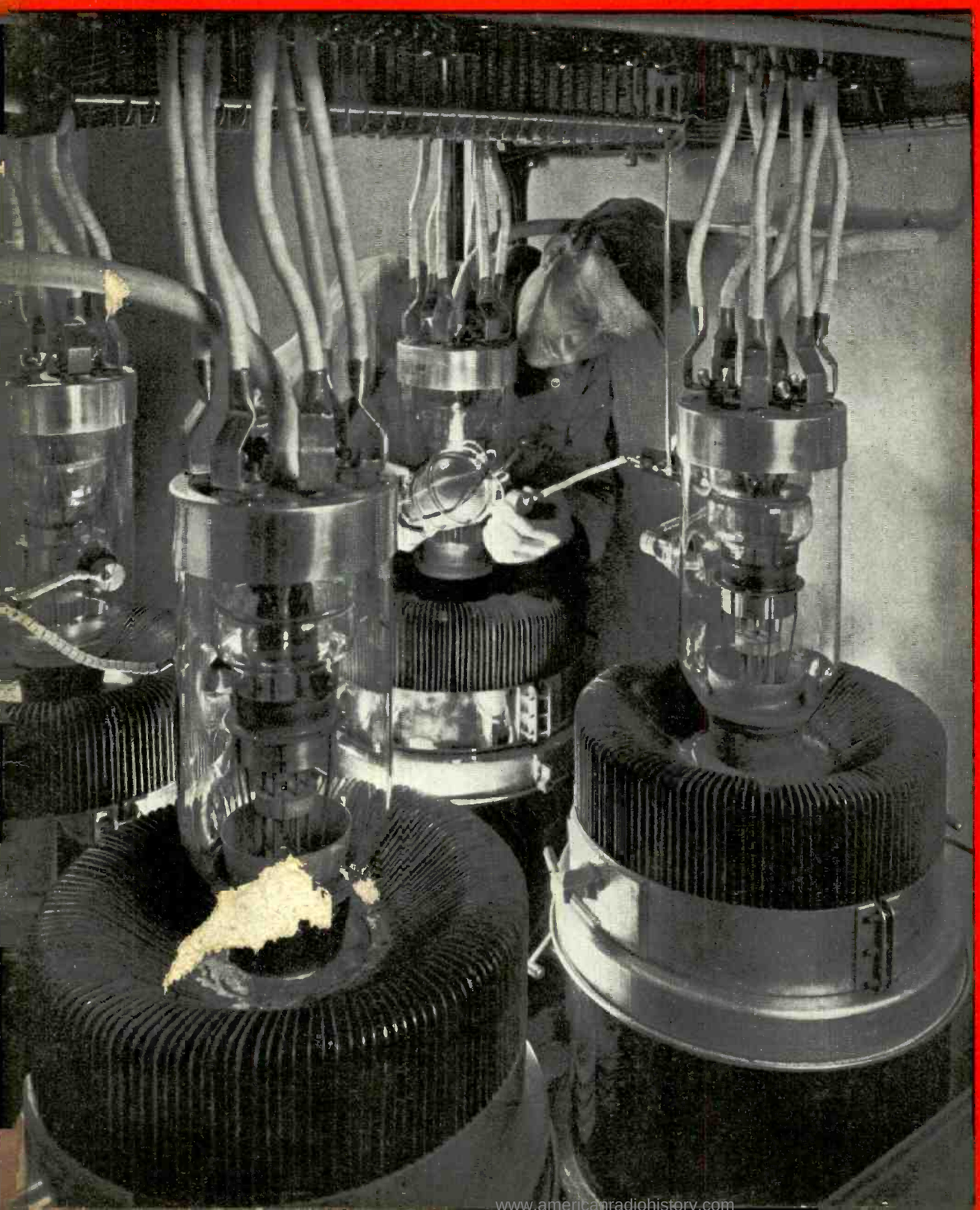
electronics

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



MAY
1940

Price
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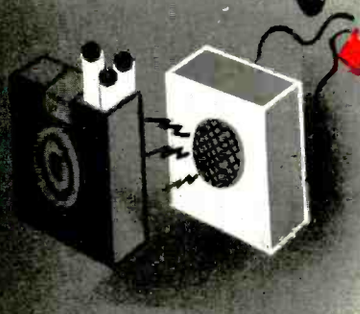
Of Weight and Such



Hearing aid units combining microphone and vacuum tube amplifier have been reduced in size to a point where they are no larger than a package of cigarettes. Part of this program was made possible by the UTC output reactors providing 75 HYS.-.5 MA. in a 6/10 OUNCE unit.

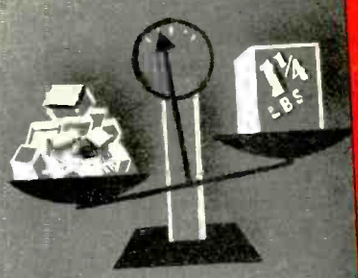
One of the devices, now being manufactured with UTC transformers makes possible physical measurements of ONE MILLIONTH INCH.

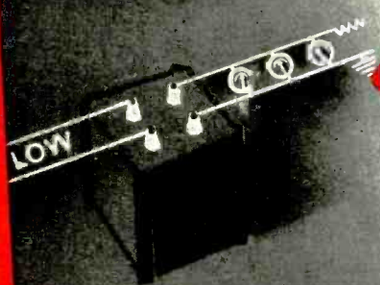
Brain wave amplifiers require negligible phase shift and amplitude distortion down to one-half cycle. Output coupling for these units has been made possible by new UTC transformers suitable for HALF CYCLE operation.

Power transformers for aircraft equipment must be light. A typical 100 WATT UTC unit now weighs 1½ POUNDS.

One special UTC output reactor weighs only 35 OUNCES PER 100 UNITS, yet employs 8,000 TURNS of wire in the coil.

A still unparalleled UTC aircraft filter weighs only 1¼ POUNDS, yet contains TWO OUTPUT TRANSFORMERS, SIX HIGH "Q" CHOKE COILS, and SIX CONDENSERS totalling FOUR MFDS.



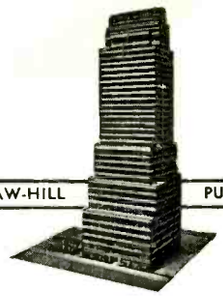


The capacity loss of shielded cable is generally important only at high frequencies. In a special high gain SIXTY CYCLE UTC transformer, however, the capacity loss of the shielded lead is over 2 DB PER FOOT. COAXIAL CABLE is needed in this case, FOR 60 CYCLES.

UNITED TRANSFORMER CORP.

150 VARICK STREET ★ NEW YORK, N. Y.

EXPORT DIVISION: 100 VARICK STREET NEW YORK, N. Y. CABLES: "ARLAB"



A McGRAW-HILL PUBLICATION

electronics

CONTENTS—MAY, 1940

DEPARTMENTS

ELECTRONICS, May, 1940. Vol. 13, No. 5. Published monthly, price 50c a copy. Subscription rates—United States and possessions, Canada, Mexico and Central American countries, $5.00 a year. All other countries, $6.00 a year or 36 shillings. Entered as Second Class matter, August 29, 1936, at Post Office, Albany, N. Y., under the Act of March 3, 1879.
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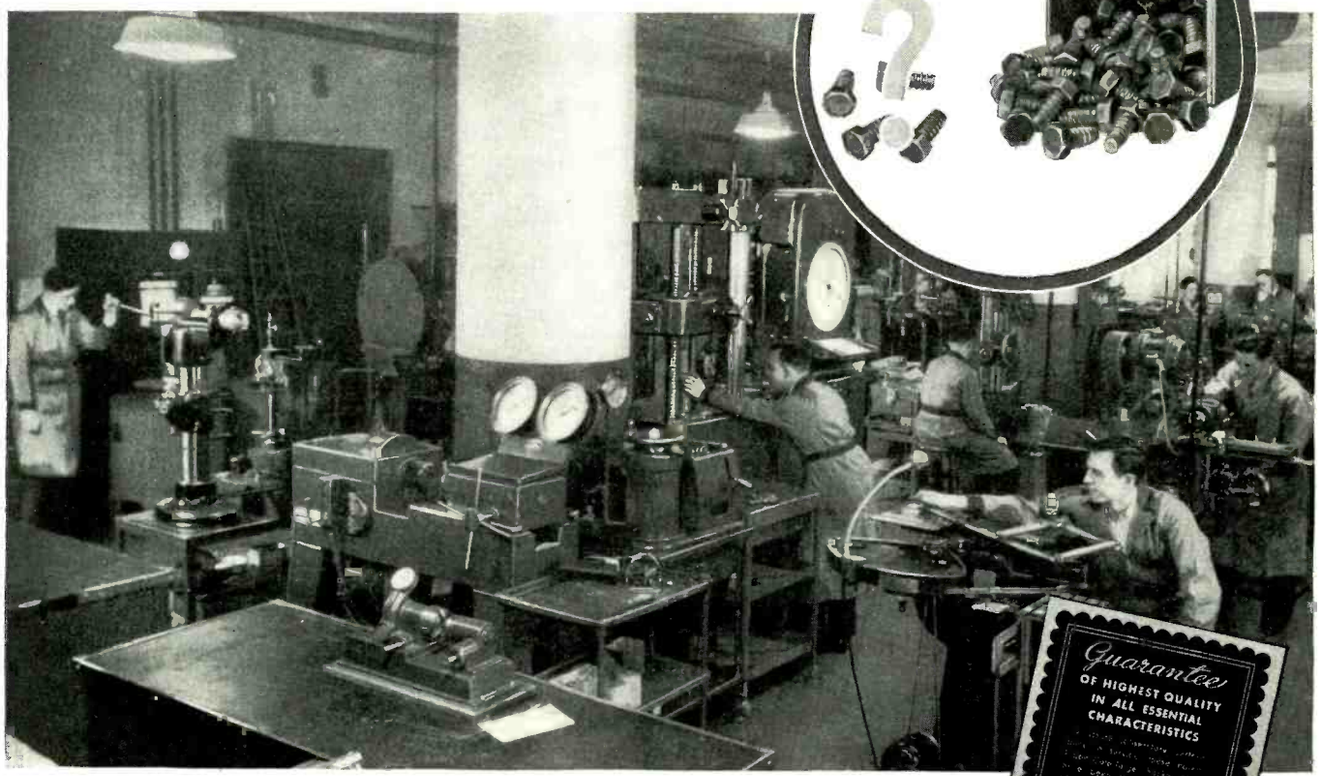
NO *Doubtful Few*

To "Gum-Up" Fastening Jobs



. . . When Parker-Kalon's Quality-Control Laboratory guarantees fastening devices

EVEN a few imperfect screws in a box can "gum-up" assembly work . . . waste time, boost costs, fail to make satisfactory fastenings. That's why thousands of plants specify Parker-Kalon and avoid all troubles caused by the "Doubtful Few."

Parker-Kalon Fastening Devices are made to standards that permit no "Doubtful Few" . . . standards that could only be attained when Parker-Kalon established a $250,000 Quality-Control Laboratory. Without counterpart in the industry, this laboratory applies a unique scientific control-routine to insure that Parker-Kalon Fastening Devices always work right and hold tight.

It pays to buy Hardened Self-tapping Screws, Socket Screws and other fastening devices that are made in the most modern plant in the screw industry. Parker-Kalon Corp., 192-194 Varick St., New York.

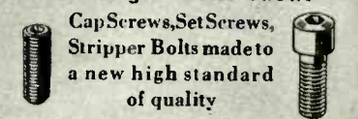
SOLD ONLY THROUGH RECOGNIZED DISTRIBUTORS

Quality-Controlled **PARKER-KALON Fastening Devices**

COSTS NO MORE *to get this Parker-Kalon Quality-Control Guarantee with every box of . . . .*

Hardened Self-tapping Screws
Types, sizes, head-styles for every assembly of metal or plastics

Cold-forged Socket Screws



Cap Screws, Set Screws, Stripper Bolts made to a new high standard of quality

Wing Nuts-Cap Nuts-Thumb Screws
Cold-forged . . Neater, Stronger

they may look alike

but what a difference in performance!

Ball players or capacitors . . .

they look pretty much alike reporting for duty. The rookie pitcher and the veteran wear the same uniform. They may even use the same wind-up. But what a difference in performance! In the seasoned pitcher's sureness, in his stamina and dependability you recognize experience.

Behind the "uniform" of today's capacitor units, there's a difference, too. Put to the test, one capacitor — CORNELL-DUBILIER — outperforms the field in life expectancy, dependability, surviving economy. Reason: Cornell-Dubilier's thirty years of manufacturing experience. Experience is the yardstick knowing engineers use in measuring capacitor value. That is why there are more C-D capacitors in use today than any other make.

IT PAYS TO SPECIFY CORNELL-DUBILIER FOR EVERY CAPACITOR REQUIREMENT.

CORNELL-DUBILIER ELECTRIC CORPORATION
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ONLY CORNELL-DUBILIER DRY ELECTROLYTICS offer all these features

Type BR

Reg. U. S. Pat. Off.

- Exclusive electro-chemical etching process—eliminating corrosion
- Hi-pressure centrifuge impregnation—resulting in better impregnation and lower power factor
- Special C-D super purity cellulose separator—gives longer life expectancy
- Double ageing—assures uniform and stable electrical characteristics
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The Type BR etched foil electrolytics are available in both single and dual capacity combinations. For complete technical information, send for engineering bulletin.

REMEMBER! ALL C-D CAPACITORS ARE UNION MADE AND ARE COMPETITIVELY PRICED

specify CORNELL-DUBILIER!

THE WORLD'S LARGEST MANUFACTURER OF CAPACITORS...

FOR NEW TEST REQUIREMENTS OF *Frequency Modulation*

1. F.M. assigned channels 40 to 44 mc. — band width 100-200 kc.
2. F.M. intermediate frequencies 2 to 5 mc. — each stage aligned at exactly the same point.
3. Checking limiter and discriminator circuits.

WESTON Model 787
U.H.F. Oscillator

WESTON Model 776
direct-reading Oscillator

WESTON Model 772
Super-Sensitive Analyzer

HERE ARE THE ANSWERS:

1. The WESTON Model 787 is the only service Oscillator which reads 40 kc. per division at 40 mc. This precise tuning is absolutely essential to test the band width of F.M. receivers. Each instrument is individually hand calibrated at 2 mc. intervals. (The broad frequency coverage of Model 787...from 22 to 150 mc. fundamental frequencies...safeguards against obsolescence in the event of changes in assigned channels.)

2. The WESTON Model 776 Oscillator supplies an absolutely stable signal source. Laboratory tests have shown that the frequency drift is less than .05% at 5 mc. for an operation period of several hours. This stability is the result of newly improved control circuits. With Model 776, too, an individually hand calibrated scale insures dependable accuracy over its entire frequency range of from 50 kc. to 33 mc., fundamental frequencies.

3. Because of frequency limitations of present visual aligning equipment, current measurements down to 1 microampere offer the only means of checking I.F. alignments, cut-off point on limiter tube, and adjustment of discriminators. WESTON Model 772 Super-Sensitive Analyzer offers all ranges necessary to make these sensitive measurements; *plus* additional ranges for all customary voltage, current and resistance measurement needs.

Full particulars on the above instruments are available in bulletin form, and will gladly be sent on request. Weston Electrical Instrument Corporation, 618 Frelinghuysen Avenue, Newark, New Jersey.

WESTON *Instruments*

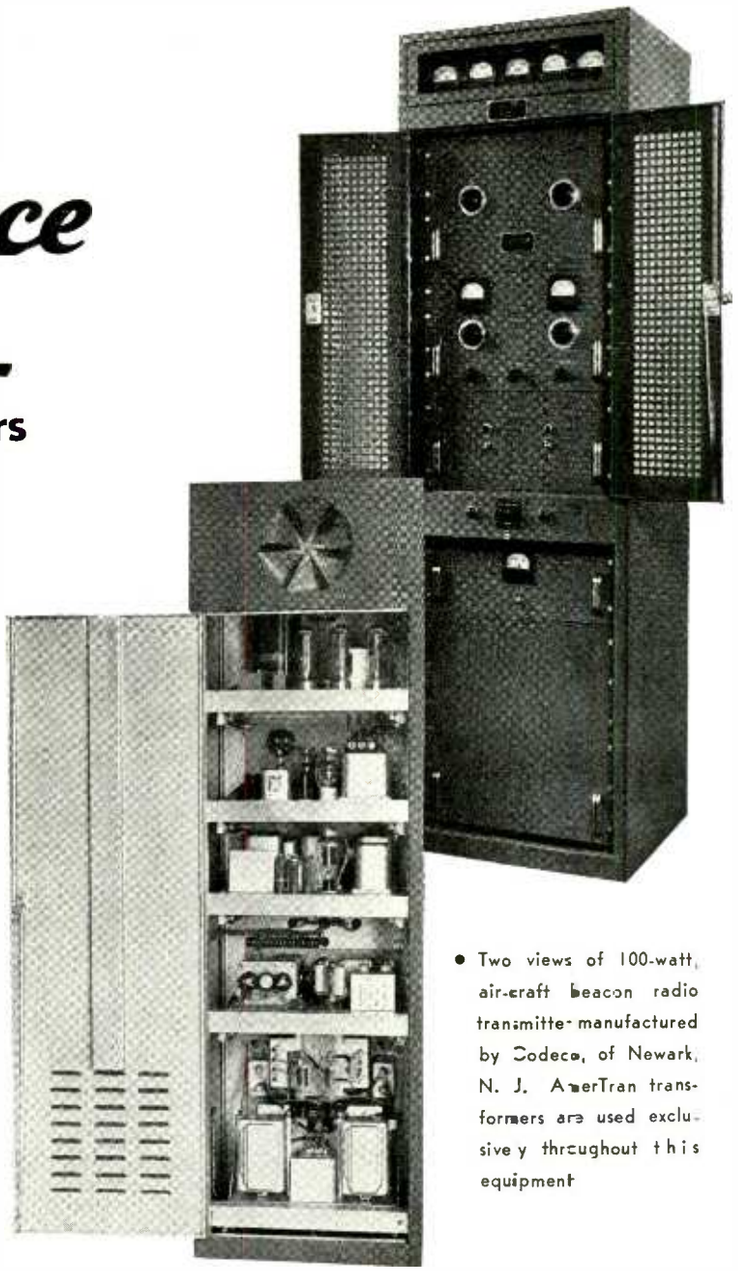
Where Performance Counts

AmerTran Transformers

Selected by Codeco

for use throughout their

Air-craft Beacon Transmitter



• Two views of 100-watt air-craft beacon radio transmitter manufactured by Codeco, of Newark, N. J. AmerTran transformers are used exclusively throughout this equipment

The safety of human life depends upon the reliability of air-craft beacon radio transmitters. When flying under adverse weather conditions pilots in commercial airplanes must frequently rely entirely on radio signals to guide them into port. This explains why so many manufacturers of radio apparatus for air-craft service specify AmerTran Transformers throughout for their designs. They have learned through experience that equipment bearing our trade-mark is always properly designed and constructed to meet requirements imposed by operating conditions.

Let us submit data on apparatus for your requirements. AmerTran transformers are available for every electronic application; are manufactured by a firm with 35 years' experience in supplying the radio industry.

AMERICAN TRANSFORMER CO.

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AMERTRAN

Manufactured Since 1901

at Newark, N. J.

Only 5/100ths of 1% Returns Out of a Million

*FP (Fabricated Plate) CAPACITORS

TRADE MARK REG. U. S. PAT. OFF.

THAT'S *Performance!*

Over 5,000,000 FP capacitors have been used in original equipment. Representative radio manufacturers** who collectively purchased 1,000,000 FP capacitors in 1939 were selected for an accurate check of their field returns. Of these 1,000,000 FP capacitors only 512 were returned and found defective—5/100 of one per cent! That's performance!

If you use Capacitors, the only thing that could keep a thrill of envy from running down your spine over a record like this would be that you yourself are using FP (Fabricated Plate) Capacitors made by Mallory.

Every leading radio set manufacturer has benefited from the tremendous investment Mallory has made in the development of the FP Capacitor. Benefits include not only greatly reduced initial costs, but more important, freedom from field trouble and elimination of service costs.

Take the time to investigate your field returns and service costs on the capacitors you have used and compare your figures with Mallory performance.

With FP Capacitors (made by Mallory) it is unnecessary to consider added gadgets that mean increased costs, to reduce your service charges.

Remember, there's a whale of a difference between an imitation and FP's made by Mallory.

Before you specify, investigate and compare. You'll buy Mallory if you do!

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MALLORY

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*Not etched construction

**Names submitted on request

CROSS TALK

► **DIPOLES** . . . Now that television has the green light (or has it?) and now that FM has a similar signal (or has it?) the matter of how to get the programs out of the air and into a receiver becomes of paramount importance. No longer can one toss a wire up in the trees or around the molding or in the attic and hope to get good results. At least that is true out where we live on Long Island, some 15 miles from Manhattan and some other, unknown, distance from Alpine, Carteret, or Long Island City where Armstrong, WOR and WQXR respectively have their FM transmitters.

Alpine, W2XMN, of course, comes in like a house afire and knocks the noise out of the receiver so that we get very fine reception. The only trouble is that the evening programs are no good. W2XR and W2XOR do not have the power nor the height of Alpine and can be heard but very poorly. At times we can also hear WDRC's FM transmitter coming across Long Island Sound.

The thing to do is to erect a better receiving antenna. So we buy some rubber-covered 2-conductor lampcord, make a doublet, nail it on a board and climb on top of the house. This works better but the discovery is made, toute de suite, that doublets are highly directional, especially in the null direction. What seems to be best for one station is not so hot for another. Still there is considerable noise on the desired stations, and so we must climb higher or persuade the transmitters to boost the power or climb higher with *their* antennas.

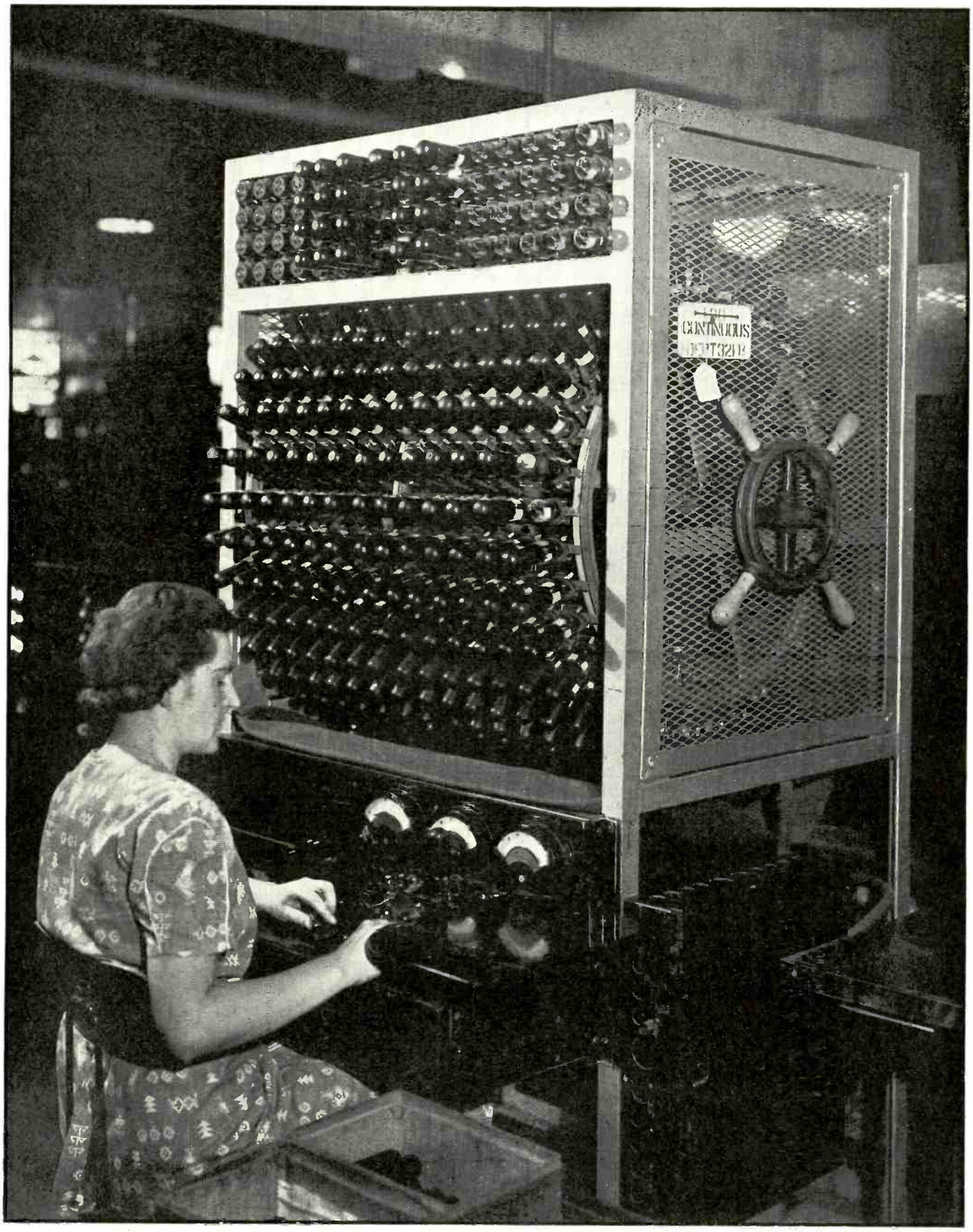
There is nothing new or remarkable about this business, of course, and the point in calling attention to it is the fact that antennas for receiving FM and television are going to be matters which must have attention. Readers are encouraged to read Stanford Goldman's article in this issue; manufacturers are encouraged to develop efficient antennas which are not going to offend the taste of the neighborhood by their appearance—for such antennas are going to be distinctly visible if they are to bring in results.

► **WAR** . . . In England, unfortunately at war, the people are showing a logical increase of interest in radio. A very large increase in licenses took place in September (41,323 new listeners) and many of the new sets went into dug-outs and air-raid shelters. Prices have risen about 10 per cent owing to increased cost of raw materials; manufacturers have been busy, particularly with battery operated receiver orders. Tubes and magnets may not be exported except under license, but this does not apply to these components when installed in receivers. Some trouble has been had with lack of experienced labor and some shortage of raw materials has been felt. The industry hopes to keep exports up to its annual high figure (£942,168 in 1938.)

✦ **ORIENTAL REQUEST** . . . *Electronics* has received a request for technical bulletins from Tsu-te Yang, U. O. Box 103/D4, Siking, Schansi, China. Mr. Yang would like manufacturers to send him catalogs of measuring instruments, tube manuals, wire tables, and catalogs of resistors, condensers, transformers. "I suppose you would excuse the handicap we have been suffering," he says.

Let us hope there are American manufacturers who can spare a catalog to Mr. Yang, who like all Chinese, is indeed suffering under a handicap at the present time.

► **MISCELLANY** . . . In *Yachting*, March 1940, appears an advertisement of the Pierce and Kilburn Boat Yard, Fairhaven, Mass., in which readers are invited to call by radio phone when in trouble.This is probably the first ad suggesting that people use radio's aid to small boat owners . . . In Europe a new allocation of medium and long wave broadcast stations was worked out at the Montreux conference. Scheduled to go into operation March 4, the plan will not take effect because of the European war . . . Passengers abroad airliners would rather listen to the Captain than to the hottest radio program of the air—so says a release from TWA. It's our guess that a lot of them would rather listen to one Stewardess than to three Captains . . . One evening per week Aerovox Corp. holds school to teach employees more about the products they make. Record attendance is reported, even though it is voluntary . . . A few years ago one of McGraw-Hill's most active editors was Allan H. Mogensen, now an industrial consultant. Mr. Mogensen's forte is to get things done quicker or with less effort and certainly with less cost. He does not achieve his ends by any sort of "speed up" but by educating employees how to be less awkward, how to simplify work. He makes pictures with a motion picture camera of operators at work; then shows them how clumsy they really are, even though the operators feel sure they have doped the best possible way to do the job. Mr. Mogensen's thesis is that all employees should think; and that processes of mind are not restricted to the front office. Of recent summers he has been training top executives and foremen at Lake Placid in a Work Simplification Conference, of which several companies engaged in our industries have taken advantage.



ON THE MARCH . . . In regimental formation, these type 333A cold-cathode glow tubes are being aged in the tube shop of the Western Electric Company on a large cylindrical rack. Each of 500 tubes stays on the rotating rack 3 hours, then is tested for starting voltage, voltage drop, and starting current. The 333A is used for selective ringing circuits on party lines.

Television and the F.C.C.

Green Light or Red Light

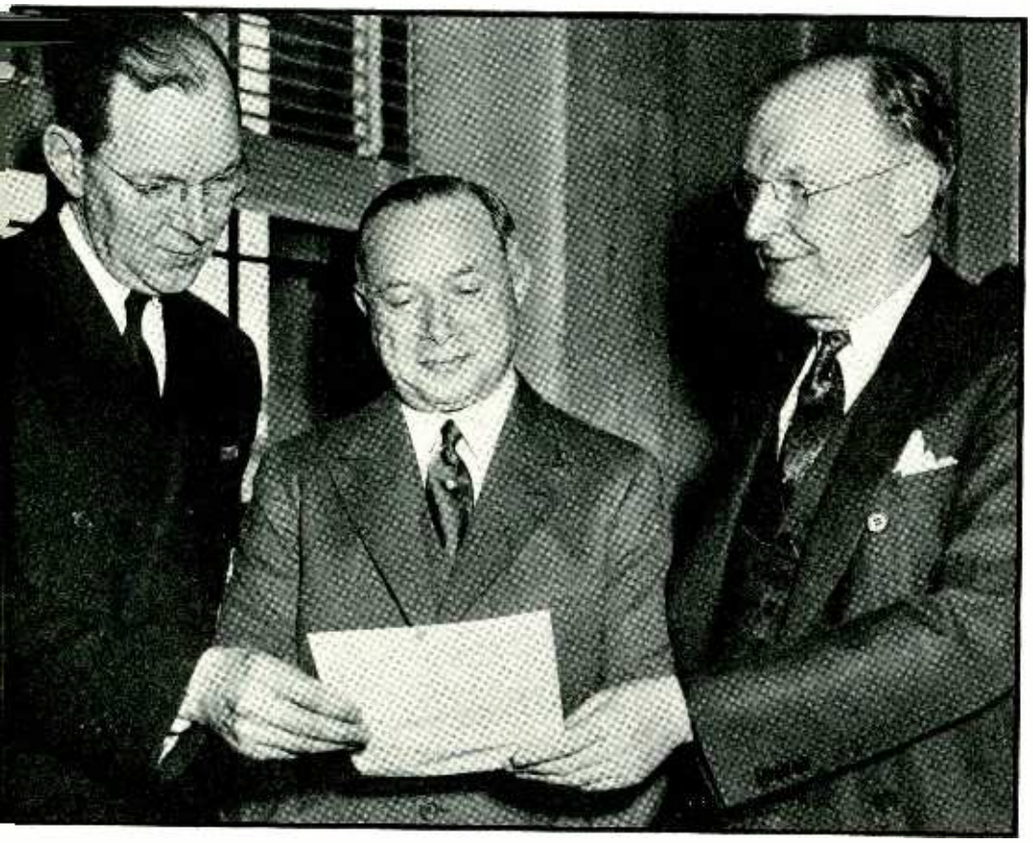
THE month of April, 1940, deserves a special place in the history of television development in the United States, for during that month the industry and the government came to grips on a matter of great technical and social importance. The question was that of television transmission standards, particularly their effect on the public investment in television equipment and on the future progress of the art. This innocent topic provoked a discussion in the public press and over the national networks the like of which the electronic field has not seen for many a year. By the end of the month, the shouting and the fury had died down to a whisper, and it looked as though the television industry had come out of the fray considerably stronger and surer of its ground than it had been before the rumpus started. All of which makes an exciting story for everyone interested in the progress of the electronic arts.

The story is a large one, involving political, sociological, and economic as well as technical elements. Here we will refer briefly to the non-technical background, reserving the remaining space for a critical comparison of the various technical proposals which were offered. For those who desire to read a complete account of the political angles, the editors recommend the April 15th issue of *Broadcasting* which has covered the situation thoroughly.

The story starts with the hearings held before the Federal Communications Commission early this year regarding the desirability of permitting limited commercialization of television broadcasts. At that hearing the industry revealed itself as rather sharply divided on the advisability of going ahead on the basis of the R.M.A. Television Standards. The largest group, including R.C.A. General Electric, Farnsworth and most of the smaller independents, gave support to the R.M.A. Standards, but Philco and Dumont urged two different proposals. The difference between them lies in the number of lines in which the picture is scanned, and in the number of frames sent per second. The R.M.A. figures are 441 lines, 30 frames. Philco urged 24 frames and 605 lines. DuMont urged 15 frames and 625 lines. Philco in addition urged vertical polarization of the transmitted waves, primarily because it permits a simpler type of self-contained antenna in receivers.

These proposals were no doubt highly sincere expressions of opinion (although in the heat of the later discussion the parties were accused either of trying to "beat the gun" or to "delay matters until the laggards could catch up"). Their effect on the F.C.C. was, however, only too obvious. If the industry was unsettled on standards, certainly the Commissioners could not be sure that any set of standards was correct. So when the Commission issued its order of February 29th, establishing September 1st as the date on which limited commercial operation of television stations would begin, it pointedly refused to set up any standards of transmission. The inference was that each broadcaster would use the standards he liked best, and the public would buy receivers adapted to the standards in use in each community. Here the trouble started. Later the Commission was forced to admit that any such plan was unwise and probably not feasible. What proved it to be unwise was what happened when the R.C.A. Manufacturing Company tried to proceed on that basis. This company began, early in March, an extensive selling effort, offering their standard line of television receivers at prices reduced 33 per cent or more, in the New York area. Full page newspaper ads were used, dealer meetings were held, and it was evident that a major campaign was underway, with a goal of selling perhaps 25,000 receivers by the end of the year. The R.C.A. receivers were designed for the R.M.A. Standards, which are in use in all the transmitters on the air (including those in New York, Chicago, Los Angeles, and Schenectady).

Then the F.C.C., with Commissioner Craven dissenting, stepped in and on March 24th announced that the order allowing limited commercial broadcasting had been suspended, pending a hearing on April 8th. The reason given was the sales



IS EVERYBODY HAPPY?

Three of the leading figures in the television investigation: (left to right) James L. Fly, Chairman of the F.C.C., the body which precipitated matters by suspending an order allowing limited commercial operation; David Sarnoff, President of R.C.A. whose company's promotional activities were under scrutiny; and Senator Burton K. Wheeler, who presided over the meeting of the Senate Interstate Commerce Committee to consider the desirability of investigating the F.C.C.

activity of R.C.A. which, the Commission believed, would have the effect of "freezing" the standards in accordance with the R.M.A. proposals. The Commission declared that it alone had the authority to fix television standards, and that any indirect fixing of the standards by commercial activity was to be stopped at its inception.

Then the rumpus started in earnest. The newspapers at once took up the torch for television, pointed out that the F.C.C. had no authority over advertising, or over the manufacture or sale of receivers, and no right to decide the merits of selling practices in the radio field. The Commission was accused of stifling an infant industry which might offer employment to thousands, even hundreds of thousands of workers. The Republican newspapers, in particular, in editorials and syndicated feature columns took the Commission to task for exceeding its authority. In Congress no fewer than three separate actions were taken to investigate the F.C.C.'s activity in the television field. Senator Lundeen of Minnesota introduced a motion to investigate the Commission for retarding television and exceeding its authority. Senator Barbour of New Jersey introduced a bill to amend the Communications Act, specifically to strip the Commission of any power to regulate radio research, experimentation, manufacture or sale. Representative Connery of Massachusetts introduced a resolution in the House, seeking a sweeping investigation of the F.C.C.'s activity in radio generally.

In light of the pressure from the newspapers, Chairman Fly thought it expedient to go on the air to explain his views (and in so doing had the misfortune to cost the N.B.C. network some $10,000 due to cancelled programs, which fact was not lost sight of by the newspapers). Mr. Fly's statement was lucid, and in the light of its premises, very convincing. The basic premises were two: (1) that the relationship of a television receiver to a transmitter is like that of a key to a lock, hence any major change to the transmitter in the interests of improvement would render the receivers useless, and (2) that the public was not sufficiently informed of this fact and should not be encouraged to buy receivers without full knowledge of the experimental, perhaps even temporary, nature of the broadcasting service.

From this statement, the radio industry took its cue. It had only to prove that the lock-and-key theory was false, or at least wrongly interpreted, and to offer to protect its customers against the effects of changing standards. When the April 8th hearings opened, the testimony almost without exception was to the effect that sufficient flexibility could be built into transmitters and receivers, at extra but not unreasonable cost, to allow the use of any standards permitted within the limitations of the 6 Mc channel assigned to television stations. Not all agreed that such flexibility was worth the price it would cost, but all did agree that it could be achieved. The R.M.A. supporters, as well as Philco and DuMont, retained their former positions regarding the desirable numbers of lines and frames, but each group agreed that a receiver could be built capable of operating on all three proposals. The extra cost involved was variously estimated at from 5 to 40 dollars per receiver.

The witnesses at the hearing were also of the opinion, almost unanimously, that if such flexibility in the standards were available, no harm would come from commercial operation of television stations. Furthermore, it was admitted that such commercial operation would make possible additional research into programming techniques, which is equally as important from the standpoint of the public interest as the technique of the transmission.

