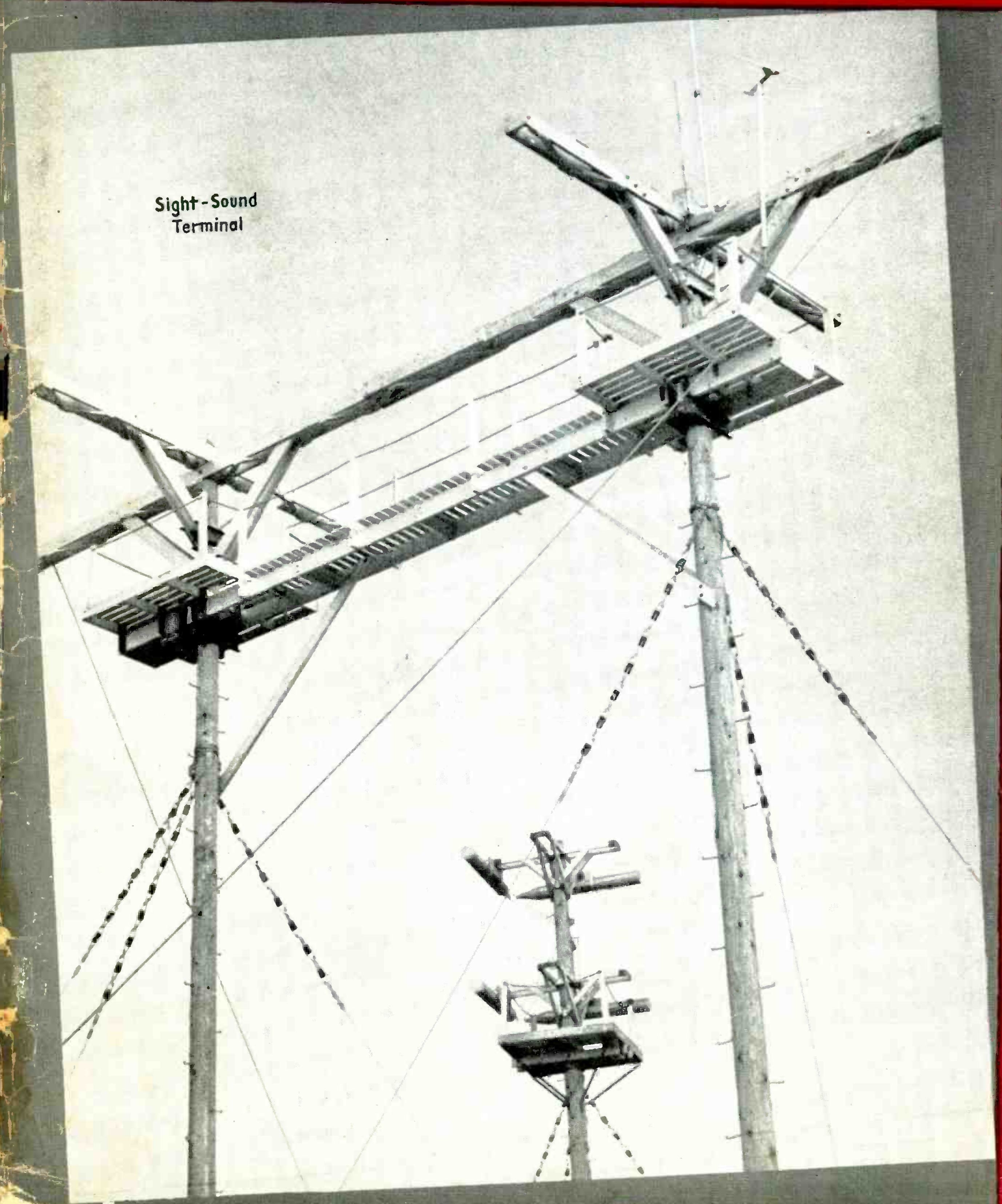
electronics

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



MARCH
1940

Price
50 Cents

McGRAW-HILL
PUBLISHING
COMPANY, INC.

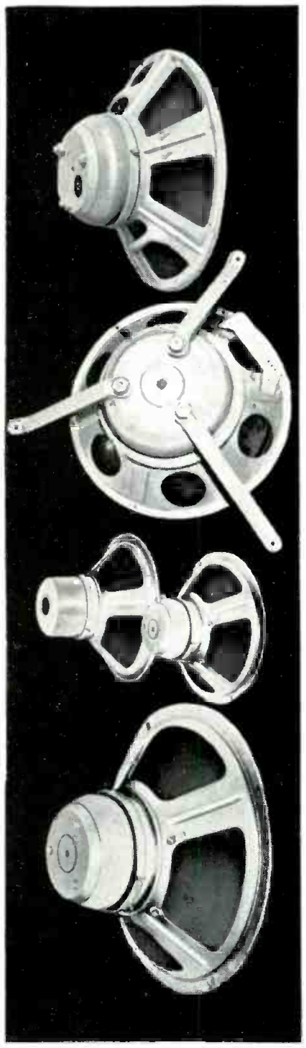
$500,000.00

Expended for development, backs our slogan
NO FINER SPEAKER MADE IN ALL THE WORLD

UNITED TELETONE CORP. CINAUDAGRAPH SPEAKERS

Linear Standard Speakers

UTC Linear Standard speakers represent the closest approach to the ideal speaker from the viewpoint of uniform response, low wave form distortion, high efficiency and dependability. These speakers are used extensively for high fidelity service in broadcast monitoring, high quality PA, frequency modulation receivers, motion picture sound, etc.



UNIVERSAL WIDE RANGE MATCHING TRANSFORMERS

UNIVERSAL PRIMARY transformers provide primary terminations for plate to plate impedances of 3.000, 5.000, 6.000, 8.000, 10.000, 14.000 ohms.

TAPS ARE ON PRIMARY

Type No.	Undistorted Peak Watts	List Price
WR-1	Up to 8	$3.50
WR-2	Up to 12	4.50
WR-3	Up to 18	5.50
WR-4	Up to 40	7.50

LINE MATCHING transformers provide primary impedances of 500, 1.000, 1.500 ohms.

TAPS ARE ON PRIMARY

Type No.	Undistorted Peak Watts	List Price
WR-5	Up to 8	$3.50
WR-6	Up to 12	4.50
WR-7	Up to 18	5.50
WR-8	Up to 40	7.50

★ HIGH FIDELITY—Unequaled high fidelity characteristics are inherent in these speakers. The curve shown illustrates the characteristics of a typical 18" unit. In view of the precise reproduction, it is important that the amplifier associated with these speakers be free from all forms of distortion.

★ LOW DISTORTION—Both the electrical and mechanical elements of these speakers have been related to effect a minimum of harmonic distortion combined with a high rate of decay, which overcomes the detrimental effects of "tails" and "hangovers".

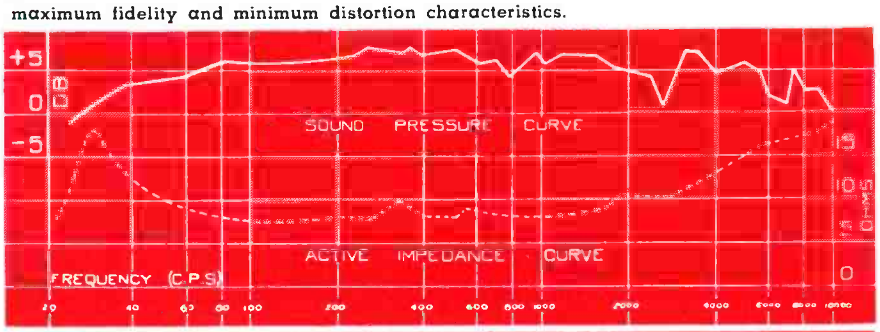
★ EFFICIENCY—The Feralnic magnet structures used on these speakers are heavy duty sizes to effect optimum efficiency. The active impedance curve shown illustrates the unusually small impedance change with frequency which assures good power delivery from the amplifier output to the voice coil.

★ POLYFIBROUS CONES—Polyfibrous cones, composed of a series of bands of different characteristics, are used in these units to widen the range of response. These cones are made in our own cone pulp plant to assure uniformity and quality of characteristics.

★ ACIM—Acim, a hard non-elastic, non-hygroscopic material, is used for the voice coil support, assuring continued full fidelity and non-distortion characteristics.

★ MOISTURE PROOF CENTERING—The net construction used in these speakers assures positive alignment of all parts with sufficient axial freedom for true low note reproduction.

★ CURVILINEAR—Curvilinear cones are used on Linear Standard speakers to assure maximum fidelity and minimum distortion characteristics.



LINEAR STANDARD PERMANENT MAGNET SPEAKERS

Type No.	Cone Housing Dia.	Undistorted Peak Watts	Undistorted Normal Watts	Peak Power Watts	Voice Coil Dia.	Voice Coil Ohms	Wt. Lbs.	List Price
LM-18-30	18"	30	25	40	3½"	6-8	72	$125.00
LM-15-25	15"	25	22	30	2½"	6-8	60	75.00
LM-13-23	13¼"	23	20	28	2½"	6-8	58	60.00
LM-13-22	13¼"	22	18	25	2"	6-8	32	40.00
LM-12-15	12"	15	12	20	1½"	6-8	17	27.50
LM-12-13	12"	13	10	18	1¼"	6-8	12	21.00
LM-10-10	10½"	10	8	13	1"	6-8	10	12.00
LM-8-8	8"	8	6	10	1"	6-8	8	10.00

LINEAR STANDARD ELECTRODYNAMIC SPEAKERS

Type No.	Cone Hsg. Dia.	Und. Peak Watts	Und. Norm. Watts	Peak Power Watts	Field Volts	Field Ohms	Field Watts	Voice Coil Dia.	Voice Coil Ohms	Wt. Lbs.	List Price
LE-18-35	18"	35	30	45	110 V.D.C.	300	35/50	3½"	6-8	80	$100.00
LA-18-35	18"	35	30	45	110 V.A.C.			3½"	6-8	90	125.00
LE-15-30	15"	30	25	35	110 V.D.C.	350	22/35	2½"	6-8	55	50.00
LA-15-30	15"	30	25	35	110 V.A.C.			2½"	6-8	65	75.00
LE-13-25	13¼"	25	22	30	110 V.D.C.	350	22/35	2½"	6-8	40	35.00
LA-13-25	13¼"	25	22	30	110 V.A.C.			2½"	6-8	50	60.00
LE-12-16	12"	16	13	21	110 V.D.C.	600	14/21	1½"	6-8	23	20.00
LE-12-14	12"	14	11	19	110 V.D.C.	850	10/15	1¼"	6-8	18	15.00
LE-10-10	10½"	10	8	13	110 V.D.C.	1000	8/12	1"	6-8	15	12.00
LE-8-8	8"	8	6	10	110 V.D.C.	1000	8/12	1"	6-8	12	10.00

The LM-18-30 combines all the superior characteristics inherent in the previous Cinaudagraph model SU-18-12. Through the use of a specially treated curvilinear cone and other acoustical design refinements, the response of the new LM-18-30 has been extended more uniformly and greater high frequency projection has been made possible. The unusual power handling ability of this speaker makes it ideal for use in large indoor areas. This speaker is the ultimate choice of the discriminating music lover, and is recommended for those applications where only the finest in musical reproduction will be acceptable.

The LM-13-23 replaces the previous HW-13-13 model. The new LM-13-23 answers all requirements where low distortion, high fidelity, and great efficiency are required. Superior to most 14 and 15" speakers, this unit has found wide acceptance for custom built radio receivers, quality talking picture installations, and other purposes where strict fidelity standards are of paramount importance.

The LM-12-15 replaces the HY-12-12, accepted as the most outstanding 12 inch high fidelity speaker. Some of the added features in the new LM-12-15 are a specially treated curvilinear cone and extended response in both low and high frequencies. The LM-12-15 is the ultimate in a heavy duty, highly efficient, high fidelity 12" speaker.

The new LM-10-10 has an extended low frequency range in addition to its excellent high frequency response characteristics. The combination of a large Feralnic magnet together with new design improvements make the LM-10-10 one of the most powerful high fidelity 10" speakers. It is especially suited to portable, wide range amplifier combinations, small high fidelity receivers, etc.

Excepting our 27" custom built models, the LE-18-35 is the most powerful, most efficient, high fidelity Electrodynamic 18" speaker available. It combines all the exceptional features to be found in our regular Permanent Magnet LM-18-30, plus greater power handling ability. The extended low frequency range and the excellent high frequency response of the LE-18-35 speaker assure exceptional performance.

The LE-13-25 is the most powerful high fidelity 13" Electrodynamic speaker available. It combines all the exceptional features of the LM-13-23 with greater power handling ability. It is the ideal speaker where efficiency and power handling ability in excess of those available from a 12" speaker are desired, and of course the LE-13-25 will fit most baffles designed for 12" units. Superior to contemporary 14" or 15" Electrodynamics in power handling ability and efficiency.

The LE-12-16 is the most efficient 12" Electrodynamic Linear Standard model. All the outstanding performance characteristics inherent in the LM-12-15 are available, plus greater power handling ability. The ideal 12" Electrodynamic for high fidelity applications.

NO FINER SPEAKER MADE IN ALL THE WORLD

UNITED TELETONE CORP.

