-40, issued by the Anaconda Wire & Cable Co., 25 Broadway, New York. The bulletin describes applications, and electrical and physical properties of parkway cable.

25. **Sensitive Relays.** Bulletin 251 issued by the Ward Leonard Electric Co., Mount Vernon, N. Y., lists about thirty sensitive relays for operation on direct and alternating current. The relays are available in sensitivities down to about 1 milliampere.

26. **Composition Fixed Resistors.** An 8-page illustrated booklet in color, issued by Centralab, Inc., 900 East Keefe Ave., Milwaukee, Wis., contains considerable information on carbon composition fixed resistors. The publication is entitled "Engineering Data, Centralab Fixed Resistors," Form 647.

27. **Wind-Operated Charger.** The Wincharger Corp., Sioux City, Iowa, has published a 4-page bulletin entitled "Around the World with Wincharger," outlining the advantages of their wind-driven battery chargers.

28. **Electrical Iron.** A 12-page folder on iron for electrical purposes is issued by the Swedish Iron & Steel Corp., 17 Battery Pl., New York City.

29. **Receiver Components.** Two bulletins on receiving equipment are available from the J. W. Miller Co., 5917 So. Main St., Los Angeles. One of these describes a band pass tuned radio frequency coil kit. The other bulletin deals with wave traps.

30. **Amplifier for D-C Circuit.** An amplifier having an output of 10 watts, utilizing four 25L6 metal tubes, and suitable for operation from the direct current line is described in bulletin PA-15 of the Jefferson Electric Co., Bellwood, Ill.

New Products

Precision Condensers

An entirely new type of precision condenser for radio production purposes is announced by the F. W. Sickles Co., Springfield, Mass. This condenser uses a conducting film of silver chemically deposited on thin sheets of mica. Connection to the film is by means of silver-plated terminal clips which are pressed down over the ends of the mica. As a result of this construction, the capacitance is maintained constant throughout the life of the condenser. Adjustment of capacitance is accomplished by removing the amount of silver deposit.

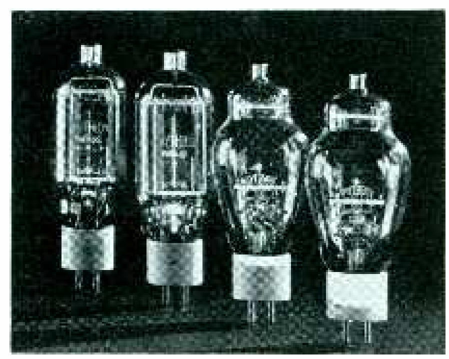
Triode Hexode Converter

A multi-unit, all-metal vacuum tube incorporating a triode and a hexode unit in the same envelope, and known as the RCA-6K8 was announced during February by the RCA Manufacturing Co., Harrison, N. J. The tube is intended primarily for use as a converter in the superheterodyne receivers, especially those of the all-wave type. The heater of the tube operates at 0.3 amperes at 6.3 volts. Maximum plate voltages of the hexode and triode portions are 250 volts and 200 volts, respectively. The screen of the hexode operates at 100 volts maximum, with a minimum grid bias of 3 volts.

Power Tubes

FOUR NEW type RK tubes for use as power amplifiers, oscillators, or frequency multipliers have been announced by the Raytheon Production Corp., 55 Chapel St., Newton, Mass.

The RK-11 is a trade power amplifier having an amplification factor of 20. It is designed for use as a power amplifier, oscillator, or frequency multiplier.



The RK-12 is a zero bias modulator tube having low distortion even at 100 watts. Like the RK-11, the RK-12 has a power output of 55 watts.

The RK-51 is a triode power amplifier, oscillator or frequency multiplier with an amplification factor of 20 and a rated power output of 170 watts.

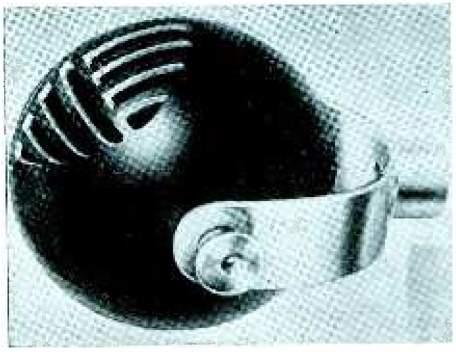
The RK-52, is a triode having a power output of 135 watts, a high amplification factor, and operates with zero grid bias.