This evidence, presented to the Commission by competent witnesses from nearly every company in the field, threw a very different light on the matter. Added to it was the increasing political pressure in the press and in Congress. Soon it became apparent that the Commission had both the opportunity and the necessity of making a reappraisal of

the whole situation. Chairman Fly after a conference with President Roosevelt said he was confident that a solution of the difficulty would be found quickly, which would lead to a speedy opening of the field to complete commercialization. Action was taken at once on the application of the DuMont Laboratories for a "public-program service" television station to be located on the skyscraper at 515 Madison Avenue, New York. This license was granted, and it was understood that the standards proposed by DuMont would be offered to the public and that receivers would be available for comparison between the two systems. (DuMont had testified that his receivers would receive either the R.M.A. standards or his proposed standards.)

At the time of writing, no further announcement has been made by the Commission concerning its future intentions, but the "informed gossip" in Washington has it as follows: That the pending licenses for television stations will soon be acted upon, and those granted will be subject to operation on a set of standards prescribed by the Commission. The standards will be set within limits, as to number of lines and number of frames, and each station must be able to operate at any value of lines or frames technically feasible within these limits. Possibly a single set of values of the lines and frames will be specified as a starting point, or offered as preferred engineering practice, with the understanding that changes to other values may be found desirable and required at a later date. Representations will then be made to the receiver manufacturers (possibly through the Radio Manufacturers Association) for assurances that the sets offered to the public will contain a similar degree of flexibility, so that the receiver may be adjusted readily (preferably by the owner himself) to any changes which may be made in the transmission standards. Such assurances received, the Commission then is expected to authorize full commercial operation of class 2 (public-program-service) television stations, possibly as early as September 1st, but probably early in 1941. The "limited" commercial operation is not now held in favor by anyone.

If any such program actually comes to pass, it is likely that television will be off to a much bigger start than if no government action had taken place. Under the influence of the great publicity of the past month in the newspapers, the American public is definitely television conscious, and realizes also that the government has taken its stand on what it considers to be the public interest. If the Commission, its objections satisfied, gives the new art its blessing, sale resistance will be a function only of the selling price of receivers and the quality and availability of programs, all of which are squarely up to the industry.

What Are the Optimum Standards?

In the meantime there is opportunity for the engineers in the industry to review the situation and decide on, or at least present the arguments for, the optimum values of the disputed standards. Perhaps no single optimum values exist, but it is highly desirable that there be some starting point, and this point must be decided on the basis of sound engineering philosophy, backed up by demonstrations in practice.

In the first place it must be understood that the basic limitation to the number of frames per second is based on the human sense of sight, while the basic limitation to the number of lines in the picture, when the frame rate has been decided upon, is determined by the available channel width in the ether. Actually the relationship, assuming equal vertical and horizontal retrace ratios, is as follows[1]:

$$f_{max} = \frac{k(w/h)mfn^2}{2} \text{ cps}$$

where f_{max} is the maximum frequency in the video range produced by scanning a picture whose width-to-height ratio is w/h, transmitted f frames per second, with n lines per frame, with horizontal resolution m times the vertical resolution, and with vertical resolution equal to k times the number of active lines in the picture.

The ratio w/h has been set at 4/3, and this standard has not been questioned. The ratio k between number of lines and vertical resolution may be given the value 0.8 as representative of most actual conditions, although values as low as 0.6 and as high as 0.9 have been suggested. If equal resolution in vertical and horizontal directions is desired, m has the value 1 (although the picture quality is not seriously impaired if values as high as 1.5 or as low as 0.6 are employed). The maximum video frequency is limited, by the 6-Mc channel width, to a value somewhere between 4.0 Mc and 4.5 Mc. Assume that 4.3 Mc is the practical limit, if interference is to be avoided with the sound channel using practical band-pass circuits. Then for each of the proposed frame rates (DuMont, 15; Philco, 24; R.M.A., 30) a corresponding number of lines may be calculated. For the DuMont proposal the number of lines is 735; for the Philco proposal 580; for the R.M.A. case 518. These are theoretical calculations. The actual values chosen should preferably be odd numbers composed of odd factors, to allow odd-line interlacing without complications. Hence DuMont chose 625 (5x5x5x5); Philco 605 (11x11x5); R.M.A. 441 (3x3x7x7). It will be noted that the R.M.A. value is somewhat out of line with the theoretically calculated values. A close value to the theoretical for the R.M.A. case would be 507 lines (13x13x3).

From this reasoning it appears that the R.M.A. standard of 441 lines is somewhat on the low side. It should be remembered, however, that the value of 441 lines was chosen with double sideband operation in mind, i. e. $f_{max} = 2.5$ Mc and with $k = 0.64$, $m = 1$. When single sideband became feasible and f_{max} become 4.0 to 4.5 Mc, the number of lines was not increased, but rather the horizontal resolution was allowed to increase relative to the vertical resolution, giving a value of m about 1.6. This improved the picture quality by nearly the same degree that increasing the number of lines would have allowed, but produced improvement in detail only in the horizontal direction. One possible advantage of having this higher degree of horizontal resolution is that it gave the receiver manufacturer some tolerance. Thus if the effective bandwidth in a receiver falls below 4.0 Mc (and this may be said to be true of most present-day receivers) the resolution ratio falls back toward unity, rather than away from unity which would occur if the number of lines had been increased.

(*Continued on page* 79)

[1] The complete derivation of this equation may be found in "Principles of Television Engineering," by D. G. Fink, McGraw-Hill Book Co., 1940, pp. 52–54 and 184–189.

An Electronic Switch for Fluorescent Lamps

The combination of a new thermal switch using a gas-discharge and series inductance eliminates the necessity of high voltage transformers to produce the transient voltage required to start fluorescent lamps

By R. F. HAYS

Westinghouse Lamp Division
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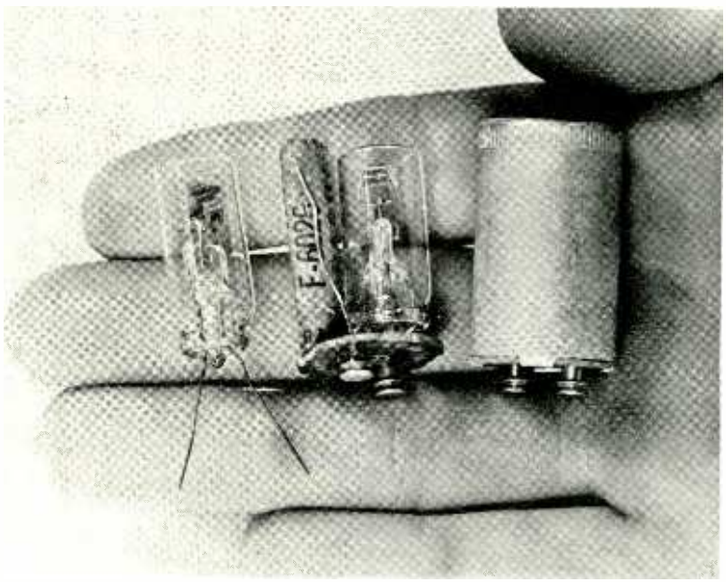
EVER since fluorescent lamps were introduced, starting and restarting them has been something of a problem without any satisfactory solution. A 15- or 20-watt lamp may be operated from a 115-volt a-c line, once the arc is started, but voltages as high as 400 may be required to start it. If the lamp electrodes are preheated so that they emit a copious supply of electrons, the arc may be started at 200 or 300 volts. Preheating also prevents blackening at the ends of the lamp and insures long life.

A new electronic switch, known as the Glow-switch, has simplified starting and embodies a new engineering principle, for it is a thermal switch without a heater. It starts fluorescent lamps quickly under conditions which contribute to long lamp life. Because of its small size and simple construction, it can be produced by automatic machinery at a low cost.

Since the lamp has a negative volt-ampere characteristic, it must be operated in series with an inductance which serves to limit the flow of current. The most simple circuit, then, consists of a lamp in series with an inductance and a switch connecting the electrodes in series for preheating, as shown in the diagram.

The Glow-switch serves to make and break this connection automatically. As shown in the photograph it consists of a glass bulb filled with a rare gas and containing a pair of contacts one of which is actuated by a strip of thermostatic bimetal. Normally the contacts are open so that when line voltage is applied its full value appears across the switch. This voltage establishes an abnormal glow discharge between the bimetal and a contact welded to a lead wire. Heat produced by the glow discharge causes the bimetal to deflect and close the contacts, short-circuiting the discharge so that no more heat is produced. After a short time, during which current flows to heat the lamp electrodes, the bimetal cools and disengages the contacts. The sudden interruption of current flowing through the inductance produces a transient voltage sufficient to strike the arc in the lamp. The voltage drop across the lamp is not high enough to maintain the glow discharge in the switch, so the contacts remain open and no energy is consumed. If for any reason the arc in the lamp does not strike the first time, the contacts quickly close and open again.



Left to right, the Glow-switch, the switch and parallel condenser to reduce radio interference, and the complete unit mounted in an aluminum can

Since the duration of the transient voltage is very short, its value must be somewhat greater than the steady voltage necessary to strike the arc. Special steps had to be taken to make the transient high enough to insure reliable starting. The familiar expression $e = L \frac{di}{dt}$ is inadequate in this case. The transient voltage should be thought of as being equal to the product of current at the instant the contacts open and the resistance of the switch at that instant, or the current divided by the conductance of the switch. To produce a high voltage the conductance must be small. This conductance is a result of arcing at the contacts and of re-establishment of the glow discharge.

Since perfectly smooth surfaces do not exist, the current is carried by a single microscopic point connec-

tion just as the contacts separate. Because of its small size the resistance of this point is so high that it may be melted and even vaporized by the flow of current. The hot spot on the contact supplies electrons by thermionic and field emission and the hot vapor serves as an excellent conductor, so that arcing occurs. To minimize arcing, the contacts should be made of a material with good heat and electrical conductivity, high melting and vaporizing temperature, and high work function. For these reasons tungsten was chosen. Since the use of tungsten reduces the amount of vaporized contact material to a minimum the arc is carried largely by the gas with which the switch is filled. Hence, the lower the gas pressure, the lower the conductance.

Conductivity of the glow discharge, which is re-established by the transient voltage and simultaneous application of line voltage, is proportional to the surface area of the electrode serving as cathode and proportional to the square of the gas pressure. The conductivity from this source has been reduced to a minimum by using only one strip of bimetal and welding the other contact to the lead wire as close to the press as is possible without cracking the glass, thereby reducing the surface area of one electrode to a minimum. Of course the highest transient voltage is produced only when this electrode serves as cathode for the glow discharge at the instant the contacts open, which will average half the time. This is of little importance since the contacts open and close quite rapidly.

Effect of Pressure

The lower the gas pressure, the higher the transient voltage which may be produced; but other factors must be considered in choosing the pressure. For a given voltage across the glow discharge the current which flows to heat the bimetal varies as the square of the gas pressure. The higher the pressure, the faster the contacts close. As the switch is used, atoms of gas are driven into the electrodes by the high-voltage surges and gas is also cleaned up by metal particles sputtered from the electrodes. As the gas pressure is reduced by clean-up below a critical point, the striking voltage increases rapidly and the switch soon becomes inoperative. Furthermore high gas pressure increases the life of the contacts. The final choice of gas pressure was a compromise between speed of operation, reliability of lamp starting, and life of the switch. Coating the bimetal with magnesium and shaping it so as to form craters into which the discharge is concentrated results in a considerable increase in the amount of heat produced. This makes it possible to have the contacts close at such a high temperature that operation is practically independent of ambient temperature. The combination of the magnesium coating and a filling of neon and argon results in an r-m-s breakdown voltage of 80, which is safely above the highest lamp voltage of 63 and well below line voltage.

Applying high voltage to a fluorescent lamp with cold electrodes causes such terrific ionic bombardment that the life of the lamp is shortened and the ends of the bulb are blackened by material being sputtered off the electrodes. It is highly desirable that the Glow-switch contacts remain closed until the lamp electrodes are hot before the high transient voltage is applied. The necessary time delay is produced by corrugations in the bimetal.

Concentration of the glow discharge in these corrugations causes this part of the bimetal to heat much faster than the central part. After the contacts close, heat flows to the cooler central part. Since contact motion is due almost entirely to temperature changes at this point, the contacts are held together for a while even though the total amount of heat in the bimetal is decreasing. The time delay is determined by the distance from the central part of the bimetal to the craters formed by the corrugations. By the time the contacts open the heat is quite uniformly distributed so that a very small gain or loss of heat will cause the contacts to close or open again. Consequently, if the lamp does not start on the first try, the cycle is quickly repeated but without the time delay which is unnecessary when the lamp electrodes are already hot.

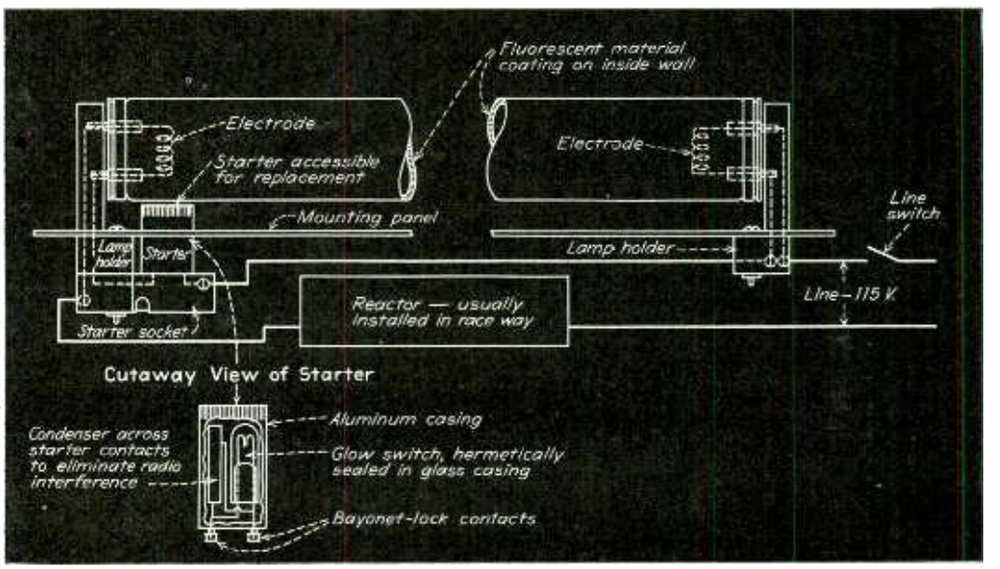


Diagram showing circuit and installation of the Glow-switch and fluorescent lamp. The electrodes of the lamp are preheated so a low starting voltage may be used

In order to simplify wiring, the Glow-switch and a condenser for eliminating radio interference are placed inside a small aluminum can. The can is fitted with a two-pin base which plugs into an extension of the lamp socket.

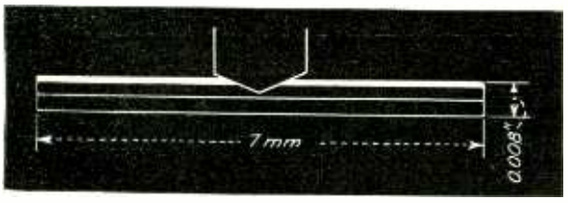
If a lamp refuses to start because of loss of emission of the electrodes, the switch operates continuously in an effort to start the arc and in doing so is worn out. Under such a condition of continuous operation it will last 6 to 7 days. Under normal conditions the switch will start a lamp approximately a million times. With a 115-volt line the device starts lamps in 1 to 1½ seconds under conditions which are ideal for preserving lamp life and appearance.

Photoelectric Tape Recording

A recording method in which the recording is done by mechanical engraving and without further processing is ready for reproduction by photoelectric means. A great advantage of this system is the ease of editing the program after its recording has been completed

IN recent years sound recording systems have been designed in a great variety of forms. One of the more interesting is that developed by the Miller Broadcasting System. This system is at present being used to broadcast over the Mutual network the "College of Musical Knowledge" program after it is originally broadcast by another chain of stations.

The recording medium is an acetate-base tape consisting of three distinct layers of material. The acetate base is similar to the base used in motion picture film. The center layer is a special emulsion through which the cutting stylus can cut freely. These two layers are transparent. The third layer is very thin and very densely opaque. It is this thin layer of opaque material which is removed to form a variable-width sound track. The advantage of this method of recording is that all processing subsequent to the actual cutting of the record is eliminated and the tape is ready for playback immediately. As a matter of fact, there is provision on the recording unit for the program to be played back one-third of a second after it has been recorded.



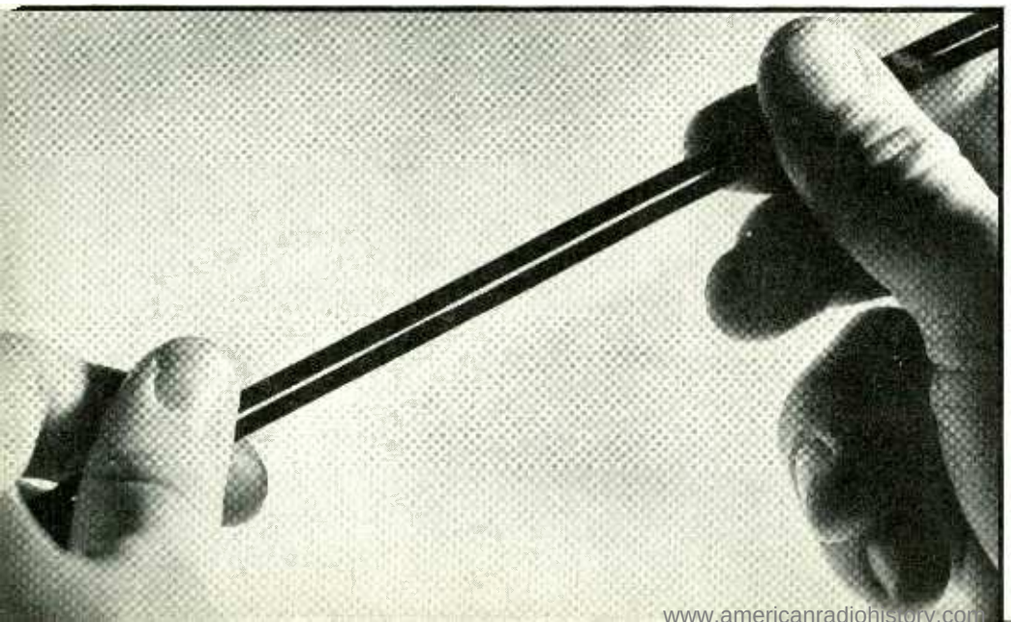
Cross section of the recording tape showing the three layers of material. The deeper the stylus cuts, the more opaque material it removes

In addition to the advantages in the production of the recordings due to the mechanical simplicity of the system, an important advantage is gained because of the ease of editing the program after it has been recorded. It occasionally happens that after a program has recorded and the cast dismissed, an error is found. Instead of calling back the entire cast, it is sometimes only necessary to eliminate that part of the tape by cutting it out and splicing together the ends of the tape. An example of this type of correction is in the case where one of the cast used the word "Mrs." instead of "Miss." The portion of the tape containing the second syllable of Mrs. was eliminated and the script corrected with a minimum loss of time and little annoyance. If the correction requires the substitution of words instead of elimination of words, it is necessary to call back only those members of the cast involved and have them speak the words necessary for the change and substitute the correct tape for that originally recorded. Sometimes, to get the proper accent or emphasis on a word it is necessary to speak the entire sentence, in which case the unwanted parts of the repeated words are discarded and only the wanted words are used.

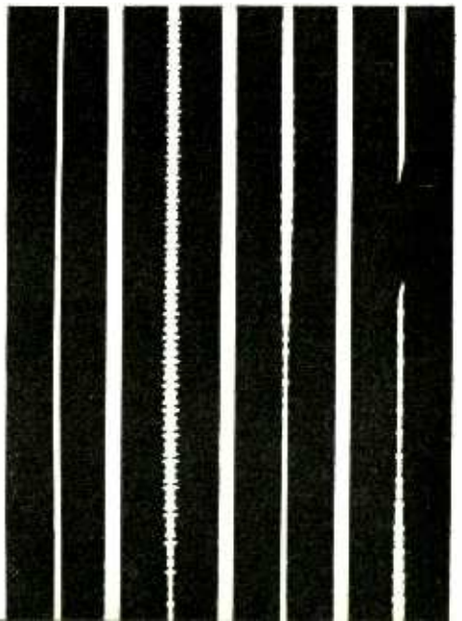
Ease of Editing the Program

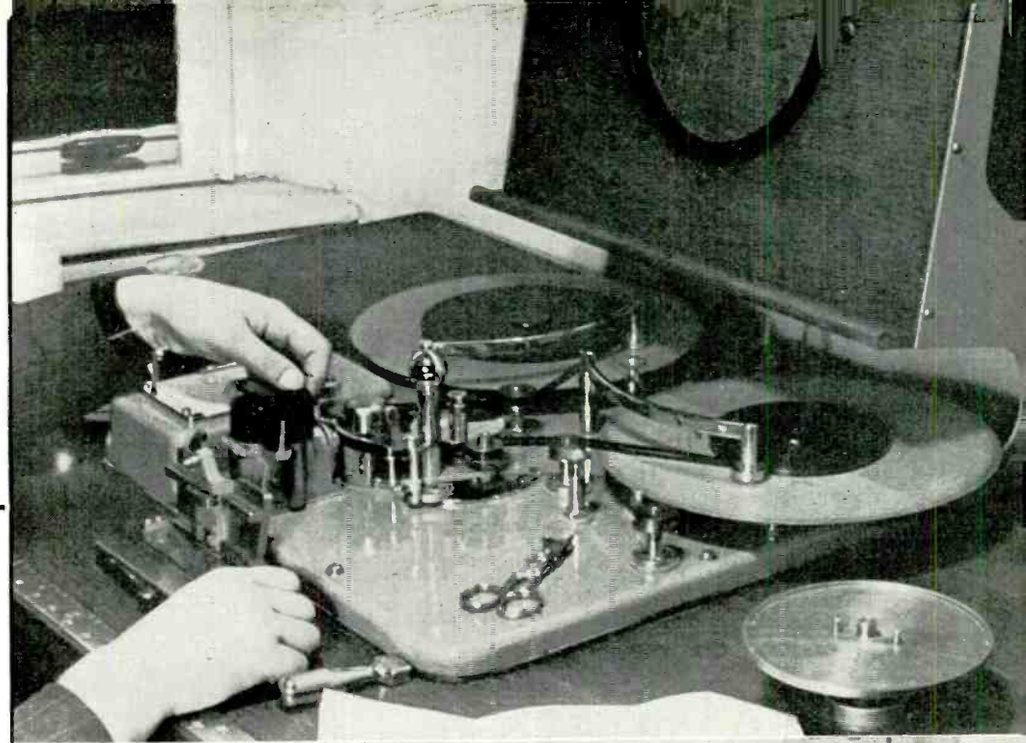
Sometimes a program is recorded and is found to be too long to fit into the time assigned to it by the broadcast station. The remedy for this is to reproduce it at a rate just a little faster than normal by substituting drive wheels of a slightly

The variations in the transparent portions may be seen in this photograph. After the mechanical cutting process, the tape is immediately ready for playback by photoelectric means

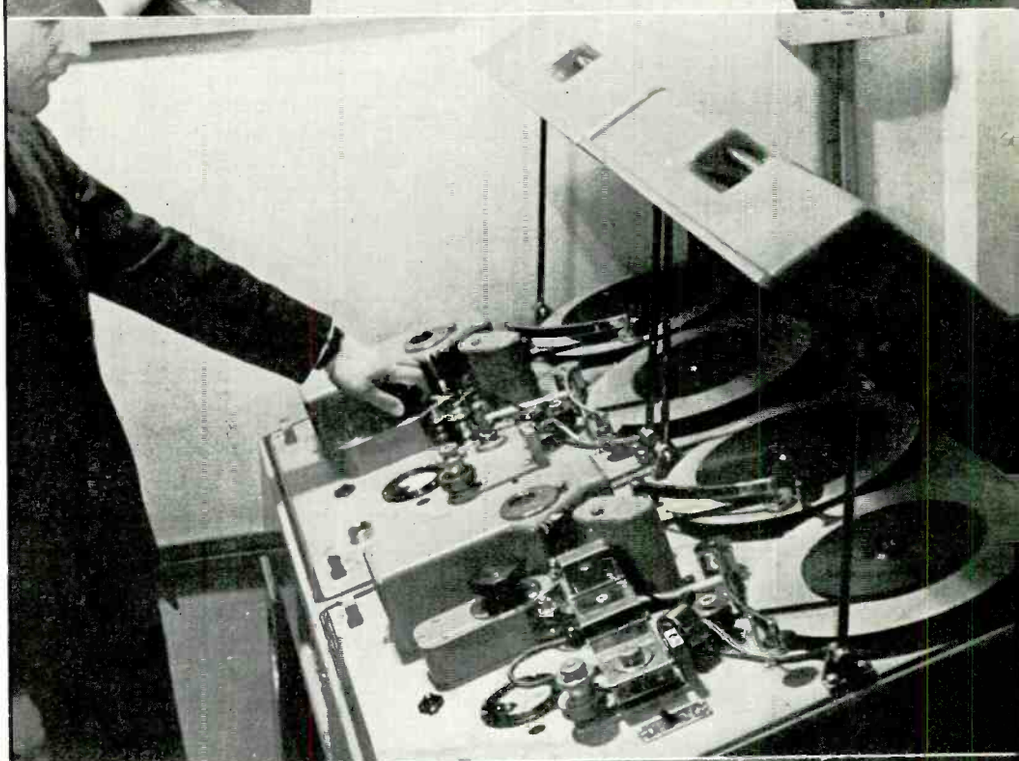


Four portions of tape showing sound track with zero signal, a loud signal, variation in track width to prevent overmodulation and a splicing patch which produces no audible effect

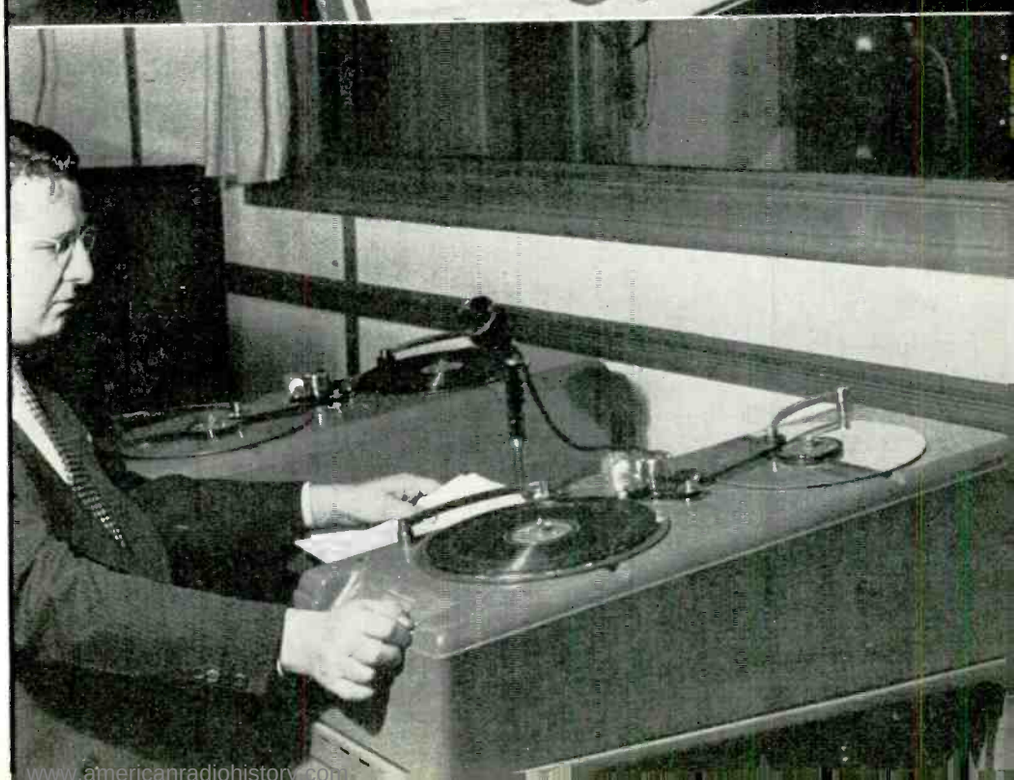




The editing machine shown here permits easy localization of the portions of the program which are to be edited



The dual recording unit permits the recording of long programs. Playback occurs one-third of a second after recording



Dual reproducing unit. A unique method of cueing permits switching over from one unit to the other at any convenient time during the 30 seconds of dual operation

different size in the driving mechanism. Thus, if a program one hour in length is about 20 seconds too long, it will be shortened by about one-half per cent. This means that all tones will be increased in pitch by about one-half per cent. This, however, is not very serious because so few people are able to detect such a small difference in the frequencies of musical sounds or the human voice.

If it should happen that it is not possible to start recording from the beginning of the program, a simple remedy is available. Such an occasion can arise for a variety of reasons, for instance, the previous program may run a fraction of a minute overtime, and the incoming program (which is to be recorded) starts on time, but is not available to the recording studio until the channels are cleared of the program just ending. In this case the first half minute or so of the program which generally includes the commercial announcement is lost. The remedy is to use the commercial announcement of the week previous or of some other time and splice it on the beginning of the tape. In this way a complete program is provided.

It also happens at rare intervals that the quality of the music may be poor. Here, the answer is to use a recording of music played by the same orchestra at another time and substitute it in place of the faulty music. The editor of such tape recordings has considerable freedom in arranging the material for presentation to the audience. He may lengthen the program by the judicious addition of material or he may shorten it by using only the most interesting parts of it. As an example, the Good Will Hour as it was presented in its original form was

one hour long, but when it was rebroadcast it was only one-half hour long, the less interesting material having been deleted.

The applications of this system of recording are by no means limited to the broadcasting field. It is of great use wherever the recorded program requires revision or correction. One of its important applications is the recording and editing of material which is to be later re-recorded on disc records. Anyone engaged in the various phases of commercial recording will appreciate the advantages offered by the use of this type of recording in that the program as recorded must not necessarily be accepted as final, but may be changed and corrected to fulfill the conditions for which the record was made.

Detail of the photoelectric reproducing head. The tape is driven by means of the friction driving wheels

Mechanical Design

The mechanical layout of the recording unit is shown in the accompanying photograph. The tape is provided in lengths of approximately 1000 feet on reels very much like motion picture reels. The supply reel is on the right hand side of the apparatus. The tape is threaded through the machine in a very simple fashion. There is enough slack in the tape when properly threaded so that the total mass involved in starting or stopping is very small. Therefore the inertia is very small and the starting or stopping operation may be performed very rapidly.

Stylus Operation

The actual recording operation is performed by a sapphire stylus driven by a magnetic cutting head. The cutting stylus moves in a vertical direction relative to the surface of the tape in a manner determined by the frequency and amplitude of the impressed signal. The depth to which the stylus cuts is determined by the amplitude of the signal, the greater the amplitude, the greater the depth. Therefore, because of the wedge-shaped cutting surface of the stylus, greater portions of the opaque layer are removed when the tape is cut to greater depths. The angle of the point of the stylus is only a few degrees less than 180 degrees. Hence, even for signals of the greatest amplitude, the motion of the stylus is but a few thousandths of an inch. This is the basis by which a variable-width sound track is obtained. At the point of engraving, the tape is backed up by a highly polished steel base and is driven very uniformly at the rate of 60 feet per minute. In order to reduce noise to a minimum, a suction pump is used to draw off the small black particles removed from the tape by the engraving process. Otherwise, these small pieces might become attached to the tape in the sound track and reduce the amount of light reaching the phototube during reproduction, thereby causing background noise.

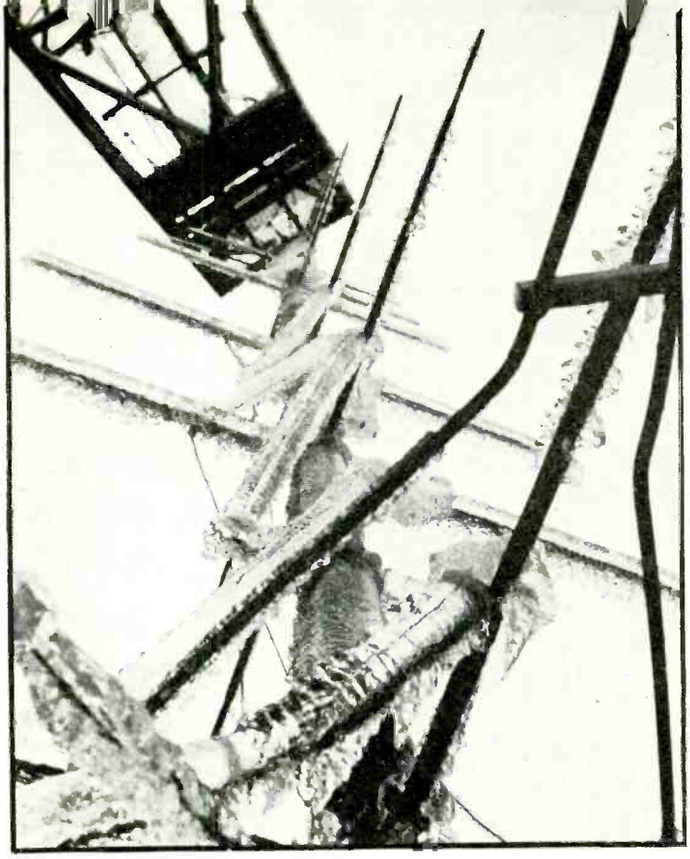
At a point four inches along the tape from the stylus there is located a phototube reproducing unit used for monitoring the recording. The monitoring takes place one-third of a second after recording, as determined by the speed of the tape and the length of tape between the recorder and the reproducer.

Provision is made so that the percentage of modulation in relation to the average width of the sound track is always at an optimum value. With zero signal to be recorded, the stylus will cut a narrow track of constant width. When a signal of relatively small amplitude is impressed, the fluctuations in the waves in the sound track are not very great and they are accommodated in the narrow track. If, however, a strong signal is impressed, the fluctuations become too great to be properly accommodated in the narrow track and a track of greater average width is cut. The track is made narrow or wide according to the strength of the impressed signal by taking a portion of the signal and passing it through a rectifier. The output of the rectifier is then applied to the coil of the cutting head as a d-c component which determines the average width of the sound track.

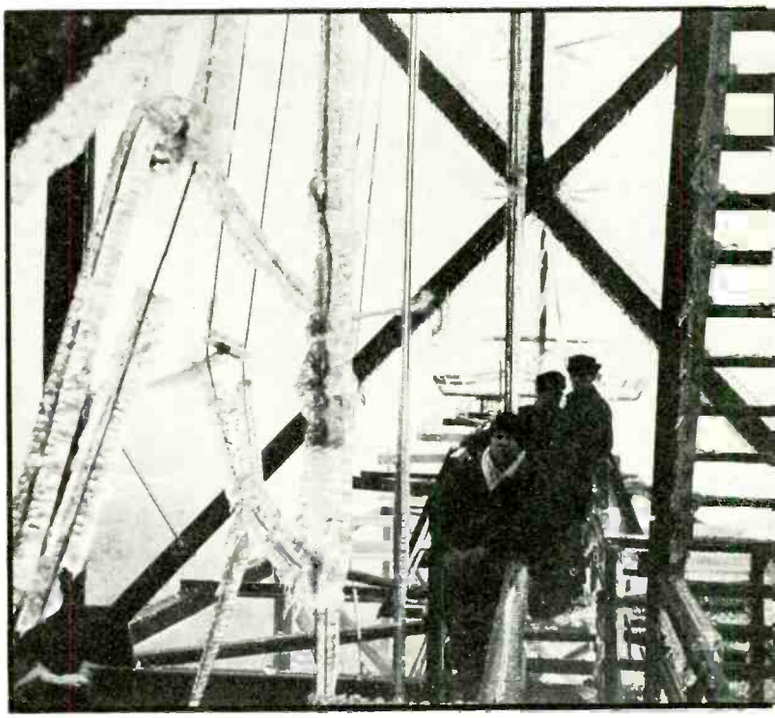
Programs to be recorded very frequently exceed in time of performance the capacity of one reel of tape. This circumstance requires the use of two recording units, and when the program is to be reproduced there are required two reproducing units. Each reel of tape will accommodate about fifteen minutes of recording. When the program approaches the capacity of the reel, it is recorded, not on one tape, but on two tapes for a period of about 30 seconds. At the end of this time the first recorder is stopped and the second unit is used to carry on the process. By an ingenious system of cue marks placed on the tapes during recording, switching over from one reproducer to the other at the proper instant becomes a very simple task. Just previous to the time when the program is being impressed on both tapes, a series of white marks are placed on both tapes in the same positions relative to the positions of the recorded material. During reproduction, when the first tape is nearing its end, a long warning cue mark appears at which time the operators get ready to start the new tape. A second, shorter warning mark appears at which time all is in readiness for starting the new take and at the appearance of the third mark (also a short one) the tape is started. The new tape then starts running past its photoelectric sound pickup head in synchronism with the first tape (which is still being used). At some convenient time within the next 30 seconds or so during which both tapes have recorded on them the same material, the switchover is made. It is generally made at some short interval during which there is no sound, but with a little practice on the part of the operator, it becomes quite simple to make the change during continuous music.—C.W.