150 VARICK STREET ★ NEW YORK, N. Y.

Export Division: 100 VARICK STREET, NEW YORK, N. Y. Cables: "ARLAB"

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CONTENTS—MARCH, 1940

DEPARTMENTS

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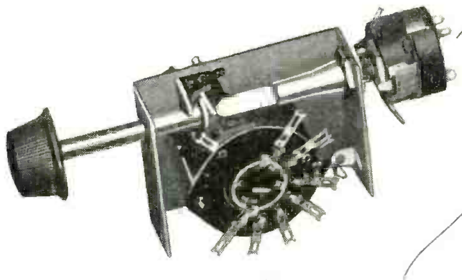
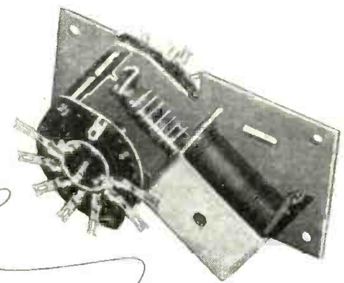
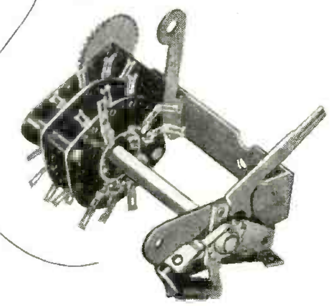


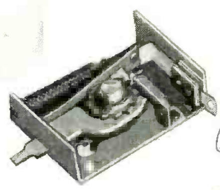
Coincidental single shaft operated selection switch, and volume or tone control. Station selection in automobile or home radio or wave band selection.



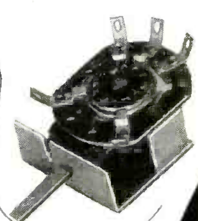
Single push button operated selector switch for Automobile or home radio. Station selection or wave band switching.



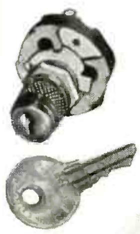
Solenoid operation selector switch. Single push button, automobile, or home radio controlled remotely.



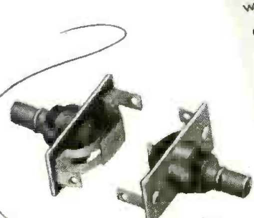
Special single contact switch to operate remote solenoid and index dial at same time.



Single-Push operated tone switch. Selections of various tone positions.



Key operated line or tone switch, where unauthorized adjustment is imperative such as coin phonographs. Can be applied to any type of shaft operated switch.



Momentary open and closed circuit switches, Meter insertion, Record rejection, Record selection, Simple On-and-off switch.

Centralab

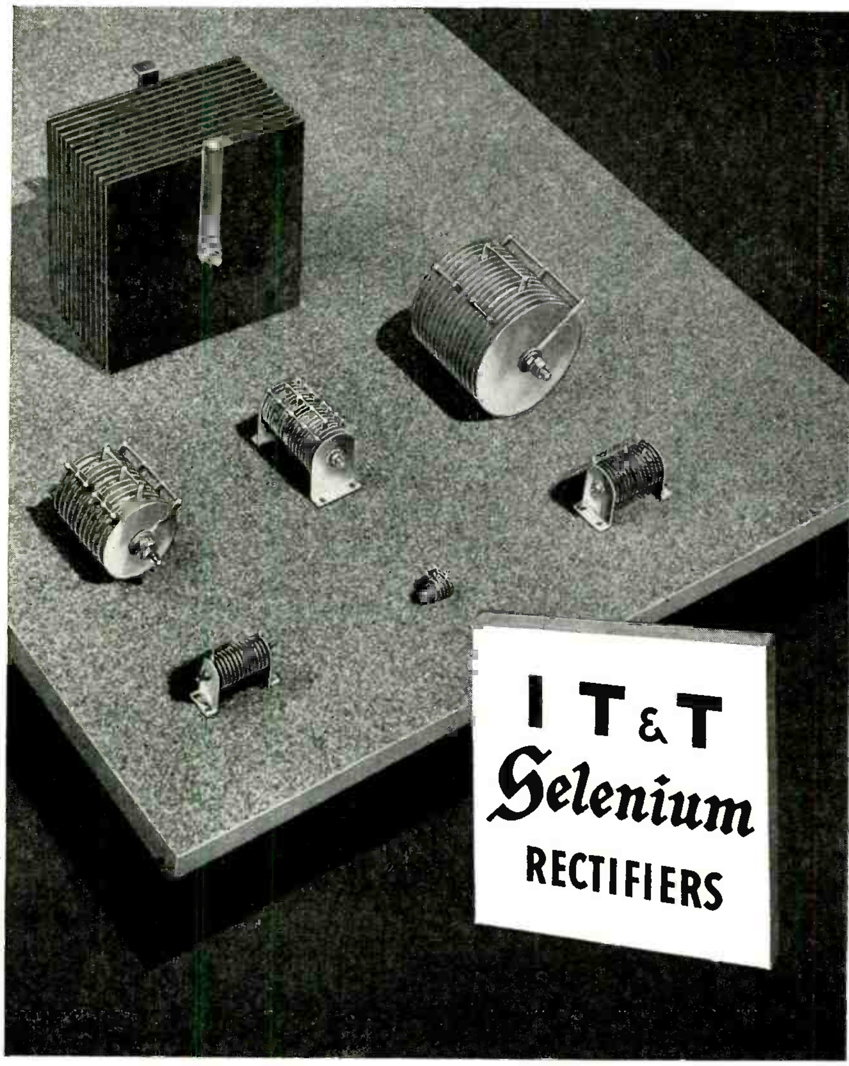
Special Purpose Switches

Versatility . . . **beside the orthodox type, we are equipped to design and create switches and controls for various special applications, including complicated switching mechanisms.**

Our Engineers **are capable of developing any type of special control or switch apparatus from the "idea stage" to a successfully operating mechanism.**

See us about any special application problem.

CENTRALAB: Div. of Globe Union Inc.
MILWAUKEE WISCONSIN



HERE is an outstanding development in modern rectifying equipment—an exclusive product which has achieved a notable operating record during years of wide use for obtaining continuous current from alternating current sources.

Designed to meet the most rigorous operating conditions, the I. T. & T. Selenium Rectifier, by making use of the rectifying action of Metallic Selenium, combines all rectifying essentials in one sturdy plate. These plates of proper size and number are assembled for any requirement.

It is completely reliable . . . it is compact, efficient and versatile . . . it is economical both in first cost and operation . . . it has practically unlimited life.

Complete information on the characteristics, performance and application of I. T. & T. Selenium Rectifiers is available in bulletin form. We shall be glad to send you a copy upon request to the Rectifier Division.

A FEW OUTSTANDING FEATURES OF I. T. & T. SELENIUM RECTIFIERS

The wide, general-purpose application of the I. T. & T. Selenium Rectifier is as a rectifier for high or low currents at high or low voltages. It also has many other uses, such as: a spark quencher, polarizer, tone generator, etc.

Low Costs

In addition to low first cost, the high efficiency of the Selenium Rectifier assures economical operation and, furthermore, it requires no maintenance.

Reliable Long Life

The Selenium Rectifier has no moving parts, it requires no adjustments or replacements . . . there is nothing to get out of order. Consequently, once installed, there is no reason why it should not last forever without attention.

Wide Temperature Range

A most unusual feature of the Selenium Rectifier is its ability to operate throughout an extremely wide temperature range. It operates instantly in ambient temperatures of minus 40° C. The maximum rectifier temperature is 75° C. for continuous service—higher for intermittent service.

Time Tested Performance

The operating record of the Selenium Rectifier during many years of wide use shows that it gives good regulation and stable output . . . that efficiency is constant over a wide load range . . . and that it will withstand short overloads of ten or more times the normal rated current without damage.

Compact Small Size

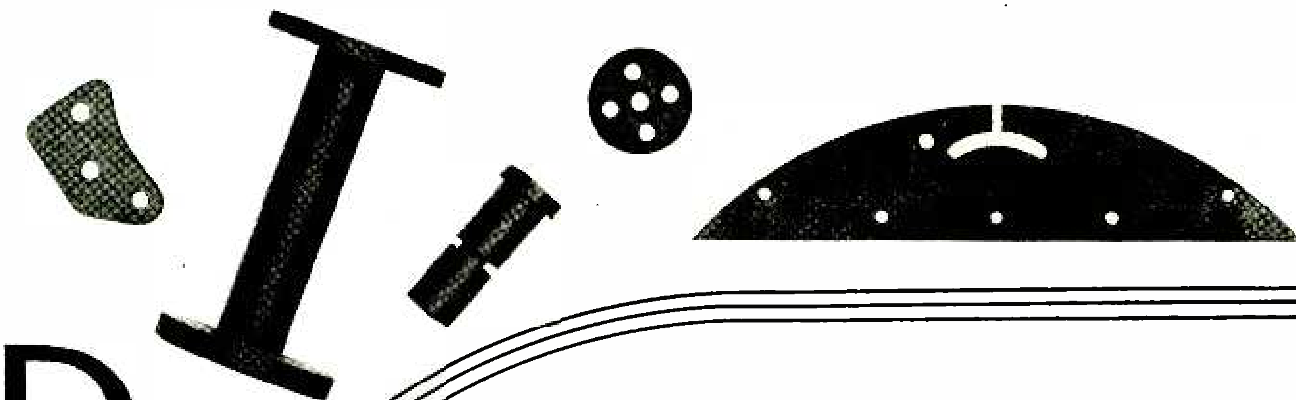
The high permissible back voltage of the Selenium Rectifier plates holds to a minimum the number required. Also the high current density permits the use of small plates. These features together with simplicity of design make it a comparatively small compact unit.

Light Weight

The one piece rectifier plate minimizes the number of parts. This together with the assembly under light pressure permits use of light hardware, making the I. T. & T. Selenium Rectifier extremely light in weight.

INTERNATIONAL TELEPHONE DEVELOPMENT CO., INC.

137 Varick Street, New York, N. Y.



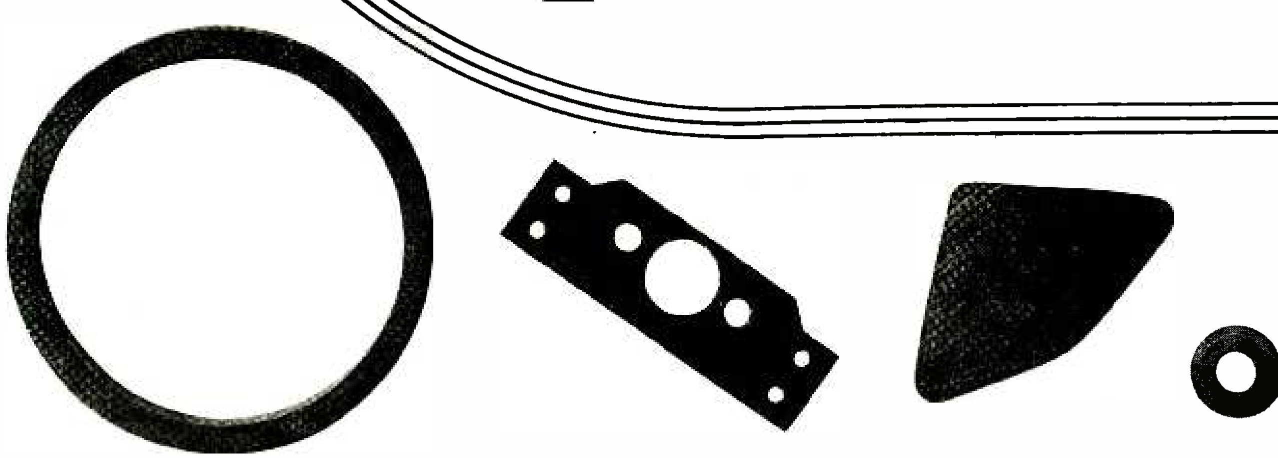
DEPENDABLE INSULATION FOR MORE THAN 25 YEARS

SINCE 1913 Formica has concentrated on just one product laminated sheets, tubes and rods. It equipped itself early with a well manned and efficient laboratory which has worked steadily on the development of new grades and the improvement of old grades of laminated insulating material.

There are now available special variants emphasizing nearly all of the useful properties of the sheet for special purposes — and one can be selected that will meet your exact requirements. Send us your blue prints for quotations.

The Formica Insulation Co., 4638 Spring Grove Ave., Cincinnati, O.

FORMICA




Wherever lump Capacitance is needed . .
LAPP GAS FILLED CONDENSERS WILL SAVE SPACE, SAVE POWER, SAVE MONEY
In any transmitting system, there are numerous places where installation of Lapp gas-filled condensers will improve transmission efficiency with economy of space and security of operation.
Installations now in service include: plate tuning circuits — fixed condensers for coil tuning, variable condensers for condenser tuning; antenna coupling circuits; tuning circuits for directional antenna arrays; filter networks—tuned circuits to eliminate harmonics.
To every application the Lapp condenser brings notable mechanical and electrical advantages: practically zero loss, minimum space requirement, non-failing, puncture-proof design, constant capacitance under varying temperature conditions. Fixed, adjustable and variable types in three voltage ratings and capacitances, 100 to 2000 mmf—54 models in all, price $75 to $500. *Descriptive literature is available on request. Want to see it?*
LAPP
INSULATOR CO., INC.
LEROY, N. Y., U. S. A.

New 357A is ideal for ultra high radio broadcasting

In its first six months this Western Electric tube has found many jobs to do. So radically different are its design features that they suggest uses in most modern transmitters, such as those for amplitude and frequency modulated broadcasting.

Features of greatest importance to users in the ultra-high frequency band are:

Heavy copper low inductance leads; cylindrical construction which permits low internal capacitances; shielded ceramics which contact only one electrode; molded glass which makes possible the shortest leads and permits easier neutralization; plate dissipation rating of 350 watts; full voltage ratings up to 100 megacycles; assurance of 500 to 1000 watts output at the lowest tube hour cost.

Include the Western Electric 357A in the line up for your new transmitter.