Gammatron

THE TYPE HK-54 Gammatron manufactured by Heinz & Kaufman, South San Francisco, Calif., is a general purpose triode suitable for use as a class B or C amplifier, frequency modulator, oscillator in circuits intended for operation at high frequency. The amplification factor is 27, plate impedance 7,500 ohms, and normal plate dissipation is 50 watts. The filament operates at 5 volts and 5 amperes.

Ball Microphone

HOUSED IN a spherical metal case 3 in. in diameter, having an impedance of approximately 50,000 ohms, or 200 ohms, with a flat frequency response from 30 to 10,000 cycles, the ball microphone of the Transducer Corp., 30 Rockefeller Plaza, New York City, has recently been announced. Sensitivity of the microphone is — 52 db.

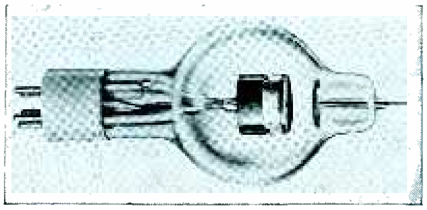


Marking Materials

A fluorescent chalk which glows with a strong green light, is visible at a distance, and which marks like ordinary chalk under normal light, has been developed recently by the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa. The company has also developed ink for marking on glass, porcelain, and metal. Glass marking inks in black, white and silver are available.

Gas Tubes

Two gas type tubes of new design have been recently introduced by Eitel and McCullough Inc., San Bruno, Cal. One of these, the Eimac type KY-21 tube, is a mercury vapor triode suitable for use as a rectifier and power control tube. The tube permits of the control of 5 kw. of power (3,500 volts at 1.5 amperes) by a negligible power expenditure in the grid circuit. The fila-



ment operates at 10 amperes and 2½ volts. The peak inverse voltage is 11,000, and the peak plate current is 3 amperes.

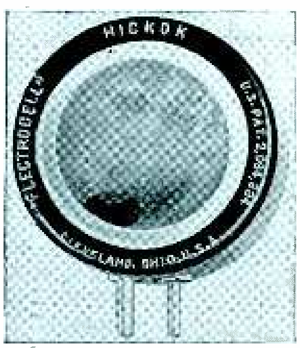
The other gas tube is the type RX-21 mercury vapor rectifier, with a filament operating at 2.5 volts and 10 amperes, the peak inverse voltage is 11,000 and the peak plate current is 3 amperes. Both tubes are similar in appearance, although the illustration shows the mercury vapor triode.

Triode-Heptode Converter

THE KEN-RAD TUBE & LAMP CORP., Owensboro, Ky., has developed a triode-heptude converter type tube which will be known as the type 6J8G. This tube is designed especially for converter operation in high frequency receivers and incorporates a triode oscillator and a multi-grid mixer within a single envelope. In specially designed circuits, this tube features higher conversion gain with low frequency drift as a result of terminal voltage variation.

Photocell

A dry disc self-generating photocell of the blocking layer type, mounted in a one-piece molded bakelite housing and provided with prongs to fit a standard 4-pin radio socket has been



placed on the market by the Hickok Electrical Instrument Co., Cleveland, Ohio. The active surface is 1½ in. in diameter. The sensitivity is approximately 6 microamperes per foot candle.

Photoelectric Control

PHOTO SWITCH, manufactured by Photo-Switch, Inc., 21 Chestnut St., Cambridge, Mass., is a photoelectric control designed expressly for industrial purposes. It is simple in design, rugged

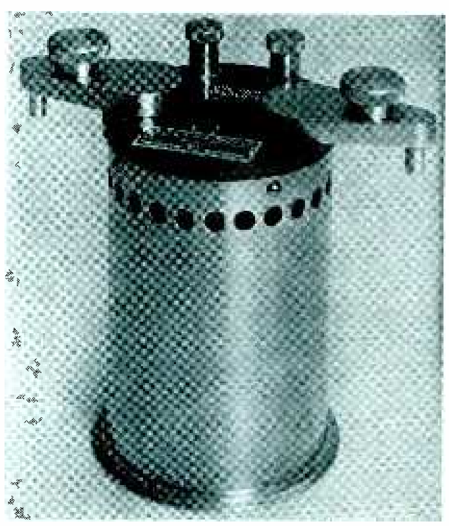
in construction, and both the control and light source are furnished in weatherproof housing suitable for installation in any factory location. Provides control in less than 1/30 second and operates from 150-volt line, a.c. or d.c.