ICE AGE Hits Alpine

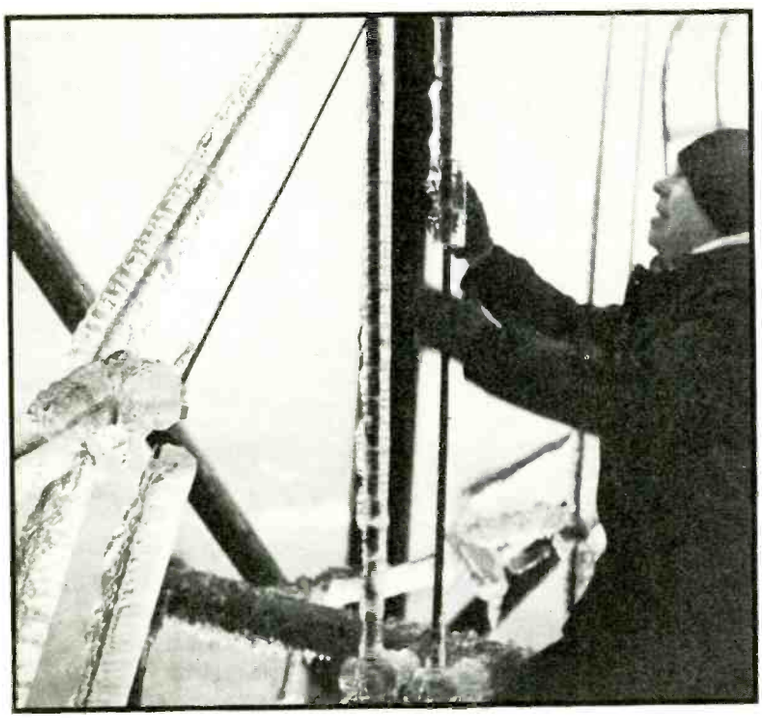
On March 4th last, the ice storm which visited the East laid down tons of ice on the tower of Major E. H. Armstrong's frequency modulation transmitter at Alpine, N. J. Fearing trouble, the Major, caretaker Paciello, and construction superintendent Fowler (left to right, below) climbed the tower during the storm, chipping ice from the stairs as they went. Arthur E. Linell of the Yankee Network was present and climbed along also to get these unusual pictures



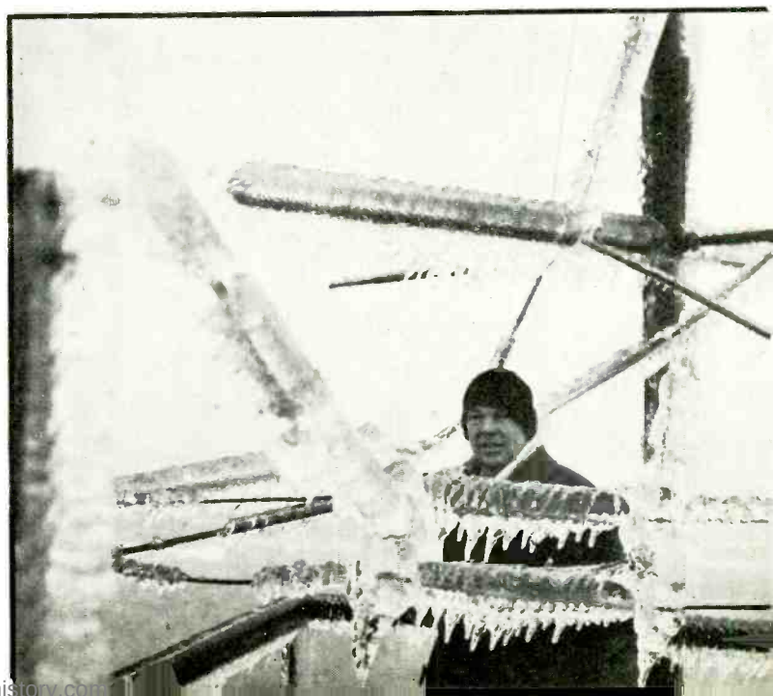
This view of the turnstile is from the same vantage point as that which appeared on the cover of *Electronics* in March 1939, with glacé trimmings added. The turnstile elements, feeder wires, and v-shaped matching section (lower right) were almost completely covered until the ice was broken away by the climbers. For a time, it was feared that a cross-arm of the tower might buckle under the extra weight, if solid sheets of ice were allowed to build up



At the foot of the turnstile antenna, the climbers found 2½ inches of ice on the north-east edge of every wire, ¼ inch on the opposite edge. On the insulators the ice was 4 inches thick in places. Nevertheless the station was ready to go on the air at any time during the storm, and only a power-line failure prevented a continuous schedule. Experience atop Mount Washington also has proved that ice does not short circuit an antenna array even if it totally encloses the structure



Although the weight of the ice exceeded many times the weight of the ¼-inch wires on which it formed, the conductors did not break and no damage was done during the storm. Later, when the ice melted and fell to the ground, it hit several ceramic insulators on the way down and shattered them. Here Major Armstrong shows the approved method of de-icing a matching stub. Note the distribution of the ice on the feeder wires at the left



DIPOLES and REFLECTORS —a Short Review

By STANFORD GOLDMAN
General Electric Co.

A DIPOLE antenna is commonly used for reception in the ultra-high-frequency band, in which television and f-m programs are now being broadcast. The reason for using a dipole at these frequencies, rather than the single wire antenna which is ordinarily used in the broadcast band, is that the former can be made sensitive and can readily be oriented to receive the desired signal, while the latter is in general either insensitive or is highly directional for the ultra-high-frequencies, and its direction of response cannot readily be changed to bring in the desired signal.

A Few Fundamental Considerations

Figure 1 shows how a dipole is connected to the input of a receiver. The signal picked up by the dipole is carried down the balanced transmission line to the input terminals. A properly balanced input system allows all pick-up along the transmission line to be eliminated, leaving only the signal generated at the dipole. In this way, the dipole can be located in the most advantageous location for reception, without too much concern about interference arising along the lead-in.[1]

While it is generally desirable to build up as much signal as possible on the antenna, the thing that really counts is how much signal is delivered to the grid on the first tube. Consequently impedance matching considerations are very important. Consider the circuit in Fig. 1. If Z_L is the characteristic impedance of the transmission line, and E_L is the voltage which the signal picked up by the dipole delivers at B, then the current at B is

$$i_B = \frac{E_L}{Z_L} \qquad (1)$$

If the transmission line is properly matched at the input circuit of the receiver, and n is the gain of the input transformer, then the voltage delivered to the grid of the first tube is

$$E_i = n Z_L i_B \qquad (2)$$

Consider next the antenna itself. The emf developed in the antenna by the current, i_B, is

$$E_A = i_B Z_A \qquad (3)$$

and Z_A is the impedance of the antenna at B. Now if e is the field strength of the incoming wave and h is the effective height of the antenna, then the power which the incoming wave delivers to the antenna is

$$e h i_B$$

By the conservation of energy, it follows that

$$ehi_B = i_B^2 (Z_L + Z_A) \qquad (4)$$

From the preceding four equations, we arrive at the formula

$$E_i = n e h \frac{Z_L}{Z_L + Z_A} \qquad (5)^2$$

In Equation (5), if h is measured in meters, and e in microvolts per meter, then E_i is measured in microvolts. In the derivation of Equation (5), attenuation of the signal along the transmission line has been neglected.

In order to make E_i a maximum, two impedance matching conditions should be met. In the first place, the gain of the input transformer should equal the square root of the secondary impedance divided by the transmission line impedance.

$$n^2 = \frac{Z_i}{Z_L} \qquad (6)$$

where Z_i is the impedance from grid to ground of the first tube. The second impedance matching condition for maximum gain is

$$Z_L = Z_A \qquad (7)$$

If the antenna is to operate in a narrow frequency band, conditions (6) and (7) can and should be met. If, however, the antenna is required to operate over a wide band, a compromise is necessary.

Equation (6) shows the desirability of having a low impedance antenna for reception, because this allows more gain to be obtained in the input transformer. Fundamentally, a low impedance antenna means higher antenna current, which in turn means that the power absorbed from the incoming wave, ehi_B, is larger.

Dipole Impedances

Figure 2 shows the calculated impedance Z_A (measured at B) as a function of frequency, of two 10 foot dipoles of one inch and one-half inch diameters, respectively. The abscissa in Fig. 2 is reactance and the ordinate is resistance. It may be seen in Fig. 2 that dipoles of smaller diameters have more reactance and have a greater range of impedance variation over the frequency band. This characteristic is similar to that of uniform transmission lines, the smaller diameter dipoles have more inductance and less capacitance per unit length and therefore have larger Q ratios and more impedance variation. The curves in Fig. 2 are approximately circular in shape with a slight inward spiral.

Several important conclusions can be drawn from Fig. 2 and the data used in plotting the curves shown there. In the first place, the statement frequently heard that a half wave dipole has an impedance of 73 ohms is found to be erroneous. The resistive component of the impedance of a half wave dipole is 73

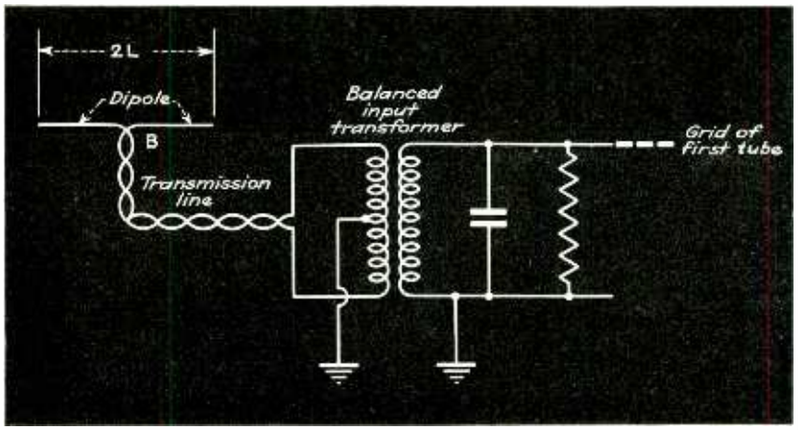


Fig. 1—Connection of dipole antenna to a receiver. When the transmission line and input transformer are properly balanced the antenna can be located in the most advantageous position

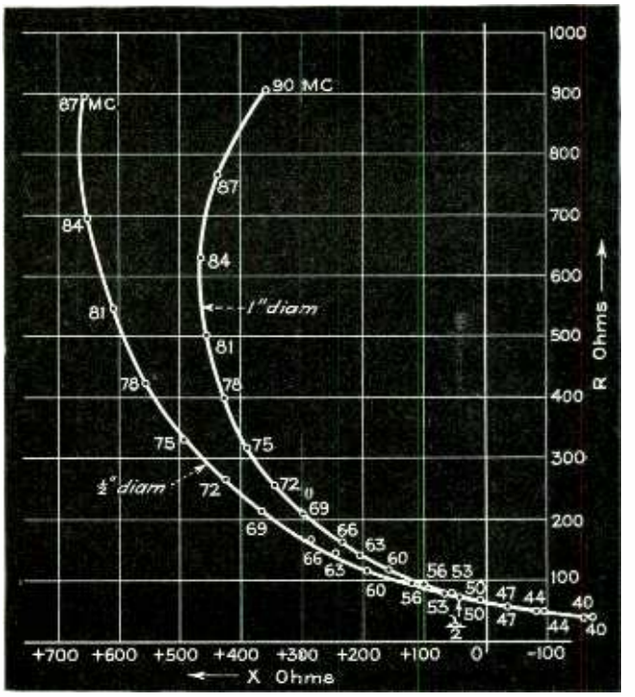


Fig. 2—Impedance diagrams of dipoles ten feet long. Note that the smaller diameter dipole has greater reactance and a greater impedance range

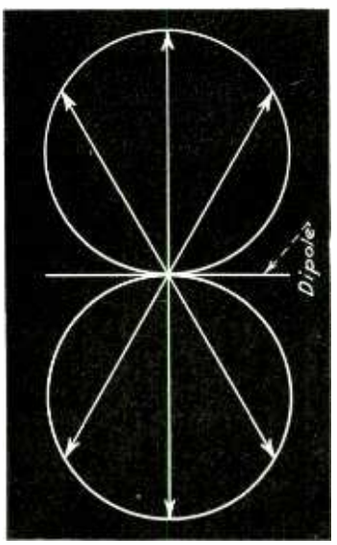
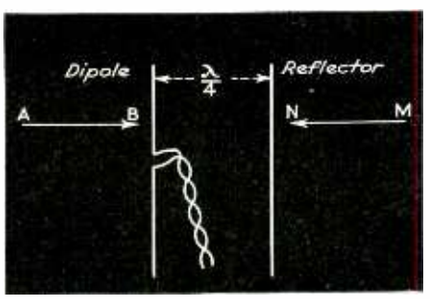


Fig. 3—Directional pattern of a dipole. Since radio waves exert transverse electic forces, the dipole detects only those forces directed along its length

Fig. 4—The addition of a reflector increases the sensitivity in the direction AB and decreases it in the direction NM



ohms, but such a dipole also has 42 ohms of reactance, so that its actual impedance is 84 ohms.[1] On the other hand, at the frequency at which the dipole is purely resistive its impedance is less than 73 ohms.

Either of the dipoles, whose impedance curves are shown in Fig. 2, is resistive when its length is about 95 per cent of that of a half wave. At this frequency its impedance is approximately 67 ohms. On the other hand, a wire dipole, because of its small diameter, may have an impedance as high as 70 ohms at the frequency at which it is resistive.

The less rapid change in impedance of larger diameter dipoles makes them more suitable for wide band reception, such as is desired in television. It should be noted that the proper transmission line impedance to match the dipoles (whose characteristics are shown in Fig. 2) over the band from say 44 Mc to 56 Mc should be at least 100 ohms, in order not to lose too much signal at the edges of the band. On the other hand, the comparatively narrow band requirements of the present frequency modulation transmissions, 41–44 Mc, makes it quite feasible to use a transmission line with a characteristic impedance of 70 ohms in conjunction with a dipole tuned to the f-m band, thus giving, in view of Equation (6) a somewhat higher sensitivity than could be obtained with a 100 ohm line.

Directivity

A dipole has considerable directivity and the directional characteristics of a simple dipole is shown in Fig. 3. The lengths of the arrows show the relative sensitivity of the dipole in various directions. It may be seen that the dipole is completely insensitive to signals travelling in the direction in which it is pointed. The reason for this directional pattern lies in the fact that radio waves are transverse, that is, the electric force of a radio wave is exerted perpendicular to the direction in which the wave is travelling, and the dipole picks up only that component of the force in the direction of its length.

The sensitivity and directivity of a dipole can be increased by using a reflector. A reflector in the simplest case is another dipole insulated from the receiving dipole and usually spaced behind it about one quarter wave length. Such an insulated dipole is called a "parasitic" or "radiation coupled" reflector. A diagram of a dipole and reflector array is shown in Fig. 4.

Reflectors

In order to explain the action of a reflector, the idea of the mutual impedance between elements of an antenna array is introduced. Suppose that a current, i_R, flowing in the reflector induces a voltage e_1 in the dipole and that a current i_D flowing in the dipole induces a voltage e_2 in the reflector. Then it can be proved by the Reciprocity Theorem that

$$\frac{e_2}{i_D} = \frac{e_1}{i_R} = Z_m \qquad (8)^3$$

Z_m is called the mutual impedance between the dipole and reflector.

Consider now the array in Fig. 4. If an incoming wave travelling in the direction AB generates a voltage eh_D cos ωt in the dipole, then due to the time taken for the wave to travel from the dipole to the reflector, the wave generates a voltage $e\ h_R$ cos $(\omega t - 90_0)$ in the reflector. Thus the currents in the dipole and reflector are determined by the Equations

$$h_D\, e \cos \omega t = i_D (Z_D + Z_L) + i_R Z_m \qquad (9)$$

$$h_R\, e \cos (\omega t - 90°) = i_R Z_R + i_D Z_m \qquad (10)$$

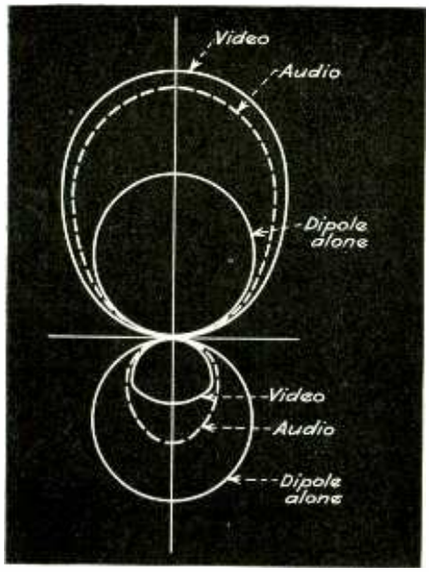


Fig. 5—Directional pattern of a dipole with a reflector, showing effects for video and audio signals separated by 4.5 megacycles

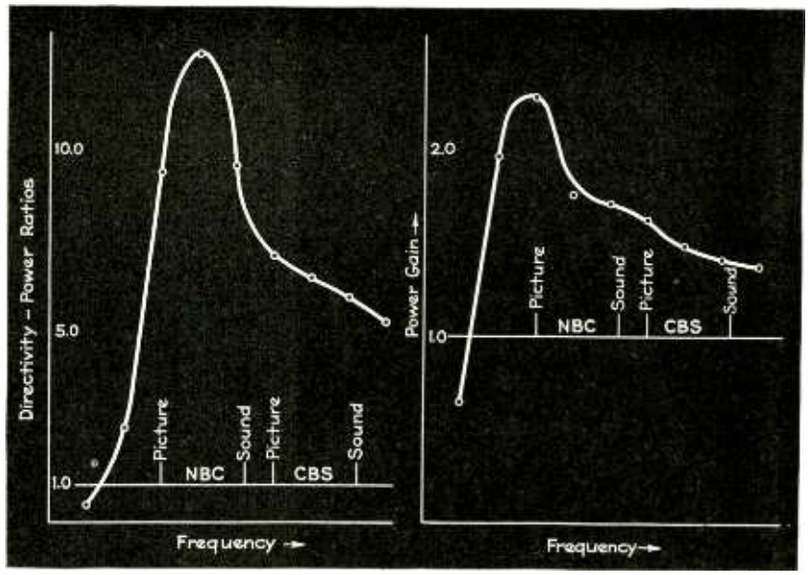


Fig. 6—Gain and directivity curves of a dipole and reflector array tuned to the television band. Note the loss of sensitivity in the forward direction slightly below the resonant frequency

where i_D and i_R are the dipole and reflector currents, Z_D and Z_R are the respective impedances, and h_D and h_R are the effective heights. Z_L is the impedance of the transmission line. If the spacing between the dipole and reflector is not a quarter wavelength, then the phase difference is no longer 90 degrees and must be changed accordingly in Equation (10). Solving Equation (11) shows that a para- obtain

$$i_D = \frac{h_D e \cos \omega t - \frac{Z_m}{Z_R} h_R e \cos\ (\omega t - 90°)}{Z_D - \frac{Z_m^2}{Z_R} + Z_L} \qquad (11)$$

Equation (11) shows that a parasitic reflector has two general effects on a dipole:

(1) It changes the apparent impedance of the dipole from its original value, Z_D, to a new value

$$\left(Z_D - \frac{Z_m^2}{Z_R}\right) \text{ and}$$

(2) It causes an additional voltage of amount

$$- \frac{Z_m}{Z_R} h_R e \cos (\omega t - \phi)$$

to be effectively generated in the dipole. In the latter expression, ϕ represents the difference in phase between the incident waves reaching the dipole and the reflector.

The first of the two above listed effects causes a change in the apparent dipole impedance, which effect varies with frequency. However, unless the reflector spacing is very close, so that Z_m is large, the change in the effective impedance is of secondary importance in comparison with the effect of the additional voltage. This latter causes the characteristic directivity introduced by a reflector, as well as the major part of the increased sensitivity. Furthermore, in it is contained the reason for the critical length of a reflector.

Examining the expression

$$- \frac{Z_m}{Z_R} h_R e \cos (\omega t - \phi)$$

it is seen that the angle, ϕ, has opposite signs for waves coming from the directions *AB* and *MN* in Fig. 4. Consequently, if the spacing between the dipole and reflector is $\lambda/4$, the voltage due to the reflector will be a subtracting voltage for a wave travelling in the direction *MN* if it is an adding voltage for a wave travelling in the direction *AB*. This is the explanation of the unidirectionality of a dipole plus reflector array. Figure 5 shows the measured directional pattern of such an array in the lowest television channel (44–50 Mc). The spacing in this case was somewhat less than $\lambda/4$ as a compromise design between the lower two television channels.

Since the length of the reflector is approximately $\lambda/2$, reference to Fig. 2 shows that the phase angle of Z_R changes rapidly with frequency. Furthermore, the change in phase of Z_m with frequency is such as to accentuate this effect. Consequently, the voltage due to the reflector

$$- \frac{Z_m}{Z_R} h_R e \cos (\omega t - \phi)$$

changes from an adding voltage to a subtracting voltage if the frequency is decreased by only a few megacycles. The result of this effect is shown in Fig. 6, where frequency characteristics are shown of the sensitivity and directivity of a particular dipole plus reflector array. It is seen that only a few megacycles below its resonant frequency, the array shows loss instead of gain in the forward direction.

The foregoing gives the principal facts regarding reflectors. A reflector is valuable for increasing the sensitivity of a dipole in a weak signal area, and the unidirectionality which arises with its use is particularly helpful in diminishing interference from sources in the rear.

REFERENCES

[1] For further information on dipole theory, see P. S. Carter—*Proc. IRE* June 1932 p. 1017. G. H. Brown—*Proc. IRE* Jan. 1937 p. 86.

[2] n, h, Z_L and Z_A have both magnitude and phase. When the system is operating at maximum efficiency, the phase angles of these quantities are all nearly zero.

[3] As is well known, the current and voltage distributions in a dipole are not constant but vary along its length. It is therefore necessary to specify the points at which the currents and voltages in Equation (8) are to be measured. Consequently it is specified that they are to be measured at the respective centers of the dipole and reflector.

A paper by the present author in the Nov. 1939 issue of the *RMA Engineer* may also be consulted. The figures of the present article are taken from the latter paper.

A Multi-Frequency Oscillator for Audio Testing

By JACK QUINN

The Human Engineering Laboratory of Stevens Institute of Technology needed for psychological research, records containing a series of pure tones of short duration, in rapid succession and evenly spaced in time. The records were made with the instrument described by Mr. Quinn. As the outstanding feature of this multi-frequency audio generator, 15 separate oscillators are made to beat with a single master oscillator in a sequence determined by perforations in a paper tape similar to a player piano roll.

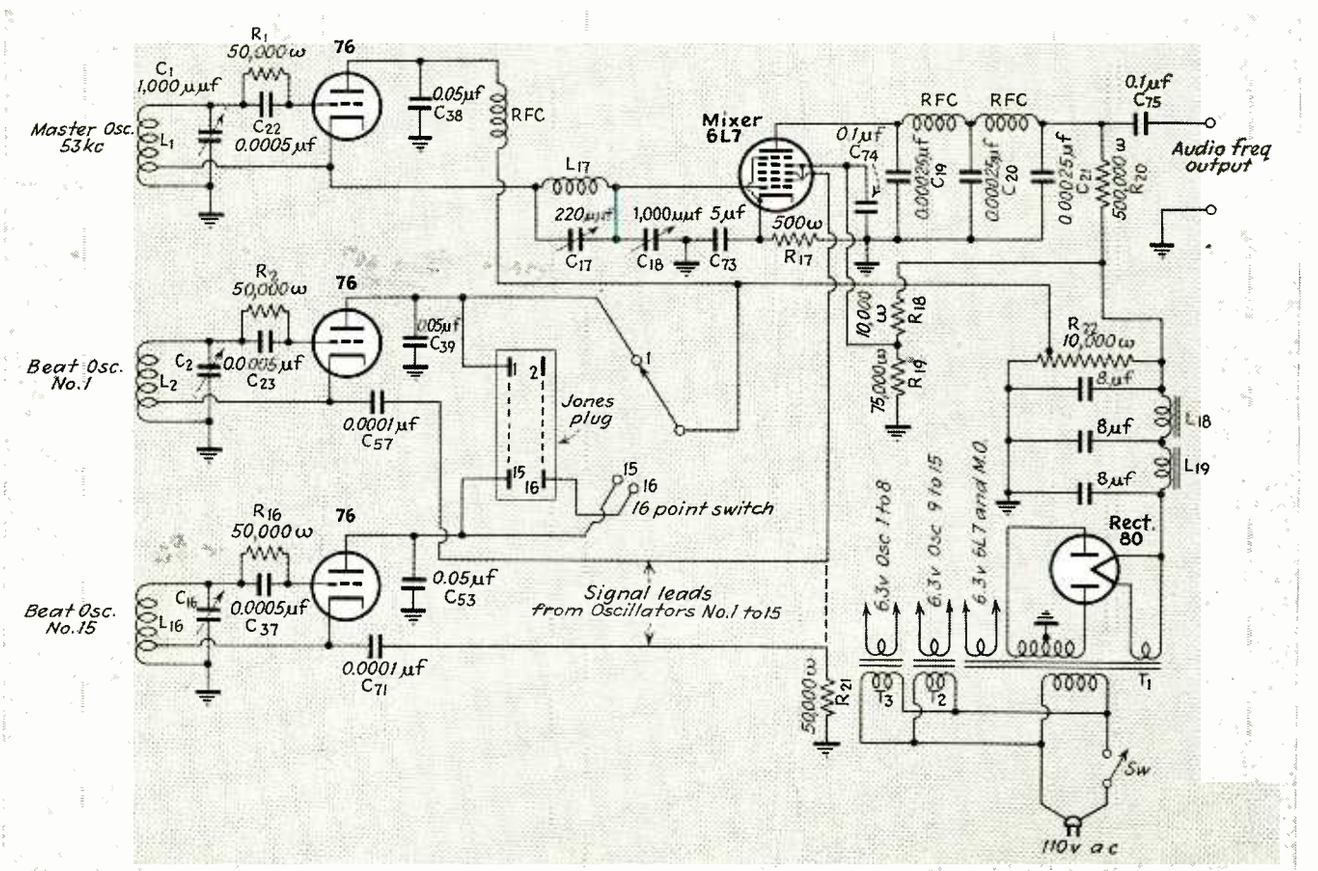
IN the course of research into the traits, abilities and failings of the human mind one of the more interesting capacities to be investigated is that of tonal memory. While it is not the purpose of this article to delve into the various aspects of tonal memory as a mental element, certain details affecting the administration of tests on this aptitude are of interest.

Tonal memory means the recognition of a particular tone or frequency upon its repetition, or as in the case at hand, it's failure to reappear. For this purpose a group of tones, say three in number, are played to the person being tested. This same group is then repeated but with one tone changed. If the examinee recognizes the tone changed it is to the credit of his tonal memory.

It is important that factors other than tonal memory do not find their way into such a test. One disturbing element that might be introduced would be the use of tones so close in frequency that their difference could not be easily recognized. This condition would test tonal discrimination rather than tonal memory. Since the marks obtained in such a test are compared with those of a large number of others taking the same test the tones used in the test must be in a frequency range not too high nor too low. Along this same line the overtones should be entirely eliminated if possible as some persons might conceivably be able to remember a tone better if it contained overtones. The tempo with which the test tones are given to the examinee must be very even and not too fast or the effect of rhythm memory or ones stenographic speed in recording the answers will affect the results obtained.

Since it would be extremely difficult to reproduce exactly any given group of tones from time to time as required it becomes immediately apparent that recordings must be made so that each one tested will receive exactly the same test. The criterion that the tones be pure precludes the use of any stringed or wind instruments. Bells and other percussion instruments produce notoriously poor tones. One of the easiest methods of obtaining pure tones (within limits such that the ear cannot detect the overtones) is by the use of a vacuum tube oscillator.

Fig. 1—Circuit diagram of the fifteen tone audio generator. For simplicity, beat oscillators 2 to 14 are omitted



The maximum number of tones required during the test was set at fifteen. The rapidity with which the various tones would be required was set at 0.01 minute, the duration of each tone to be a fraction of that time so that an interval exists between the various tones. The oscillator to be described produces fifteen tones separately and independently, at any audio frequency. The method of production of the audio tones is not new, that of beating two radio frequency signals together to obtain the desired audio tone. However, the use of fifteen separate pre-tuned high frequency oscillators all beating against one master oscillator is a step that has not been taken before. It is believed that such an oscillator may have many other uses in audio frequency testing.

The circuit diagram is shown in Fig. 1. The oscillators are of the electron coupled type for stability and ease of coupling. The inductances are National SRO coils originally designed for use in quench oscillator circuits in superregenerative receivers. These coils originally had two separate windings but were modified slightly by connecting the two windings in series to give a single winding with a tap. The mixing of the two high frequency signals is done in a type 6L7 tube since it was thought that such a tube would provide sufficient isolation between the various circuits without recourse to more complicated schemes. No trouble has been experienced with locking of the various circuits although the shielding of the various components is meager.

The tuning condensers shown in the circuit diagram and Fig. 3 are satisfactory in spite of the generally accepted belief that ordinary mica condensers are unstable. They would not be satisfactory if the oscillator had to maintain its frequency calibration over long periods of time, but since one hour of steady operation is all that is required to make a record, the more expensive and more stable combination of ceramic padder and air dielectric tuner was not used. Considering the stability requirements, the successful use of mica condensers is unusual. The frequency tolerance aimed at was better than 3 per cent of the audio tone. The actual oscillating frequency of the circuits is about 53 kc. Thus a deviation in frequency of one oscillator of less than 0.06 per cent would shift the resultant audio tone undesirably. Of course resort to lower oscillating frequency would improve the situation somewhat. However, since all the circuits were built as nearly alike as possible it was s-sumed that any change in one oscillator would be accompanied by a similar change in all the others. As it was, the unit had to be run through several heat cycles, for a period of over a week, to bring it to a stable operating condition. After that time, however, the stability was better than had been anticipated. The frequency of the fifteen tones would hold to within 2 per cent for considerable known periods of time.

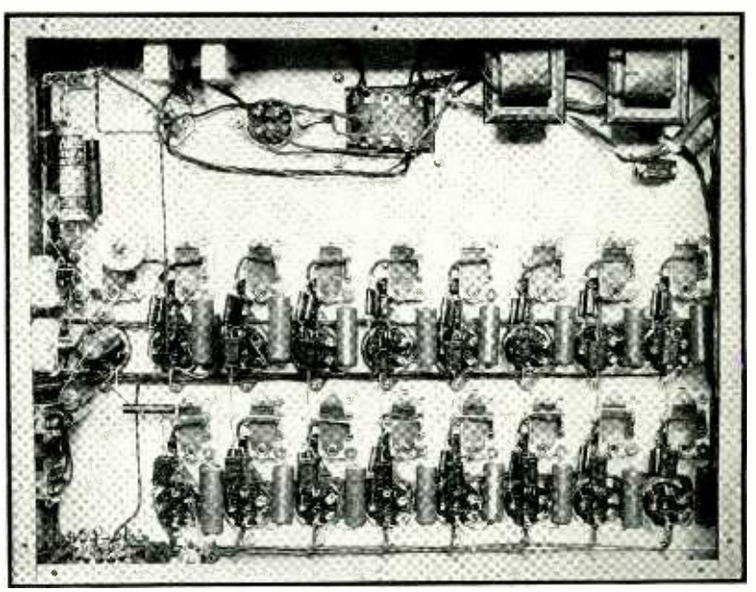
In the input circuit of the number 1 grid of the 6L7 is a small but effective filter[1] for reduction of harmonics in the output of the oscillator. Since it was one of the major requirements of the unit, that it have little or no harmonic output, considerable effort was made to see that this criterion was fulfilled.

The output of the high frequency oscillators were rich in harmonics, especially the 2nd and 3rd. At first it was suspected that rather complicated filtering would have to be resorted to before mixing the signals. Consideration of the mechanics of the production of audio harmonics from the harmonics of the r-f signals disclosed that eliminating the harmonics from only one of the signals would completely eliminate the audio overtones. This was fortunate as only one such filter, on the master oscillator, would be needed. The filter is a combination of series and parallel tuned circuits. C_{17} and L_{17} are made anti-resonant at the second harmonic frequency of the master oscillator, while L_{17} and C_{18} are made resonant to the master oscillator frequency to accept the fundamental. The third harmonic is attenuated by the mutual effect of both circuits and is negligible at the grid of the 6L7. Since all the signals here are above audible frequencies the tuning was done with a cathode ray oscillograph. A simple double—pi network of 80 mh chokes and 0.00025 μf condensers after the mixer eliminates most of the rf in the output without seriously affecting the linearity of the audio output.

In coupling the fifteen oscillators to the mixer the signal is obtained

Fig. 2—Top of chassis showing arrangement of tubes and parts. The outputs of the 15 beat oscillators and the master oscillator are mixed in the 6L7 (metal tube)

Fig. 3—Bottom of chassis. Proper location of parts reduced the length of most leads to a fraction of an inch



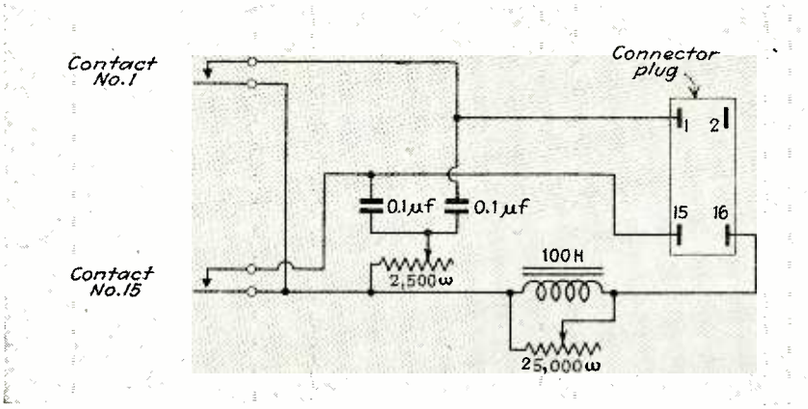


Fig. 4—Click reducing circuit. This is necessary to successful operation because the switching takes place in the plate circuits of the various oscillators

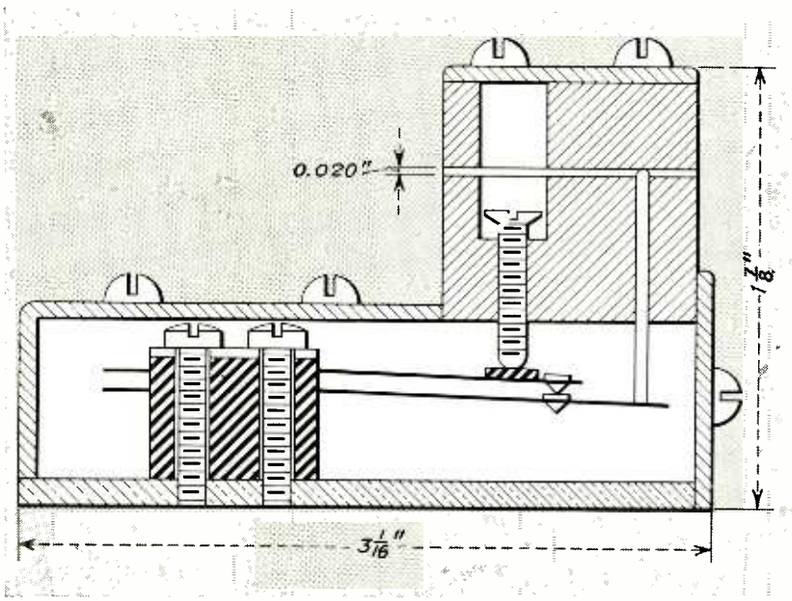


Fig. 5—Contact of the timing mechanism. The perforated tape passes through the 0.02 inch slot and actuates the steel pin pressing on the lower of the two contacts

from the tap on the coil as is done in some radio receivers. That meant that the lower ends of all the coils would be in parallel. Since plenty of voltage would be available, a 0.0001 μf condenser was inserted in the lead from each oscillator to isolate them somewhat from each other. There remains some coupling so that when tuning the complete set of fifteen oscillators the job must be done twice, the second time merely retouching to compensate for the tuning of the other circuits. The tuning of the fifteen circuits is accomplished by feeding the outputs of a standard oscillator such as a General Radio 713-B and the multi-oscillator described here into a volume indicator and tuning for the zero beat point. A cathode ray oscillograph may also be used to observe the coincidence of the two frequencies. Although the tones are all audible it is quite difficult to get the adjustment correct by ear.

As the switching of the various oscillators is done in the plate leads, some form of filter is necessary to prevent key clicks from appearing in the output. Figure 4 shows the circuit used at the contacts rather than at the oscillator, which serves very satisfactorily. A modification of the circuit, to include a variable resistor in series with each of the 0.1 μf condensers instead of the common resistor, would make it possible to get slightly better adjustment on the following click as its aural effect seems to vary with the frequency setting of the audio tone. Since the oscillators are keyed in the plate circuit, the voltage applied to the plates of the tubes must be quite low, to prevent any chirp due to the application of the voltage for only short periods. Between 18 and 25 volts was used in this case.

The unit was constructed in a manner similar to a radio receiver. The chassis is a standard one available in many radio supply houses, cadmium plated 17"x13"x3". The power supply is standard except for the extra filament transformers necessary to meet the demands of the heaters of 17 tubes. The plate supply of each oscillator tube is supplied through contacts on a Jones Plug mounted on the side of the chassis and connecting to a sixteen wire cable terminated in the timing and selecting mechanism.