CHARACTERISTIC RATING DATA

Filament voltage . . . . 10 volts
Filament current . . . . 10 amperes
Amplification factor 30
At a plate current of .5 ampere:
Grid-plate transconductance . . . . . 9000 micromhos
Direct Interelectrode Capacities:
Grid to plate . . . . 4.25 mmf.
Grid to filament . . . . 9.5 mmf.
Plate to filament . . . . 2.5 mmf.
Maximum Ratings:
Maximum direct plate voltage, 4000 volts
Maximum direct plate current 0.5 ampere
Maximum continuous plate dissipation . . . . 350 watts
Maximum direct grid current 0.1 ampere

Western Electric

Graybar Distributed by Graybar Electric Company

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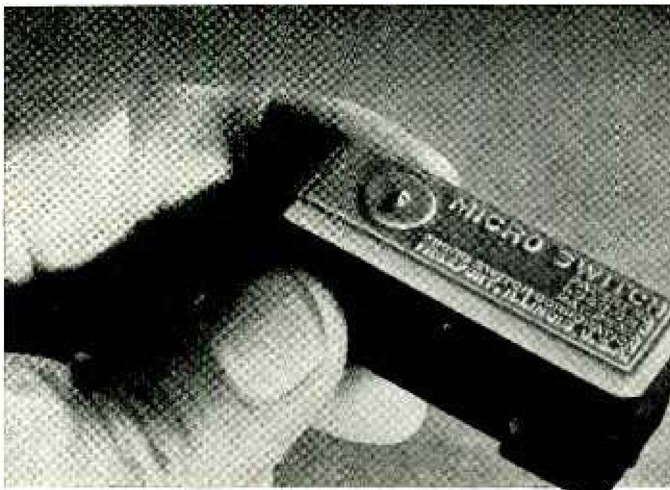
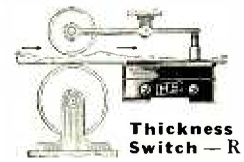
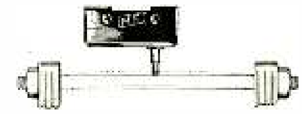
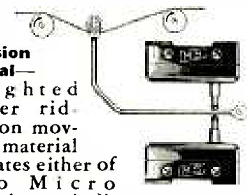




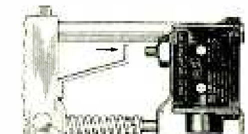
Thickness Limit Switch—Roller type actuator rides material and operates the switch if thickness limit is exceeded.



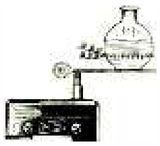
Stress Signal—The rod bends under stress and actuates a spring plunger Micro Switch.



Tension Signal—Weighted roller riding on moving material actuates either of two Micro Switches to indicate tension on material.



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



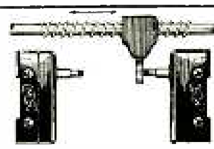
Control of Weight—Weight acts on a simple lever which in turn actuates the Micro Switch. Used to prevent complete evaporation of liquids in a container.

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.

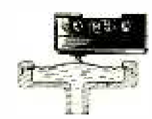
Bellows Thermostat—Fluctuations in temperature change the length of the bellows to operate the Micro Switch.

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

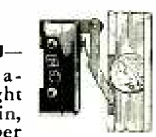
Disc and Cam Operated—A sequence of operations is controlled by means of a roller-leaf actuator following the strips on a driven drum.



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



Diaphragm Pressure Actuated—The pressure of a liquid or gas against the diaphragm actuates the Micro Switch at desired limits of pressure.



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

Accurately Repeated Split-Thousandth Precision

Industry recognizes the Micro Switch as the only time-tested precision switch that combines the light weight of 1 ounce; the small size of 1 15/16″ x 11/16″ x 27/32″; compactness; small energy requirement and precision operation with rugged construction and Underwriters' listed rating of 1200 watts up to 600 volts.

Manufacturers in every phase of industry use it in a wide variety of ways—in practically every case it permits new standards of performance or performs specific functions more dependably than the unit previously used.

Many machine tool manufacturers use it for motion and reversing limits. One hobbing machine manufacturer found that the compact sturdiness of the Micro Switch greatly facilitated the streamlining of his product. He now uses eight Micro Switches on each machine.

The larger buyers of airplanes specify Micro Switches because they are light, compact and are resistant to vibration.

Micro Switches are used in numerous plant operations where the automatic inspection of parts is held to .0001″ tolerance—on timers, counters, and similar devices.

Switching problems are specialized and therefore call for specialized experience. Micro Switch engineers have that experience. Let them help you. Tell us your problems.

Another *New* Switch!

OIL – WATER – DUST – and VAPOR-PROOF

Here is the new Water-Oil-Dust and Vapor Proof Micro Switch for non-hazardous locations. Genuine Neoprene seals and gaskets are used. Strong field wiring terminals accept No. 14 solid wire. The die cast housing is rugged—and standard ½″ conduit hub makes installation handy. Ask for Bulletin No. 5.

MICRO (MS) SWITCH

MANUFACTURED IN FREEPORT, ILLINOIS BY

MICRO SWITCH CORPORATION

New York Chicago Boston

MICRO (MS) SWITCH

MALLORY ENGINEERS

P. R. MALLORY & CO. Inc.

are Anticipating the Design Problems that Confront YOU!

FOR LOWER COST
HIGHER EFFICIENCY
MINIMUM SPACE

MALLORY-YAXLEY SWITCHES

Basic design changes to provide economy in costs and space are being made in both rotary and push button types of switches.

Mallory-Yaxley Rotary Switches—The new rotary switch anticipates every wave change, tap and tone control requirement from the standpoint of performance, flexibility and economy. Proper circuit arrangements, combined with proper indexing features for various torque requirements, are available in combinations, including single and multiple sections.

Mallory-Yaxley Push Button Switches—These include new design features and provide the most complete line available. A thorough study has been made to provide economy in push button tuning. Various types of Mallory-Yaxley Push Button Switches are available to give you the best advantages from a cost and space standpoint in all model receivers, ranging from the lowest to the highest price.

MALLORY VIBRATORS

Varying loads and circuit requirements are exactly met by either synchronous (self-rectifying) or non-synchronous (interrupter) types. The selection of Mallory-built Vibrators as original equipment by the leaders in the radio industry is sound assurance of the superiority of their design . . . performance and long life.

MALLORY CAPACITORS

No recent development has made a more vital contribution to chassis design and improved performance than the introduction of FP (Fabricated Plate) Capacitors. Smaller sizes without loss of efficiency . . . low R. F. Impedance . . . better filtering . . . surge proof construction . . . freedom from corrosion . . . these are some of the features that have sent FP Capacitors skyrocketing to leadership with the nation's leading radio manufacturers.

A consultation with Mallory engineers during the period of your own design development may easily lead to dramatic savings.

Consult with Mallory right now before your designs are complete!

P. R. MALLORY & CO. Inc.
MALLORY
YAXLEY

P. R. MALLORY & CO., Inc. • INDIANAPOLIS, INDIANA
Cable Address—PELMALLO

CROSS TALK

▶ **FREEDOM** . . . At the annual banquet of the Radio Club of America, Major Lenox Lohr, of N.B.C., stated that there was no and could be no freedom of speech on the air as exists on the street corner or in newspapers. The reasons are as follows. First there is only a limited amount of "air." Freedom of speech implies that all who want to can talk—but this is obviously impossible with the severe limitations imposed on the broadcast set-up both as to available channels and available time. Therefore the broadcast station must decide who is to get time. Controversial subjects, therefore are virtually taboo.

There are other reasons why broadcasters must refuse to give time to all who want to spout. This is the terrific responsibility of the broadcasters involved in the use of their straight path to the average man's home. There is no controlling who is to listen; and a highly susceptible and emotional audience is always eavesdropping, ready for juicy morsels. The unreasoning nature of the average listener is something to pause and ponder about.

For example; on a certain program was a woman whose name, let us say, was Aunt Betsy. The script was written by someone the listeners never saw nor heard of. It was read into the mike by another person never seen by the audience. There was actually no Aunt Betsy. One day the announcer stated that this fictitious aunt had a garden and grew swell petunias in it and that if listeners wanted some of the seeds from the petunias, they could write the station inclosing a dime and some cartons of the product being plugged.

Something around a million dimes were received. Now the misguided women who wanted the petunia seeds could have done much better to go to the grocery store where such seeds can be got for a nickel—but no, they wrapped the dime up in paper, bought cartons of stuff, wrote a letter, stamped it and mailed it to get seeds from a non-existent garden planted and nurtured by a non-existent woman.

In another case, one of the news commentators was given permission by Western Union to state that this great communication agency would be glad to send the commentator a free telegram of good wishes from any of his friends who might be listening in. The hundred thousand or so telegrams received swamped W.U. facilities, flooded the broadcast station—and many of them came by Postal and had to be paid for by Western Union.

There is no telling what people will do when they hear a broadcast well done.

Incidentally we overheard some mechanics recently. They have got up a little club among themselves, with quite a few members and each day they get together and gloat over what they have got free (!) by writing to a broadcaster or an advertiser. Women's magazines are specially good hunting grounds for free samplers, and some of the things these mechanics had got amused them no end. Some would be positively embarrassing—to us!

▶ **DEC. 27, 1939** . . . "This afternoon," writes R. H. Marriott, "while going from the I.R.E. office at 330 W. 42 st., N.Y.C. to the 8th ave. subway, I saw a sign on a bar window which indicated that television was in there. I went in. I heard and saw folks in costume, sing Noel songs in French and saw them dance. I heard the bartender explain television to a group of customers. He said: 'Marconi discovered how to send sound, Steinmetz discovered relativity, then a fellow by the name of Deforest put them together and perfected television.' Those and a glass of beer for a dime!"

Dr. Frank Conrad, Assistant Chief Engineer of Westinghouse, receives the Gold Medal of the American Institute of the City of New York from Robert T. Pollack, President of the Institute, David Sarnoff, President of R.C.A. looks on

The Business Side of Television

Factual data based on NBC's first nine months of public television service, including opinions and preferences gathered from the viewing audience. Gathered to show the direction in which commercial television service is headed, hence of interest to all those who have a stake in the new art

By NORAN E. KERSTA
Assistant Television Coordinator
National Broadcasting Company

IT is practically a universal thought that the day of technically successful television broadcasting is here, but the question remains, "Is television as a broadcast service and a business venture getting anywhere?" Over the years, the purely technical engineering phases of television have been written about, photographed, and marveled at. On the other hand, little or no discussion or data have been available relative to television broadcasting as a business. This is regrettable, because the business and economic problems of television are in many ways more difficult to ponder than the technical. The primary reason for the lack of this type of information, indispensable to the commercial engineer, has been the lack of exploration in the basic operations of regularly scheduled television broadcasting.

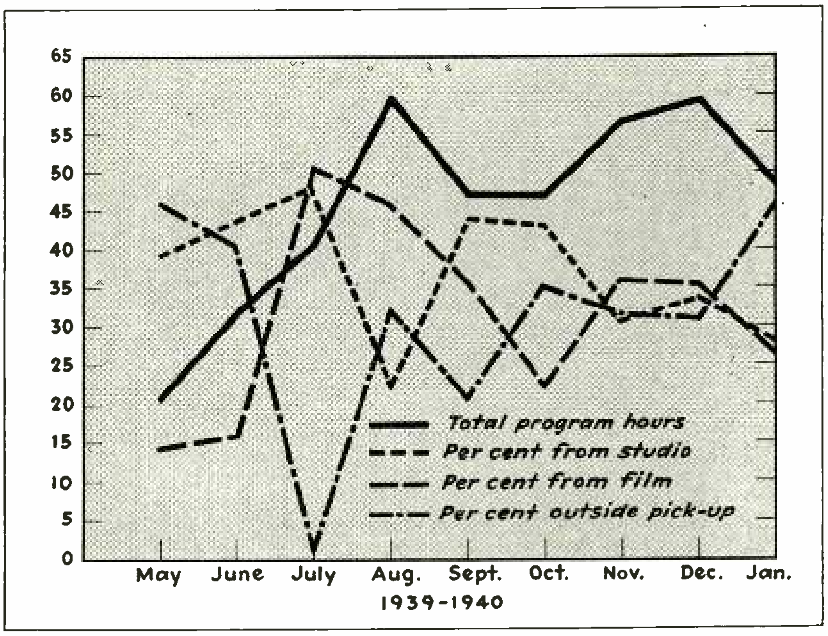


Fig. 1—The extent of the service: Number of program hours by months and percentages of origination from studio, film, and outside pick-up

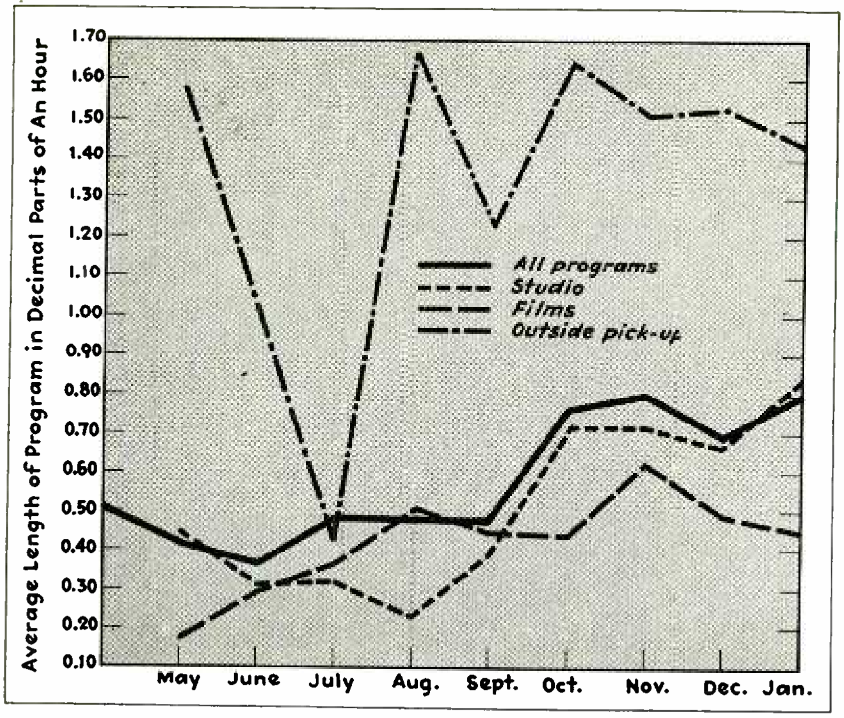
Today we may look back on many months of actual experience in regular television broadcasting in the New York Metropolitan Area. The extent and variety of equipment used should make the data gathered from this experience vital to all interests presently active and to those considering participation in some phase of television. In fact, analysis of existing experience in methods of broadcast operation can be used to considerable advantage in guiding studies on the amount and nature of equipment necessary for a given purpose. For instance, in the planning of a television broadcast plant in a given market, it should be beneficial to know what portion of the total hours on the air can be depended upon to be furnished by motion picture film, by direct pick-up from the studio, and by portable equipment in the field. Also, it is just as important to know what the audience is likely to think of the program fare thus furnished, and to know the cost of furnishing service by the different methods of program origination.