Compact Paper Condenser

A compact paper condenser 2¼ in. long and 1½ in. in diameter has been developed by the Tobe Deutschmann, Inc., Canton, Mass. This type condenser is supplied in various capacitances and single or multiple sections to operate at voltages up to 1,000 volts d-c.

Standard Resistors

A NEW 1 OHM resistance standard has been announced by the Leeds & Northrup Co., 4908 Stenton Ave., Philadelphia, for use as a precision standard. The units are a modification of the Thomas type of standard developed at the National Bureau of Standards. The



standards are adjusted in terms of the absolute ohm which will become effective Jan. 1, 1940. Certificates may be obtained from the National Bureau of Standards giving the value of the particular standards, to one part in a million, in terms of the ohm as maintained by the Bureau.

Aircraft Transmitters

A NEW MODEL aircraft transmitter, type 17D, having an output of 100 or 175 watts, with a frequency range of from 2,800 to 12,000 kilocycles is announced by the Collins Radio Co., Cedar Rapids, Iowa. The transmitter

weighs approximately 60 lb. complete with tubes and crystals, but without dynamotor. Any of ten carrier frequencies can be selected in 3½ seconds, through the use of a dial tuning arrangement.

Transmitting Condensers

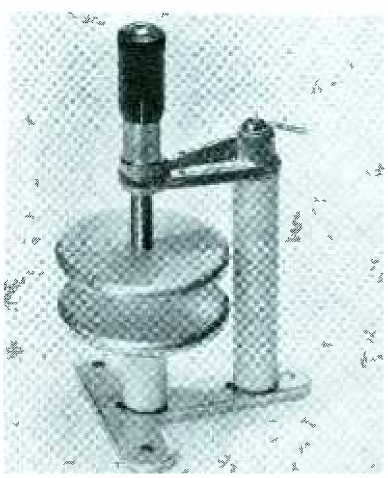
A NEW junior line of transmitting condensers for amateur and commercial work has been announced by Bud Radio, Inc., 5205 Cedar Ave., Cleveland, Ohio. In order to conserve weight and space, brass stator and rotor plates are soldered to their respective shafts, permitting a permanent low resistance connection.

Miniature Condensers

A MICA CONDENSER molded in bakelite, in ranges of from 2.5 to 50 microfarads and known as type GL condensers has been placed on the market by the Micamold Radio Corp., 1087 Flushing Ave., Brooklyn, N. Y.

Neutralizing Condenser

A NEW VERSION of their neutralizing condenser for use in power circuits is



announced by the National Company of Malden, Mass.

Deflecting Yoke

RECENTLY INTRODUCED by the Kenyon Transformer Co., Inc., 840 Barry St., New York, their deflecting yoke type T-700 is designed for use with cathode ray tubes of the electromagnetic deflection type. The yoke may be used on

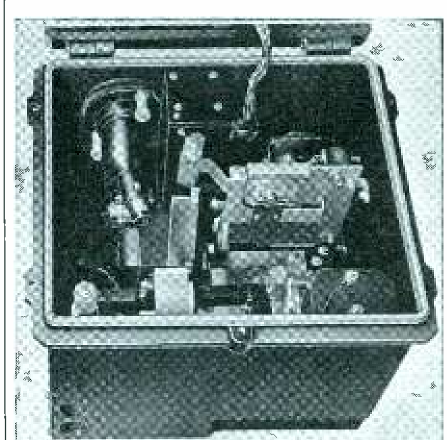
9-in. tubes operating at plate voltages of 6,000. Type T-111 high frequency sweep output transformer also recently introduced is available for the production of a linear deflection with magnetically deflected cathode ray tubes.