The timing and selecting of the required tones is done by means of a paper tape with holes of the proper size cut at the proper points. Since the timing of the notes was to be one every 1/100 of a minute, the machine was adjusted to pull the tape through at the rate of 100 inches per minute. This simplified calculations of time intervals to the direct substitution of inches for hundredths of a minute. The electrical contact is made through silver points mounted on springs similar to relay contacts. The spring is actuated by a rounded 0.075" dia. stainless steel rod that presses on the paper by reason of the spring itself. The movement of the contact is therefore only the thickness of the paper from which the tape is cut. The paper must be rather tough to push the pin back at the end of a hole, at the same time it must be thick enough to operate the contact. Paper about 0.006 inch thick was found to be satisfactory as thicker papers were as a rule more fibrous and more apt to tear. Figure 5 shows a cross sectional view of the contacts. The tape itself is pulled through by two rubber rollers driven by a synchronous motor stepped down with a worm gear. The take up spool is driven by a light spring belt, similar to those used on movie projectors, and doesn't affect the speed of the tape in any way.

In conclusion this may be said that the fifteen tone oscillator is a special piece of equipment, designed and built to meet certain requirements called for in a specific job. It is a laboratory unit used for experimental work. In some cases certain parts could have been improved, if a later model were to be built. Nothing was done however as all that was desired was satisfactory operation of the unit while the test records were being made. The requirements, stability and tolerance of frequency, absence of appreciable harmonics and accurate timing of the notes, are all met in this oscillator and its associated timing mechanism.

1. Fink, D. G. A Laboratory Television Receiver, *Electronics* October 1938.

A Picture Signal Generator—II

In the second installment of this series the synchronization signal generator, including the timer and shaper units, is described. While designed for the R. M. A. type of signal, the generator is capable of producing various specifications of synchronizing signals

By M. P. WILDER
and J. A. BRUSTMAN
American Television Corporation

IT is the function of the timer unit in the picture signal generator to generate properly synchronized pulses from which are produced the vertical and horizontal sync pulses as well as to assure synchronization with the power-line frequency when the field frequency is to be related to the power frequency. The function of the shaper unit is to take the pulses transmitted to it by the timer and to shape them to correspond to the requirements set by the standards under which the system is operating. The flexibility of the unit, which was originally designed for the standard R.M.A. pulse, is such that any practical standard signal can be generated by changing a few simple *L-C* and *R-C* components in the timing unit and making the corresponding adjustments in the shaping unit. The authors have found the R.M.A. standard signal the most practical for their purposes and the constants given are those required to generate that signal.

The timer and shaper units used follow closely those developed at the R.C.A. License Laboratory by Harmon B. Deal, and described on pages 402 to 413 in "Principles of Television Engineering" by D. G. Fink, McGraw-Hill Book Co., New York, 1940.

A 13,230 cps sinewave is used as the original voltage source from which all other frequencies are derived. In order that odd-line interlacing will result, the second harmonic of this frequency, 26,460 cps, is divided by means of four multivibrators in the ratios of 7:7:3:3 to sixty cps. This frequency is in turn compared with the local 60 cps of the power lines by means of a double diode discriminator circuit, in a manner similar to that employed in the familiar a-f-c circuit. Should there be a difference in frequency or phase between the 60 cps generated by the power company and that produced by the sync generator, a voltage is produced of an amplitude proportional to the difference in frequency between the two, and of a sign depending on whether the locally-generated 60 cps is leading or lagging the power line frequency.

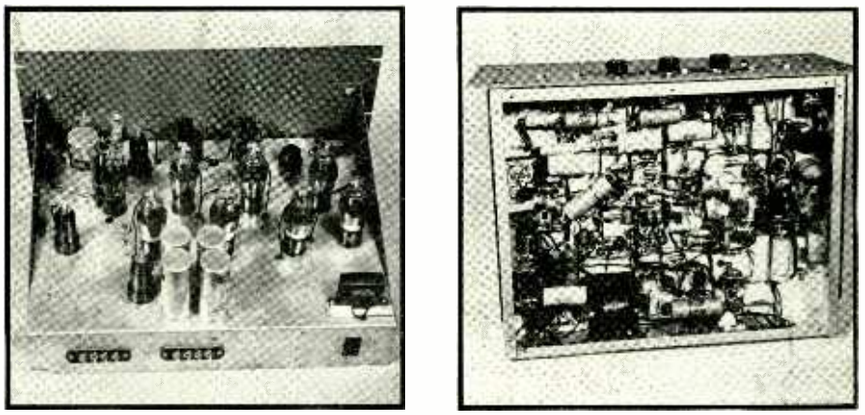


Fig. 1—Views of the timing unit, which generates 60 cps and 13,230 cps pulses which are shaped to form the vertical and horizontal synic signals

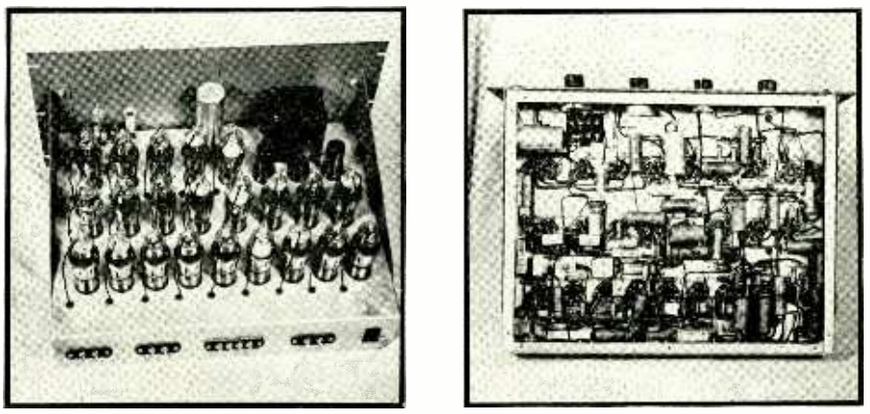


Fig. 2—Views of the shaper unit which generates the horizontal, vertical and equalizing sync pulses, as well as the keying signals, under the control of timing unit

This voltage must be well filtered to remove all traces of 60 cycles or any other frequency which might have been superimposed on it and applied to change the transconductance of a control tube so that the control tube's input capacitance varies as a function of the voltage delivered to it. This change in capacity will change the frequency of the 13,230 cps sinewave oscillator in the direction of balance. Balance will be achieved when the 13,230-cps wave, after frequency multiplication and division in the timer, appears as

a 60 cps wave which is the same phase as that of the power line. At this point the discriminator circuit supplies a constant bias to the control tube and it no longer alters the frequency of the 13,230-cps master oscillator. Should either the 13,230-cps oscillator or the 60-cps line frequency tend to shift to another slightly different frequency the discriminator circuit and control tube circuit will cause the timer to hunt for a new balance but as this action is going on continually, balance is, with rare exceptions, constantly maintained. It is essential after obtaining the 26,460-cps sinewave from the master oscillator that all traces of the original 13,230-cps wave be removed. This is accomplished by suitable filters.

It is one of the requirements of odd-line interlace that odd multiples of 26,460-cps be used for frequency division. It was found essential in this timer to employ a minimum of 4 steps of division in order to assure good interlace. Buffers are provided between stages and adequate decoupling is used throughout. If the decoupling is not adequate, all the frequencies present in the timing generator will appear in scallop-like patterns on the vertical edges of the picture.

For convenience in alignment a jack is provided in each buffer stage. The last multivibrator in the chain produces the 60 cps field frequency. The 3000 $\mu\mu$f variable condenser in the plate circuit of the last multivibrator determines the vertical blanking pulse width. This saves a shaping operation later on. An electronically-regulated power supply provides power for the timer and a second unit of identical design supplies power for the shaping unit.

In adjusting the unit it is necessary to first adjust the Colpitts oscillator to 13,230 cps by means of a beat frequency oscillator. Then the 26,460-cps filters should be adjusted to a maximum output at 26,460 cps without any 13,230 cps ripple being present. The 60, 180 and 540 cps multivibrators should then be set against a 60 cycle time base on an oscilloscope. The 13,230-cps sinewave oscillator tube should be removed for this test as it will simplify adjustment. On the oscilloscope, against a 60 cps time base the output of the final multivibrator will appear as one pulse. The 180 cps multivibrator will appear as three, and the 540 cps oscillator as 9 pulses. The 3780 cps output will appear as 54 pulses and will therefore be too difficult to count on most oscilloscopes, so should be set by a beat-frequency oscillator.

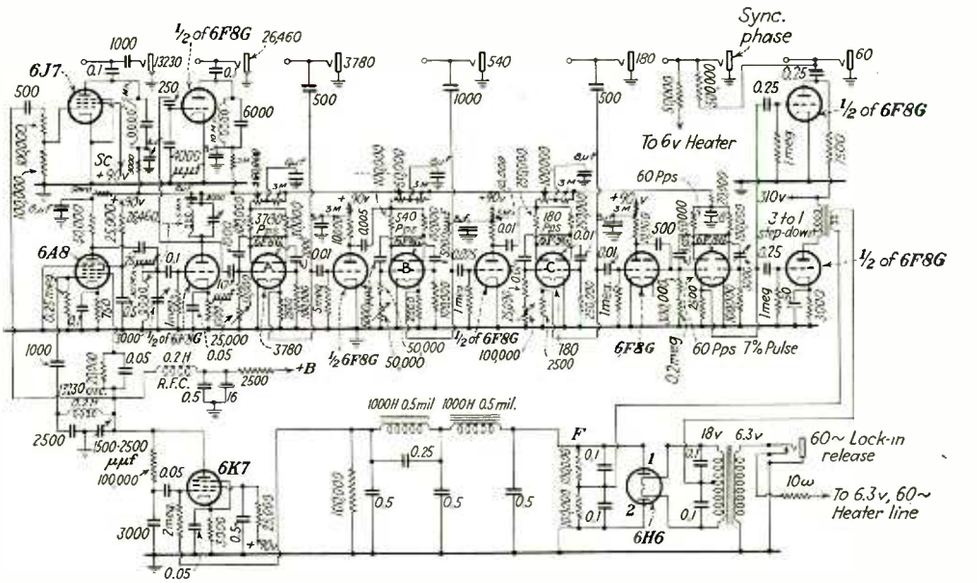


Fig. 3—Complete circuit diagram of the timing unit, including oscillator, doubler, multivibrators, and frequency-control discriminator

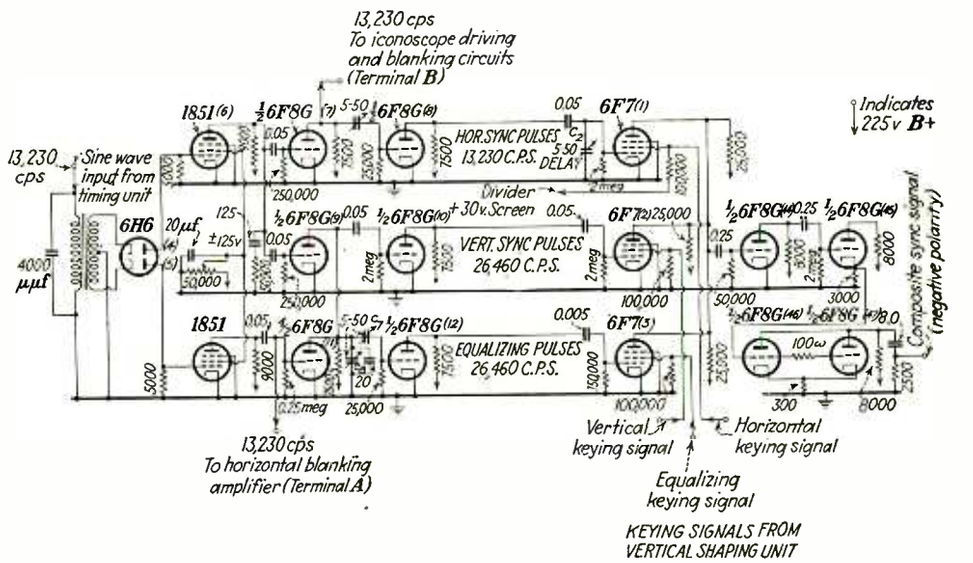


Fig. 4—Horizontal section of the shaping unit. Under the control of the timing unit, the composite synchronizing signal is assembled by means of keying signals

The sine oscillator which was previously set to 13,230 cps should be set in operation by inserting the 6K8 oscillator tube. As a final check remove the automatic interlock by inserting a plug in the last jack. The oscillator can then be adjusted slightly to produce 60 cycles of very nearly the same phase as that of the local 60 cycle mains without the discriminator circuit. When this plug is removed the discriminator will take over and hunt a few seconds, finally settling down to a steady interlock with the power line frequency. Severe line surges will disturb the balance momentarily.

Shaping Unit

The shaping unit shapes the two fundamental frequencies 13,230 cps and 60 cps, the latter already present with a duration of 7 per cent of 1/60 of a second. These two voltages are operated upon by tubes performing four functions: clipping, narrowing, integration (delaying) and keying (inserting).

Clipping is accomplished in a vacuum tube by driving its grid negative beyond the plate-current cutoff point. This results in a flat topped voltage wave across the plate circuit resistance. More than one wave may be applied simultaneously

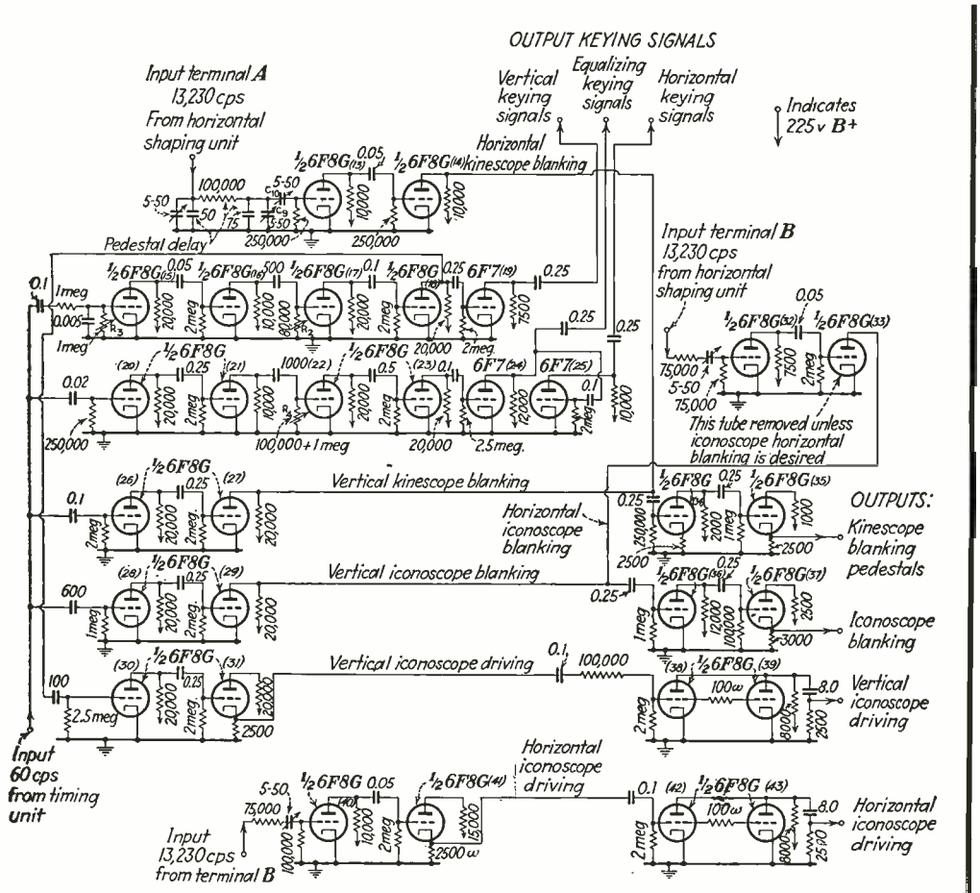


Fig. 5—Vertical section of the shaping unit, which accepts 60 cps from the timer and generates keying and vertical blanking signals

and clipped in turn. If this waveform is again clipped in another stage and if the driving voltage is high and the cut-off sharp, a wave with steep sides will result. The duration of the pulse can also be determined by clipping at a desired point on the sloping side of a sinewave, amplifying the resulting waveform and clipping again to obtain a square waveform.

Narrowing may be accomplished by passing a pulse through a small condenser followed by amplification and clipping to restore the square wave shape. Delaying or integrating circuits are those that discriminate against high frequencies. In general they are used to delay an amplified pulse with respect to its original. The desired result is accomplished by passing a pulse through a series resistor to a shunt capacitor. The shunt capacitor shapes the leading edge of the pulse by attenuating the high-frequency components. Subsequent clipping of this tilted wave results in squaring it up again. The front edge of the wave is thus delayed by the amount of time it takes the wave to build up to the clipping voltage.

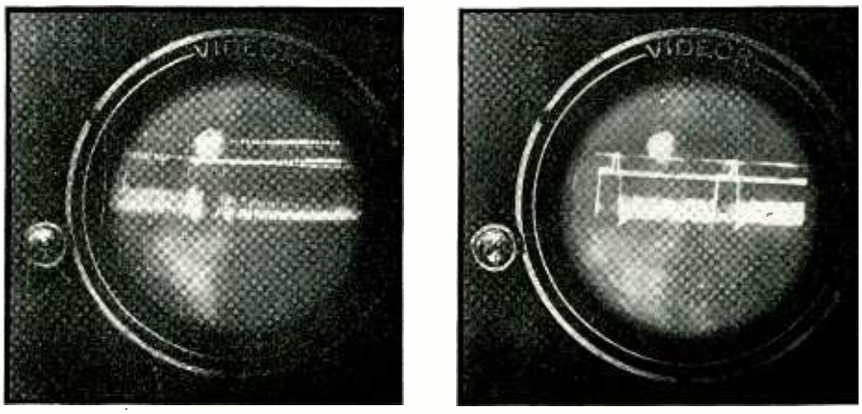
After the synchronizing pulses, equalizing pulses and blanking pulses are formed, it becomes necessary to key them in or out at their proper places in the complex picture signal. This can be accomplished by applying pulses of the proper width to the screen grids of three pentodes feeding a common plate circuit. When it is desired to "key in" equalizing pulses it is necessary of course to "key out" the sync pulses. By adjusting the width of a vertical pulse it is possible to key in the six desired equalizing pulses while keying out the sync pulses. To do this it is necessary to remove the sync pulses by bucking out the screen voltage of pentode No. 1 (see Fig. 4) with a negative pulse and to apply screen voltage to pentode No. 3 with another pulse of opposite sign. Pentode No. 2 has vertical sync pulses of the proper width and shape on its grid and operates only when the other two pentodes have been removed from operation by removing their screen voltage. Four other signals are available from this unit: horizontal iconoscope drive, vertical iconoscope drive, iconoscope blanking pulse, and kinescope blanking pulse.

Operation of Shaping Circuit

Referring to the diagram of Fig. 4 the 13,230 cps input is applied to the cathodes of the two diodes 4 and 5 in phase opposition through the transformer (a Western Electric 77A repeat coil is satisfactory). The outputs must be symmetrical and the transformer of high quality. The resulting waves are clipped in the grids of the two following pentodes and the width adjusted by the 50,000-ohm potentiometer. These pulses have a duration of slightly less than one half period. One chain of tubes 6, 7, and 8 shapes and narrows the pulse to the desired width before applying it to the grid of the first keying pentode (1). This tube will pass these pulses unless its screen is keyed negative, that is, unless either equalizing pulses or vertical pulses are being inserted.

The next chain of tubes, 9 and 10 operates at double frequency since both halves of the output of the diode are present. These pulses are shaped to form the equalizing pulses and the vertical sync pulses at 26,460 cps. The width of these pulses is set by the differentiating condensers. The pulses are then applied to the grids

Fig. 7—Complete video signal waveform as viewed on the oscillograph: left, vertical sync pulse and blanking pedestal showing 6 equalizing pulses before and after vertical pulse; right, two complete lines, showing camera signal, pedestal and horizontal sync pulse. Direction of increasing time is from right to left



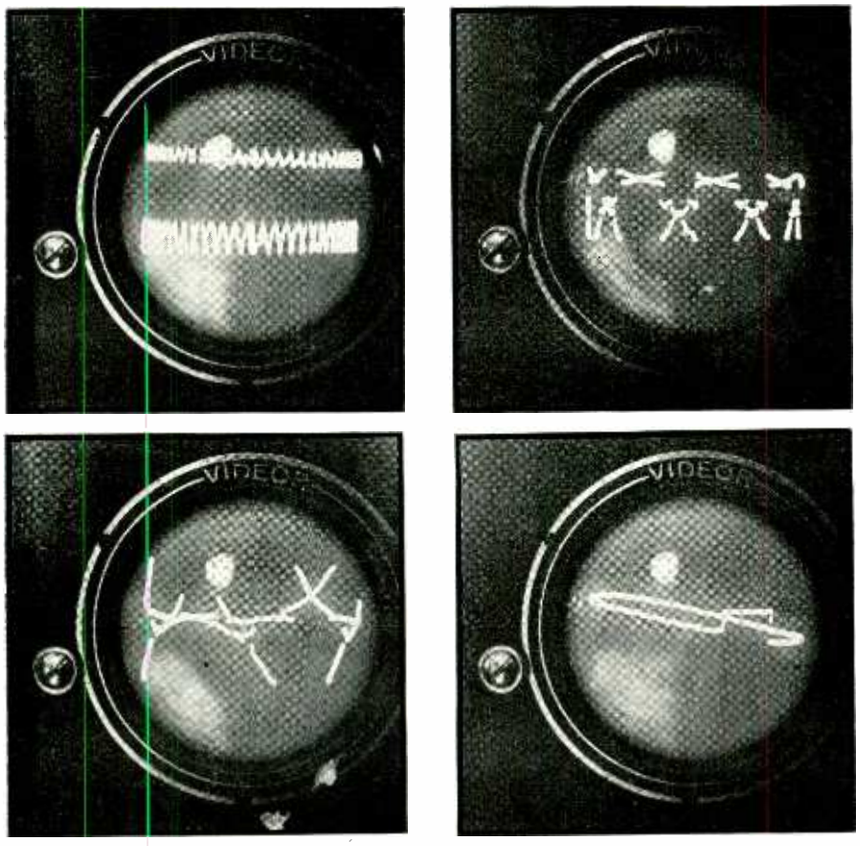


Fig. 6—Oscillograms of the output waveforms from the various multivibrators, using 60 cps sinewave sweep: upper left 3780 cps, upper right 540 cps, lower left 180 cps and lower right 60 cps

of pentodes 2 and 3. These pentodes operate only when their screens go positive. It is obvious that instead of the serrated vertical pulse, any kind of a vertical pulse could be applied, for example, the DuMont 500 kc vertical sinewave pulse.

The pulses appearing in the plate circuits of the three pentodes are not in general of even height and must be clipped and trimmed before passing on to an output circuit as shown. The 60-cps output of the timer is properly narrowed and clipped by the three rows of tubes 15 through 25 in Fig. 5 to produce the proper width pulse to key in the equalizing and vertical pulses or, after a phase reversal, to key out the horizontals during the assembly of the vertical pulse.

The bottom three pairs of tubes, 26 through 31, are also excited by 60 cps pulses which are shaped to provide vertical kinescope blanking, vertical iconoscope blanking and vertical iconoscope driving pulses.

Suitable tubes and circuits are provided to form a low impedance output circuit, tubes 32 through 39. A train of shapers and clippers excited by 13,230 cps is provided to supply horizontal iconoscope driving, in tubes 40 through 43.

The alignment of the keying pulses proceeds as follows: Adjust the width of the vertical keying pulse by setting R_2 in the grid of tube 17 until 6 broad pulses appear in the output of tube 3. The delay is adjusted by R_3 in the grid of tube 15 until 6 equalizing pulses precede the vertical pulse. Finally, R_4, the narrowing circuit of tube 22 is adjusted until six equalizing pulses follow the last broad vertical pulse. A good oscilloscope at the output of tube 47 will show the complete synchronizing signal. It is essential that the leading edges of the three components making up this signal be exactly coincident. Variable shunt condensers C_2 (tube 1 grid) and C_7 and C_8 (tube 12 grid) can be adjusted until coincidence occurs. The width of the horizontal synchronizing pulse, and of the preparatory pulses can be adjusted by means of series variable grid condenser of tubes 8 and 12.

It is important to note that the blanking signals (pedestals) are not formed from the same square pulse from which the synchronizing pulses are made, but are made from the output of diode 4 which leads in time the latter pulse by ½ the horizontal period. This pulse is then delayed in the network preceding tube 13 until the pedestal leads the synchronizing pulse by the required one per cent of the horizontal periods. The amount of delay may be varied by the trimmer C_9 and the width set by the trimmer C_{10}. The driving pulse circuits employ the same technique. The iconoscope blanking signal is usually narrower than the kinescope blanking and obtained from the kinescope blanking pulses. The rise and fall of all leading and lagging edges can be set to 0.5 per cent of the horizontal period thus meeting the standards set by R.M.A. All outputs are from 100-ohm sources so the wave forms will remain substantially unchanged after passage over reasonable lead lengths. Horizontal iconoscope blanking is not used in this unit.

The next article in this series will describe the mixing amplifier, line amplifier, shading source, including adjustments, and power supply.

Fig. 8—Specifications of the R.M.A. Standard Video Signal, used as a basis for lining up the timer and shaper to produce this type of signal (compare with Fig. 7)

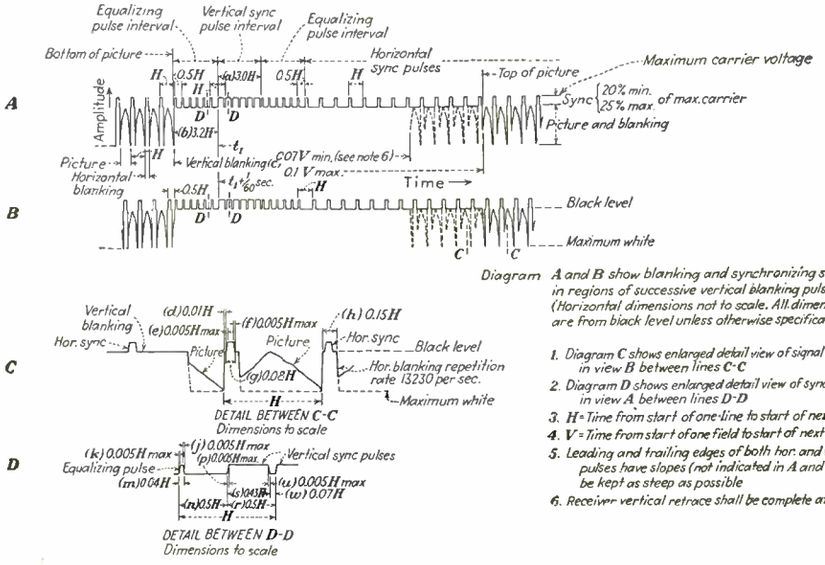
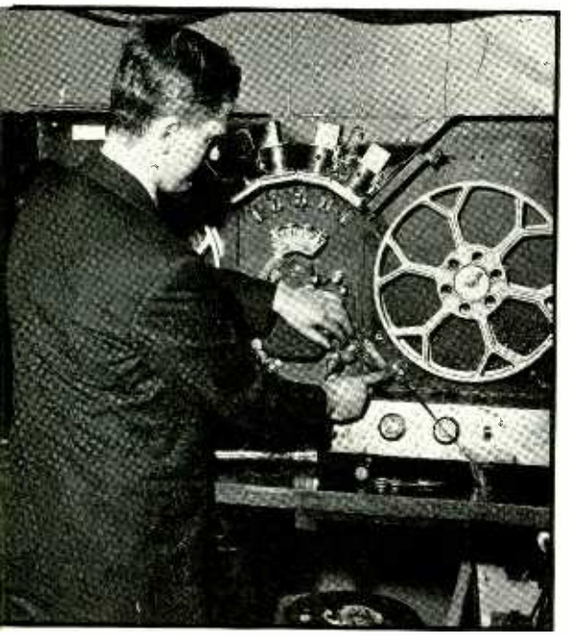


Diagram A and B show blanking and synchronizing signals in regions of successive vertical blanking pulses. (Horizontal dimensions not to scale. All dimensions are from black level unless otherwise specifically indicated)

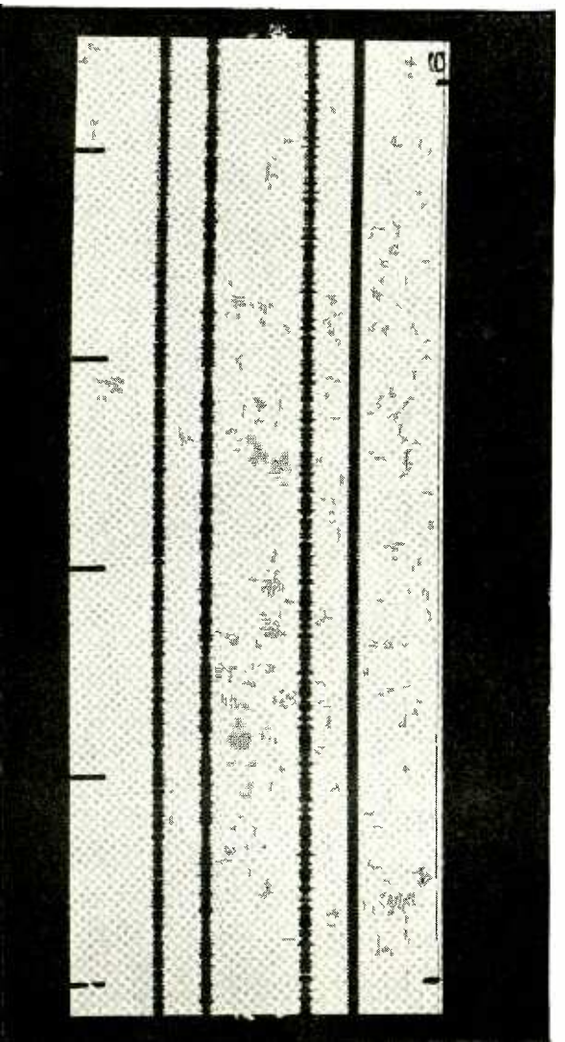
1. Diagram C shows enlarged detail view of signal in view B between lines C-C
2. Diagram D shows enlarged detail view of sync signal in view A between lines D-D
3. H = Time from start of one line to start of next line = 1/13230 sec
4. V = Time from start of one field to start of next field = 1/60 sec = 220½ H
5. Leading and trailing edges of both hor. and vert. blanking pulses have slopes (not indicated in A and B) which should be kept as steep as possible
6. Receiver vertical retrace shall be complete at end of 0.07 V

Enhanced Stereophonic Recordings Demonstrated by Bell Laboratories



The reproducing unit which includes four phototube units, one for each sound track and the expansion control track. L. A. Elmer is threading the film through the machine

The negative film containing a sound track for each of the three channels and the control track (right). The film travels at a rate of 90 feet per minute



ON the evenings of April 9 and 10, the Bell Telephone Laboratories presented in Carnegie Hall a demonstration of its newly developed stereophonic recordings. A wide variety of music, drama and opera was included in the program. There were several numbers by the Philadelphia Orchestra under the direction of Leopold Stokowski, several selections by the choir and organists of the Salt Lake City Tabernacle and a dramatic presentation by Paul Robeson. The program was arranged to include musical and dramatic material which would show the new recording system to good advantage. On the stage of the concert hall was a curtain which during the evening was illuminated with colored lights and served to attract and hold the attention of the eyes while the audience was listening to the music. Behind the screen, which was light and porous enough to permit transmission of sound through it with but little interference, were located three high quality loudspeaker units from which the music emanated. To say that the quality of these recordings was excellent hardly does them justice.

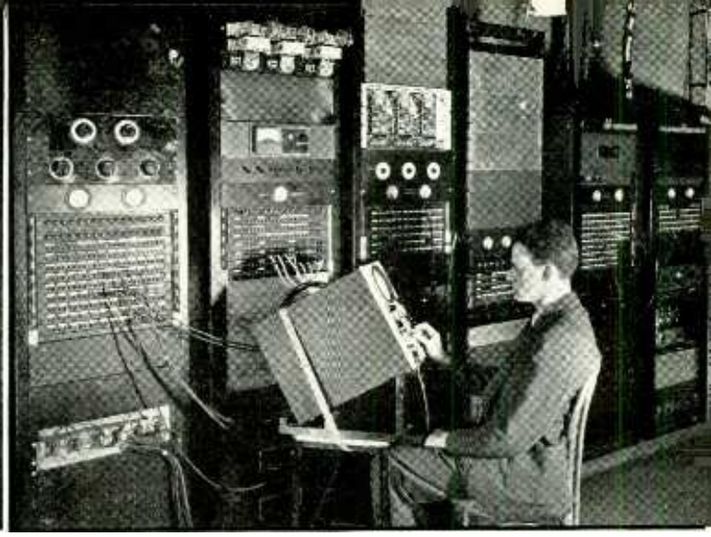
The technique of stereophonic recording was developed by Dr. Harvey Fletcher and his associates, Messrs. E. C. Wente, J. C. Steinberg, W. B. Snow, R. Biddulph, L. A. Elmer, A. R. Soffel and A. B. Anderson. The method of stereophonic reproduction of music in a large auditorium was first demonstrated in April 1933 when the Philadelphia Orchestra played in the Academy of Music in Philadelphia and the music was reproduced stereophonically in Constitution Hall in Washington by means of high quality telephone lines. The purpose of the April 1940 demonstration was to show the same effects with recordings, with some additional features such as increased dynamic range and enhancement of the music by the conductor after it had been recorded. It is interesting to note that stereophonic reproduction was first attempted in the early days of transmission of sound by wire. It was in 1881 during the Paris Electrical Exhibition that a musical performance was reproduced over a telephone system. Headphones were provided for the use of the audience and separate channels were used for each phone to give the listener a sense of "localization".

The purpose of stereophonic reproduction is to create in the minds of the audience a strong illusion of the actual presence of the performers whether they are members of an orchestra, chorus or dramatic cast. Another effect achieved through the use of electronic recording and amplification is the tremendous increase in the dynamic range of the sound. There is a definite limit to how soft an orchestra may play notes and have those notes retain their musical characteristics. The loudness of an orchestra or a singer or speaker, on the other hand, is determined by the physical limitations of the human body. It is possible in an electronic recording and reproducing system to decrease the volume of the soft passages and to increase the volume of the loud passages, thereby increasing the dynamic range. That the loud passages were really loud is shown by a newspaper headline the next morning "Third Dimension Music Terrifies, Bell Laboratories Demonstration Literally Rocks Walls of Carnegie Hall". This headline, however, is not to be taken seriously. The sounds were of the order of 110 db above the threshold of hearing. At the other end of the scale, the music was reproduced at so low a volume that, while it was perfectly audible in all parts of the auditorium, seats squeaking as far away as 25 feet were definitely annoying to a person listening attentively to the music.

Enhancement

The term "enhancement" as it is applied here refers to the fact that the conductor of the orchestra or

Leopold Stokowski enhancing a program while Dr. Fletcher looks on and W. B. Snow takes care of the monitoring. Enhancing removes the physical limitations of the orchestra



Amplifiers and control equipment used in the reproduction of enhanced stereophonic recordings. A total of 1500 watts output is available through three separate sound channels

chorus can, after the recording is made, "rearrange" the music as far as the volume range, and to a certain extent the frequency range, are concerned. Enhancement is carried out in the following manner. As the first recording is being played back, the conductor has in front of him a series of knobs to control the volume and to some extent the harmonic content of the music in the three separate sound channels. Thus, he is enabled to reinforce the crescendos and to diminish the diminuendos to suit his desires without the usual mechanical limitations of the orchestra. A series of networks are provided so that he can adjust the relative volume of any portion of the audible frequency spectrum. Hence, it is possible to boost the bass so that the kettle drums are predominant, or to boost the treble to accentuate the violins, flutes or other high pitched instruments. By the use of this new musical tool the conductor is enabled to give a fuller meaning to his interpretation of what the composer had in mind. No doubt the new technique will find wide use in the manufacture of high quality records.

The recordings are made on motion picture film by the use of three microphones which record three separate sound tracks, parallel to each other on the film. The microphones are placed in front of the sound source (orchestra, chorus, actors, etc.), one to the left, one in the center and one to the right. Each microphone picks up a different signal depending on the character and intensity of the sound sources near it. When the program is reproduced there are in front of the audience three loudspeaker units in approximately the same relative positions as the microphones. The outputs of the loudspeakers are the same as the inputs of the respective microphones and the sound pattern radiated is the same as the original sound source.

Because the dynamic range of the film recording system is not as great as that of the original program in the great majority of cases, the recorded sound must be compressed, that is, all parts of the program, whether they are loud or soft, are recorded at nearly the same volume on the film. This is done by an automatic compressor circuit and the amount of compression is recorded on a fourth sound track. There are three compression signals impressed on the fourth track, one for each sound channel. These signals are sinewaves of different frequencies and the amplitude of each is determined by the amount of compression introduced into the corresponding channel. During playback the compression signals are picked off the film and separated by suitable filter circuits and are used to control expander circuits which restore the various portions of the program to their original volume levels or to the level determined by the conductor during enhancement.