Over a period of months, the National Broadcasting Company has explored this new field, and the discussion which follows is based on data gathered over this period. However, before going to facts and figures, it may be well to review some of the fundamental philosophies associated with broadcasting as a public service, in order to justify the nature of the particular data presented.

The Broadcasting Objective

The objectives of television broadcasting (and of sound broadcasting as well), are to increase the size of the audience, and to endeavor to establish more and more of the audience's good-will. These are the vital objectives because the larger the audience and the more good-will a station enjoys, the more successful is that station as an advertising medium—whence it derives its subsistence. As in all business it follows, then, that one of the most important considerations for operation becomes: What is the lowest practical unit cost of creating this good-will?

To reduce the unit cost of good-will, it is necessary to reduce the cost per hour of programming. Also, the unit cost of good-will may be reduced by increasing the audience acceptability of programs, which automatically increases the number of receivers in the field, and the average number of viewers per receiver. Of course there are additional factors, such as the price of receivers, which have much to do



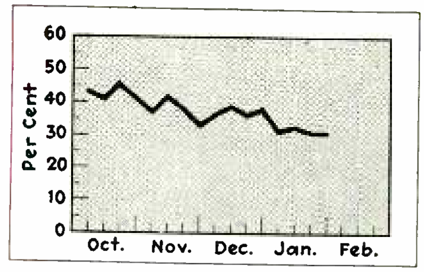


Fig. 3—Audience cooperation: Percentage of listeners who return the postcards with comments on the week's program schedule

Fig. 2—Left, the length of individual programs, which show a definite trend toward longer programs, averaging about three-quarters of an hour

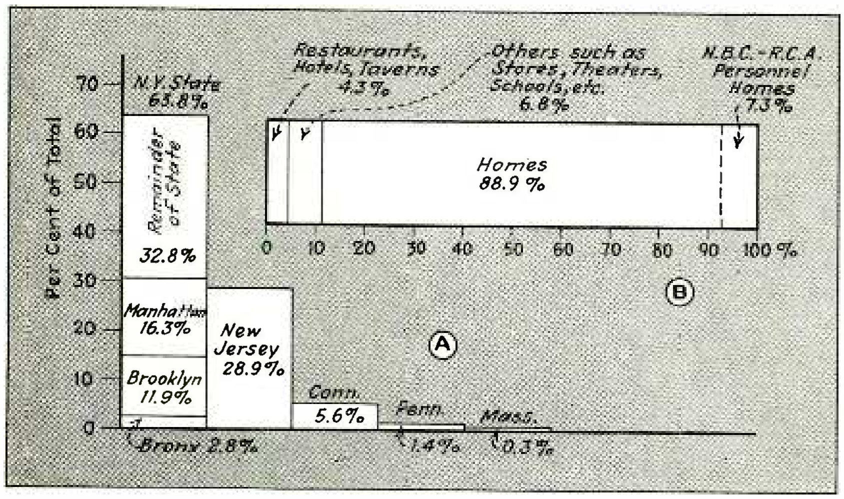


Fig. 4—Distribution of receivers, geographically and by type of establishment. Data revealed by questionnaires circulated to the audience

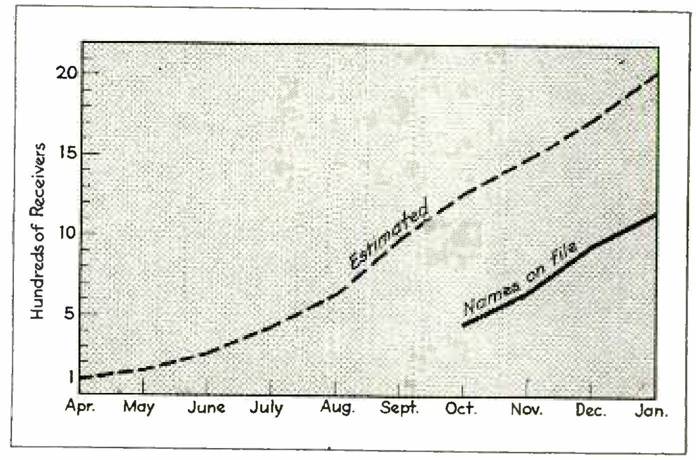


Fig. 5—The size of the audience: The solid line shows the number of names in the N.B.C. file; the dotted line gives the probable actual number of receivers

with the audience size. Here, however, only factors associated particularly with program service will be discussed. Three such factors which immediately suggest themselves, upon consideration of the "unit cost of good-will", are: size of the audience, good-will, and costs.

The good-will of the audience is a function of the number of programs, the program entertainment and educational value, the technical quality of reception, the program schedule punctuality, and additional audience considerations in the form of schedule publication and reliability. Keeping cost records of operation presents no novel problem. However, the form of such records is important if they are to permit swift and accurate analysis.

The first question, then, is the number of scheduled program hours. Regular program service for the public started April 30, 1939, with the broadcast of President Roosevelt's address at the opening of the New York World's Fair. Figure 1 shows the number of program hours broadcast each month since that date. The total of 409.8 hours is an average of a little more than ten hours a week since the beginning of service. The ten hour service is rendered on a schedule of two hours a day, Wednesday through Sunday, an hour in the afternoon and an hour in the evening.

The second question is the value of the program material. The programs have consisted of live talent studio shows, outside pick-ups, and film. The breakdown of the origination of the programs for the nine months is shown in Fig. 1. It may be noticed from the curves that early operation was more or less a catch-as-catch-can proposition on program material. However, starting in October, there is a gradual smoothing-out of program scheduling. Figure 2, showing the average length of programs by type of program origination, indicates also the "cut" and "try" period for the first six months, followed by a more uniform operation.

During the first nine months of programming, the watchword had been "try everything". For the purposes of analysis, all programs are broken down into twenty-nine classifications. For summary purposes Table I shows the breakdown of the entire nine months' program material by only the nine major classifications. From the table it can be seen that News, Special Events, and Current Events, at an average of 35.7 per cent; Drama at 29.3 per cent; and Educational at 15.7 per cent lead the other classifications.

These three account for 79.5 per cent of the total program fare. News, Special Events, and Current Events are generally covered by portable equipment in the field, Drama by the live-talent studio set-up, and Educational chiefly by film.

Weekly Program Mailing Cards

Since the week of October 1st the National Broadcasting Company has offered to send weekly television programs to all television receiving set owners who submitted their names and addresses by mail. A letter was mailed with the first program schedule requesting data on the type of receiver being used, etc. and requesting comments at any time. The three objectives in mailing out the program schedules were to compile a file of receiver owners, to obtain a means of studying audience reaction to various types of programming, and to create a "Television Family" feeling with the audience, i.e. to foster the idea that the National Broadcasting Company is studying to match its television programs as closely as possible to the desires of the audience. These objectives have been realized satisfactorily, and much useful data has resulted, including information here presented.

Figure 5 shows the number of receivers recorded monthly, since the beginning of the survey in October, 1939. On a few occasions, by comparing the number of names in the file with a complete list of receiver owners known to be in a given area as submitted by receiver distributors in the area, it has been possible to estimate quite satisfactorily the actual number of receivers in the entire area. The dotted line of Fig. 5 was plotted, using these statistical projections. On October 8th, it was estimated that one-fourth of the total names were on file; on November 3rd about one-third the total; and on January 5th, about one-half. The figure of 100 receivers at the beginning of May was an estimate current in the trade at that time.

From a survey conducted the first week in February it was found that on an average there were 2.4 present at receivers in homes during the daytime broadcasts and 5.4 present during the evening. In hotels, stores, and taverns, average figures were 17.6 in the daytime, 31.4 in the evening.

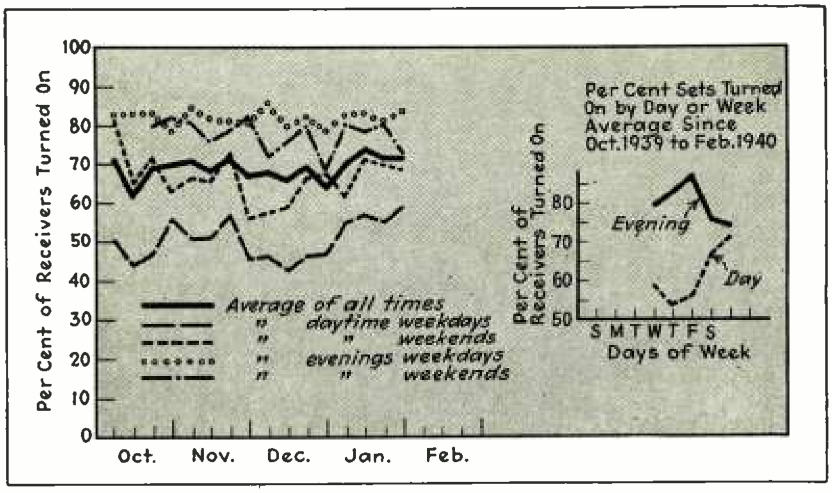


Fig. 6—Percentage of the viewing audience according to the time of the day and the part of the week, as well as by individual days

Using these data on the estimated number of receivers in the area, the potential daytime audience is 9,500 and the evening audience is 19,000.

As of February 9th, Fig. 4 shows the distribution of receivers in the New York Area by type of establishments in which receivers are installed, and the geographic distribution of receivers. The inclusion of the states of Connecticut, Pennsylvania, and Massachusetts in the chart may seem unusual, because of the reception this involves of television images from the Empire State Building beyond the horizon distance of about 50 miles. The receivers included in the geographic survey which are beyond the horizon distance can be assumed to be located in very favorable, high terrain or using special receiving antenna installations, or both. In some instances, special receiving equipment may be in use as well. At these extreme distances it can be safely assumed that the reception cannot be compared as to technical quality, with the reception on receivers located within the dependable coverage area—the horizon distance.

While a discussion of the distribution of manufactured brands of receivers may be a digression from the purpose of this paper, it is included to indicate the types of receivers, i.e., size picture, etc., which are in the hands of the audience. Table II offers data by manufacturer and by tube sizes for all receivers other than those in the hands of dealers. Table II shows the percentage distribution of all receivers by manufacturers, also in homes only, and in taverns, hotels, restaurants, and other establishments combined. These data must be tempered with the fact that they represent only 40% of the total receiver installations recorded in file, this percentage being the portion of the file for which these facts have been found.

Measurement of Good-will

The following data deal with the measurement of the good-will developed over the nine months of operation:

During the first week of October, 1939, when the first batch of program schedules was mailed to the receiver owners, about half of the mailing list responded by mail to a letter which accompanied the schedule requesting comments and sug-

TABLE I—Monthly Breakdown of Program Material

Major Program Type	PERCENT OF TOTAL									
	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Monthly Aver.
Children's	....	....	....	.4	....	.5	.4	1.5	....	.3
Dancing	4.0	.9	.8	....	....	....	....	.4	....	.7
Drama	16.5	13.0	43.6	35.3	34.9	27.4	34.1	31.9	26.8	29.3
Educational	7.3	21.6	19.7	16.2	19.5	20.9	15.6	15.2	5.6	15.7
Miscellaneous	1.8	4.5	12.6	1.2	.6	1.5	.3	.8	.5	2.6
Music	4.1	4.0	7.6	4.4	3.9	1.2	1.8	1.3	1.2	3.3
News — Special & Current	49.2	44.2	6.0	39.3	29.8	32.0	32.5	38.2	49.7	35.7
(Sports)	(21.6)	(11.2)	(.4)	(27.6)	(14.5)	(28.5)	(13.9)	(27.7)	(38.1)	....
Variety	17.1	11.8	9.7	3.2	11.3	16.5	15.3	10.7	16.2	12.4

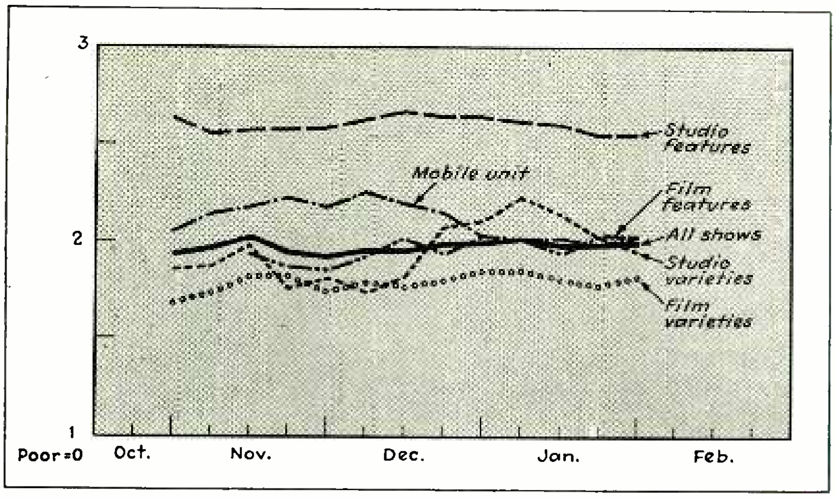


Fig. 7—Audience reaction: On the basis of 0 poor, 1 fair, 2 good, and 3 excellent, the average program rates as good

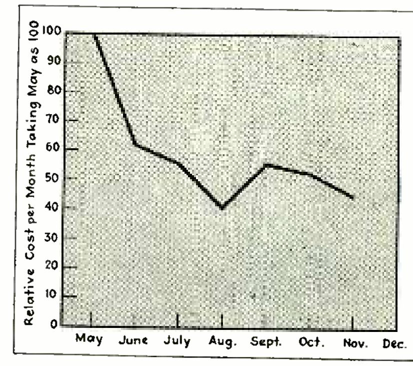


Fig. 8—Program costs have decreased rapidly, roughly in inverse ratio to the number of program hours

gestions. Some of the replies were two or more pages long, containing suggestions and thoughts aimed to help match programs more closely to the various individuals' desires.