Megohm Meter

A NEW MODEL megohm meter, type DM, which may also be used as a portable a-c and d-c voltmeter with a range of 600 volts has been placed on the market by Herman H. Sticht & Co., 27 Park Pl., New York City. A 500-volt generator is employed and resistances from 0 to 100 megohms may be measured.

Electric Furnace Control

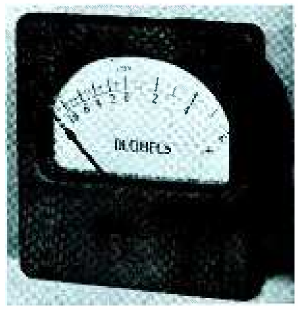
THROUGH THE USE of an indicating potentiometric controller with detection of the position of a light beam reflected from a mirror galvonometer through the use of a phototube, throttling control of electric furnaces and ovens is available. With this automatic controller, manufactured by



the C. J. Tagliabue Mfg. Co., Park & Nostrand Aves., Brooklyn, N. Y., the heat supply is made to vary inversely as the temperature. A safety feature of this electric controller is that the power is shut off when the lamp burns out.

Power Level Indicator

For measuring levels of audio frequency signals a line of miniature power level indicators has been developed by the Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa. The



unit makes use of a dry rectifier and d'Arsonval meter movement. All indicators have scales marked from —10 to +6 db., although other ranges can be provided.

Sound Reproducing System

A new sound reproducing system manufactured by the Sound Apparatus Co., 150 W. 46th St., New York City, having a frequency response characteristic flat from 40 to 8,000 cycle uses a lateral cut recording system with a dynamic pick-up. Power consumption is 80 watts at 110 volts, 60 cycles.

Speaker Enclosures

Enclosures for 18-in. and auditorium speakers are announced by the Jensen Radio Manufacturing Co., 5601 So. Laramie Ave., Chicago. The enclosures are shipped knocked down and all that is necessary to do is to set up the enclosure and put the speaker into place.

Air-tight Capacitators

Designed to operate under any humidity and temperature condition, a special test given to the type BH dykanol condenser manufactured by the Cornell-Dubilier Electric Corp., calls for im-

mersion under boiling water for a minimum period of 15 min. The type BH series is available in a capacity range of from 0.05 to 2 microfarads, at voltages of 400, 600 and 1,000 volts, d.c.

NEW BOOKS

Electrical Measurements

By Frank A. Laws, *Late Professor of Electrical Engineering, Massachusetts Institute of Technology. McGraw-Hill Book Co., New York, 1938. (Price $6.00, 739 pages, 476 illustrations.)*

For twenty-one years, Laws' "Electrical Measurements" has been "a compendium of information on the subject of electrical measurements and, at the same time, a textbook suitable for use by undergraduate students in technical and other schools." The soundness with which the book has been written is indicated by the fact that it is familiar in practically all schools of electrical engineering, and in the further fact that in its fundamental treatment and arrangement, the second edition differs little from the first. New material developed during the past two decades has of course been included, and the second edition is somewhat larger and more extensive than the first.

The new edition is a general text on electrical measurements, and does not contain the emphasis on communication subjects which other recently written books do. But in the field which it aims to cover, it is comprehensive, complete, carefully and accurately prepared, and contains sufficient of the background material to make evident the development of the art.—B.D.

• • •

Principles of Radio

(Third Edition)

By Keith Henney. *(John Wiley & Sons, Inc. 1938, 495 pages, price $3.50.)*

The first edition of this book appeared eight years ago. In this time numerous printings and three editions have appeared. Not a printing has been made without change to keep the text alive and up to date. Originally aimed at the reader who had to study without the benefit of an instructor, it has, nevertheless, found its way into many trade schools and indeed into some colleges. The approach is, in general, non-mathematical. The book serves as an introductory text to the engineering underlying radio reception and transmission.

The new edition contains new material and has lost material that is no longer pertinent to the new art. There are many problems and numerous experiments, all endeavoring to acquaint the student with the apparatus and values of circuit constants he will find in practice.

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New advertisements must be received not later than March 24th for the April issue

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