Microphones and Loudspeakers

The microphones used were of the dynamic type with fairly smooth frequency response from 40 to 15000 cps. The loudspeaker units consist of a high frequency speaker and a low frequency speaker, each mounted in a horn. The high-frequency horn is of the multi-cellular type and the low-frequency horn is of the folded type. The frequency response matches that of the microphones with the large speaker radiating frequencies under 300 cps and the small high frequency speaker radiating the sounds between 300 cps and 15000 cps. It is a characteristic of musical instruments that the high frequency instruments are more directional in character than the low frequency instruments. This is also true of loudspeakers. When loudspeakers are used to radiate the sound, the directional characteristics of the various frequencies are approximately the same as those of the orchestra. Hence, the reverberation patterns of the music and the auditorium are not disturbed appreciably by this method of reproduction.

Amplifiers

The amplifiers were designed with particular emphasis on the reduction of distortion and reduction of extraneous circuit noises. Several stages of voltage amplification were used ahead of the final power amplifier. These are standard Western Electric units. The power amplifier uses triode power tubes and is transformer coupled, using transformers capable of passing a wide range of audio frequencies. There is no feedback employed in this amplifier as the distortion is less than 1 per cent for outputs up to 150 watts.

Each channel has its own amplifier system and the electrical power output of the entire system is 450 watts at 1 per cent distortion, 900 watts at 5 per cent distortion and has a maximum output of 1500 watts. This far exceeds the power producing capabilities of the largest symphony orchestra and provides enough reserve power to permit the conductor to raise the volume of the crescendos to his heart's content.—C.W.

NEGATIVE FEEDBACK APPLIED TO OSCILLATORS

By SAMUEL SABAROFF
WCAU, Philadelphia

FACTORS contributing to the instability of an oscillator may be external, such as the effects due to temperature, mechanical shock and so on, or internal, which include the effects of varying voltages and changes in certain circuit components. Remedial measures against instability due to varying external factors are ordinarily self evident, usually involving correct mechanical design. It is sometimes possible to decrease the effect of some varying external factor by appropriate circuit methods.

The frequency-determining element may be mechanical, such as a crystal, or electrical, in which case circuit elements are utilized. Oscillators whose frequency is largely determined by a crystal resonator have in the past been fully described.[1, 2, 3] These oscillators attribute their stability to both the high Q of element and optimum disassociation of elements. The disadvantage of such oscillators is their lack of any great frequency range of operation.

A high order of stability cannot usually be obtained in oscillators utilizing circuit parameters though in the past few years some developments have indicated a considerable improvement. Such circuits may involve a further separation of elements[4, 5, 6] or may utilize the compensating effect of internal parameters varying in opposite directions.[7] The relation between harmonic content and stability has also been investigated indicating that an increase in stability accompanies a reduction in harmonics in the oscillatory circuit.[8]

Negative feedback as a means of automatic compensation has been applied to oscillator stabilization forming the basis of the various automatic frequency control systems used in receivers.[9] A receiver for the reception of frequency modulated signals has recently been described in which negative feedback as applied to an oscillator is used.[10]

These systems utilize negative feedback in such a manner as to stabilize an oscillator with respect to a received signal. In this sense the oscillator could be considered to be frequency controlled though the control is not exact.[11]

Negative feedback can be applied to the self stabilization of an oscillator. A block diagram of such an arrangement is shown in Fig. 1. The oscillator feeds a frequency discriminator thus applying a voltage varying with frequency to a frequency control which in turn changes the oscillator frequency. The discriminator control operates in such a direction as to oppose any change in the frequency of the oscillator. If we let ω_D equal the oscillator frequency without discriminator-control and let $f(\omega)$ be a measure of the effect of discriminator-control then the oscillator frequency can be written

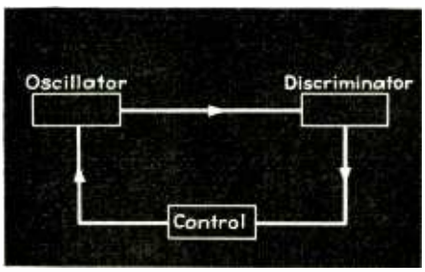


Fig. 1—Basic discriminator oscillator control circuit

$$\omega = \omega_D + f(\omega) \qquad (1)$$

Differentiating

$$d\omega = \frac{d\omega_D}{1 - f'(\omega)} \qquad (2)$$

Equation (2) is similar in form to the equivalent expression for negative feedback as applied to ordinary amplifiers. When $f'(\omega)$ is negative and large, the frequency stability becomes less dependent on any change in an oscillator parameter. For a certain parameter variation, the change in oscillator frequency when using discriminator control is less than the change without discriminator control in the ratio $1 \div [1 - f'(\omega)]$. This affords a simple way of determining the value of the feedback factor.

It must be noted that Eq. (2) is true for small variations only or for that portion of the discriminator-control characteristic where $f(\omega)$ approaches linearity in terms of ω. Portions of the discriminator-control characteristic may have values of $f'(\omega)$ that are positive thus increasing instability. A runaway condition appears when $f'(\omega)$ equals unity. These factors limit the range of frequencies over which a particular discriminator-control arrangement is effective.

It is possible for the discriminator to operate on a multiple or submultiple of the oscillator frequency, or by means of a stable heterodyne oscillator the discriminator can be operated on some intermediate frequency.

An experimental arrangement utilizing the principles outlined above is shown in Fig. 2. Ordinary broadcast receiver parts were used in its construction with no particular effort being made toward either mechanical or electrical stability. The oscillator is an electron coupled arrangement and operates on a frequency in the neighborhood of 470 kilocycles. The control tube acts in such a manner as to vary the inductance in the *LC* circuit thus tending to vary the oscillator frequency. The effective inductance is approximately $L(1 + g_m R)$ where g_m is the mutual conductance of the control tube. R is

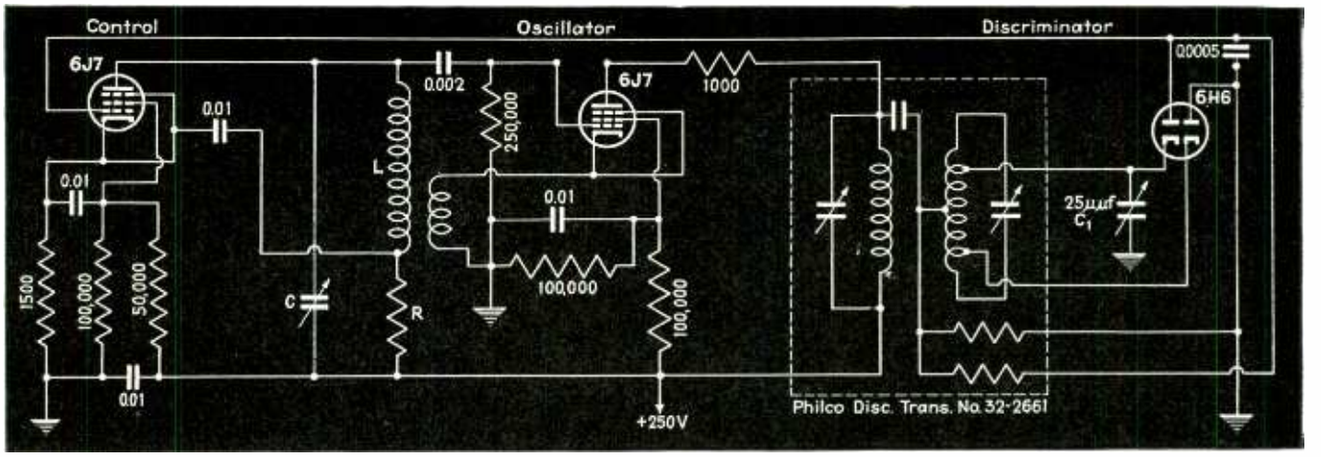


Fig. 2—Complete circuit diagram of stabilized oscillator employing two 6J7 pentodes and a 6H6 diode

small, of the order of 150 ohms.

The discriminator operates on the oscillator frequency and is of a type used in the a-f-c circuits of some broadcast receivers. This discriminator is similar to some described in the past[12] but with the further addition of a small phasing condenser C_1. By varying the adjustable parameters in the discriminator it is possible to vary the range and slope of its characteristic.

The discriminator voltage output with respect to varying frequency is like that shown in Fig. 3. The portion of the characteristic used is that included in *AB*. It is necessary that the polarity of the discriminator be such that $f'(\omega)$ is negative over the used portion of the characteristic, otherwise no stabilization will take place. With reversed discriminator polarity the frequency change with respect to an oscillator parameter variation becomes discontinuous when approaching the points *A* or *B*, jumping from one to the other depending on the direction of approach. The current variation in the control tube follows the discriminator output fairly closely and is useful in arriving at the proper discriminator characteristic.

A measure of the stability is obtained by noting the effect of applied voltage variation and the drift during warmup. In this arrangement with maximum feedback, a ten per cent variation in the *B* supply or the filament voltage produced a maximum change in frequency of 25 parts per million. During warmup, at the end of one minute the frequency was within 50 parts per million of the final frequency and at the end of twelve minutes was within one part per million of the final frequency. Using the oscillator alone, a ten per cent change in the applied voltages changed the frequency about 400 parts per million with the changes during warmup having approximately the same proportionate increase. The effect of negative feedback in this case decreased any

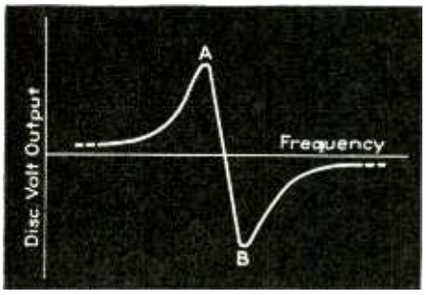


Fig. 3—Voltage vs frequency control characteristic of circuit shown in Fig. 2

oscillator frequency instability by a factor of sixteen.

It must be noted that no account is taken of ambient temperature since it was practically constant during the course of the above measurements. Over a period long enough to encounter changes in ambient temperature it is not expected that the effect of negative feedback on the frequency stability of an oscillator will be quite so pronounced because of drift in the parameters included in the feedback circuit. A disadvantage of the described arrangement is that the frequency range over which stabilization takes place is less than a kilocycle. It is possible, by appropriate design, to vary the feedback parameters and oscillator frequency simultaneously so that the point of optimum stabilization is maintained over any required frequency range.

The use of negative feedback for frequency stabilization can be applied to any type of oscillator operating at almost any usable frequency. The design of an appropriate discriminator may offer difficulty. By operating the discriminator at a harmonic, subharmonic or intermediate frequency and by the possible use of a direct current amplifier between the discriminator and control, such difficulties can usually be overcome.

One immediate application of such a stabilized oscillator is as a source of frequency modulated signals. It is simply necessary to apply a modulating signal to the frequency control thus tending to vary the oscillator frequency.

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(2) S. Sabaroff, A Voltage Stabilized High-Frequency Crystal Oscillator Circuit, *Proc. I. R. E.*, Vol. 25, No. 5, p. 623, May, 1937.

(3) S. C. Hight and G. W. Willard, A Simplified Circuit for Frequency Substandards Employing a New Type of Low-Frequency Zero Temperature-Coefficient Quartz Crystal, *Proc. I. R. E.*, Vol. 25, No. 5, p. 549, May, 1937.

(4) G. F. Lampkin, An Improvement in Constant Frequency Oscillators, *Proc. I. R. E.*, Vol. 27, No. 3, p. 199, March, 1939.

(5) F. E. Terman, Resonant Lines in Radio Circuits, *Electrical Engineering*, Vol. 53, No. 7, p. 1046, July, 1934.

(6) F. B. Llewellyn, Constant Frequency Oscillators. *B. S. T. J.*, Vol. 11, No. 1, p. 67, January, 1932.

(7) J. B. Dow, A Recent Development in Vacuum Tube Oscillator Circuits, *Proc. I. R. E.*, Vol. 19, p. 2095, December, 1931.

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(9) C. Travis, Automatic Frequency Control, *Proc. I. R. E.*, Vol. 23, No. 10, p. 1125, October, 1935.

(10) J. G. Chaffee, The Application of Negative Feedback to Frequency Modulation Systems, *Proc. I. R. E.*, Vol. 27, No. 5, p. 317, May, 1939.

(11) S. Sabaroff, Frequency Controlled Oscillators, *Communications*, Vol. 19, No. 2, p. 7, February, 1939.

(12) R. L. Freeman, Improvements in AFC Circuits, *Electronics*, Vol. 9, No. 11, p. 20, November, 1936.

Square Wave Harmonics

A tabular compilation of the relative amplitudes of the harmonic components of square waves of unity amplitude, of particular interest in television development. Computed to the 30th harmonic, for pulse widths from 10 to 90 per cent of the total period

By DONALD L. HERR

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General Electric Company

IN this table are tabulated the first 30 harmonics in square waves of zero to 100 per cent pulse-width, in steps of 10 per cent pulse-width. The harmonics have been computed on the basis of unit pulse amplitude and x per unit pulse-width, as shown in Fig. 1. For pulse-widths up to and including 50 per cent ($x \leqq 0.50$) the harmonic amplitudes, with proper signs, are obtained directly from the table. The harmonic amplitudes for a square wave with pulse-width greater than 50 per cent ($x > 0.5$) are numerically equal but opposite in sign to those of the square wave with per unit pulse-width $1\text{-}x$.

The amplitudes of the sinusoidal components form the group

$$\frac{2}{\pi}\left[\frac{1}{m}\sin\left(m\,\pi\,x\right)\right]$$

where m is the order of the harmonic. Values of m which are integral multiples of $1/x$ correspond to harmonics of zero amplitude. For $0< x <1$, the amplitudes of the higher-order harmonics approach zero in value. For x very small (corresponding to very narrow pulses), the amplitudes of the lower-order harmonics all approach the same value, $2x$. The values are obtained from a Fourier expansion throughout the interval $t = 0$ to $t = 1$.

For the wave-form of Fig. 1, using the base line as reference,

Order of Harmonic	Pulse Width — In per cent of total period of the wave				
	(90) 10	(80) 20	(70) 30	(60) 40	50
(Fundamental) 1	0.197	0.374	0.515	0.605	0.637
2	0.187	0.302	0.302	0.187	0
3	0.172	0.202	0.0656	−0.125	−0.213
4	0.150	0.0936	−0.0936	−0.151	0
5	0.127	0	−0.127	0	0.127
6	0.101	−0.0635	−0.0624	0.101	0
7	0.0738	−0.0866	0.0281	0.0471	−0.0910
8	0.0468	−0.0758	0.0758	−0.0468	0
9	0.0218	−0.0416	0.0573	−0.0675	0.0707
10	0	0	0	0	0
11	−0.0179	0.0341	−0.0469	0.0551	−0.0578
12	−0.0312	0.0504	−0.0504	0.0312	0
13	-0.0397	0.0281	−0.0152	−0.0288	0.0490
14	−0.0432	0.0267	0.0267	−0.0432	0
15	−0.0424	0	0.0424	0	−0.0424
16	−0.0378	−0.0234	0.0234	0.0378	0
17	−0.0303	−0.0356	−0.0116	0.0220	0.0374
18	−0.0208	−0.0336	−0.0336	−0.0208	0
19	−0.0104	−0.0197	−0 0271	−0 0318	−0.0335
20	0	0	0	0	0
21	0 00936	0.0178	0.0245	0.0288	0.0303
22	0.0170	0.0275	0.0275	0.0170	0
23	0.0224	0.0263	0.00853	−0.0162	−0.0277
24	0.0252	0.0156	−0.0156	−0.0252	0
25	0.0255	0	−0.0255	0	0.0255
26	0.0233	−0.0144	−0.0144	0.0233	0
27	0.0190	−0.0224	0.00728	0.0139	−0.0236
28	0.0134	−0.0216	0.0216	−0.0134	0
29	0.00681	−0.0129	0.0178	−0.0208	0.0220
30	0	0	0	0	0

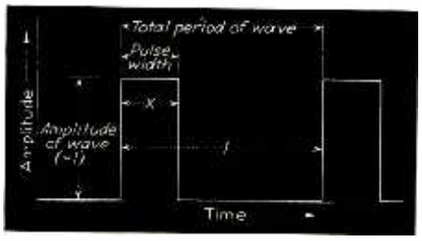


Fig. 1—Basic pulse

$$f(t) = \begin{cases} 1, & 0 < t < x \\ 0, & x < t < 1 \end{cases} \qquad (1)$$

In general, for a Fourier expansion throughout the interval c,

$$(t) = \frac{1}{2}b_o + b_1\cos\frac{\pi t}{c} + b_2\cos\frac{2\pi t}{c} + \ldots$$

$$\ldots\ldots\ldots\ldots + b_m\cos\frac{m\,\pi\,t}{c} + \ldots\ldots\ldots \qquad (2)$$

where

$$b_m = \frac{2}{c}\int_o^c f(t)\cos\frac{m\,\pi\,t}{c}\,dt \qquad (3)$$

By virtue of Equation (1) the expression for the coefficients becomes

$$b_m = 2\int_o^x \cos m\pi t\,dt \qquad (4)$$

from which

$$\frac{1}{2}b_o = x$$

$$b_m = \frac{2}{\pi}\,\frac{\sin m\pi x}{m}$$

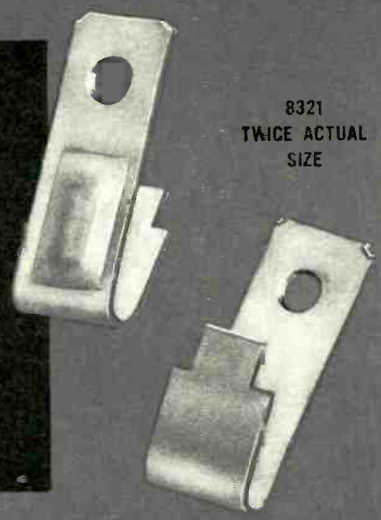
From Equation (2), therefore,

$$f(t) = x + \frac{2}{\pi}\sum_{m=1}^{\infty}\frac{1}{m}\sin m\pi x\ .\ \cos m\pi t \qquad (5)$$

using the base line as reference.

JUST A COUPLE OF LUGS...

HOLDING AN UNSHAKABLE POSITION IN ANY SET



8321
TWICE ACTUAL SIZE

8358 ACTUAL SIZE

Shielding Can Lugs... a real time saver

Designed and produced by "CINCH" to "hold tight", these mounting lugs perform where, when and how you want them to. By their record ... which includes service in America's finest radio sets ... they *deserve* a place on every front in the war on vibration. "CINCH" parts requiring spring action are properly tempered and may be had with special "CINCH" solder coating or in "hot tinned" finish.

Note the detail in construction; utility pointed grip for mounting. No. 8321 for inside of can, No. 8358 for outside of can. Both will mount into either round or special slotted rectangular holes in chassis.

"Shock-proof" is the advantage when Nos. 1100 and 1089 cup washers, pictured below, are used with rubber grommets to mount variable condensers.

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

1100

1089

ACTUAL SIZE

B402
ACTUAL SIZE

Especially designed, this "CINCH" exclusive tube holder with spring tension, grips and holds the tube *firmly*. A little part ... but a big *insurance* against vibration Illustrated in actual size. A positive guard against tubes being jolted out of the socket. Set with same socket rivet. Simple in *design*, inexpensive to attach, yet performs an important service.

CINCH MANUFACTURING CORPORATION

2335 W. Van Buren Street, Chicago, Illinois

SUBSIDIARY OF UNITED CARR FASTENER CORP., CAMBRIDGE, MASS.

New Books

Principles of Television Engineering

By DONALD G. FINK, *Managing Editor, Electronics. Published by McGraw-Hill Book Company, New York, N. Y. 1940, 541 pages, 313 figures. Price $5.00.*

THIS IS A COMPREHENSIVE and well-balanced treatment of present-day engineering practice in this country in the field of television broadcasting. The presentation follows a logical sequence from the studio camera to the home receiver, each part of the system being dealt with in its turn by analysis of the fundamental problems involved, by statements of the important principles most often used to solve these problems, and by descriptions of specific equipments or installations embodying these principles. The book is notable for its clear style and avoidance of involved mathematical derivations. A working knowledge of radio and general communication engineering principles is assumed. Emphasis is placed upon apparatus and systems developed in accordance with the standards promulgated by the Radio Manufacturers Association, and the complete Transmission Standards, Recommended Practices, Definitions and Names of Receiver Controls adopted by the RMA are given in an appendix.

In a single volume as broad in its scope as this one, it is to be expected that no one aspect of the general subject can be dealt with exhaustively except at the expense of other phases of the subject. In this case the author has handled the necessary abridgment skillfully and has achieved a remarkable uniformity of coverage, although some experts in the field will probably feel that their particular specialty has been dismissed too briefly. These specialists will find the book quite helpful, however, in bringing themselves up to date on recent progress in those phases of the art with which they are not in intimate contact.

In the discussion on random "noise" currents in circuits and tubes (pp 200–204), the conclusion reached regarding the relative importance of shot effect and thermal agitation in practical camera pre-amplifiers is at variance with the most recent findings of some investigators. This is the more regrettable because of the lack of reference to published articles on the subject of random "noise", although the selection of references in other sections of the book is quite commendable. In fairness to the author, however, it should be mentioned that the results of some of the latest work on this subject are just appearing in the technical journals.

The above-noted discrepancy and a very few other minor errors do not affect the importance of this work, which fills the presently growing need for a book that will aid engineers and technical operating personnel in the radio field to familiarize themselves with current television practice.

R. E. SHELBY,
National Broadcasting Company

Complex Variable and Operational Calculus

By N. W. MCLACHLAN, *University of London, Cambridge University Press and Macmillan Co., New York, 1939. 355 pages. Price, $6.50.*

DR. MCLACHLAN'S LATEST CONTRIBUTION to mathematical physics and engineering is definitely of a caliber which the advanced student and research worker will appreciate, but which may be somewhat beyond the mathematical capabilities of the usual practicing engineer or undergraduate student. According to the author, "the purpose of this book is to provide a modern treatment of the so-called operational method, and to illustrate its application to problems in various branches of technology." The operational method of calculus, originated by Heaviside, may be regarded as a simplified short cut method for solving linear differential equations with constant coefficients—equations of the type which are frequently encountered in mathematical physics and modern technology.

The volume is divided into four parts as follows: Part I, on the theory of complex variables, discusses the technique of integration of a complex function and is the basis upon which the subsequent sections of the book are built. Part II, on the theory of operational calculus, develops the operational method by the use of complex integration methods which are developed in the first part. Part III, on technical applications, provides a number of practical applications of the first two parts by considering practical problems from mechanics, physics, communications and other fields of technology.

In his technical papers as well as his previous book on "Loudspeakers", Dr. McLachlan has given the serious technologist ample justification to expect the careful, logical treatment which the present book exhibits. While it does not appear to be as well suited as a text for students as other books on the subject, it is likely to find a well deserved place in technical literature as a reference work and supplementary text. The volume should be well received by graduate students in technology and research engineers who require facility with modern methods of mathematical analysis.—B.D.

Applied Acoustics

By HARRY F. OLSON AND FRANK MASSA, *2nd edition. P. Blakiston's Sons & Co., Philadelphia, 1939. 494 pages. 278 illustrations. Price, $5.50.*

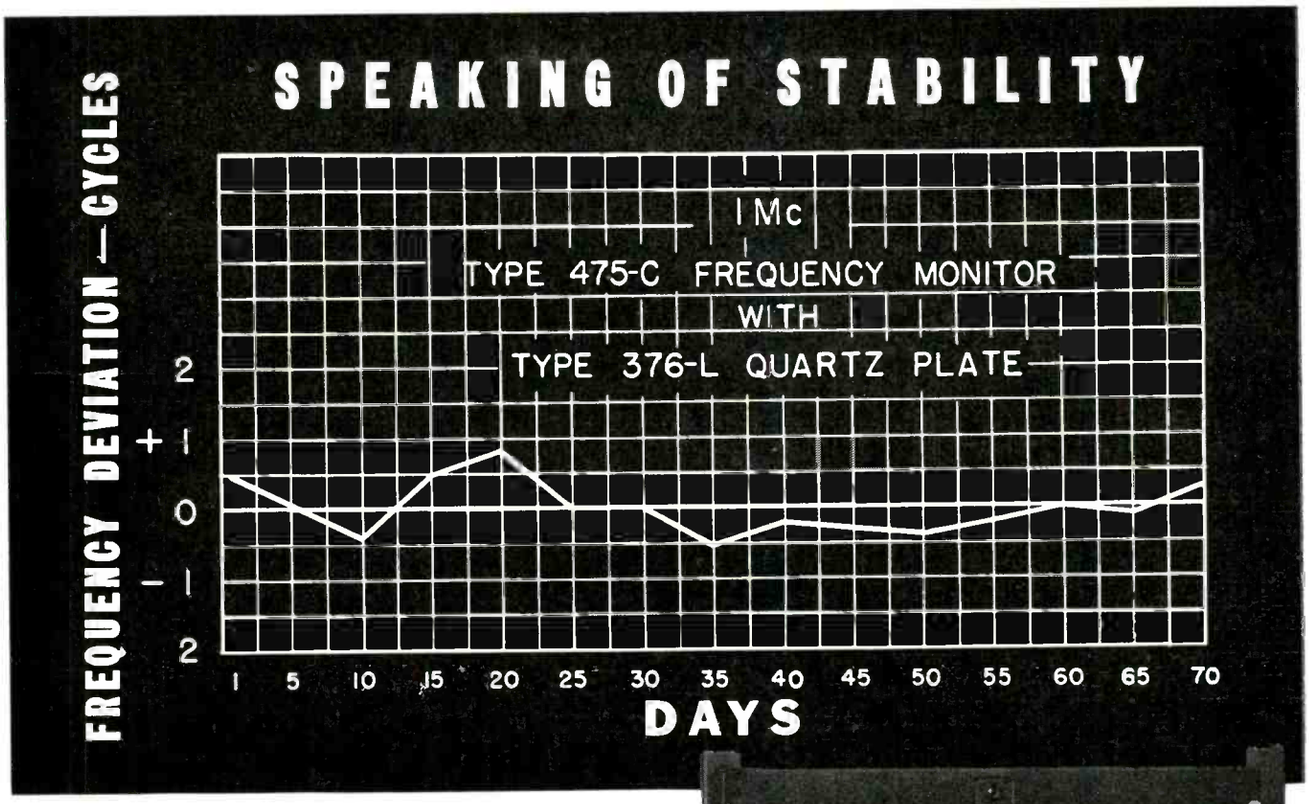
THE FIRST EDITION OF "APPLIED ACOUSTICS" introduced a new type of textbook on acoustics in which a sound theoretical treatment was combined with a highly practical engineering approach to the solution of problems which any acoustic engineer would be likely to encounter. The second edition carries still further those features which made the first edition a well-used and valued reference, and it includes the outstanding developments which have been made during the past five years, especially in microphones and loudspeakers.

The scope of the book may best be determined from the chapter headings, which are as follows: Fundamental Equations and Definitions; Dynamical Systems; Mechanical and Acoustical Elements and Systems of Elements; Fundamental Acoustical Measurements; Electrical Apparatus for the Acoustical Laboratory; Microphones; Telephone Receivers; Loudspeakers; Horn-type Loudspeakers; Calibration of Microphones; Testing of Loudspeakers; Measurements upon Dynamical Systems; Architectural Acoustics; Measurement of Noise; Physiological Acoustics; Miscellaneous Acoustic Applications, (which include sound signalling, supersonics, stereophonics, and musical instruments).

The first two chapters are likely to awe the practical engineer who disdains—or professes to disdain—theory, for the discussions are sufficiently mathematical as to require a knowledge of differential equations and vector analysis. While the foundation in these chapters is a necessary part of the working tools of any who engage in acoustical problems, the reader is immediately confronted with a treatment which appears formidable, and may fail to realize that he can derive a very great deal of benefit from the book even though the introductory chapters are not completely mastered. The remainder of the volume, while not devoid of mathematics, gives the impression of being much more practical, and will be found highly useful to those engaged in acoustic work.

The book is designed as a practical guide to the design, construction, operation, and analysis of modern acoustics and electro-acoustic apparatus. The authors have fulfilled this aim unusually well and are entitled to anticipate a hearty reception of the second edition.—B.D.

SPEAKING OF STABILITY



THE CURVE above shows the frequency deviation of a 1 megacycle G-R Broadcast Frequency Monitor, taken from stock and run continuously for seventy days from October 2, 1939 to December 12, 1939. The maximum deviation was less than one cycle! Remember, this was a STOCK model, not one especially tricked up, and is typical of the performance reported to us by many owners.

The G-R Broadcast Frequency Monitor assures your complying with Rule 3.59 of the F.C.C. at all times. The new deviation meter now reads to ± 30 cycles and is direct reading to one cycle.

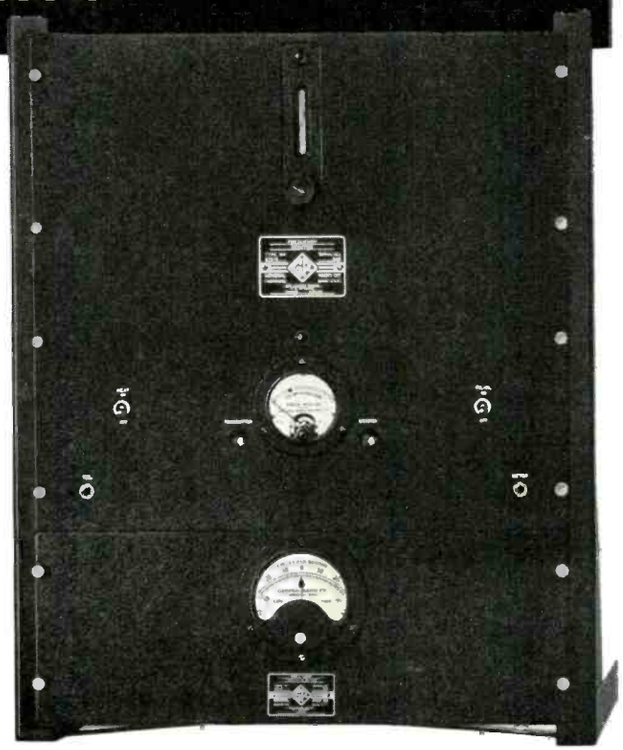
Many new electrical and mechanical features are incorporated in the G-R Monitor, which bears F.C.C. Approval No. 1461.

ELECTRICAL FEATURES

1—High-stability crystal oscillator circuit as used in primary standards
2—Amplifier to isolate crystal oscillator
3—Input amplifier to isolate transmitter
4—Diode voltmeter to adjust input level
5—New foolproof temperature-control system
6—Improved highly stable frequency-deviation meter circuit
7—AVC circuit on deviation meter
8—Simplified operation
9—New inside layout for simplified replacements

G-R Monitors are now equipped with dress panels so that you can now secure a monitor to match any of five standard broadcast-equipment panel finishes from stock. Unfinished panels can be supplied for finishing by the user and subsequent assembly by us so that your monitor can have ANY panel finish desired.

You can't go wrong in selecting a G-R Monitor. G-R has pioneered in the broadcast frequency measuring field since broadcasting started. G-R Monitors are used by hundreds of the leading stations.



TYPE 475-C FREQUENCY MONITOR	$330.00
TYPE 681-B FREQUENCY DEVIATION METER	$145.00
TYPE 376-L QUARTZ PLATE	$ 85.00
BROADCAST FREQUENCY MONITOR	$560.00

Write for Bulletin 576

GENERAL RADIO COMPANY CAMBRIDGE MASSACHUSETTS

TUBES AT WORK

A new electron microscope, 1,000,000-volt X-ray machine put into service, a mass spectrometer, killing power of ultraviolet rays and artificial lightning used to test f-m receiver

New Electron Microscope Developed at Camden

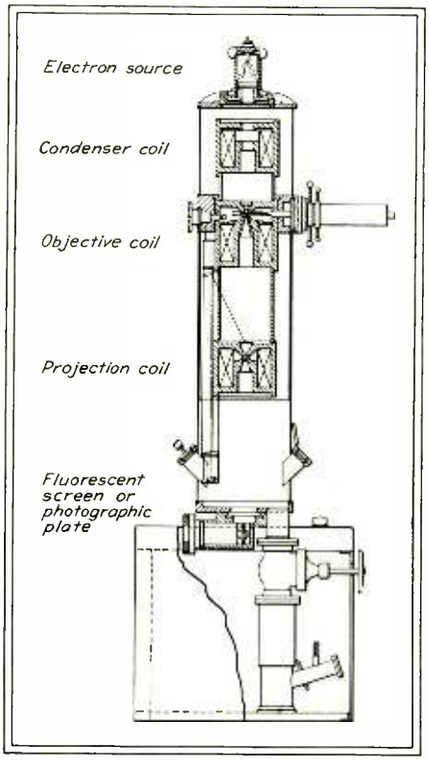
THE LATEST PRODUCT to come out of the research laboratories of RCA at Camden is the powerful transmission-type electron microscope capable of magnifying to a maximum of 25,000 diameters. The microscope, as shown in the accompanying photograph and sketch, is of the magnetic-focusing type employing three coils. The electron source at the top of the instrument is focused by a condenser coil and the scene thereby formed is directed to the objective coil. The specimen to be examined is inclosed within this coil. A system of air-locks and micrometer adjustments is available to shift the specimen relative to the axis of the instrument.

Dr. Marton with the newly developed RCA electron microscope

After the beam passes through the specimen, the objective coil forms an image enlarged about one hundred diameters which is directed to the projection coil which further magnifies the image about 250 times. The overall magnification of the device is accordingly 25,000 times. At the bottom of the instrument a fluorescent screen or photographic plate is used to record the final enlarged image.

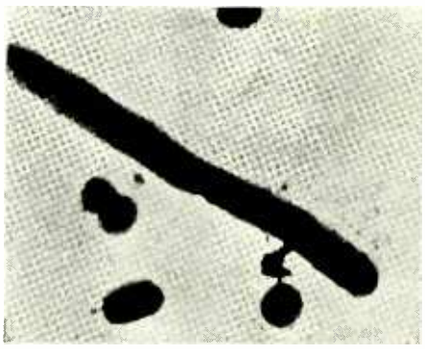
In order to obtain a high degree of useful magnification, it is necessary that the resolution of the electron beam be extremely great. The resolution in turn depends on the diffraction produced by wave interference in the beam. The wavelength of electrons in a beam depends on the velocity with which they move. By utilizing accelerating voltages from 30,000 to 100,000 volts, it is possible to make the wave length of the electrons about 1/100,000 as long as that of visible light and the circle of confusion formed by diffraction patterns is correspondingly small. In fact, the resolution of the device is so great that it is possible to obtain a four-time increase in useful magnification, simply by photographic enlargement of the final image. Accordingly, it is quite feasible to obtain a useful magnification of 100,000 times from the device.

The new electron microscope was developed, under the general direction of Dr. V. K. Zworykin, by Dr. Ladislaus Marton, and a group of associates, A. W. Vance, M. C. Banca and J. F.

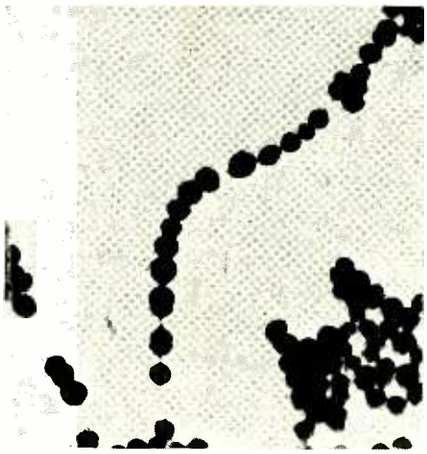


Diagrammatic view of the electron microscope

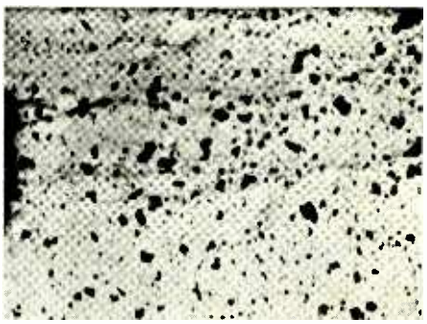
Enlargement to 15,000 diameters of commercial iron oxide, used for polishing mirror surfaces



A 20,000-diameter enlargement of the micro-organism which produces whooping cough



Chain-like virus of streptococcus haemolyticus, magnified 25,000 diameters



Magnification of one of the finest types of particles known to chemistry, colloidal gold magnified 25,000 diameters

If You Wish to Measure the Whisper of a Watch Tick . . . or Limit the Movement of a 5500 Ton Press . . . .

. . . . . or have any other switching problem where small size, light weight, precise operation and long life are essential, then you should investigate the application possibilities of the Micro Switch.

The Micro Switch is smaller than your thumb and weighs only one ounce. It requires energy ranging from only .004 to .0003 ounce inches, depending on the type of switch desired.

The Micro Switch meets requirements for repeated operation at a precise point. It provides positive, clean snap action *even* on slow actuation, although it *will* operate at the rate of 300 times per minute for as high as ten million trouble-free operations.

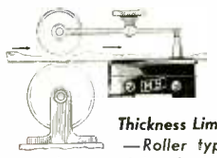
The Micro Switch is rugged, has low electric resistance, high dielectric resistance, resists vibration and requires no leveling. It is listed by the Underwriters' Laboratories with a rating of 1200 watts up to 600 volts.