In addition to this initial indication of interest, Fig. 3 shows the percentage of returned audience reaction questionnaires for the 16 weeks for which data are available. It is interesting to note that not only has the percentage of return been quite consistent, but also that the high average of 37.5 per cent return is quite unusual for a weekly mailing of this nature. It is practically always the case that should there be a deviation either in timing or in program content from the released schedule, phone inquiries and letters promptly become reminders of the sincere and active interest of the television audience.

Since the start of analysis in October on the amount of use of receivers, by the audience, there has been a gradual increase in the average percentage of receivers in use during broadcasts. Figure 6 shows these percentages along with breakdowns of these figures for day and evening weekdays and weekends. The chart in the inset shows the consistency of audience attendance by days of the week.

Using the reaction questionnaire attached to the weekly program schedule, every receiver owner has an opportunity to voice his opinion as to the quality and acceptability of each individual program broadcast. In offering this opportunity to the television audience, and keeping operation flexible, programs can readily be trimmed as closely and as quickly as possible to the majority vote of the audience. The results of this weekly reaction survey forms a very sensitive measuring rod of the status of the audience good-will from week to week. A compilation of the findings from these weekly surveys is shown in Fig. 7.

For analysis purposes, weightings of 3 for excellent, 2 for good, 1 for fair, and 0 for poor, are used. The audience rating averages since October 8, 1939 to date for the five types of programs are:

Studio Features 2.61
Mobile Unit 2.07
Film Features 1.98
Studio Varieties 1.93
Film Varieties 1.78
Average of all programs to date 1.97

In addition to programs broadcast for the home audience, a certain amount of "Test Signal" for television dealers and service men, was furnished, to aid in the work of receiver installation and maintenance. The amount of this signal plus the regular program hours amounted to 1050.27 hours for the nine months, or an average of 26.26 hours a week on the air for the industry to test, install, and service television receivers in the field.

TABLE II—Manufacturers Distribution of Receivers in Homes

	SIZE OF PICTURE TUBE				
Manufacturer	5 inches or less	7 inches	9 inches	12 inches	Total
1	16.6	....	26.9	56.5	35.2
2	77.4	....	5.7	16.9	17.2
3	....	....	3.4	96.6	9.4
4	4.5	...	40.9	54.6	7.1
5	100.0	....	....	....	6.2
6	25.0	....	50.0	25.0	2.6
7	....	100.0	....	....	1.9
Home made	31.1	17.8	20.0	31.1	14.6
13 Others.......	16.7	5.6	22.2	55.5	5.8
	31.8	4.9	19.2	44.1	100.0

Manufacturers Distribution of Receivers in Taverns, Restaurants, Hotels, Stores, Schools, Theaters, etc.

Manufacturer	5 inches or less	7 inches	9 inches	12 inches	Total
1	11.1	....	16.7	72.2	45.0
2	100.0	....	....	....	10.0
3	....	....	27.3	72.7	27.5
All others.......	....	14.3	14.3	71.4	17.5
	15.0	2.5	17.5	65.0	100.0

What Price Good-Will?

Having an interested audience and generally pleasing it with a given program fare is all well and good, but at what price?

In connection with costs, it is always a consideration whether organization, administration, and cost control can progressively show continued efficiency. The following facts indicate a favorable realization of improving efficiency.

1. The costs of operation are remaining quite constant from month to month, but the end results, the average audience rating of pro-

(*Continued on page 90*)

Narrow-Band Carrier Telephony

By shifting the carrier frequency in accordance with the power level in speech, it is possible to locate the active sideband components continuously within a narrow channel and thereby conserve bandwidth. Based on the correlation between speech frequencies and power

By JOHN A. CSEPELY

Something for Nothing? . . . The search for means to beat the sideband game goes on and on. And whenever someone comes to *Electronics* with a scheme for transmitting more information in a given band in a given time than our schooling says *is* reasonable, your editors think of Warren Horton, of the Department of Biology and Public Health, M.I.T.

Mr. Horton's background at the Bell Laboratories and at General Radio and his interest in these sideband-beating schemes eminently fit him to discuss articles like the one published here. With Mr. Horton's permission and that of the author, we report his judgment of Mr. Csepely's scheme:

"There is no error, fundamentally, in the scheme proposed by Mr. Csepely. It does, in fact, take advantage of an important characteristic of a particular kind of signal wave and the system has a theoretical advantage. Stated in general terms the point is this. We have as a basic theorem the fact that the product of the bandwidth by the time of transmission is a measure of the amount of information carried by a given channel. Stated in other words: the bandwidth of a transmission channel is a measure of the "information carrying capacity" of that channel and shows the limiting rate at which it is capable of conveying information. Now it is a rare occurence indeed for any channel to be called upon to transmit information at its maximum rate. We say that a wide band is required for orchestral music, but often, as during a flute solo, we use only a single frequency at a time. A broadcast channel, then, may be worked at a poor load factor as far as its information carrying capacity is concerned. Mr. Csepely's scheme, in these terms, involves an attempt to reshape the signal wave so that it may be transmitted at a better information load factor.

"For speech this seems theoretically possible. At one instant a narrow band, located at one part of the frequency spectrum, is needed. At another time a band of comparable width, but located at another position on the spectrum, is needed. It is customary to provide a channel which makes any band in the required spectrum continuously available for use whenever called for but which leaves it idle at other times. Mr. Csepely provides only a single narrow band and juggles the signal spectrum so that the active frequencies —those existing at any given time—are pushed into that band. He is able to do this because of the fact, established by Steinberg, that in speech the frequency location of the active bands and their power levels have a linear correlation.

"Although this scheme is theoretically sound a number of quantitative assumptions have to be made to put it into practice. The most important, it seems to me, is that the rate at which the signal band must be moved in order to keep the active frequencies in the restricted region available for transmission must be low compared with the lowest frequency in the original signal. A second assumption is that the saving in band width used for the signal is sufficient to off-set the added channel required to transmit the band shifting control. Unless I missed the point in looking through Mr. Csepely's manuscript he ignores the important effect of variations in transmission efficiency of this control channel.

THE problem which the author set out to solve was to devise a wave transmission system which would effectively narrow the frequency bandwidth required for the transmission of intelligence without losing those component frequencies which are essential for satisfactory reproduction. This paper describes a system which accomplishes the desired result for the special case of carrier current speech transmission over wires.

Historical Review

In order to make the fullest possible use of the commercially available frequency range, single sideband, carrier suppressed transmission was developed and introduced in 1920[1]. This type of transmission reduces the frequency bandwidth required for each speech channel to the minimum possible width obtainable with amplitude modulation.

However, numerous systems have since been proposed for reducing this band width still further, all of them performing a "compressing" operation on the wave band at the transmitter, and a suitable "expanding" operation at the receiver. These proposed systems may be broadly divided into the following classes:

A. Systems employing the Doppler effect. In a typical proposal[2] based on this effect the signal wave is propagated along a circular guiding medium at a fixed velocity. A device traveling along the same medium at a different velocity picks up the component signal frequencies and slows them down for transmission over the line. Since this pick-up process must be interrupted at the end of each traversal of the guiding medium, the transmitted signal is mutilated.

B. Systems which divided the original signal frequency range into two or more smaller adjacent frequency ranges by means of wave filters. In one of these systems[3] it is proposed to separate the high frequency, low energy consonant sounds from the low frequency, high energy vowel sounds. A modulator and marginal relay are used to shift the low energy consonant sounds down into the frequency range occupied by the vowel sounds. This causes an unavoidable overlap of the vowel sounds and the shifted consonant sounds, and the switching relay sets up undesirable switching transients.

C. Systems which frequency-modulate the message band. One proposal advanced[4] was that the carrier frequency be modulated cyclically at a rate of about 1000 cps, the object being to transmit, in succession, different portions of the original frequency range through a narrow band pass filter. This system is objectionable because the sidebands due to frequency modulation cannot be disregarded when such high modulation rates are employed. In addition, these sidebands are not functionally related to the wave components in the original message.

The author's system belongs to class C, but the rate of frequency shifting is relatively slow, corresponding roughly to the low frequency energy variations or undulations in the signal. Such frequency modulation of the signal in terms of itself does not introduce any appreciable

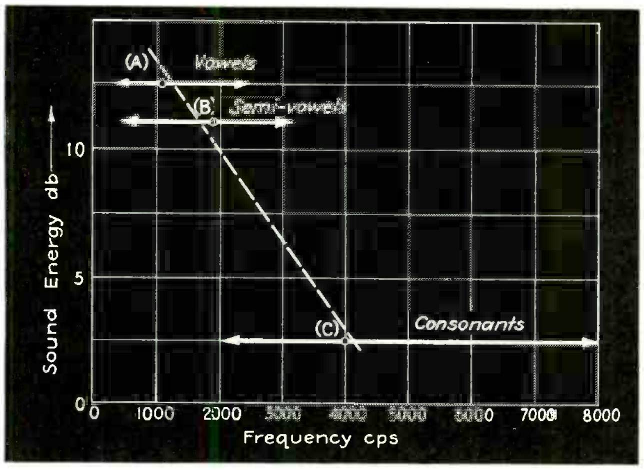


Fig. 1—The relationship between the frequency components and the corresponding power levels associated with various speech sounds, on which Mr. Csepely's scheme is based

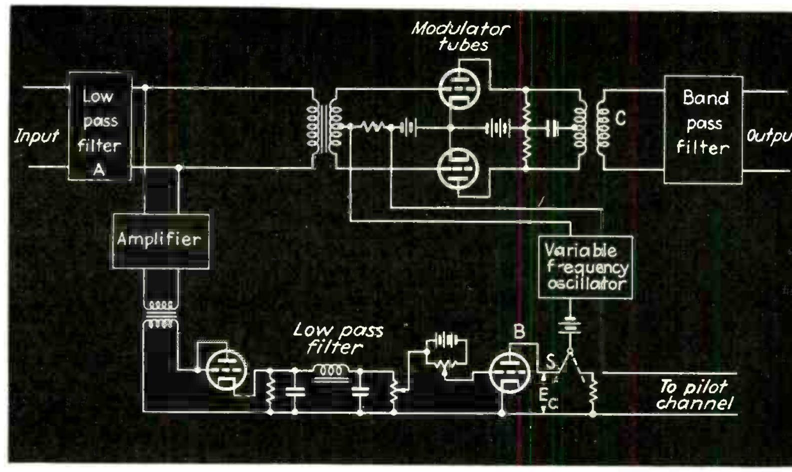


Fig. 2—Practical means of shifting the sideband components from instant to instant so that they fall within the channel limits for use at the transmitter

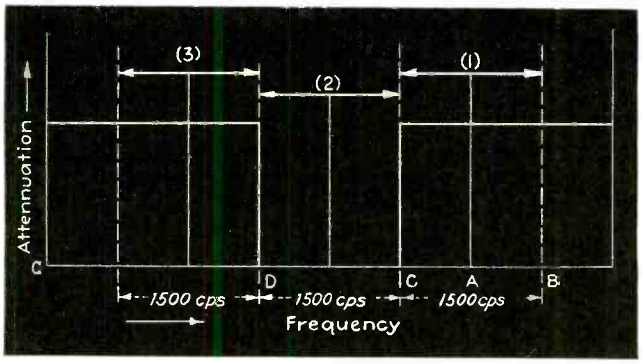


Fig. 3—Characteristic of an ideal 1500-cps bandpass filter, showing how a region 4500 cps wide may be shifted into the pass region

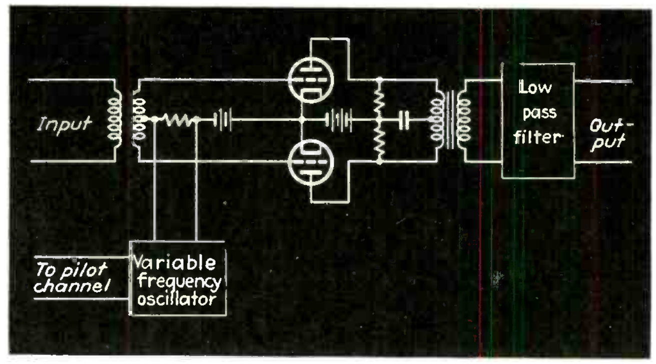


Fig. 4—The receiving end of the narrow-band system. The pilot channel controls a variable oscillator which reverses the shift introduced at the transmitter

distortion, and the sidebands due to frequency modulation can be disregarded for all practical purposes.