Micro Switches are used on machine tools, in aircraft, in bottling and packaging machines—wherever time, temperature, pressure, weight, relays or solenoids are involved in control.

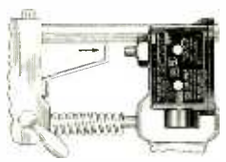
Micro Switch engineers are skilled in the application of precision switching to many types of equipment. Present your problems to them.

Here Are Only a Few of Thousands of Micro Switch Applications

Straight Cam Control—*Cam on rod or bar actuates roller arm which operates the Micro Switch. Used on machine tools and packaging machinery to control operation.*

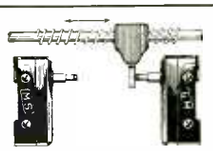


Thickness Limit Switch—*Roller type actuator rides material and operates the switch if thickness limit is exceeded.*



Lathe Carriage Stop—*Lathe carriage actuates the Die Cast Micro Switch at end of travel.*

Stress Signal—*The rod bends under stress and actuates a spring plunger Micro Switch.*



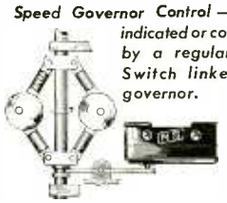
Screw Operated Carriage *actuates, at each end of travel, a Micro Switch which reverses or stops motor drive.*

Coin Actuated—*In a coin machine, the weight of a falling coin, through a proper lever, operates a regular sensitive Micro Switch.*

Solenoid Control—*Plunger of solenoid actuates Micro Switch to control other circuits.*

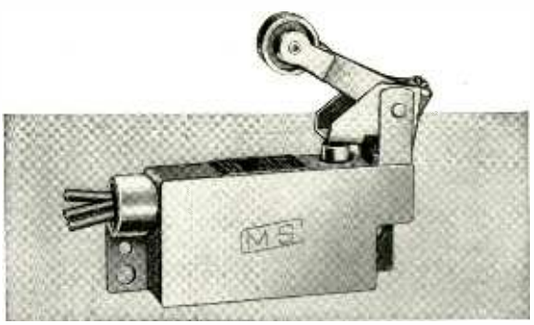
Disc and Cam Operated—*A sequence of operations is controlled by means of a roller-leaf actuator following the strips on a driven drum.*

Metal-Clad Micro Switch *with snap spring actuated by magnet.*



Speed Governor Control—*Speed indicated or controlled by a regular Micro Switch linked to a governor.*

A NEW Roller-Actuated Metal Clad Micro Switch



This is the new Model LK-2 Limit Switch—an improvement of the well-known and widely used LK Limit Switch. It is designed for use where rotating or sliding cams contact the roller.

. . . . The roller arm is a strong casting attached integral with the steel housing and is adjustable to any position through an arc of 225°. The roller is case hardened, concentric to .002" and rides on an oilless bronze bearing. It is fully described in Data Sheet No. 8. Write for it.

MICRO MS SWITCH

TRADE MARK

Manufactured in FREEPORT, Illinois, by Micro Switch Corporation. Sales Offices: New York, Chicago, Boston

Bender. The microscope has a useful magnification from 20 to 50 times as great as that available with the finest optical microscope available. The instrument is commercially available, and will be built on order for research organizations, hospitals, etc, who may desire to use it.

In a demonstration recently given at Camden, several biologic and inorganic specimens were photographed, including the virus of whooping cough, streptococcus haemolyticus, colloidal gold, iron oxide, which are shown in the accompanying pictures.

Among the unusual features of the device is a method employed in preparing specimens for examination. Since ordinary glass is opaque to the electron beam, it is necessary to place a specimen on a very thin supporting member. In the method developed by Dr. Marton, a very thin film of nitrocellulose (about 1,000,000th of a centimeter thick) is used as the supporting film. The film is in turn stretched over an extremely fine wire mesh. Other features include the air locks which are used to introduce the specimen into the vacuum chamber, as well as to introduce the photographic plate at the bottom of the instrument. These locks somewhat resemble in principle the escape chamber of a submarine. Gears and screws are provided to permit motion of the specimen from the outside, without breaking the vacuum seal. An observation window is provided for examining the fluorescent images.

• • •

Record-Breaking Magnetic Field Employed in New Mass Spectrometer

A NEW MASS SPECTROMETER developed by John A. Hipple, Jr., Westinghouse research fellow, makes use of one of the strongest magnetic fields yet attained in any magnet not containing iron. The magnetic field is used to deflect streams of ions and thus to separate the ions on the basis of their relative masses. In order to obtain a high degree of separation, a correspondingly high magnetic field is required. Dr. Hipple's apparatus is in the shape of a hollow ball, the ball being made up of 7,000 feet of hollow copper tubing, ¼ inch in diameter. This tubing is fed 45 kw of power, 300 amps at 150 volts. Distilled water passes through the tubes at a rate of 10 gallons per minute to remove the heat generated.

Within the ball is contained a semicircular vacuum tube. At one end of this tube the elements to be examined are bombarded by electrons, thereby producing ions which may be accelerated to the other end of the tube. As they pass through the tube, the ions are deflected owing to the effect of the magnetic field. At the other end of the tube the various ions have been separated according to their relative masses, and may be passed through an exit slit to the collector electrode beyond. The current to or from this

IRC SPIRAL SPRING CONNECTOR

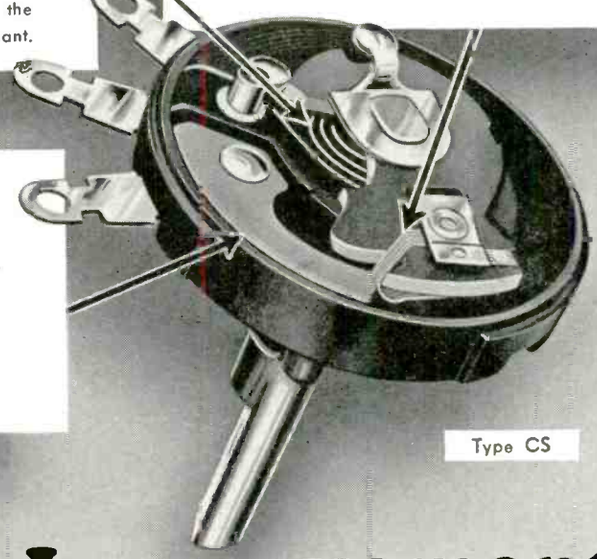
The conventional collector ring has been supplanted by a spiral spring connector which provides positive electrical contact. This eliminates sliding metal-to-metal contact and avoids the possibility of noise developing as the result of accumulated dust or dirty lubricant.

IRC 5-FINGER "KNEE ACTION" CONTACTOR

The multiple-finger element contactor acts in a "knee action" manner to maintain independent contact at all times for each finger, to prevent loss of contact and to eliminate shifting of point of contact. Contactor surfaces are round and smooth, eliminating abrasion and wear.

IRC METALLIZED TYPE ELEMENT

The IRC Metallized type resistance element permanently bonded to a moisture-proof phenolic base provides an exceptionally smooth, durable surface for noise-free contact. Cured and seasoned at high temperatures, it is long-wearing and outstandingly stable.



Type CS

3 Major Improvements

assure greater dependability for *your* product

Long ago, IRC fixed resistors reached a point where they were no longer a factor in customer complaints on the products in which they are used.

Today, thanks to a program of intensified engineering development and improved manufacturing technique, IRC Controls are rapidly reaching the same point. No better proof may be had than in their steadily increasing use in radio and electrical equipment of the most exacting sort. It is not uncommon today to find IRC Controls giving excellent service on applications where, heretofore, costly attenuators were required.

The steady development of IRC Controls is clearly demonstrated by the features illustrated above. These, coupled with the painstaking design and precision manufacture of even the most inconspicuous part, represent "plus" values that are available only in IRC Controls. They pave the way to dependability of a type essential to the trouble-free performance of your product in the hands of the ultimate consumer.

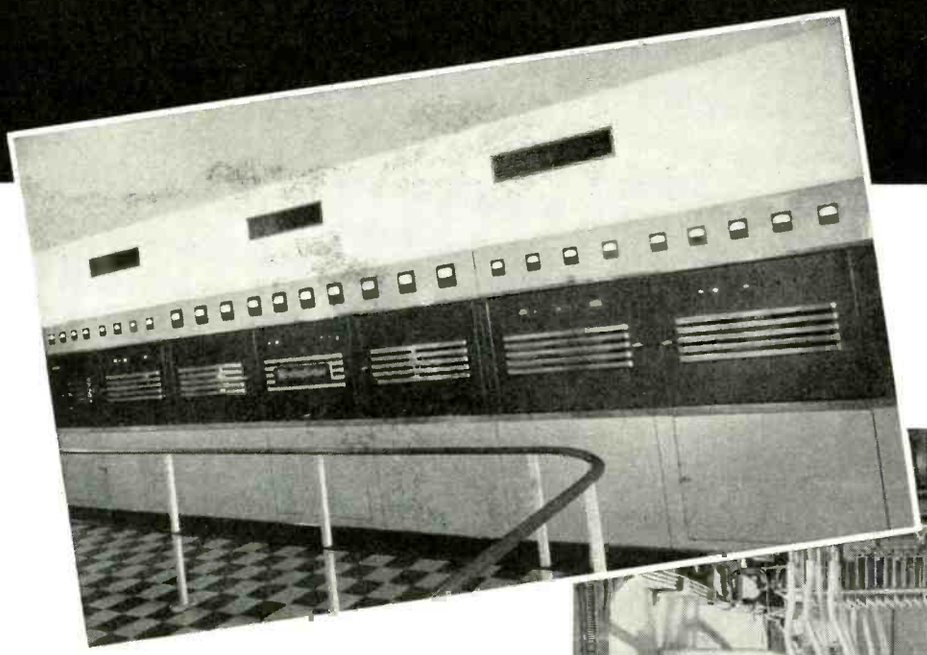
INTERNATIONAL RESISTANCE COMPANY
403 NORTH BROAD STREET, PHILADELPHIA, PA.

IRC
REG. U.S. PAT. OFF.

CONTROLS

VOLUME—TONE—POTENTIOMETER

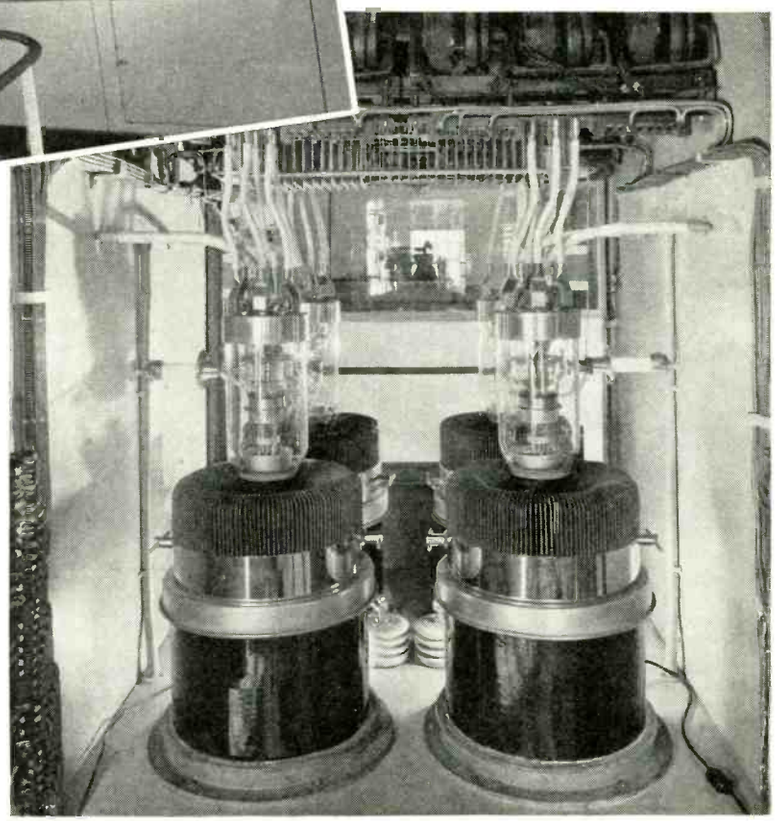
For HIGH EFFICIENCY



Front view of 50 kw transmitter at KDKA showing clean-cut modern appearance.

OPERATING ADVANTAGES

1. Air-cooled tubes in all stages.
2. Extremely low operating costs.
3. Rectox rectifiers throughout except main high voltage rectifier.
4. Inductive neutralization of the power amplifier.
5. Equalized feedback.
6. Compressed gas condensers.
7. Complete elimination of fuses.
8. Spare rectifier tube at operating temperature.
9. Ease of adjustment.
10. Unit construction throughout.
11. Full automatic control.
12. Relatively low plate voltages.
13. Conservative operation of all tubes.



Rear view of modulator cubicle, showing air-cooled operating and spare tubes. Current-limiting filament transformer at the top.

Westinghouse

. . . the New Westinghouse 50 KW TRANSMITTER

New standards for radio broadcast equipment are being set by Westinghouse Type HG 50 kw transmitter—and proved by performance at KDKA. Make any comparison you like, and you'll find this new equipment leading others in both the *quality* and dependability of broadcast, and ease and economy of operation . . . for instance, here is a comparison of power input with other well-known transmitters:

TOTAL POWER INPUT FOR 50 KW OUTPUT

% Program Modulation	0	Average	100%
Transmitter A	137 Kw	142 Kw	172 Kw
Transmitter B	125 Kw	135 Kw	170 Kw
Westinghouse	105 Kw	115 Kw	145 Kw

A new circuit principle, proved in operation, helps bring about this high efficiency—over 80% in the power amplifier alone—more than twice the plate efficiency of conventional circuits, and at least 20% above other equipment.

Air cooling of all tubes eliminates water jackets, pumps, radiators, tanks and maintenance expense, and permits use of exhaust air for heating the building. Rectifier tubes may be changed by remote push-button control, a spare tube being maintained in operating temperature and ready for service.

Ask for complete details of the many operating advantages of this new type of transmitter, listed at the left. Your Westinghouse office will gladly supply you with further information.

J-08012

WESTINGHOUSE RADIO TRANSMITTING TUBES

From the same production line that has been producing radio tubes continuously since the first broadcast, Westinghouse makes available a complete line of transmitting tubes for broadcasting and other uses. These tubes reflect in quality and performance the accumulated experience of the oldest name in commercial radio broadcasting . . . Westinghouse, which pledges the resources of its great research and engineering laboratories to the continued advancement and prestige of the radio industry.

Write for descriptive bulletin TD-92, Westinghouse Special Products Division, Bloomfield, N. J.

Broadcast Equipment

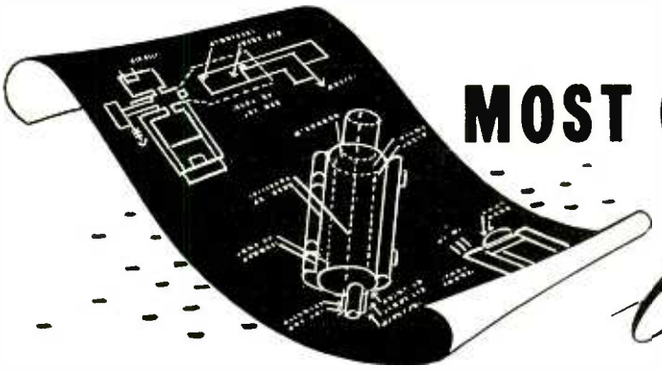
The mass spectrometer makes use of a very strong magnetic field supplied by a non-ferrous magnet

electrode can be measured by a galvanometer. The particular type of ion which falls on the exit slit may be controlled by adjusting the accelerating voltage in the tube. The sensitivity of the device is such that one part in 100,000 of a substance may be detected.

• • •

Simplified Spectrophotometer Uses Self-Generating Photo Cell

A NEW AND HIGHLY ACCURATE means of measuring the relative transmission of liquids and other specimens at different wavelengths has been developed through the joint efforts of Dr. Charles Sheard of the Mayo Clinic and the Central Scientific Co. Essentially the device is quite similar to the standard comparators in which a photovoltaic cell is exposed to light traveling through specimens to be compared, and the ratio or difference of the resulting photocurrent measured in a meter. The improvement in the new spectrophotometer is the use of a spectrum as the source of light, such that any portion of the spectrum may be presented to the two specimens being compared. External to the spectrophotometer is a standard 6-volt, 18-amp tungsten lamp with a ribbon filament. The light from this source is condensed and applied to a slit in the side of the instrument. This slit is constructed with optical precision. The incandescent light is passed to a concave diffraction grating of the reflecting-replica type which projects a spectrum of the light to the opposite end of the instrument housing. Here an exit slit, adjustable by a micrometer to a width including 5, 10 or 20 milli-micron wavelength, passes a portion of the spectrum to the photocell beyond. A crank is provided which turns the diffraction grating on its diameter, thus causing the spectrum to move over the exit slit, and allowing any portion of the spectrum to be selected for measurement. The rotating mechanism also shifts the grating so that the part of the spectrum on the



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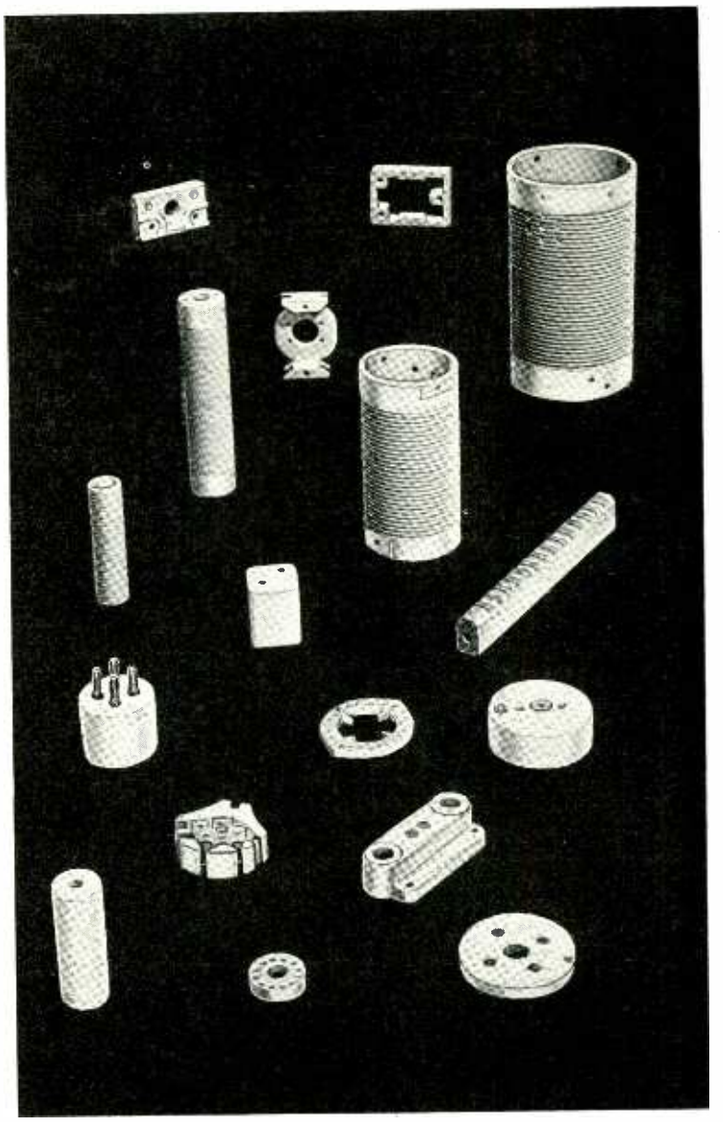
Engineers know they can rely on AlSiMag for low dielectric losses at high frequencies . . . remarkably uniform mechanical and thermal characteristics . . . true stability even under difficult operating conditions. Engineers moreover have found that AlSiMag-for-Insulation is the answer to another problem: how to win friends in the Purchasing Department. High quality AlSiMag is competitively priced — whether your order is for thousands or single pieces.

Our staff of engineers is always glad to help in solving individual design problems. Next time, why not send us *your* blueprints? Bulletin No. 39 on request.



The TEST STORY of AlSiMag No. 196

Water Absorption
Extruded Material .02-.00%
Pressed Material .05-.00%

Heat Resistant
(safe limit for const. temp.) 1000° C.

Tensile Strength
Unglazed 8000 lbs./in.²
Glazed 8500 lbs./in.²

Modulus of Rupture
Unglazed 22,000 lbs./in.²
Glazed 24,000 lbs./in.²

Compressive Strength
Unglazed 65000 lbs./in.²
Glazed 75000 lbs./in.²

Dielectric Strength
(step 60 cycles. Test disc ¼" thick) 200 Volts per mil

Dielectric Constant
60 Cycles 6.5
1000 K.C. 6.0
10 M.C. 5.8

Power Factor
60 Cycles .14%
1000 K.C. .06%
10 M.C. .04%

AlSiMag
Trade Mark Reg. U.S. Pat. Off.

FROM CERAMIC HEADQUARTERS

AMERICAN LAVA CORPORATION • CHATTANOOGA • TENNESSEE

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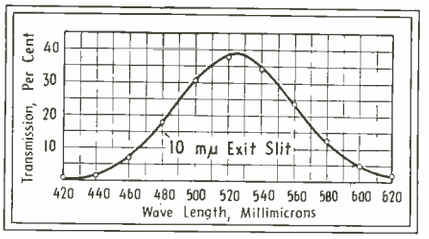
slit is kept in sharp focus. A counter geared to the mechanism indicates the wavelength in the middle of the range passed by the slit.

The light passing from the exit slit to the phototube passes through a carriage containing two cells, or hollow containers in which the liquid or other specimen being examined, is placed. Ordinarily, the device is used for chemical determinations, and in that case clear solvent is placed in one cell, whereas the same solvent containing the substance to be examined is placed in the other cell.

The cell carriage is rotated so that either one or the other of the liquid cells is brought into the path of the light leaving the exit slit and entering the photocell. The current induced in the photocell is passed through a standard moving-coil galvonometer where the relative readings may be observed.



Comparison of measured spectral responses using Sheard spectrophotometer (dots) and Hardy instrument (solid line)

This simple arrangement is capable of giving an extremely accurate determination of the spectral transmission of a chemical solution. An example is shown in the accompanying graph, which gives the transmission curve of a glass filter. The solid curve was measured on the Hardy recording spectrophotometer, generally recognized to be the most elaborate and flexible device of its kind, whereas the points on the curve were obtained with the simple instrument here described.

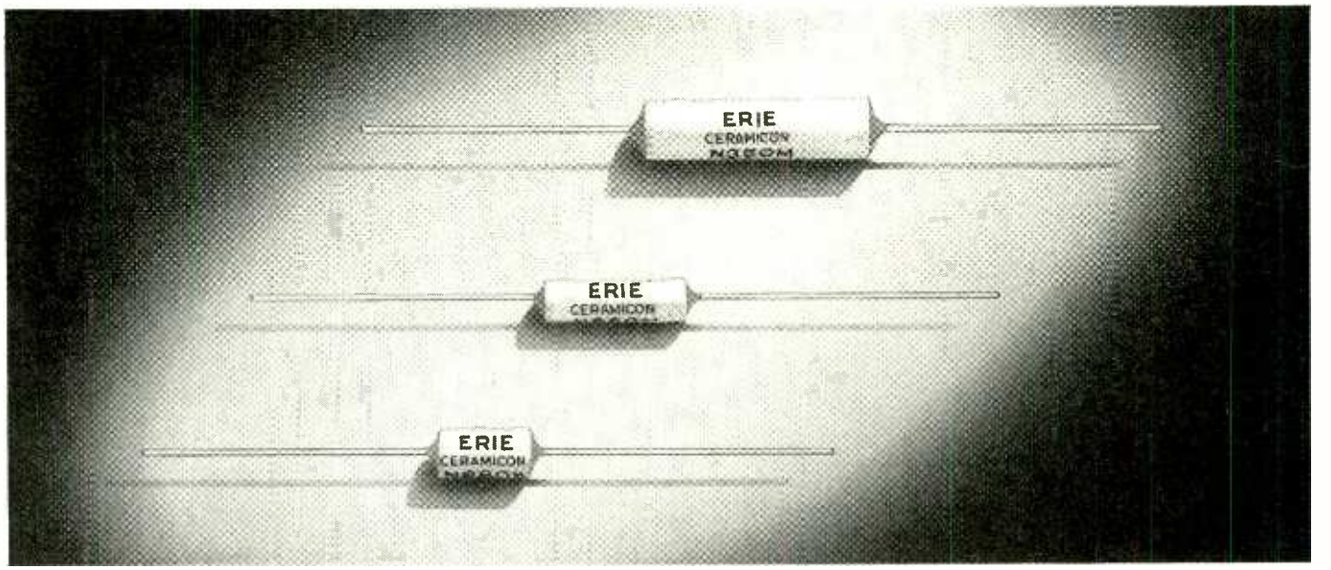
• • •

Artificial Lighting Used to Test Frequency Modulation Performance

AS A SPECTACULAR means of demonstrating the efficiency of frequency modulation in discriminating against noise, engineers of the General Electric Co. recently undertook to operate f-m receivers in the immediate vicinity of the artificial lighting equipment in Steinmetz Hall at the New York World's Fair. The receiver used was one having both f-m and standard broadcast bands, arranged so that it could be tuned simultaneously to Station WABC, 50-kw C.B.S. standard broadcast station and to Station W2XMN, the f-m transmitter at Alpine, N. J. The same program was being broadcast over both stations. A dipole antenna was installed on the roof of the building, since the copper shielding of the hall constitutes an al-

THE MOST EFFICIENT WAY TO ELIMINATE FREQUENCY DRIFT

is the simplest, too . . .



. . . *use an* ERIE CERAMICON

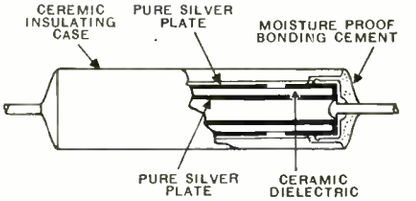
REG. U.S. PAT. OFF

Frequency drift due to temperature in radio receivers rarely confines itself to one component, usually it is caused by a number of different physical and electrical changes that occur in several components. While it is theoretically possible to eliminate the drift in each component, practically it is more efficient to compensate for the total amount by introducing an equal amount of drift of the opposite sign.

This can be done efficiently and easily by using a single unit Erie Ceramicon as part or all of the capacitive reactance. These ceramic dielectric condensers have a definite, linear and reproducable temperature coefficient and are available to counteract any amount of drift from +.00012 mmf/mmf/°C to —.00068 mmf/mmf/°C.

Several leading radio manufacturers have found Erie Ceramicons to be the answer to stabilizing the operation of their automatic tuning receivers. If you are experiencing difficulty with frequency drift, our engineering department will be glad to show you how Erie Ceramicons can efficiently solve your problem.

WHAT IS A CERAMICON ?



An Erie Ceramicon is a small fixed capacitor with silver plates in intimate contact with a ceramic dielectric. Because of the characteristics of these materials, Ceramicons are not only unusually stable in capacity but they can be manufactured with any desired straight line temperature characteristic between +.00012 and —.00068 per °C. Ceramicons between 50 and 350 mmf are completely insulated and sealed against moisture. Non-insulated ceramicons are available up to 1100 mmf.

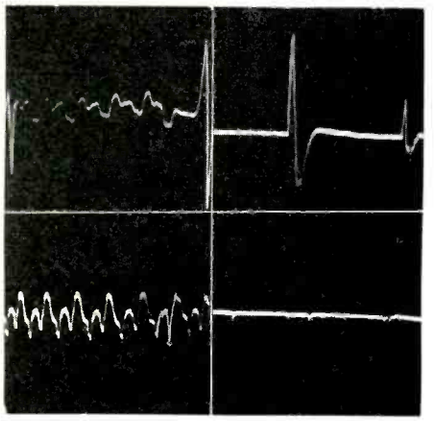
RESISTORS
SUPPRESSORS
CERAMICONS
SILVER-MICA CONDENSERS

Erie RESISTOR CORPORATION, ERIE, PA.

TORONTO, CANADA • LONDON, ENGLAND • PARIS, FRANCE - J.E. CANETTI CO.

MOLDED BEZELS
PUSH BUTTONS AND KNOBS
POLYSTYRENE COIL FORMS

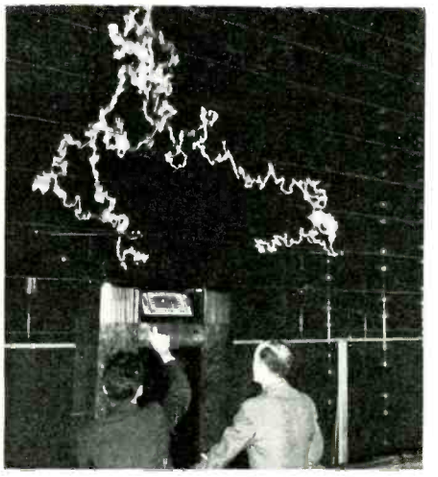
most perfect barrier against all radio signals. Because of the great audible noise associated with the 10,000,000-volt artificial lightning, this type of discharge was not used in the test, since it would be impossible to listen to the radio program at the same time. Rather the 1,000,000-volt, three-phase continuous discharge, which produces



Oscillograms of a-m and f-m reception. Top, amplitude modulation with and without modulating signal; bottom, same on f-m receiver

visible corona on wires, was employed as the noise source. The noise produced by this discharge is continuous, and displays hissing and crackling characteristics quite similar to extremely heavy static. On the standard broadcast band, the noise interference was so great that the program was completely obliterated. When frequency modulation was employed, the program was heard with almost perfect clarity and with only a slight static buzz.

As an additional proof of the efficacy of the frequency modulation against noise, H. F. Mayer of the General Electric's engineering staff of the Schenectady laboratories, employed a cathode ray oscillograph to record the wave form at the output of the receiver for the two types of modulation. A 1,000-microvolt signal was fed to the re-



Receiver set up in Steinmetz Hall for artificial-lightning noise studies

FORMICA panels are used on a great many electronic devices for clinical purposes as well as for meters, and testing devices of various sorts. These panels are printed in gold and silver and are drilled and machined for the attachment of controls. The picture shows a Formica panel on the "Radioclast" manufactured by the Electronic Instrument Company.

Formica has several printing and marking processes by which such panels may be prepared, and they may be completely machined, ready for assembly, in the Formica factory.

Send your blue prints for quotations.

THE FORMICA INSULATION CO.
4638 Spring Grove Ave., Cincinnati, O.

FORMICA

ceiver on the standard band and on the 40 megacycle band for amplitude and frequency modulation respectively. (In the f-m case the signal source was the visual alignment signal generator described in the April issue of *Electronics*.) The noise in this case was obtained from a nearby spark coil in order to make the record sufficiently simple for interpretation. Oscillograms were taken with sinewave modulation, with complex modulation from a harmonica program and with unmodulated input. Several of the results are shown in the accompanying oscillograms. While the noise is not completely eliminated in the frequency modulation reception, its amplitude is so small in the latter case that it has virtually no effect on the quality of the program.

• • •

Discharge Tube Aids Study of Ultraviolet Killing Power

TO AID IN STUDYING the effect of ultra violet light on various types of bacteria and other micro-organisms, Dr. H. C. Rentschler and Milton Hoyt of the Westinghouse Research Laboratories at Bloomfield, have employed a mercury gas discharge tube mounted directly on the stage of a microscope. The research is to determine the sensitivity of micro-organisms to short exposures of ultraviolet radiation. Micro-organisms are supported in a few drops of

Microscope fitted with ultra-violet "death-ray" tube

liquid and examined by a projector microscope which forms an image magnified at about 200 diameters. Around and slightly above the pool is the discharge lamp, which is a type of the Sterilamp tube developed at Westinghouse. The lamp is energized by direct current from a bank of capacitors. In most cases, when the discharge occurs all of the bacteria in the culture are killed instantaneously, and some of them appear to be exploded by some internal eruption.

YOUR TUBE DOLLAR--

IS IT INVESTED---OR SPENT?

TO BE invested, every dollar you put into transmitting tubes should provide:

1—dependable, economical performance today

2—research to assure even better tubes tomorrow

If the tubes in your transmitter are marked "General Electric" your tube dollar is invested, because G-E transmitting tubes year by year will give you improved performance, and at the lowest possible operating cost.

The GL-857B is a noteworthy example—a tube whose history is another story of G-E achievement:

G-E Engineers . . .

— developed the hot-cathode mercury-vapor rectifier.

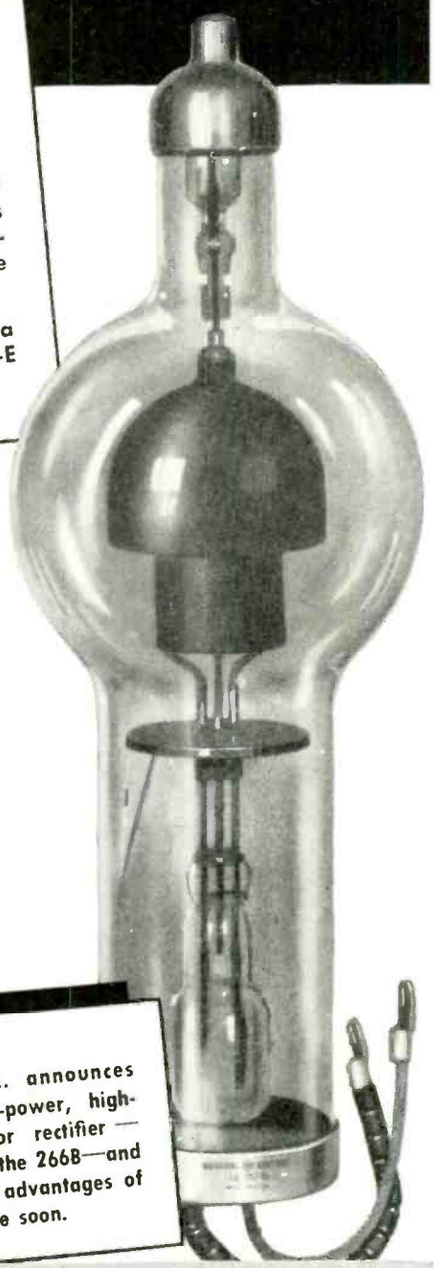
— built the first high-voltage mercury-vapor rectifiers, which were soon accepted as standard throughout the industry.

— introduced the 857, and later the new 857 which reduced arc-backs, cut voltage drop and power loss between electrodes, and gave longer life and greater dependability.

— produced a more efficient cathode that cut filament power in half.

— developed the first accurate rectifier emission test, which assured even greater dependability in G-E built tubes.

— designed a new, rigid filament structure, which greatly increased cathode life.



NOW — G.E. announces the GL-266B, a high-power, high-voltage mercury-vapor rectifier — interchangeable with the 266B—and incorporating all the advantages of the GL-857B. Available soon.

Bulletin GEA-3315A gives technical information and prices on the complete G-E transmitting tube line. Get one from the nearest G-E Office, or write direct to General Electric, Radio and Television Dept., Schenectady, N. Y.

GENERAL ELECTRIC

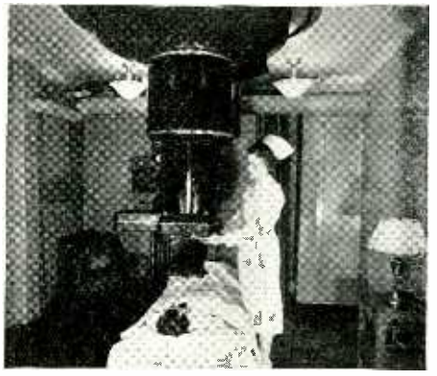
161-3

Million Volt X-Ray Goes Into Medical Service

THE SECOND OF TWO one million volt X-ray machines has been installed at the St. John's Hospital in Cleveland, Ohio. The first of these instruments was installed last year at the Memorial Hospital in New York. Both were developed by the General Electric X-Ray Corp. The new million volt machine replaces the 400,000-volt unit but despite the great increase in voltage, the new device requires less space than

Upper portion of million-volt X-ray installation

the old. The entire apparatus weighs 4,000 lb, including about 1,000 lb of protecting lead. Some idea of the compactness of the installation is indicated by the installation of the transformer tank and accessory apparatus, which are installed on the first floor in what was formerly a private room in the hospital. Ports for directing the X-ray radiation to the patient extend downward into a specially constructed cubicle on the ground floor. The apparatus is controlled in a therapy control room just outside the treatment cubicle.