The advantages gained through the use of the author's system may be summarized as follows:

1. The number of speech channels can be increased by at least 50 per cent.

2. The signal-to-noise ratio can be increased.

3. A reduction in transmitter power is obtainable.

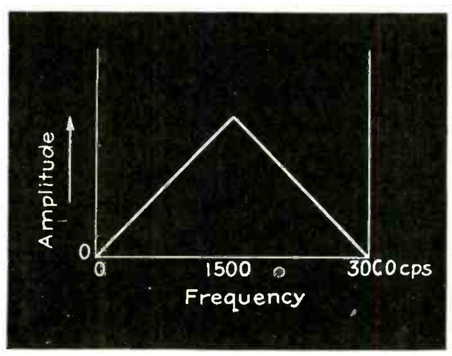


Fig. 5—Frequency response characteristic of the output when oscillator frequency varies continuously

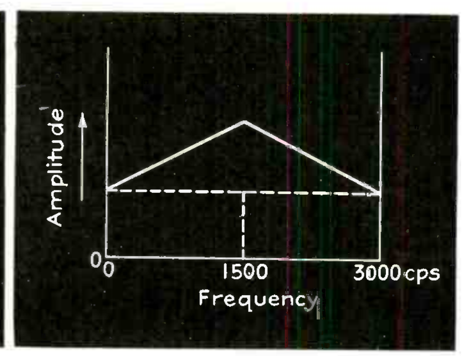


Fig. 6—Characteristic when oscillator frequency remains constant one third of the time

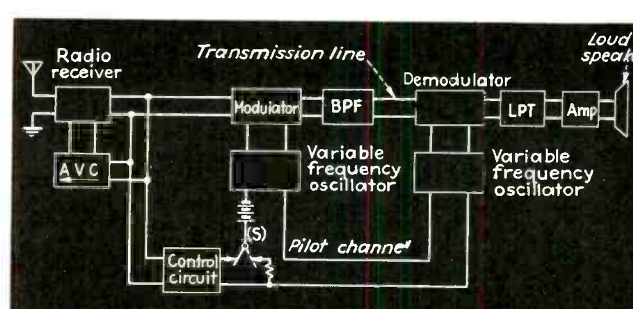
Energy—Frequency—Time Characteristics of Speech

Ordinary conversational speech is composed of vowel and consonant sounds which follow each other in more or less rapid succession. These sounds, in addition to being separated in time, are also distinguished by differences in volume and frequency levels. Points A, B, and C in Fig. 1 show approximately the average sound energy in db of the vowel and consonant sounds and the corresponding average frequency levels. The fundamental or pitch frequency is disregarded in this chart. This is satisfactory for the purposes of the following discussion, since the frequency range 0 to 300 cps is not usually transmitted in commercial telephone practice.

The curve drawn through points *A*, *B*, and *C* is approximately a straight line. Denoting the average frequency level by $\overline{F}$, and the corresponding r-m-s microphone output energy by $\overline{E}$, the following approximate relation is obtained:

$$\overline{E} \simeq -k\,\overline{F} + b \qquad (1)$$

Fig. 7—Simplified block diagram of the complete system as used for experimental verification of the theory



Intermediate vocalizations are used when passing from one sound to another except during pauses. The r-m-s energy $\overline{E}$, and hence the average frequency $\overline{F}$, may therefore be broadly classified as continuous functions of the speech signal.

The average frequency range occupied by the various sounds is shown by the arrows in Fig 1. Since the frequencies above 3000 cps are

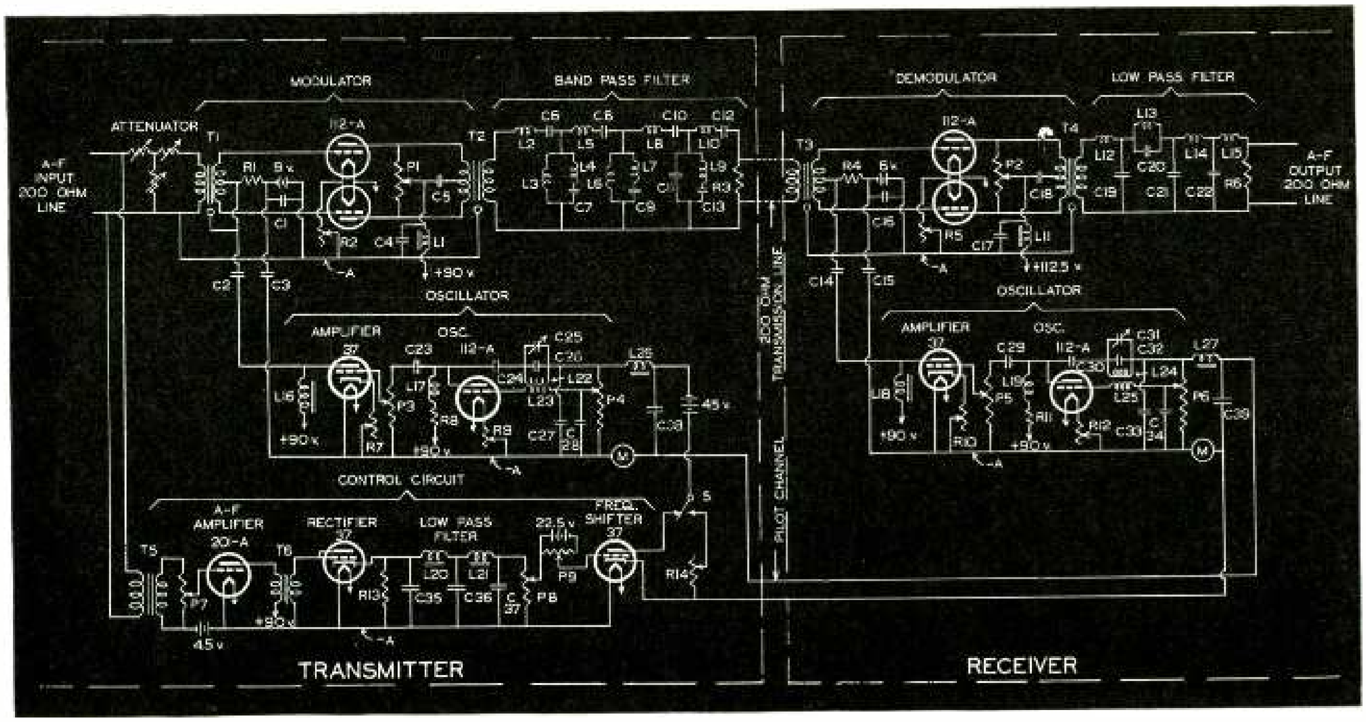


Fig. 8—Complete circuit diagram of experimental narrow-band set-up

C_1, C_{16}, C_{24}, C_{30} 1.0 μf
C_2, C_3, C_{14}, C_{15} 0.5 μf
C_4, C_{17} 2.0 μf
C_5, C_{18} 4.0 μf
C_6, 0.018 μf
C_7, 0.048 μf
C_8, C_{10} 0.01 μf
C_9, 0.142 μf
C_{11}, 0.479 μf
C_{12}, 0.021 μf
C_{13}, 0.468 μf
C_{19}, 0.424 μf
C_{20}, 0.145 μf
C_{21}, 0.42 μf
C_{22}, 0.509 μf
C_{23}, C_{29} 0.25 μf
C_{25}, C_{31} 1000 μμf, variable
C_{26}, C_{32} 0.001 to 0.01 μf mica
C_{27}, C_{28}, C_{33}, C_{34}, C_{37} 0.03 μf
C_{35}, 0.032 μf
C_{36}, 0.016 μf
C_{38}, C_{39} 0.5 μf
R_1, R_4 4000 ohms
R_2, R_5, R_9, R_{12} 6 ohms
R_3, R_6 200 ohms
R_7, R_{10} 10,000 ohms
R_8, R_{11} 4700 ohms
R_{13}, 50,000 ohms
R_{14}, 10,000 ohms
L_1, L_{11} filter chokes
L_2, 23.0 mh
L_3, 1.76 mh
L_4, 6.38 mh
L_5, 42.3 mh
L_6, 1.09 mh
L_7, 1.74 mh
L_8, 46.5 mh
L_9, 1.93 mh
L_{10}, 19.7 mh
L_{12}, L_{15} 10.6 mh
L_{13}, 12.76 mh
L_{14}, 21.2 mh
L_{16}, L_{18} 400 ohms filter chokes
L_{26}, L_{27} 5 h
L_{17}, L_{19} 42 mh
L_{20}, L_{21} 2000 h at 0.1 ma dc and 10 v ac
L_{22}, L_{23}, L_{24} L_{25} 55 mh
T_1, Line to push-pull grids
T_2, Plates to line
T_3, Line to grids
T_4, Plates to line
T_5, Line to grid
T_6, Interstage Ratio 1:3
P_1, P_2 3100 ohms
P_3, P_5, P_8 250,000 ohms
P_4, P_6 3000 ohms
P_7, 500,000 ohms
P_9, 100,000 ohms
M, 0 to 10 ma d-c meter

not usually transmitted in carrier telephony, it will be seen that most of the higher frequencies of the consonant sounds are cut off.

The rate at which the various syllables of speech are spoken is known as the syllabic rate, and corresponds to frequencies between 2 and 20 cps.

Figure 1 shows that the energy of the consonant sounds is on the average about 10 db less than that of the vowel sounds.

Description of System

In the following description the device at the transmitting station is called the frequency compresser and the corresponding device at the receiving station is called the frequency expander.

In the transmitter the signal is divided between two parallel paths. In one, the signal goes to the modulator tubes and thence to the transmission line. In the other path, the signal is amplified, rectified and passed through a low pass filter which has a cutoff frequency of about 80 cps. It is then passed through a frequency shifting circuit after which it emerges as the oscillator control voltage (for both transmitter and receiver) E_c of Fig. 2. The transmitter and receiver oscillators are capable of operating at several different carrier frequencies depending on the nature of the impressed signal. The control voltage E_c is transmitted to the receiver by means of a separate pilot channel. The signal modulates the carrier frequency and the modulated carrier signal is transmitted to the receiver where it is demodulated by means of the output of the receiver oscillator which is of the same frequency, but of the opposite phase.

The functional behavior of the frequency compresser may be considered by referring to the simplified schematic circuit of Fig. 2. The carrier generated by the variable frequency oscillator is more or less completely suppressed by the push-pull arrangement of the modulator tubes. The bandpass filter is arranged to transmit the lower side band and to suppress the remaining residual carrier frequency. The low pass filter *A* transmits speech frequencies up to 3000 cps.

The carrier frequency is controlled by the control voltage E_c, which is derived from the line through an amplifier, a rectifier, a low pass filter and a frequency shifting circuit. The low pass filter in the control circuit is designed for a cut-off frequency of approximately 80 cps. The frequency shifting circuit uses a triode tube *B*, the grid of which is biased to beyond cut-off. The output voltage of this tube is simultaneously impressed on the plate and grid circuits of the oscillator tubes at the transmitting and receiving stations, a pilot channel being used to convey the control current.

The gain of the control circuit and the grid bias of tube *B* are so adjusted that for all volume levels below a predetermined minimum the oscillator frequency remains constant at its maximum value. The oscillator frequency is maintained substantially constant at its minimum value when the plate current of tube *B* approaches saturation at high volume levels.

In the system built and demonstrated by the author the maximum carrier frequency was made 10,000 cps. and the minimum frequency 8,800 cps. The bandpass filter was designed to pass the frequency band 7000 to 8500 cps. At low volumes, therefore, the signal frequencies transmitted over the line corresponded to an original frequency range of 1500 to 3000 cps., while at high volumes they corresponded to an original frequency range of 300 to 1800 cps. The total frequency range transmitted over a considerable period of time corresponded to an original frequency range of 300 to 3000 cps.

The throw-over switch S was used in the demonstration system for making comparison listening tests between the new type of transmission and standard single sideband transmission. When the switch was in the dotted position, a steady direct voltage was applied to the oscillator tubes to maintain the oscillator frequencies constant.

The following analysis is confined to the particular conditions assumed in designing the demonstration system.

The delay introduced by the low pass filter in the control circuit is assumed to be negligible. Ideal modulation and demodulation are assumed. The average carrier frequency $\frac{\omega_o}{2\pi}$ is 8500 cps, the maximum frequency shift $\frac{\omega_o h}{2\pi}$ is $\pm$ 750 cps, and the maximum rate of shifting $\frac{p}{2\pi}$ is 20 cps.

Assume that the oscillator tank circuit capacity C_o is varied in conformity with a low frequency signal $\frac{p}{2\pi}$, and let the instantaneous capacity be

$$C = C_o\ (1 - 2h \cos pt) \qquad (2)$$

where h is an amplitude factor proportional to the signal intensity.

When $h << 1$, the instantaneous radian frequency ω can be written,

$$\omega = \omega_o + \omega_o h \cos pt \qquad (3)$$

When $p << \omega_o$, the oscillator output is given by the equation,

$$I = a \cos [\int \omega_o dt + \omega_o h \cos pt\, dt]$$

$$= a \cos [\omega_o t + \frac{\omega_o h}{p} \sin pt] \qquad (4)$$

the arbitrary phase constant being omitted for the sake of simplicity.

Let the voice input be $b \sin qt$. Since the carrier frequency is suppressed, the modulator output at C is given by the expression

$$k\, a\, b \cos [\omega_o t + \frac{\omega_o h}{p} \sin pt] \sin qt$$

$$= \tfrac{1}{2} A \sin [(\omega_o + q)\, t + \frac{\omega_o h}{p} \sin pt] \qquad (5a)$$

$$- \tfrac{1}{2} A \sin [(\omega_o - q)\, t + \frac{\omega_o h}{p} \sin pt] \qquad (5b)$$

Each of these equations represents a wave whose phase varies cyclically between the limits

$$+ \frac{\omega_o h}{p} \text{ and } - \frac{\omega_o h}{p}$$

These waves can be shown to be equivalent to two "carrier" waves of radian frequency $(\omega_o + q)$ and $(\omega_o - q)$, each of which is accompanied by an infinite number of sideband frequencies. These frequencies are separated from the "carrier" by integral multiples of p. The "carrier" and sideband amplitudes are given by Bessel functions of argument $\frac{\omega_o h}{p}$ and increasing order.