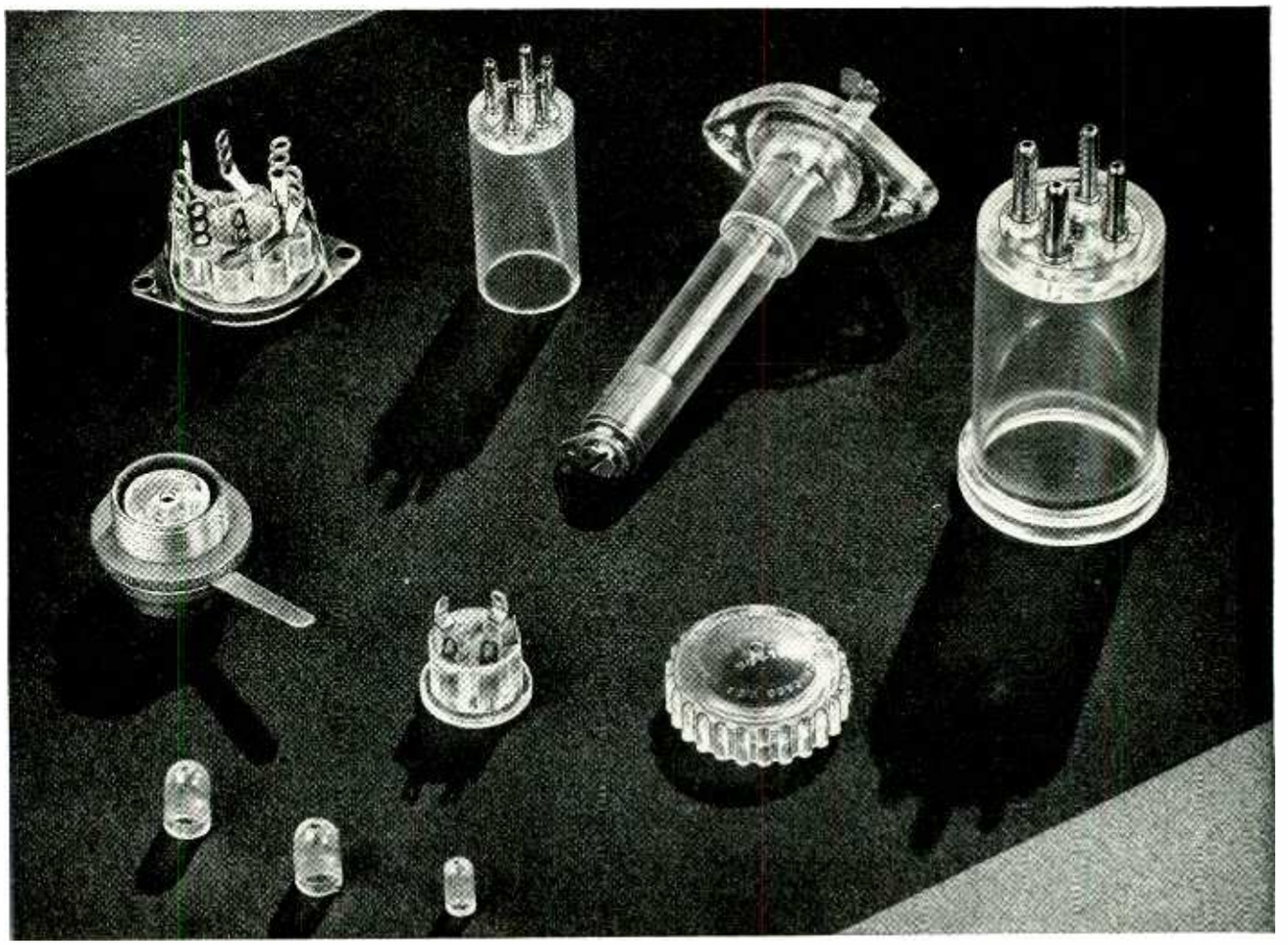
Treatment port of St. John's Hospital high-voltage X-ray

The power consumption of the outfit at maximum voltage is approximately 3,000 watts, 1,000,000 volts at 3 milliamperes. The tube is 3½ inches in diameter and 56 inches long. The insulation used is dichlorodifluormethane, a gas used in refrigeration and commonly known as freon. Also in the new X-ray department is a transformer capable of providing heavy-current, low-voltage output (85,000 volts at 500 milliamperes) for very short exposures which permit stop-motion studies.

Minimum Power Loss – Maximum Efficiency

FOR HIGH FREQUENCY APPARATUS

with Bakelite Polystyrene Insulation



UNEXCELLED by any other organic insulation, because of superior low-loss characteristics and resistance to moisture, Bakelite Polystyrene plastics present exceptional opportunities for greater efficiency in high frequency apparatus.

Among the numerous Bakelite Polystyrene parts providing improved dielectric performance, there are many made by American Phenolic Corporation. These include low-loss coil forms for high frequency receivers and low power transmitters, as well as sockets that eliminate drift at tube bases. There are also sturdy insulators for stand-off and feed-through purposes that reduce surface leakage to a minimum. Outstanding, too, are specially designed low-loss insulating beads permitting flexing of high frequency or high voltage leads without uncovering the wire.

Learn how Bakelite Polystyrene plastics can be profitably employed in your own electronic equipment by enlisting the cooperation of Bakelite Research and Development Laboratories.

BAKELITE CORPORATION
Unit of Union Carbide and Carbon Corporation
247 PARK AVENUE, NEW YORK

BAKELITE

PLASTICS HEADQUARTERS

Consider these advantages of BAKELITE POLYSTYRENE for high frequency equipment

POWER FACTOR
(60 to 50,000,000 cycles)
.0002—.0003

DIELECTRIC CONSTANT
(60 to 50,000,000 cycles)
2.50—2.60

LOSS FACTOR (60 to 50,000,000 cycles)
.0005—.0008

DIELECTRIC STRENGTH (60 cycles)
500 to 525 volt/mil

VOLUME RESISTIVITY
Over 10^9 megohm cms.

ARC RESISTANCE
(proposed A.S.T.M. method)
120 to 140 secs.

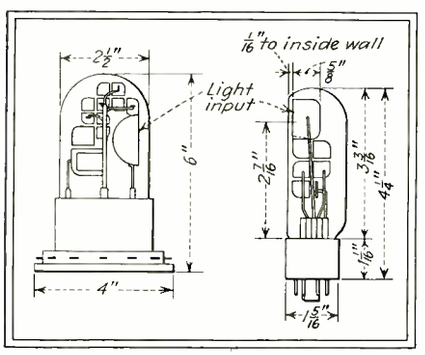
TUBES

A new multiplier phototube of great sensitivity is described. The tube registry list is given for March 1940 and the second and third quarters of 1938

Electron Multiplier Phototube

THE NEW FARNSWORTH MULTIPLIER PHOTOTUBE combines in one highly evacuated envelope a phototube and an electron multiplier. These tubes are highly sensitive and are responsive to light of the order of a fraction of a millilumen. They are therefore applicable to any work involving the delicate measurement of light.

The tube is available in two sizes, a 6-stage unit having an average sensitivity of 20 ma per lumen at 100 volts per stage and a collector dissipation of 0.01 watt, and an 11-stage unit with corresponding figures of 3 amperes and



Sectional views of the 11-stage unit (left) and the 6-stage unit. The peak of sensitivity is at 8500 Angstroms

0.1 watt. There are two types available in each size. Type A is highly sensitive and Type B is considerably less sensitive, with the dark current and noise correspondingly reduced. The light-current characteristic is linear over a wide frequency range.

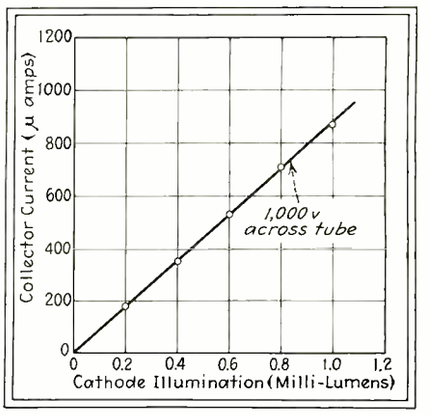
The peak of the caesium coated cathode photoelectric sensitivity is in the near infra-red region at about 8500 Angstroms. It is therefore well-suited to operation with light from a tungsten lamp. The lamp may be lighted with 60 cycle alternating current unless the 120 cycle component is objectionable, in which case direct current should be used.

The action of the electron multiplier is based upon the principle of secondary emission from a series of caesiated surfaces at successively higher potentials. The impact of each primary electron in each successive stage causes the emission of from 2 to 5 secondary electrons, thus amplifying the current in geometrical proportion to the number of stages. The accompanying diagram shows the arrangement of the multiplier stages in which the progress of the electron stream may be traced.

The sensitivity of the tube is given approximately by the equation

$$S = 10\left(\frac{\sqrt{v}}{3}\right)^{n} \text{ microamperes,}$$

where v is the voltage per stage and n is the number of stages. This gives the safe value above which the Type A tube usually remains, but is not the average value. For the Type B tube, 3 should be replaced by 3.5. The characteristic of the 11-stage unit with 77 volts per stage is shown in the accompanying diagram. These tubes may be operated between a lower limit imposed by the noise level and an upper limit established by the heat dissipation of



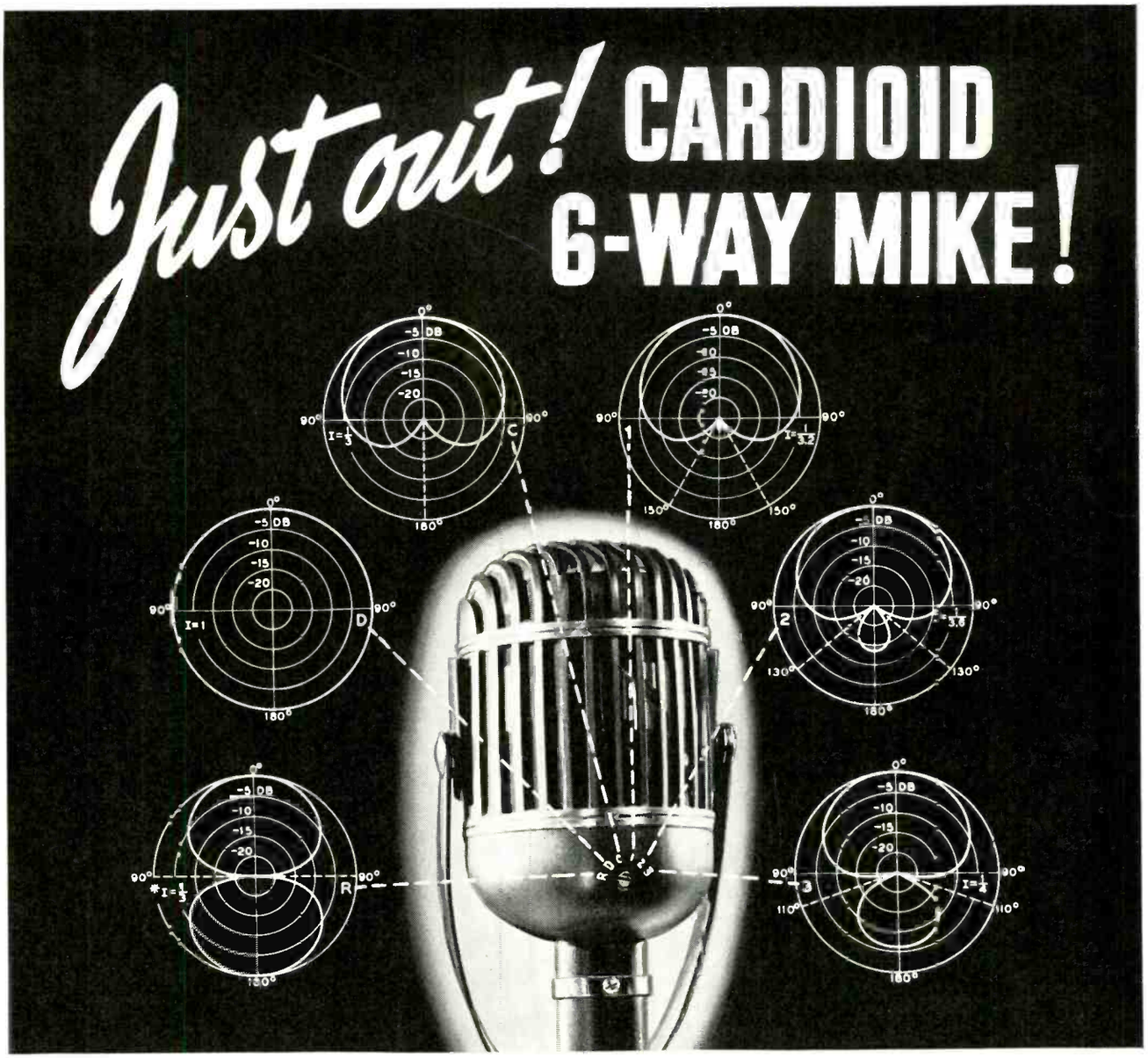
Output characteristic of the 11-stage multiplier phototube

the collector and last stages. Under favorable conditions, the difference between these limits may amount to 70 db. Greater light intensities may be accomodated by using a lower voltage with consequent reduction in sensitivity.

The low inherent tube noises are for the most part due to the shot effect variations in the dark current which is caused by thermionic emission from the cathode surface in the phototube at room temperatures. Only about 30 per cent of the noise is caused by the

HONORS TO KDKA'S ORIGINATOR

Dr. Frank Conrad (left) assistant chief engineer of the Westinghouse Electric and Manufacturing Co. and William L. Laurence (right) of the New York Times, receiving medals for meritorious achievement from Robert T. Pollack, president of the American Institute of the City of New York. Dr. Conrad was cited for his pioneering work in short wave radio communication and for developing the first radio broadcasting system. Mr. Laurence gained honors for his brilliant and accurate reporting in the daily press of the achievements of science and technology



NEW 639B gives you 6 pick-up patterns at the turn of a switch!

To select the best performance for any given condition, just set up the 639B and try each of its six patterns by a simple "flip of the switch."

In addition to non-directional, bi-directional and cardioid directivity patterns, it gives you *three new patterns*, 1, 2 and 3, that reduce effects of reverberation to an even greater degree than the already famous 639A.

The 639B permits shifting the angle of minimum response to 150°, 130° or 110°, enabling the operator to avoid particular reflections or feed-back paths.

These patterns, which are realized at unusually low frequencies, are particularly effective in reducing low frequency reverberation inadequately suppressed by many studio treatments.

Again Bell Labs and Western Electric lead the way to *Better Broadcasting!* Get full details of the 639A and 639B Microphones from Graybar.

Western Electric

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multiplier stages, since the secondary emission is a random effect. When the dark noise is expressed as an equivalent light fluctuation, it is of the order of 2×10^{-7} lumen for a frequency range or 10 kc. The increased shot effect due to the electron current when the light is on is offset by the increase in the signal-to-noise ratio as the light increases. For the Type A tube operating with a light input of millilumen, the signal-to-noise ratio is about 60-db. For the Type B tube the ratio is higher.

The tubes operate efficiently with potential differences ranging from 30 to 120 volts per stage. To insure that all electrons from the cathode enter the multiplier, a voltage which is double the potential difference between stages is applied between the cathode and the first stage. If the grid resistor of the following amplifier stage is 0.1 megohm and the output current of the phototube is 100 microamperes, a voltage drop of 10 volts will result. This is sufficient to drive a type 6G6 tube.

• • •

Tube Registry

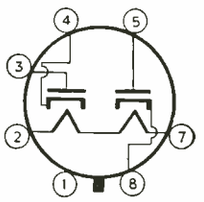
NOTICE: The basing designation for tube type 117Z6 GT has been changed from 7-AR as shown on page 68 of the November 1939 issue of *Electronics* to 7-Q.

Type 117Z6 (GT)

Prototype 117Z6 (G)

FULL wave rectifier-doubler; heater type; (T-9) glass envelope, seated height 2¾ inches (max); 7 pin, small metal shell wafer base.

e_b = 117 v
e_{ac} = 117 v (max)
i_{dc} = 60 ma (max)
i_b = .075 amp
Basing 7-Q



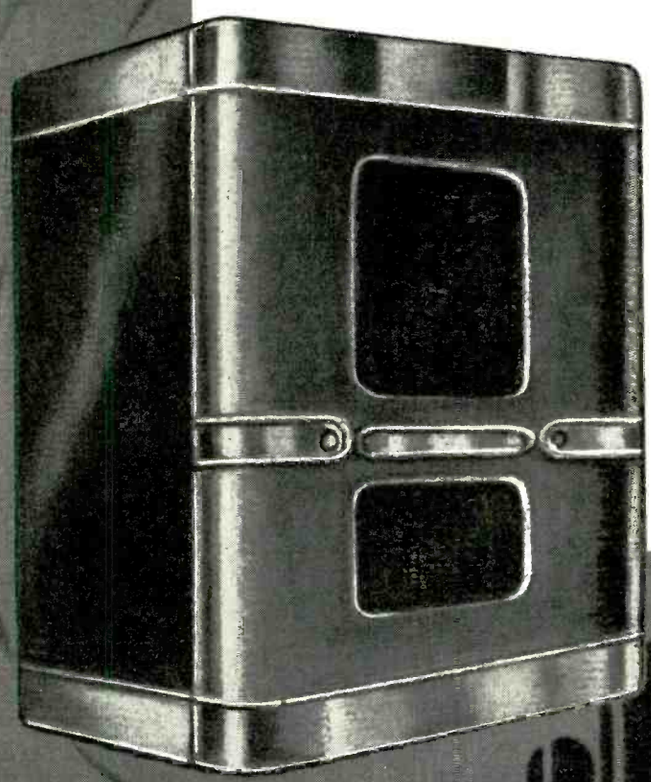
Tube Types Registered by R.M.A. Data Bureau During March 1940

ATTENTION is called to the use of additional symbols in the basing designations to indicate which terminals, if any, are connected to external or internal shields (or to the metal tube envelope). The first additional symbol indicates the number of the terminal connected to an external shield. The second additional symbol indicates the number of the terminal connected to an internal shield. Other base connections are indicated by letters appropriate to the pertinent base detail, such as *L* for the lug of the locking-in type of base.

FOR *Better* REPRODUCTION OF *Any* SIGNAL

MODEL MT-8 is a high fidelity Reproducer employing an especially designed eight-inch PM loud speaker, working in conjunction with the well known Jensen *Peri-dynamic* and *Bass Reflex* principles.

Mean energy density acoustic measurements, when conducted in an average listening room, show an excellent frequency response characteristic from 50 to 10,000 cps. No noticeable depreciation in high frequency output is observed within a 45° angle and the performance is highly satisfactory within a 60° angle; thus the polar characteristic of the Reproducer is substantially superior to that of any comparable single speaker device we know.



Model MT-8 is extensively used in broadcasting stations, recording studios, monitoring and audition work.

The Bass Reflex cabinet is solidly constructed of three-quarter inch plywood, finished in neutral brown lacquer with contrasting trim. Dimensions: 24 x 17½ x 11¼. Comes complete with brackets for wall mounting if desired. List price.....$29.50

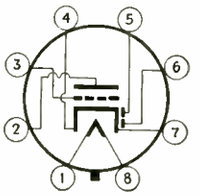
Jensen
Bass Reflex
Speakers

Type 14B6 (GL)

Prototype 7B6

DOUBLE-DIODE, hi mu triode; heater type; (T-9) integral glass envelope-base; 8 pin loktal base.

E_h = 14 v
I_h = 0.16 amp
E_b = 250 v
E_c = − 2 v
I_b = 0.9 ma
μ = 100
g_m = 1100 μmhos
r_p = 91,000 ohms
C_{in} = 3.0 μμf
C_{out} = 3.0 μμf
C_{gp} = 1.5 μμf
Minimum diode current @ 10 volts dc = 0.8 ma per plate
Basing 8W-L-0

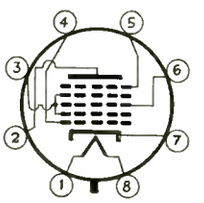


Type 14Q7 (GL)

Prototype 7Q7

HEPTODE converter, heater type; (T-9) integral glass envelope-base; seated height 2¼ inches (max) 8 pin, loktal base.

E_h = 14 v
I_h = 0.16 amp
E_b = 250 v (max)
E_{c2} = 100 v
E_{c3} = − 2 v
E_{c5} = 0 v
E_{c1} = 20,000 ohms × 0.5 ma = 10 v
I_b = 3.5 ma
$I_{c2,4}$ = 8.5 ma
I_{c1} = 0.5 ma
g_c = 450 μmhos
r_p = 1 megohm
$C_{rf\ in}$ = 9.5 μμf
$C_{if\ out}$ = 9.0 μμf
Basing 8AL-L-5



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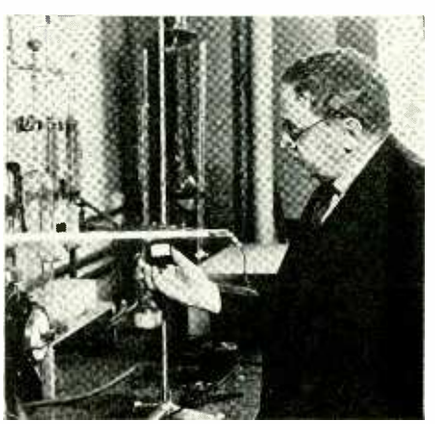
MEASURING GERMICIDAL RADIATIONS

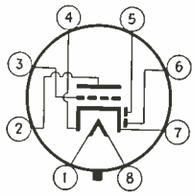


H. C. Rentschler, Westinghouse's director of research, measuring the bactericidal output of a Sterilamp. A glass filter over the meter filters out the visible spectrum, but permits passage of ultraviolet radiations which strike a fluorescent screen, causing it to glow. The glow of the fluorescent screen, is proportional to the output of the lamp, and is measured by a photoelectric cell and meter

Type 7B6-LM

DOUBLE diode, triode; heater type; (MT-8) metal envelope; seated height 2 3/32 inches (max); octalox 8 pin base.

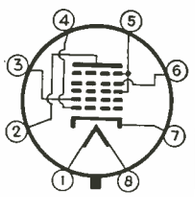
E_h = 6.3 v
I_h = 0.3 amp
E_b = 250 v (max)
E_c = − 2 v
I_b = 0.9 ma
μ = 100
r_p = 91,000 ohms
g_m = 1100 μmhos
Basing 8-W-L-0



Type 7B8-LM

PENTAGRID converter; heater type; (MT-8) metal envelope; seated height 2 3/32 inches (max); octalox 8 pin base.

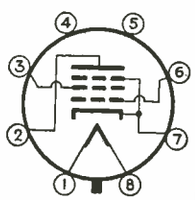
E_h = 6.3 v
I_h = 0.3 amp
E_b = 250 v (max)
$E_{c3,5}$ = 100 v (max)
E_{c4} = − 3 v (min)
E_{c2} = 170 v
E_{c1} = − 20 v
I_b = 3.5 ma
$I_{c3,5}$ = 2.7 ma
I_{c2} = 4 ma
r_p = 0.36 megohm (approx,
g_c = 550 μmhos
$C_{rf\ in}$ = 10 $\mu\mu$f
$C_{if\ out}$ = 12 $\mu\mu$f
Basing 8X-L-0



Type 7B5-LT

POWER amplifier pentode; heater type; (T-9) glass envelope; seated height 2⅝ inches (max); octalox 8 pin base with metal sleeve.

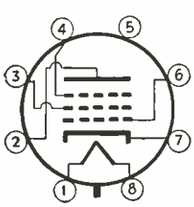
E_h = 6.3 v
I_h = 0.4 amp
E_b = 315 v (max)
E_{c2} = 250 v (max)
E_{c1} = − 21 v
I_{bo} = 25.5 ma
I_{c2o} = 4 ma
r_p = 75,000 ohms
g_m = 2100 μmhos
r_l = 9000 ohms
P_o = 4.5 watts (15%)
Basing 6AE-0-0



Type 7L7 (GL)

R-F pentode, sharp cutoff; integral glass envelope base, seated height 2¼ inches (max), 8 pin loktal base.

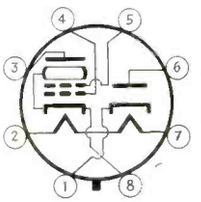
E_h = 7 v
I_h = 0.32 amp
E_b = 250 v
E_{c2} = 100 v
E_{c1} = −1.5 v
I_b = 4.5 ma
I_{c2} = 1.5 ma
g_m = 3100 μmhos
r_p = 1 megohm (approx)
C_{in} = 8.0 $\mu\mu$f
C_{out} = 6.5 $\mu\mu$f
C_{gp} = 0.01 $\mu\mu$f (max)
Basing 8V-L-5



Type 117M7 (GT)

RECTIFIER-BEAM power amplifier; heater type; (T-9) glass enevelope; seated height 2⅞ inches (max); 8 pin octal base.

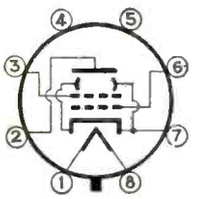
E_h = 117 v
I_h = 0.09 amp
RECTIFIER
E_p = 117 v (max)
I_b = 75 ma
E_b = 20 v (drop) @ 150 ma
BEAM POWER AMPLIFIER
$E_b = E_{c2}$ = 100 v
E_{c1} = 5.5 v
I_{bo} = 50.0 ma
I_{c2o} = 4.5 ma
g_m = 7000 μmhos
r_p = 15,000 ohms
r_l = 2000 ohms
P_o = 1.3 watts (8%)
Basing 8-AO-0-0



Type 7C5-LT

BEAM power amplifier; heater type; (T-9) glass envelope; seated height 2 27/32 inches (max); octalox 8 pin base, with metal sleeve.

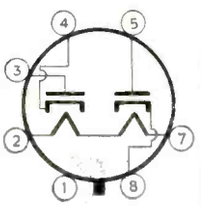
E_h = 6.3 v
I_h = 0.45 amp
E_b = 315 v (max)
E_{c2} = 225 v
E_{c1} = − 13 v
I_{bo} = 34 ma
I_{c2} = 2.2 ma
g_m = 3750 μmhos
r_p = 77,000 ohms
r_l = 8500 ohms
P_o = 5.5 watts (12%)
Basing 6AA-0-0



Type 35Z6G

RECTIFIER doubler; heater type; (ST-14) bulb seated height 4-1/16 inches; 7 pin octal base.

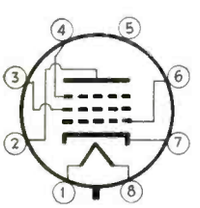
E_h = 35 v
I_h = 0.3 amp
HALF WAVE RECTIFIER
E_b = 235 v (max)
I_b = 2 (110 ma) max
E_{in} = 700 v
E_b = 22 v (drop @ 220 ma)
Basing 7Q-0-0



Type 7H7 (GL)

R-f pentode, semi-remote cutoff; heater type; (T-9) integral glass envelope-base; seated height 2¼ inches (max) 8 pin loktal base.

E_h = 7.0 v
I_h = 0.32 amp
E_b = 250 v
E_{c2} = 150 v
E_{c1} = − 25 v
I_b = 9 ma
I_{c2} = 2.5 ma
g_m = 3500 μmhos
r_p = 1 megohm
E_{c1} = @ 1% of g_m = − 19 v
C_{in} = 8.0 μμf
C_{out} = 7.0 μμf
C_{plp} = 0.005 μμf (max)
Basing 8V-L-5

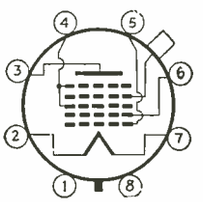


Tube Types Registered by R.M.A. Data Bureau During the Second and Third Quarters of 1938

Type 1A7 (G)

PENTAGRID converter, filament type, (T-9) glass envelope, 8-pin octal base.

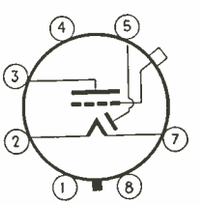
E_f = 1.4 v
I_f = 0.05 amp
E_b = 90 v (max)
$E_{3,5}$ = 45 v
E_{c4} = 0 v
I_b = 0.55 ma
$I_{c3,5}$ = 0.6 ma
g_c = 250 μmhos
r_p = 0.6 megohm
Basing 7-Z



Type 1H5 (G)

DIODE triode, filament type, (T-9) glass envelope, 7-pin octal base.

E_f = 1.4v
I_f = 0.05 amp
E_b = 90 v
E_c = 0 v
I_b = 0.15 ma
r_p = 240,000 ohms
μ = 65
Basing 5-Z



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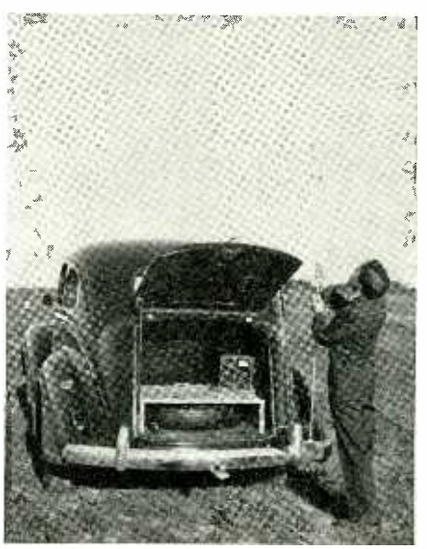
RADIO EQUIPPED SAILPLANE INDICATES ITS COURSE

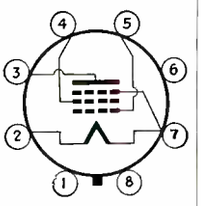


As the radio equipped sailplane soars along, most of the time out of sight, the ground crew follows it along by receiving broadcasts from the pilot in his flight. To insure better reception and transmission, the telescopic antenna in the automobile used by the ground crew, is extended to its full length of eight feet.

Type 1C5 (G)

POWER amplifier pentode, filament type, (T-9) glass envelope, 8-pin octal base.

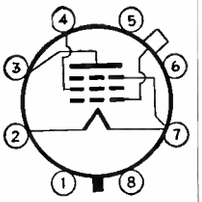
E_f = 1.4 v
I_f = 0.01 amp
E_b = 90 v
E_{c2} = 90 v
E_c = −7.5 v
I_b = 7.5 ma
I_{c2} = 1.6 ma
R_l = 8000 ohms
r_p = 115,000 ohms
g_m = 1550 μmhos
P_o = 240 milliwatts (10%)
Basing 6-X



Type 1N5 (G)

R-f pentode, filament type, (T-9) glass envelope, 8-pin octal base.

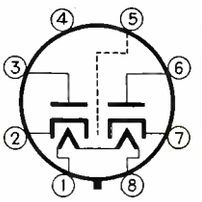
E_f = 1.4 v
I_f = 0.05 amp
E_b = 90 v
E_{c2} = 90 v
E_c = 0 v
I_b = 1.2 ma
E_{c2} = 0.3 ma
r_p = 1.5 megohms
g_m = 750 μmhos
Basing 5-Y



Type 7A6 (GL)

DUODIODE, heater type, glass envelope-base, 8-pin loktal base.

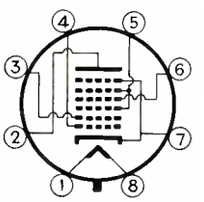
E_h = 7.0 v
I_h = 0.16 amp
$E_{p\ ac}$ per plate (rms) = 150 v (max)
$I_{p\ dc}$ = 10 ma (max)
E_{drop} (I_p = 10 ma) = 8 v
Basing 7-AJ



Type 7A8 (GL)

OCTODE converter, heater type, glass envelope-base, 8-pin loktal base.

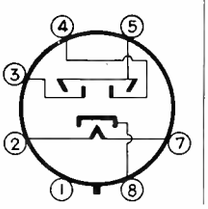
E_h = 7.0 v
I_h = 0.16 amp
E_b = 250 v (max)
$E_{c3,5}$ = 100 v (max)
E_{c1} = − 3.0 v
E_{c2} = 250 v (max)
I_b = 3.0 ma
$I_{c3,5}$ = 2.8 ma
I_{c2} = 4.5 ma
I_{g1} = 0.4 ma
g_c = 600 μmhos
Basing 8-U



Type 6AD6 (G)

TUNING indicator, heater type, (T-9) glass envelope, 7-pin octal base.

E_h = 6.3 v
I_h = 0.15 amp
E_{target} = 150 v
I_{target} = 3 ma
Basing 7-AG



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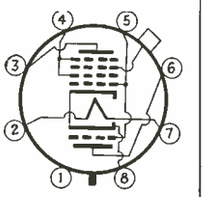
Type 6K8 (G)

TRIODE-HEXODE converter, heater type, glass envelope, 8-pin octal base.

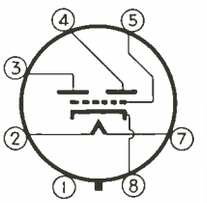
E_h = 6.3 v
I_h = 0.3 amp
$E_{b\ hex}$ = 250 v (max)
$E_{c2,4}$ = 100 v (max)
E_c = − 3.0 v
$E_{p\ triode}$ = 100 v
$I_{p\ hex}$ = 2.5 ma
$I_{c2,4}$ = 6.0 ma
$I_{b\ triode}$ = 3.8 ma
g_o = 350 μmhos
I_{c1} = 0.15 ma
Basing 8-K



Type 6AE6 (G)

SINGLE grid, twin plate control tube, heater type, glass envelope, 7-pin octal base.

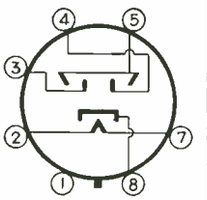
E_h = 6.3 v
I_h = 0.15 amp
PLATE No. 1
(Remote cutoff)
E_b = 250 v
E_c = − 1.5 v
I_b = 4.5 ma
g_m = 1000 μmhos
μ = 25
PLATE No. 2
(Sharp cutoff)
E_b = 250 v
E_c = − 1.5 v
I_b = 4.5 ma
g_m = 950 μmhos
μ = 33
Basing 7-AH



Type 6AF6 (G)

TUNING indicator, heater type, (T-9) glass envelope, 7-pin octal base.

E_h = 6.3 v
I_h = 0.15 amp
E_{target} = 135 v
I_{target} = 1.5 ma
Basing 7-AG



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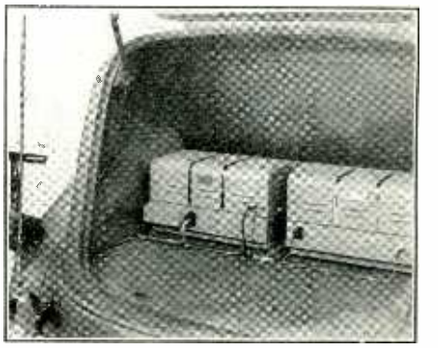
EUROPEAN TELEVISION

The chassis of a Ferranti television receiver which produces a picture 9 by 11 inches on the end of the large cathode ray tube



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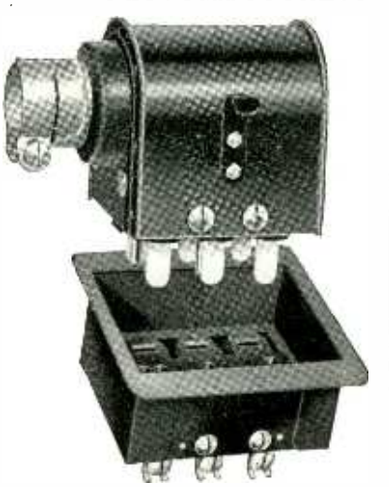

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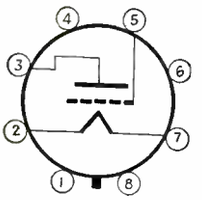
Type 2A4 (G)

THYRATRON, hot cathode, argon filled, single grid, filament type, glass envelope, 8-pin octal base.

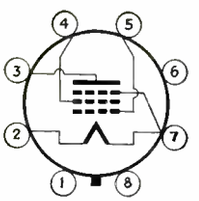
E_f = 2.5 v
I_f = 2.5 amp
Anode voltage (instantaneous)
Forward = 200 v (max)
Reverse = 200 v (max)
Max voltage between any two electrodes = 250 v
Anode Current
Peak = 1.25 amp (max)
Avg = 0.10 amp (max)
Max averaging time = 45 sec
Tube voltage drop = 15 v
Cold starting time = 2 sec
Basing 5-S



Type 1A5 (G)

POWER amplifier pentode, heater type, (T-9) glass envelope, 8-pin octal base.

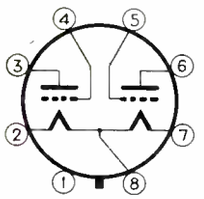
E_f = 1.4 v
I_f = 0.05 amp
E_b = 90 v (max)
E_{c2} = 90 v (max)
E_c = − 4.5 v
I_b = 4.0 ma
I_{c2} = 0.8 ma
r_p = 0.3 megohm
g_m = 850 μmhos
R_l = 25000 ohms
P_o = 115 milliwatts (7%)
Basing 6-X



Type 4A6 (G)

TWIN triode power amplifier, filament type, glass envelope, 8-pin octal base.

SERIES
E_f = 4.0 v
I_f = 0.06 amp
PARALLEL
E_f = 2.0 v
I_f = 0.12 amp
CLASS A (ONE TRIODE)
E_b = 90 v
E_c = − 1.5 v
I_b = 1.2 ma
μ = 25
r_p = 28000 ohms
PUSH PULL CLASS B (IDEAL CONDITIONS)
E_b = 90
E_c = − 2.0 v
I_b (no signal = 1.6 ma
I_b (max signal = 21 ma
R_l = 8000 ohms
P_o = 1.0 watt
Power input (at peak of cycle) = 75 milliwatts
Distortion (3rd harmonic) = 5%
Basing 8-L



Erratum

IN the Index of tube types registered by the R.M.A. Data Bureau which appeared in the March 1940 issue of *Electronics* erroneous reference is made to the withdrawal of tube type 83V. This reference should have been made to type 82V.