However, it can be shown[5] that when $\frac{\omega_o h}{p} >> 1$, say in the neigh-

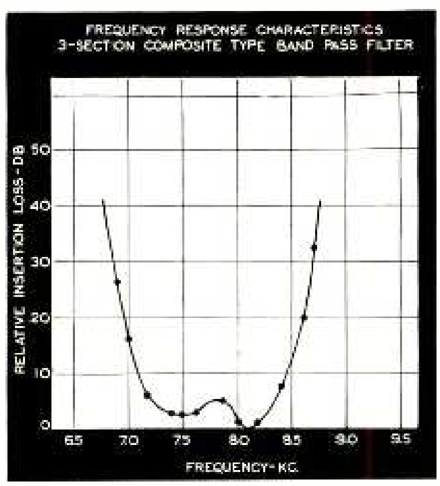


Fig. 9—Response characteristic of three-section bandpass filter used in circuit in Fig. 8

borhood of 40 or more, those sideband frequencies extending more than $\pm \frac{\omega_o h}{2\pi}$ beyond the "carrier" frequency are of very small amplitude, and can be disregarded for all practical purposes. For the case under discussion, therefore, the frequency spread of the waves (5a) and (5b) is given very closely by $\omega_o + q \pm \omega_o h$, and $\omega_o - q \pm \omega_o h$, respectively.

Let Fig. 3 represent the ideal bandpass filter into which the modulator of Fig. 2 works. A represents the location of the average carrier frequency $\frac{\omega_o}{2\pi}$, and B and C its upper and lower frequency limits, respectively. $DC = BC =$ 1500 cps or one-half the bandwidth of the original speech input frequencies. 1, 2 and 3 represent, respectively, the location of the side band frequency $\frac{1}{2\pi}(\omega_o - q)$ for $\frac{q}{2\pi} =$ 0, 1500 and 3000 cps. The heavy arrows indicate the spread of the modulation frequencies which accompany the frequency $\frac{1}{2\pi}(\omega_o - q)$.

All terms of Equation (5a) are therefore suppressed, the bandpass filter transmitting only the terms in Equation (5b).

Expanding Equation (5b) in the usual manner, we obtain for the output of the bandpass filter:

$$-\tfrac{1}{2} A\ [J_o\ (x) \sin (\omega_o - q)\ t]\ \phi_1 (q)$$
$$-\tfrac{1}{2} A\ [(-1_n)\ J_n\ (x) \sin (\omega_o - q - np)\ t]\ \phi_2\ (q) \qquad (6)$$
$$-\tfrac{1}{2} A\ [J_n\ (x) \sin (\omega_o - q + np)\ t]\ \phi_3\ (q)$$

where $x = \frac{\omega_o h}{p}$, and $\phi_1 (q)$, $\phi_2 (q)$ and $\phi_3 (q)$ are amplitude factors defining the action of the bandpass filter on the various side frequencies, and $J_n (x)$ is the Bessel function of the first kind.

The Frequency Expander

The frequency expander at the receiving station is shown in the simplified schematic circuit of Fig. 4. The oscillator frequency is controlled by the current received over the pilot channel. The low pass filter is designed to transmit frequencies up to 3000 cps.

Assuming ideal transmission over the line, the received current is given by Equation (6). When this is demodulated by the local oscillator frequency,

$$a \cos [\omega_o t + \frac{\omega_o h}{p} \sin pt]$$

the lower side band, or demodulation products, consist of the desired frequency of the form

$$B \cos qt\ [\phi_2\ (q) + \phi_3\ (q)] \qquad (7)$$
$$B \cos qt\ [\phi_2\ (q)]$$
$$B \cos qt\ [\phi_3\ (q)]$$

and distortion products of the form

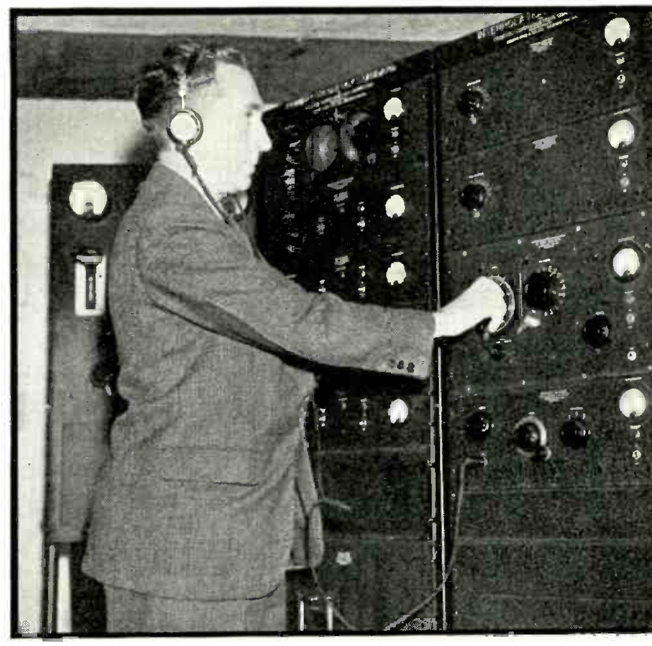
$$B\, J_o\ (x)\ J_n\ (x) \cos\ (q - np)\ t.\ \phi\ (q)$$
$$B\ J_o\ (x).\ J_n\ (x) \cos\ (q + np)\ t.\ \phi\ (q) \qquad (8)$$
$$B\ [\ J_n\ (x)]^2 \cos\ (q - 2\ np)\ t.\ \phi\ (q)$$
$$B\ [J_n\ (x)]^2 \cos\ (q + 2\ np)\ t.\ \phi\ (q)$$

where n is any positive integer.

The amplitude factors $\phi_2 (q)$ and

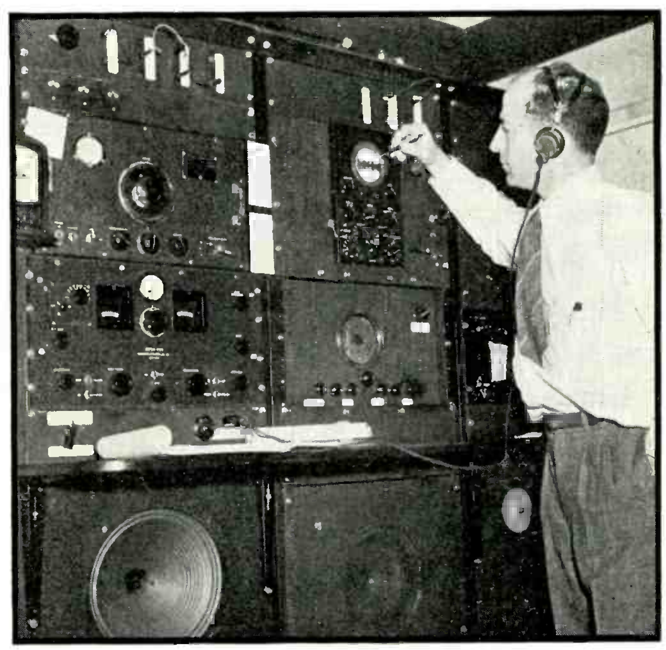
(*Continued on page 88*)

The F.C.C. monitoring station at San Pedro, California is one of seven maintained in the United States for the purpose of checking the frequency and quality of licensed transmissions as well as running down unlicensed stations



A frequency standard, here operated by Inspector James H. Chapple, is available for checking frequencies throughout the spectrum on which stations are allocated. Harmonics and subharmonics are used to obtain off-crystal frequencies

AIR WAVE CHECK-UP



Percentage modulation and other aspects of the modulation envelope are monitored on a cathode ray oscilloscope, fed from any of several calibrated communication receivers. James Homsy, inspector in charge of the station, is shown on the job

Portable equipment, fitted with a rotatable loop antenna, is available for tracking down unlicensed transmitters. A. L. Ritter is shown recording bearings for locating the signal by triangulation

FULL WAVE RECTIFIER ANALYSIS

By C. M. WALLIS
University of Missouri

WITH single anode or half wave rectifier circuits only fractional amounts of power may be rectified due to current cutoff in each half cycle. This occurs regardless of the type of load imposed on the rectifier from the d-c side. However with the full wave rectifier circuit, if the load is made sufficiently inductive in character, load current cutoff may be prevented and the d-c component of load current built up to much larger value. Loads on the d-c side of the rectifier having a so-called condenser input, that is, capacitive type loads, always produce tube current cut-off during a portion of the voltage cycle. Usually the tube currents with this type of load are highly peaked and of low average or d-c value.

In the following analysis of the full wave rectifier circuit, equations for the current and voltage wave forms are derived for two general types of loads, namely inductive and capacitive. In case of inductive loads, an equation in terms of the load circuit parameters is given which enables one to predetermine whether current cutoff does or does not occur. The use of operational calculus in the analysis simplifies the solution a great deal. Sinusoidal impressed alternating voltages of constant effective value are assumed. The analysis deals primarily with circuits using gas filled tubes, which have an anode to cathode voltage drop that is practically constant and independent of the tube current magnitude.

Consider the single phase full wave circuit shown in Fig. 1. If the transformer is mid-tapped as indicated, the rectifier circuit has balanced anode voltages of $e_1 = E_m \sin x$ and $e_2 = E_m \sin (x - \pi)$. The type of voltage wave which the rectifier impresses upon the load circuit is of the pulsating type shown in Fig. 2C. This type of voltage function may be considered as a product wave[1], i.e., it is the result of multiplying two functions of x together: one, the sinusoidal function $E_m \sin x$, shown in Fig. 2A, the other, a unit rectangular wave function, which is shown in Fig. 2B, and designated as S' function. That is $S' = +1$ from $x = 0$ to $x = \pi$, $S' = -1$ from $x = \pi$ to $x = 2\pi$, etc. Consequently, $S'E_m \sin x$ designates a completely rectified sine wave since the negative loops are made positive.

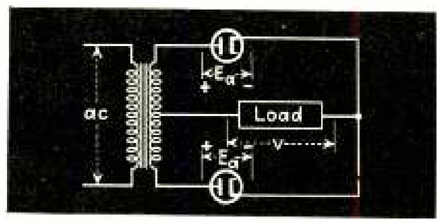


Fig. 1—Circuit diagram of typical full wave rectifier

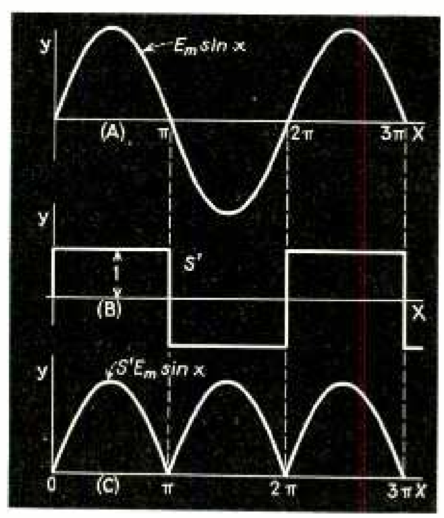


Fig. 2—Typical voltage curves of the full wave rectifier

The general voltage equation for the rectifier load circuit during the period of current flow in either first or second half cycle may be written as

$$0 = S'E_m (\sin x) - v - E_a \quad (1)$$

where v is the instantaneous value of the voltage across the load and E_a is the tube drop.

Inductive Loads

As previously stated, if the load be sufficiently inductive in character continuous flow of load current occurs. Let it be assumed that the load has L henrys inductance, R ohms resistance, and an e.m.f. of E volts acting in circuit opposition to the current flow as indicated in Fig. 3. The instantaneous load voltage may be expressed as

$$v = Ri + L\omega \frac{di}{dx} + E$$

i being the instantaneous value of load current. The above equation may be written in the form

$$v = L\omega (p + \eta) i + E \quad (2)$$

where $\eta = R/L\omega$ and p is the differential operator d/dx. Equation (1) for this particular case, by substitution of v becomes

$$i (p + \eta) = \frac{E_m}{L\omega} S' (\sin x) - k \quad (3)$$

which is the differential equation of the load current, and $k = \frac{(E_a - E)}{E_m}$.

The complete solution of Eq. (3) may be written in the form[2]

$$i = \frac{E_m}{L\omega} \left[\frac{S' \sin (x - \delta)}{\sqrt{1 + \eta^2}} - k/\eta + A\epsilon^{-\eta x} \right] \text{ amperes} \quad (4)$$

where $\delta = \cot^{-1} \eta$ and A is a constant for any one half cycle.

Non-Cut Off Case

Equation (4) gives the instantaneous load current as a function of the time angle x. It should be noted however, that the term $S' \sin (x - \delta)$ is a discontinuous function; an abrupt change in its value occuring at $x = \pi$, $x = 2\pi$, etc. If load current cutoff does not occur then the latter must vary continuously from one half cycle to the next. Consequently, the quantity A must be discontinuous in a manner such as to make i continuous. Hence A is constant for any one half cycle, varying however from half cycle to half cycle. For the steady state condition, that is where i is periodic, A may be evaluated by setting the current at the beginning of a half cycle, where $x = 0$, and $S' = +1$, to the current at the end of the half cycle, where $x = \pi$, and $S' = +1$. By so doing, through the use of Eq. (4)

$$A = \frac{2}{(1 + \eta^2)\,(1 - \epsilon^{-\eta\pi})} \quad (5)$$

A may be determined for successive half cycles in a like manner. However since the current function is the same over each half cycle this need not be done. The type of current wave occurring in the non-cut off case is shown in Fig. 4A, or in more detail in Fig. 5.