THE ELECTRON ART

Horizontal vs vertical polarization, photoelectric time-interval meter, distortionless amplifier, an automatic pressure control and horn radiators are reviewed

Horizontal vs. Vertical Polarization

"MOBILE FIELD STRENGTH RECORDINGS of 49.5, 83.5 and 142 Mc from Empire State Building, New York—Horizontal and Vertical Polarization," by G. S. Wickizer, appears in the April 1940 issue of the *RCA Review* and gives the results of a survey made by the author and his associates, of field strength out to the edges of the service areas of transmitters located in the Empire State Building. The same path was traversed in each case, thus providing a direct comparison of field strength on the two polarizations and also supplying additional information on propagation of these frequencies. The path followed was from Middletown, Conn., and along the Long Island Sound shore line, through New York City, Bayonne, N. J., and Staten Island to a point near Camden, N. J., and also from a point north of Poughkeepsie, N. Y., into New York City. The first path was from the northeast to the southwest and the second path was from north to south.

The results of all comparisons have been summarized indicating the following conclusions: Horizontal polarization varies over a wider range, has a higher maximum value and produces a higher average field strength than vertical polarization, other things being equal. It should be remembered that these results apply only to the three general directions covered by the mobile measurements. A comparison made over a salt-water path or a high-conductivity ground might show the vertical polarization to be considerably more effective than the horizontal polarization.

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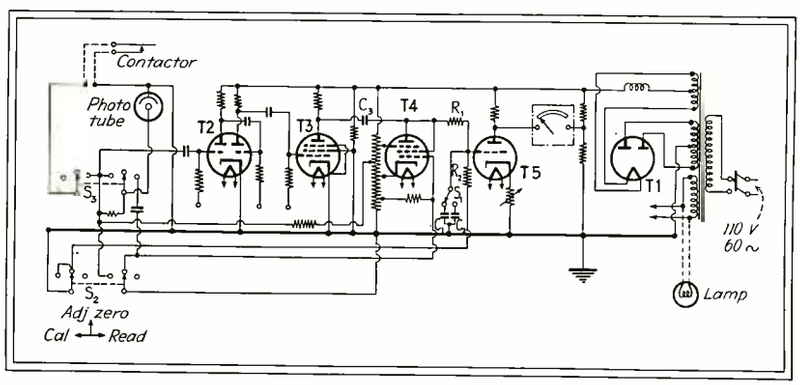
Photoelectric Time-interval Meter

A NEW PHOTOELECTRIC time-interval meter operating in the range of 0.001 to 1 second is described in the March 1940 issue of the *General Electric Review* in an article by T. M. Berry, entitled "A Photoelectric Time-Interval Meter." This instrument employs the secondary emission characteristics of vacuum tubes and was designed primarily for the measurement of speed of camera shutters and photoflash synchronizing mechanisms.

In this instrument the difficulties of a mechanical connection to the system being measured are avoided inasmuch as the detection of the desired motion is accomplished by means of a light beam and phototube. By proper switching the apparatus can be made to measure the time interval between two electrical impulses or contacts, the time interval between two light impulses to a phototube, or the time interval between an electrical impulse and a light impulse. It is calibrated in milliseconds and normally has two scales, 0.01 and 0.1 seconds, but may be arranged to cover a range from 0.001 to 1 second.

A circuit diagram is shown in the accompanying diagram. The tubes T_2 and T_3 are employed in a more or less conventional three-stage amplifier circuit. Tube T_4 is employed in a somewhat unorthodox manner. The anode and screen grid of T_4 are connected together and there is no external source of direct current. Direct current, however, does flow in the anode circuit. It arises from the emission of electrons from the screen grid and anode elements. These secondary emission electrons flow from the anode and screen grid to the suppressor grid which is maintained at a higher positive potential. The control grid voltage is fixed except for the application of a voltage impulse which will stop the flow of secondary emission current once it has started to flow in the circuit. The flow of secondary emission current is started by the application of a positive voltage impulse to the anode from the amplifier circuit through the capacitor C_3. It may be stopped by a negative voltage impulse on the anode through capacitor C_3 or a voltage impulse applied to the control grid. The secondary emission current which is constant flows through the resistor R_1 and charges a capacitor C_1 or C_2. The voltage across the capacitor is directly proportional to the length of time that the current is flowing. This voltage is applied to the grid of the tube T_5. The anode circuit of which forms one leg of a bridge circuit which is unbalanced by the application of voltage to the grid. The amount of unbalance of the bridge circuit is measured by a d-c microammeter. The microammeter is calibrated in milliseconds and the deflection is a linear function of time.

The complete instrument is contained in a metal case 7 inches x 9 inches x 16 inches. The phototube has a separate housing which is attached to the end of a 4-ft. cable. The principal application to date has been in the adjusting of photo-flash synchronizers so as to open the shutter of the camera at the correct time after starting to fire the flash lamp. It is possible to calibrate the scale directly in velocity for any fixed mechanical optical system. Thus the equipment may also be used to measure velocity of rapidly moving objects.



Circuit diagram of the photoelectric time-interval meter. This instrument will also measure the speed of rapidly moving objects

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A Distortion-Free Amplifier

MR. P. O. PEDERSON EXPLAINS in the February 1940 issue of the *Proceedings of the I.R.E.* the design of an amplifier which is free from distortion, ("A Distortion-Free Amplifier," page 59). There is used in addition to the main amplifier, an auxiliary amplifier into which is fed a portion of the input signal. The transmission time through each of the amplifiers is very nearly equal. The outputs of the two amplifiers are combined in such a way that the distortion is canceled out and no phase distortion is introduced into the output because the time of transmission of the signal through each ampli-

fier is the same. A mathematical discussion of the action of the circuit is given together with a typical circuit diagram.

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Power Output Stage and Loudspeaker Design

A SURVEY OF THE PROBLEMS OF POWER-OUTPUT stage and loudspeaker design and the relation between them is presented in an article entitled "The Relationship Between The Power-Output Stage and The Loudspeaker," by F. Langford Smith, in Vol. 4, No. 4 of the *A.W.A. Technical Review* (Sydney, Australia), which was issued on Feb. 12, 1940. The article was originally published in the *Proceedings of World Radio Convention*, Sydney, April, 1938. The author states that in the many technical papers covering the operation of power-output stage the scope is limited to a treatment with an equivalent resistive load and says that this is unjustified because it does not indicate in true perspective the various forms of distortion which actually take place. The extent of symmetrical distortion of various types for varying degrees of fidelity are briefly discussed before the operation of the output stage is described. Throughout the article triode, pentode and tetrode tubes operating at various types of loads are compared, first on resistive loads, then on partially reactive loads and then on a

loudspeaker load. The effects of negative feedback on the pentode and tetrode are noted. The factors influencing the design of the loudspeaker transformer are covered in detail.

At the end of the article there are four appendices which give the damping factors of typical tubes under standard operating conditions, reduction in plate resistance through negative feedback, reduction in gain through the negative feedback and a comparison between triode, pentode and tetrode in negative feedback.

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Automatic Pressure Control

AN AUTOMATIC ELECTRONIC device for controlling pressure in a high vacuum chamber is described in an article entitled "A Sensitive Automatic Pressure Control Device," by Richard A. Smith in the April 1940 issue of *The Review of Scientific Instruments*. The instrument is designed for pressures as low as 0.01 microns. A constant current is passed through a Pirani tube and the resistance of the tube is measured with a Wheatstone bridge. Calibration of the tube enables the pressure to be interpreted from the resistance read on the bridge, which is connected to a vacuum tube circuit so that when the resistance of the Pirani tube decreases, a vacuum pump is operated and runs until the pressure is reduced and the Wheatstone bridge again balances. A beam of light can be directed on a phototube when the bridge is balanced and away from the phototube during unbalance.

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HIS HOBBY—COLLECTING VOICES OF THE PAST

C. H. Vincent has a hobby for collecting old phonograph records. Here he is shown with the re-recording apparatus he uses to transfer famous voices to new records for his collection. A prize item of his collection is the actual reproduction of the bugle call which sounded the charge of the Light Brigade in the Crimean War

Electric Hygrometer

AN ELECTRIC HYGROMETER designed to replace the wet and dry bulb psychrometer and the hair-type hygrometer especially in measurements where sudden changes in humidity are encountered is described in an article entitled "An Improved Electric Hygrometer," by Francis W. Dunmore in the *Journal of Research of the National Bureau of Standards*, December 1939. (A reprint of this paper No RP 1265 is available from the Superintendent of Documents, Washington, D. C. for 5 cents.) The instrument consists of a very thin wall aluminum tube, around which is wound a bifilar winding of bare palladium wire, upon which is a coating of a thin film of partially hydrolyzed polyvinyl acetate with the addition of a small amount of lithium chloride. The electrical resistance of the film between the two coils is a function of the humidity.

The new instrument is especially suitable for measuring upper air humidity by means of the radio sonde (meteorograph), a small radio transmitter carried aloft by a free balloon which sends back signals which represent altitude, temperature and humidity. It has the advantage of rapid response and the ability to function at very low temperatures. Results accurate to within 2 or 3 per cent are obtainable and by connecting in parallel several units containing different amounts of lithium chloride in the film, each with suitable resistors, humidity from 10 to 100 per cent is measured.

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Metal Horn Radiators

AN ARTICLE "METAL HORNS AS RADIATORS of Electric Waves" by A. P. King, appearing in the April, 1940, issue of the *Bell Laboratories Record* discusses the directional characteristics of horns of various shapes and sizes using waves of the H_1 type. Continuous waves from 10 to 15 cm in length, corresponding to frequencies of from 2,000 to 3,000 megacycles were used in the experiments under discussion. Relative gains were determined either by comparing the received power with and without the horns attached, or by determining the directional pattern from measurements of the received power as the horns were pointed in various directions relative to the transmitter.

A certain amount of directivity can be secured with a straight section of pipe. For pipe-like horns, that is, horns of two sections of straight pipe, the directivity increases lineally with the diameter until a diameter of about twice the wave length is reached. Beyond this, the increase drops off and a decrease in gain may be experienced.

If a conical horn is substituted for the straight section of pipe, an increase in gain is also obtained as the opening of the horn is increased in diameter.

In this case, however, the angle or rate of flaring also affects the gain. The results indicate that the most favorable angle is between 50 and 60 degrees. In general, longer horns have smaller optimum angles.

The most directive horn had a gain of about 22 db compared to a nondirectional device. The horns possess a moderately flat frequency characteristic and should thus permit transmission of a wideband of frequencies. At a wave length of 15 cm the characteristic is flat to 1 db over a band width of 250 megacycles.

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Powerful Television Transmitter

THE APRIL 1940 ISSUE of *Electronics and Television and Short-Wave World* mentions that the most powerful television transmitter in the world with a maximum power of 100 kw is to be installed in the tower of the Palace of Soviets now under construction in Moscow. The antenna is to be 985 feet above ground level, making it possible to cover a large area with television signals. It is planned to install a large number of receivers in the building including two projection receivers, one of which is to have a screen with an area of 478 square yards (equivalent to a screen 65 feet square) and the other to have an area of 120 square yards. The large screen receivers will be in the main hall with an accommodation for 21,000 people.

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HONORED AS "OUTSTANDING YOUNG MAN"

Philo T. Farnsworth, recently designated as one of the "ten outstanding young men of 1939" is shown at work in his laboratory-office at his company's new plant at Fort Wayne, where he is director of research

THE INDUSTRY IN REVIEW

News

✦ David C. Prince of Philadelphia, chief engineer of the switchgear department of General Electric Company, for many years, has been made Manager of the Commercial Engineering department, succeeding the late Vice-President E. W. Allen. Mr. Prince has also been named a member of the company's Advisory Committee and the Apparatus Sales Committee. His headquarters will be in Schenectady . . . The Franklin Institute of the State of Pennsylvania announced that the Franklin Medal, an award of highest rank in the field of pure science, will this year go to Dr. Arthur H. Compton, University of Chicago and Nobel Prize Winner for Physics (1927), and Dr. Leo H. Baekeland, chemist, founder and former President of the Bakelite Corp., New York . . . Armour Institute of Technology, Chicago, will conduct a three-term summer graduate institute for engineers, professional men, industrialists, and educators in engineering and science beginning with the summer of 1940. It is planned to invite scientists of great distinction to lecture each summer on modern developments in engineering and science . . . General Electric Company announced a marked reduction in the list prices of all of their television receivers . . . National Production Company, Detroit, Mich., announce that their "Safe-Line" wire rope clamp has been granted the approval of the Underwriters' Laboratories . . . The 16th Annual R. M. A. Convention and National Parts Show will be held from June 11th to the 14th at the Stevens Hotel, Chicago . . . L. S. Brach Mfg. Corp., announce the election of Alexander Norden, Jr., as Vice-President . . . A new organization devoted exclusively to the making of fine recordings with precision instruments is the Professional Recording Studios under the direction of Sam Snead. The studio will be located at 1749 N. Prospect Ave., Milwaukee, Wis. . . . Dr. Alfred N. Goldsmith announces the new location of his offices for technical consultation and the practice of engineering relative to research, development, patents, etc., at 580 5th Ave., New York City . . . Microvolts Inc., of 212 Harrison St., Boonton, N. J., announces the changing of its name to Measurements Corp. . . . The corporate title of Eisler Electric Corp., has been changed to Callite Tungsten Corp. . . . The 1000 watt Finch Facsimile station located at Columbus Circle, New York, announces a new schedule of its facsimile transmissions which will be made from 3 to 4 p.m. and from 7 to 9 p.m. except Sunday over W2XBF on 43.75 Mc, and will consist of a program "Highlights in the News."

Literature

Universal Catalogs. Three new literature pieces are available. The first is the annual issue on microphones, the second on recording machines and accessories, and the third is leaflet No. 165 on recording and playback turntables. Universal Microphone Co., Inglewood, Cal.

Characteristics Chart. RCA tubes are classified according to their cathode voltages and their function in this Characteristics Chart & Socket Connections bulletin on receiving tubes available from RCA Mfg. Co., Harrison, N. J.

House Organ. The Amphenol News is a new publication of American Phenolic Corp., 1250 W. Van Buren, Chicago. It is intended as an engineering bulletin devoted to more complete discussions of one or two of their products, their method of manufacture, and details of usage. Vol. 1, No. 1, contains a description of the new miniature tubes and sockets. No. 2, contains an item on No. 54-2 polystyrene crystal holder socket. No. 3 contains information on 2 and 3 pole receptacles and plugs. Of course, other items are included in these news bulletins.

New Products

Percent-O-Meter

A PRECISION instrument especially designed to check all types of individual "A" and "B" dry batteries and battery packs under current load conditions is Model 632 Percent-O-Meter available from Triumph Mfg. Co., 4017 W. Lake St., Chicago. It has a 3-inch meter scale calibrated in percent of new battery voltage showing "Replace-Useful Battery-New" areas. The rotary switch has a selection of 11 ranges, and the meter comes complete with 24-inch test leads, prods, instructions, and voltage conversion chart.

Vacuum Tube Timer

A VACUUM TUBE TIME DELAY relay for processing, cycling, sequencing, limiting and delaying, Model CR7-504, is available from General Electric Co., Schenectady, N. Y. Some of its characteristics are as follows: Voltage, 115 to 230, 50-60 cycles; voltage variation affects timing slightly; 5 per cent voltage increase decreases time 3 per cent, and vice versa; stepless knob adjustment, with 10 divisions of full time range; contact rating is 1 amp at 115 volts, 0.5 amp at 230 volts, which is ample for operating ordinary magnetic devices. The relay uses a radio tube which is easily replaced. The small over-all dimensions make location and installation easy. Described in Bulletin 2902B.

Ship Phone

TWO NEW, MARINE RADIO telephones of modern design are now available from Transmarine Radio, Inc., Hewlett, N. Y. The first model is the "Shiphone, Jr." which transmits on any one channel and receives all channels; normal daylight range is 50-100 miles; operates from 6, 12, or 32 volts; weighs approximately 20 lbs. "Shiphone De-

Luxe" transmits and receives on any three channels; has a dial telephone channel selector; weighs 30 lbs. and has an output of 15 watts. The instruments have means for reducing objectional noise between calls, means for conserving battery power, an electrolysis eliminator which protects underwater fittings, and antenna-coupler circuits which increase efficiency.

Condensers

TO MEET THE HIGHER voltage requirements encountered in some applications, three new types of wet electrolytic condensers are available in 4, 8 and 16 μf capacities, with a 600 volt d-c surge rating.

For applications calling for very high capacity values at very low voltages, seven popular values and voltage ratings are now offered in the midget metal-can electrolytics. The capacities range from 1000 to 3000 μf, with working voltages of 6, 12 and 15 dc.

These products are available from Aerovox Corp., New Bedford, Mass.

Pressure Gradient Microphone

THE NEW AMPERITE P.G. (Amperite Co., 561 Broadway, New York City) pressure gradient dynamic is a step forward in dynamic microphone development. The familiar mechanical sound due to diaphragm peaks is entirely eliminated resulting in natural reproduction over the entire audio range

from 40 to 10,000 cps. It has an improved elipsoid pickup pattern which reduces back pickup to a minimum. The combination of the elipsoid pickup pattern and the flat response results in a microphone that will give an unusual amount of volume before feedback. Its output is high, -55 db. The P.G. diaphragm follows air particle velocity where amplitude is a gradient of the pressure. In ordinary dynamics amplitude is restricted from following air particle velocity due to the stiffness of the diaphragm and the enclosed chamber behind it. All models are equipped with a switch and cable.

Receptacles, Plugs and Holder Sockets

A NEW SERIES of specially polarized compact 3-pole plugs and receptacles particularly suitable for use on electrical and electronic devices has just been announced by the American Phenolic Corporation, 1250 Van Buren Street, Chicago, Illinois.

Bodies are molded of high-dielectric bakelite, and receptacle contacts are of phosphor-bronze. Each blade of the plug is set at a different angle, for definite polarization. Only 1¼ in. outside diameter at the flange, this new No. 60 3-pole series fits in the same mounting holes, and mountings, as the standard Amphenol No. 61 2-pole series. The Amphenol No. 60 3-pole series is listed under the re-examination service of the Underwriters Laboratories.

Also available from American Phenolic Corp., is a new socket for crystal-holders made of transparent ultra-low-loss Amphenol "912" (pure polystyrene), which is non-hygroscopic, won't collect frost, and is tough and strong.

Transmitters and Receivers

TWO NEW products are available from Doolittle & Falknor, Inc., 7421 S. Loomis Blvd., Chicago, Ill. Mobile transmitters come in two models. Model 15X uses filamentary type tubes that require no power from the car battery during stand-by periods. It was designed to help reduce the overall battery drain when used in the average two-way installation. It has 20 watts power output and operates on frequencies between 30 and 40 mc.

Two new models of Police Receivers are also available. Models PR-2C and PR-3C are for fixed frequency station use on 1600 to 3000 kc and 30 to 40 Mc respectively. Both have integral power supplies, crystal controlled oscillators, squelch and noise eliminator circuits.

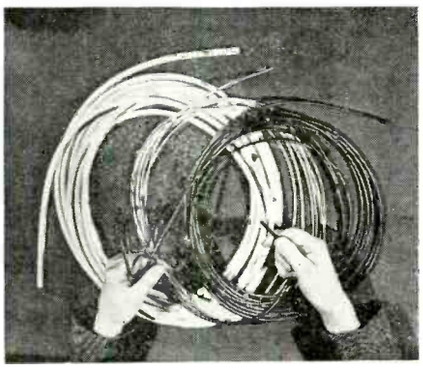
Photoelectric Controls

DESIGNATED the No. 60 series, these are general purpose controls, useful for solving reliably and economically a number of industrial problems, such as those of regulating, counting, signalling and sorting. These new controls are housed in compact 9x6½x4¾ inch battleship grey general purpose enclosures, having half-inch knockouts in the bottom for power connections, and a

fourth knockout on the top as provision for wiring in an external phototube. Rugged telephone type relays permit a maximum non-inductive load of three amps ac at operation speeds up to ten per sec. A microswitch to carry eight amps, or another contacting device handling 15 amps at 110 volts will fit the same housing. Both are available at slight additional cost. There are three models with varying applications and prices. This equipment is available from United Cinephone, Long Island City, N. Y.

Extruded Tubing

A NEW DEVELOPMENT in plastic materials is an extruded tubing known as Irv-o-lite Type XTE-30 manufactured by Irvington Varnish & Insulator Co.,



24 Argyle Terrace, Irvington, N. J. It is particularly useful in automotive, aviation, communication, electrical, instrument, marine, radio, and other fields where flexible tubing plays an important part in wire insulation against heat, moisture, oils, etc.

Transmitting Tube

RCA MANUFACTURING Co., Harrison, N. J. have available the RCA-829, a push-pull, beam power amplifier tube having a total maximum plate dissipation of 40 watts. Efficiency is made possible at the ultra high frequencies by the balanced and compact structure of the two units—internal shielding and close electrode spacing. The internal leads are short and heavy in order to minimize internal lead inductance. The terminal arangement provides insulation and is designed to facilitate symmetry of circuit layout. The heaters are arranged to allow operation from either a 12.6- or a 6.3- volt supply.

Modulation Monitor

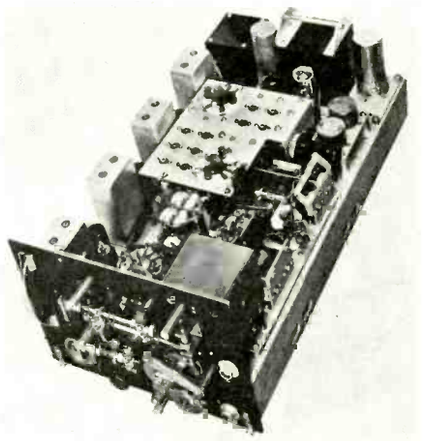
MODEL 1696A, WAS DESIGNED by Triplett Electrical Instrument Co., Bluffton, Ohio, for maximum efficiency in voice transmitting stations. The carrier reference level has only one adjustment for operating calibration, the per cent of modulation on the high-speed meter has fast upswing of meter pointer and slow downstroke, an instantaneous neon flasher indicates when per cent of modulation has been exceeded, and settings can be from 40 to 120 per cent. Other features include balance control permitting interchangeability of tubes, temperature compensation, 3-step line voltage adjustment for maximum efficiency from 100 to 130 volts, 50 to 60 cps a-c line.

Carbon-X

THIS IS A COMPOUND to fix noisy carbon controls. It is available from General Cement Mfg. Co., Radio Div., Rockford, Ill.

U-H-F Aircraft Receiver

THIS RECEIVER, made by Radio Receptor Co., 251 West 19th St., New York City, was designed in accordance with CAA specifications, and is intended for receiving both radio range and speech signals in the frequency ranges 60-66 and 123-132 Mc. Provision is made for continuously variable tuning throughout both of these frequency ranges. It also provides for crystal controlled reception on any two frequencies in the 123-132Mc range. Reception on either



crystal controlled frequency can be obtained by merely operating a switch, and without any tuning operation. The receiver can be switched from manual tuning to crystal control and back to manual tuning without disturbing the adjustment of the manually tuned portion of the receiver.

Radio Receptor also makes a 75-Mc marker receiver which gives indications of signals from fan, cone, and approach markers which operate on a frequency of 75-Mc, and employ modulation as follows: 3000 cps for fan end cone, 1300 cps for inner instrument landing marker and 400 cps for outer instrument landing marker.

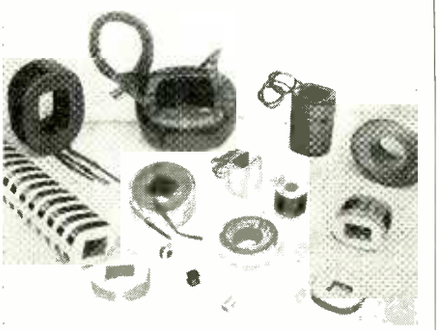
Resistors and Controls

A LINE OF GENERAL-UTILITY voltage-dropping resistors is announced by Clarostat Mfg. Co., Inc., 285-7 N. 6th St., Brooklyn, N. Y. Series HT units are now available in any resistance and wattage rating from 100 watts up. They can be used for any voltage-dropping or current-regulating purpose, such as the operation of 110-volt equipment on 220-volt supply, the dimming of photo-flood lamps, the operation of soldering irons and electric motors, and so on. A Clarostat Greenohm power resistor is the heart of this device.

Volume controls with serrated shafts, for quick and exact replacement of controls having the knurl and slot shafts, are also available. These Series KS controls are of the popular Clarostat midget type, and permit replacements without having to replace the slip-on knobs as well. Series KS units are available in all required resistance values.

Coils

SPECIAL AND PRODUCTION-RUN coils for all purposes, including industrial equipment, radio electrical communication, telephone, telegraph, television, signal-



ing, airplane, X-ray equipment and other apparatus are being manufactured by Electricoil Co., Inc., 8 Varick St., New York City.

Variable Frequency Exciter

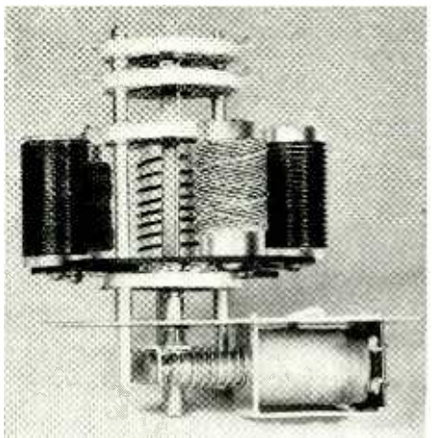
THE PURPOSE of Model Vari-X, available from Bliley Electric Co., Union Station Bldg., Erie, Pa., is to provide a variable frequency exciter having the frequency stability of a crystal controlled oscillator. The Vari-X is basically a crystal controlled oscillator, designed for use with Bliley's VF2 Wide-range Variable Crystal Unit. It is intended for installation at the station operating position. For ease of operation, a sloping front panel is used. Coupling to the transmitter is accom-

plished by means of a concentric cable supplied with each instrument. A 2 prong plug is furnished such that the cable can be connected to the plug and the Vari-X plugged into the present crystal socket in existing transmitters. The Vari-X has its own power supply which works from 110 volts 60 cycles a c. This 80 meter crystal unit has a total adjustable frequency range of approximately 12 kc. The variation approaches 24 kc when frequency doubling to 40 meters, and 48 kc when quadrupling to the 20 meter band.

Descriptive circular D-2 can be obtained from any Bliley dealer or directly from the manufacturer.

Electrical Stepping Switch

COTO-COIL CO., INC., 71 Willard Ave., Providence, R. I., have introduced a unique magnetic stepping switch for performing complicated switching operations. The motor unit is energized by momentary impulses from a push button and drives the switch sections through their predetermined sequence.



One adaption of the basic unit is to a bandswitch turret for changing the operating frequency of a radio transmitter by remote control. Various combinations of poles and contacts make it possible to adapt this switch to most any kind of a radio or industrial switching problem. Outstanding features are the versatility and low price.

Marine Filters

THE J. W. MILLER CO., 5917 S. Main St., Los Angeles, Cal., have announced a complete line of marine filters with current carrying capacities of 5 to 350 amps. The units are designed for the optimum inductance-capacity ratio, using dual inductances in each side of the line and high voltage paper condensers. Type 7874 filter which is reasonably priced, was primarily designed for use in one side of the battery line of ignition systems though it may be effectively employed as a general utility filter in circuits carrying less than 10 amps. By shielding the engine with a hood made of dural or copper and using the type 7874 filter, all ignition interference can be surpressed. Further information on noise suppression is available from Paul O'Connor, Chief Engineer of the Miller Co.

Relays

A NEW LINE OF RELAYS designed especially for radio-frequency and high voltage application have been announced by Standard Electrical Products Co., 317 Sibley St., St. Paul, Minn. These units are low priced and may be used for general control purposes. A

bulletin, Amateur Data Sheet A-2, lists and gives an illustration with complete data on four different types of relays such as r-f and remote control, antenna change-over, break-in, and communication relays.

Contact Selector Switch

AN ENCLOSED SOLID SILVER contact selector switch with 11 contacts, 2 sections, has been announced by Shallcross Mfg. Co., 10 Jackson Ave., Collingdale, Pa. This rotary selector switch, mounted on a beveled bakelite panel, housed in a cast aluminum box, with an etched dial, is particularly designed to work as a selector switch in connection with the thermocouple and any other instrument circuit or where an unusual amount of current must be broken in a small switch.

Multi-range Ammeter

SIMPSON ELECTRIC CO., Chicago, announces that a current transformer and an indicating instrument have been combined in a small a-c multi-range ammeter that sells at a low price. Known as "Micro-Tester" Model 280, this instrument provides readings in any of the five different ranges, from fractions of an amp up to 25 amps. Pocket-size, it measures only 2¾ x 5¼ x 1¾ ins, and weighs just 20 ounces.

Television and the F.C.C.

(*Continued from page 13*)

The important point is that the total range of number of lines within which the system can operate on a 6-Mc channel is roughly from 500 to 750 lines, assuming corresponding frame rates from 30 to 15 frames per second. This range is small enough to be accommodated in sweep and sync circuits without major difficulty, especially since the number of lines formed per second remains in the range from about 10,000 to 15,000 per second.

The question then resolves itself to the more basic and technically difficult problem of deciding the frame rate. Here there seems to be the biggest room for argument, because the result depends on psychological factors. The human eye can detect flicker, unevenness of motion, and smearing of motion at some point as the frame rate is decreased, but the exact point at which these effects are noticeable depends on the eye in question, the brilliance of the picture and its surroundings, the storage characteristics of the

camera and picture tubes, and a number of other less important factors. One thing can be stated clearly: each of these difficulties becomes less serious as the frame rate is increased. But as the frame rate is increased the number of lines, and the picture detail, must go down for a given channel width. So no higher a value of frame rate is to be chosen than is absolutely necessary.

What is the case for the three proposals? DuMont's 15 per second rate is the lowest of the three, and hence permits the greatest picture detail. But there are grave doubts whether a truly flickerless picture can be produced at this rate, especially if the brilliance of reproduction is increased in the future by improvements in cathode-ray tubes. DuMont has developed a "retentive" fluorescent screen of long persistence which reduces the flicker to a marked degree, but some flicker is observable, and unless the retentivity characteristic is properly chosen, the storage action of the screen tends to smear the motion. In addition, rapidly moving objects scanned at 15 frames move across the screen in jerks of motion which are exactly twice as large as they would be if scanned at 30 frames per second. The DuMont proposal is worthy of a public test, which it will get according to present plans, but it is by no means established as the final answer to the scanning problem.

The Philco proposal of 24 frames per second has considerable standing because the movies have found 24 frames suitable for professional purposes. The flicker problem and the smeared- or uneven-motion problem are probably not noticeably different from those encountered at 30 frames. But a rate of 24 frames per second presents difficulties when the power supply frequency is 60 cps. Extra filtering in the rectifier circuits, and extensive magnetic and electric shielding must be employed to avoid interaction between the 60 cps ripple and the 24 cps frame rate. If there is any such interaction, the scanning pattern may be rapidly displaced horizontally and the horizontal detail thus impaired. Moreover, if the lighting employed at the program pick-up point is operated on 60 cps power, and the scanning at 24 frames per second, a rapidly-moving flickering may be produced due to the asynchronism between

This Year

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WARNING: In order to distribute copies of JUNE ELECTRONICS on June 11th at the Chicago Show, we must have all copy in our hands by May 29th at the latest. We suggest starting your copy now.

JUNE *Double Convention Issue of* ELECTRONICS

the scanning rate and the flicker rate of the lamps. If the thermal inertia of the lamp filaments is large, the 60 cps flicker in the light source may be small enough to permit scanning at 24 frames, but on outside broadcasts it is not always possible to arrange for such lighting facilities. In studio practice, operation of the lamps from a direct current source is usual to avoid this problem, and is considered good practice even when the frame rate is 30 cps. When the frame rate is 30 cps, the scanning rate and the lamp flicker rate are synchronous and the only observable defect is a motionless change in shading from top to bottom of the picture, which may be corrected by a fixed setting of the shading-correction controls. Thus the 24 per second frame rate is not an ideal solution either, although it does permit higher picture detail than the 30 frame rate, if all other factors are under control.

The R.M.A. proposed rate of 30 per second, it is generally agreed, is free from the difficulties due to flicker and asynchronism with 60 cps power, which are associated with the other two proposals, but it does limit the picture detail to about 500 lines at the most. The difference between a 507 line picture and a 625 line picture, corresponding to a difference of frame rate of 30 and 15 per second, respectively, is definitely noticeable, especially when the two pictures are compared side by side. But the difference is not one of major proportions, certainly not serious enough to cause a complete upset of the industry if one value is decided on now and the other found equally practical at a later time. A really important change in picture detail would occur if the number of lines could be doubled, but this is not possible within the six-megacycle channel, which it is agreed is the maximum we can think of assigning on frequencies lower than 100 Mc. The frequencies above 100 Mc are another story, but these frequencies are not in question at the present time. They are to be reserved for experimentation and the eventual development of a wholly new and improved television service, provided that the engineers can lick the very real problems which now prevent their use for broadcasting purposes.

At the present time, your editors are not prepared to say without

reservation which of the proposals has the greatest merit. If asked to hazard a guess, however, that guess would be that a revision of the R.M.A. standards to 507 lines, 30 frames would be the best engineering compromise at present. However, the proponents of the other proposals have the right, and it appears the opportunity, to prove this judgment wrong.

The question remains of what to do with the two or three thousand receivers now in the hands of the public, if any change in the R.M.A. standards is made. The simple change from 441 lines to 507 lines could be accommodated without circuit alteration in a great majority of these receivers, except that in magnetically scanned units, the picture width would be reduced somewhat, and this effect might not be capable of being counterbalanced by adjustment of the scanning width control. In that event, the horizontal scanning output tube might be replaced by a tube of higher mu and greater current capability or some similar method evolved to permit the change with a minimum of annoyance to the receiver owner. In any event, a solution to the whole problem can be found, using methods now available to the industry. Moreover, if it appears expedient to retain the present R.M.A. standards, no great harm will be done, because these standards very nearly approach the full capabilities of the 6-Mc channel. If, however, the lower frame rates are proved feasible, and greater picture detail is thus made available, the fact that a mere 2000 to 3000 receivers are outstanding should not be allowed to stand in the way. Many of these receivers (15 per cent of them by N.B.C. estimates) are home built and hence capable of alteration by the original builder. Of the remaining receivers, 52 per cent are accounted for by two manufacturers, who could recall these receivers for revision at moderate cost, or possibly at no cost, provided that the way to greater sales was open and a reasonable market assured. In any event, there is every reason to believe that the proper standards required to utilize the 6-Mc channel most fully can be found quickly, and the necessary steps taken to put them into practice without major inconvenience to the public or the industry.—D.G.F.

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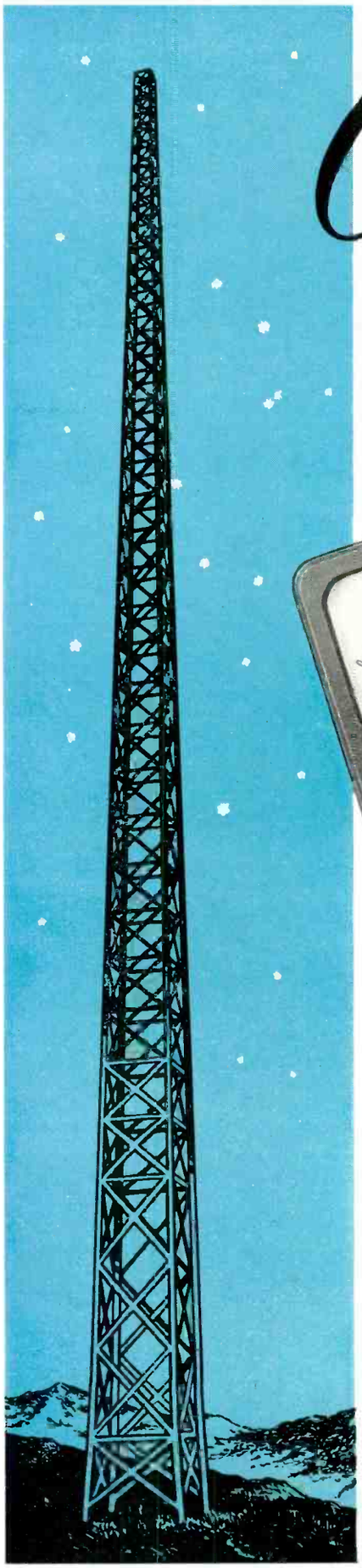

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General Electric's STANDARDIZED Vu Volume Level Indicator

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It can help you achieve more effective monitoring—permits better operation of your transmitters and amplifiers.

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The rapid pointer motion is easy to follow because of the long scale and simplified scale plate. If desired, the instrument can be supplied with a semicircular mask sprayed on the lower portion of the glass. Antiglare glass will be supplied for the scale window if desired. Both illuminated-scale and nonilluminated-scale types are available.

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The Type DO-61 volume level indicator is designed for accurate service over a wide range of frequencies. The pointer reaches its peak quickly and is so effectively damped that overshoot is negligible. The instrument is sturdily constructed to retain accuracy.

Adaptable for Mounting on Steel Panels

Volume indicators are normally calibrated for use on nonmagnetic panels, but the Type DO-61 instruments can be furnished for mounting on steel panels up to $\frac{1}{16}$ inch thick. A molded Textolite case, either natural black or grey, protects the instrument and gives it a very attractive appearance. Over-all dimensions, $4\frac{1}{2}$ by $3\frac{3}{4}$ by $1\frac{1}{4}$ inches. Call the nearest G-E office, or write for Bulletin GEA-3145, General Electric, Schenectady, N. Y.

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