The d-c component of load current obtained by integration of the current equation between limits of $x = 0$ and $x = \pi$, is

$$I_{dc} = \frac{E_m}{R}\,[2/\pi - k] \quad (6)$$

Cut Off Case

If the load circuit parameters are such as to cause load current cut off in each half cycle, as shown in Fig. 4C, then Eq. (4) may be written as

$$i\Big]_{\alpha \text{ to } \beta} = \frac{E_m}{L\omega}\left[\frac{S' \sin (x - \delta)}{\sqrt{1 + \eta^2}} - \frac{k}{\eta} + A\epsilon^{-\eta x}\right] \text{ amperes} \quad (7)$$

where (α) is the angle of firing and (β) is the angle of current cut off. The former angle is of course equal to $\sin^{-1}k$ (Refer to Fig. 4C). The value of the constant A over the first half cycle is evaluated from the boundary conditions at the point of firing. Namely at $x = \alpha$, $S' = +1$, and $i = 0$. Therefore from Eq. (7)

$$A_1 = \frac{k + \eta\sqrt{1 - k^2}}{\eta\,(1 + \eta^2)\,\epsilon^{-\eta\alpha}} \quad (8)$$

Should the current pulse continue over into the second half cycle the constant A is re-evaluated from the boundary condition at the beginning of the second half cycle. Namely at $x = \pi$ and $S^1 = -1$, $i = i_{x=\pi}$ Hence

$$A_2 = \left[\frac{(i_\pi)\,L\omega}{E_m} + \frac{1}{(1 + \eta^2)} + \frac{k}{\eta}\right]\epsilon^{\eta\pi} \quad (9)$$

Test for Cutoff

The constants A and A_1 over the first half cycle for the non-cutoff case and the cutoff case are given by Eqs. (5) and (8) respectively. The criterion for non-cutoff of load current is that $A \geqq A_1$. Or that

$$\frac{2}{(1 - \epsilon^{-\eta\pi})} \mathrel{\substack{=\\>}} \frac{k + \eta\sqrt{1 - k^2}}{\eta\,\epsilon^{-\eta\alpha}} \quad (10)$$

For a given set of load circuit constants the above equation determines readily whether the load current flows continuously or in pulses. Where the equality relationship exists in the above equation, the instantaneous value of load current just reaches zero value at $x = \alpha$. This is shown in Fig. 4B.

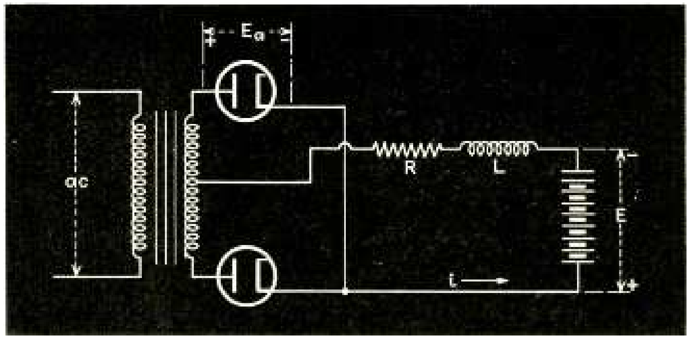


Fig. 3—Rectifier with an inductive load and a direct voltage in opposition to the rectified voltage

TABLE I

Load Currents Computed From Above Equations

x	i	x	i
0°	5.68	100°	7.23
20°	3.59	120°	8.41
40°	3.23	140°	8.75
60°	4.11	160°	7.85
80°	5.58	180°	5.68

Example 1. A single phase full wave rectifier, utilizing gas filled tube, supplies power to a d-c system. The voltage of the d-c system is 500 volts. The rectifier anode voltages are $\pm$ 1000 sin x. A smoothing inductance of 0.2 henrys and a resistance of 20 ohms are inserted in the d-c side of the rectifier. Assume tube drop $E_a = 15$ volts

$$k = (E_a + E)/E_m = 0.515$$
$$\eta = R/L\omega = 0.265$$
$$\delta = \cot^{-1}\eta = 75.15^\circ$$
$$\alpha = \sin^{-1}k = 31.0^\circ$$
$$k/\eta = 1.94 \qquad \frac{E_m}{L\omega} = 13.26$$

$$\frac{2}{(1 - \epsilon^{-\eta\pi})} = 3.54 \qquad \frac{k + \eta\sqrt{1 - k^2}}{\eta\,\epsilon^{-\eta\alpha}} = 3.23$$

Since $\frac{2}{(1 - \epsilon^{-\eta\pi})} > \frac{k + \eta\sqrt{1 - k^2}}{\eta\,\epsilon^{-\eta\alpha}}$, load current cut off does not occur and as there is continuous current flow.

By Eq. (5)

$$A = \frac{2}{(1 + \eta^2)\,(1 - \epsilon^{-\eta\pi})} = 3.30$$

The current equation for first half cycle ($S' = +1$) is

$$i = 13.26\left\{\frac{(+1)\sin (x - 75.15^\circ)}{1.035} - 1.94 + 3.30\,\epsilon^{-0.265x}\right\}\text{amperes}$$

or

$$i = [12.80 \sin (x - 75.15^\circ) - 25.7 + 43.75\,\epsilon^{-0.265x}] \text{ amperes}$$

Values of Load Current Computed From the Above Equations are given below—see also Table I:

x	0°	20°	40°	60°	80°
i	5.68	3.59	3.23	4.11	5.58
x	100°	120°	140°	160°	180°
i	7.23	8.41	8.75	7.85	5.68

The d-c value of the load current is

$$I_{DC} = \frac{1000}{20}\left(\frac{2}{\pi} - 0.515\right) = 6.05 \text{ amperes}$$

The current curve is shown in Fig. 5.

Example 2. Suppose that the voltage of the d-c system is 600 volts, other factors remaining the same as in Example 1.

$$k = (E + E_a)/E_m = 0.615$$
$$\alpha = \sin^{-1}k = 37.95^\circ$$

$$\frac{2}{(1 - \epsilon^{-\eta\pi})} = 3.54 \qquad \frac{k + \eta\sqrt{1 - k^2}}{\eta\,\epsilon^{-\eta\alpha}} = 3.71$$

Since $\frac{2}{(1 - \epsilon^{-\eta\pi})} < \frac{k + \eta\sqrt{1 - k^2}}{\eta\,\epsilon^{-\eta\alpha}}$ load current cut off occurs and the current flows in pulses.

By Eq. (8) $A_1 = \frac{k + \eta\sqrt{1 - k^2}}{\eta\,(1 + \eta^2)\,\epsilon^{-\eta\alpha}} = 3.47$

The current equation over first half cycle ($S' = +1$) is

$$i\Big]_{\alpha \text{ to } \pi} = [12.8\,(+1)\sin (x - 75.15^\circ) - 30.79 + 46.0\,\epsilon^{-0.265x}] \text{ amperes}$$

By solution $ix = \pi = 1.55$ amperes therefore current pulse lasts over into second half cycle, hence

$$A_2 = \left[\frac{(i_\pi)\,L\omega}{E_m} + \frac{1}{(1 + \eta^2)} + \frac{k}{\eta}\right]\epsilon^{\eta\pi} = 7.76$$

The current equation for remaining portion of current pulse is

$$i\Big]_{\pi \text{ to } \beta} = [12.8\,(-1)\sin (x - 75.15^\circ) - 30.79 + 102.7\,\epsilon^{-0.265x}] \text{ amperes}$$

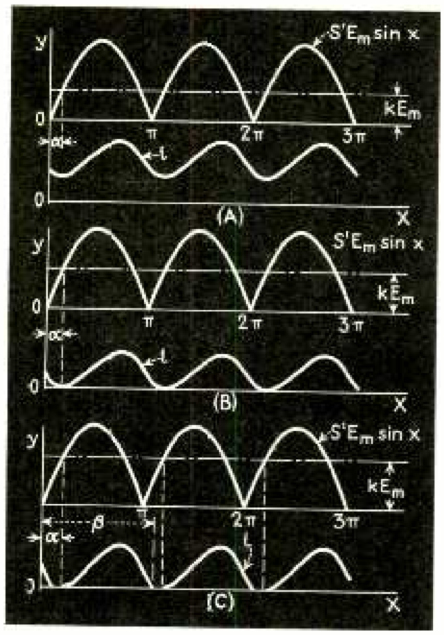


Fig. 4—Voltage and current curves of the rectifier shown in Fig. 3 for the condition of no current cut off

Values of load current computed from the two above equations are given below:

x	37.95°	40°	60°	80°	100°
i	0	0.02	0.72	2.04	3.59
x	120°	140°	160°	180°	190°
i	4.60	4.86	3.86	1.55	0.49

The current curve is shown in Fig. 6.

Capacitive Loads

To supply a d-c plate voltage to electronic equipment a rectifier circuit similar to that shown in Fig. 7 is frequently used. R_1 represents the equivalent d-c load resistance. R_2 and C represent a resistance-capacitance filter arrangement. When in operation the condenser C is charged during periods of current flow. When neither tube is conducting the condenser discharges through the load resistance R_1. The character of the load voltage variation is shown in Fig. 9.

During the period of discharge the value of the load voltage v may be expressed as

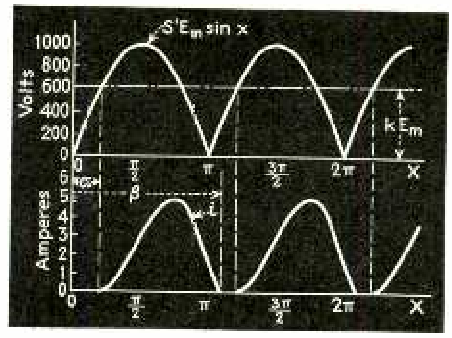


Fig. 5—The same curves as in Fig. 4A but in greater detail

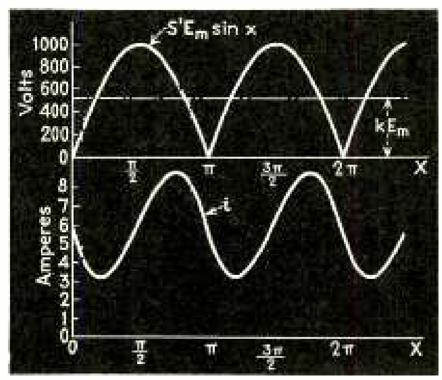


Fig. 6—The same curves as in Fig. 4C, but in greater detail

$$v = V\epsilon^{-\frac{x-\beta}{R_1 C\omega}} \quad (11)$$

where V is the load voltage at instant of tube current cutoff, i.e., where $x = \beta$.

During the period of tube current flow $v = E_m S' (\sin x) - E_a - R_2 i$

Taking the load circuit impedance, expressed in operational form as $Z(p)$, the tube current during this period is

$$i\Big]_{\alpha \text{ to } \beta} = \frac{E_m S' (\sin x) - E_a}{Z(p)} \quad (12)$$

The load impedance in terms of the circuit parameters is

$$Z(p) = \left[R_2 + \frac{R_1}{R_2 C\omega p + 1}\right] = \frac{K + B(p)}{1 + A(p)}$$

Where $K = (R_1 + R_2)$, $B = R_1 R_2 C\omega$, $A = R_1 C\omega$. Substituting in the value of $Z(p)$ into Eq. (12) and performing the indicated operations

$$i\Big]_{\alpha \text{ to } \beta} = \frac{E_m \sqrt{1+A^2}\, S' (\sin (x+\phi)) - E_a}{K + B(p)}$$

The above equation is of the same form as Eq. (3) and hence its solution may be written as

$$i\Big]_{\alpha \text{ to } \beta} = \left[E_m M\, S' \sin (x + \phi - \theta) + P\epsilon^{-\frac{K}{B}x} - E_a/K\right] \text{ amperes} \quad (13)$$

where

$$M = \sqrt{\frac{1 + A^2}{K^2 + B^2}} \qquad \theta = \tan^{-1}(B/K) \text{ and } \phi = \tan^{-1} A$$

It now remains only necessary to set up the relationships from which the constant P and the angles α and β may be found. These may be determined from the boundary conditions at the points of firing and cutoff in the following manner.

Referring to Fig. 9 it may be seen that at the instant of firing in the second half cycle, where $x = \alpha + \pi$ and $S' = -1$ that

$$(-1) E_m \sin(\pi + \alpha) - E_a = V\epsilon^{-\frac{\pi+\alpha-\beta}{A}}$$

Likewise at the point of current cutoff in the first half cycle where $x = \beta$ and $S' = (+1)$

$$(+1) E_m (\sin \beta) - E_a = V$$

Eliminating V from the above two equations yields the result

$$\epsilon^{-\frac{\pi+\alpha-\beta}{A}}\left[E_m(\sin\beta) - E_a\right] = \left[E_m(\sin\alpha) - E_a\right]$$

Again at the point of tube current cutoff, where $x = \beta$, $S' = +1$ and $i = 0$, Eq. (13) becomes

$$0 = M E_m (+1)\left[\sin(\beta + \phi - \theta)\right] + P\epsilon^{-\frac{K}{\beta}\beta} - E_a/K$$

Similarly at the point of firing where $x = \alpha$, $S' = +1$ and $i = 0$

$$0 = M E_m (+1)\left[\sin(\alpha + \phi - \theta)\right] + P\epsilon^{-\frac{K}{\beta}\alpha} - E_a/K$$

Eliminating the constant P from the two preceding equations gives the result

$$= \epsilon^{\frac{K}{B}\beta}\left[\frac{E_a}{K} - M E_m \sin(\beta+\phi-\theta)\right] = \epsilon^{\frac{K}{B}\alpha}\left[\frac{E_a}{K} - M E_m \sin(\alpha+\phi-\theta)\right] \quad (15)$$

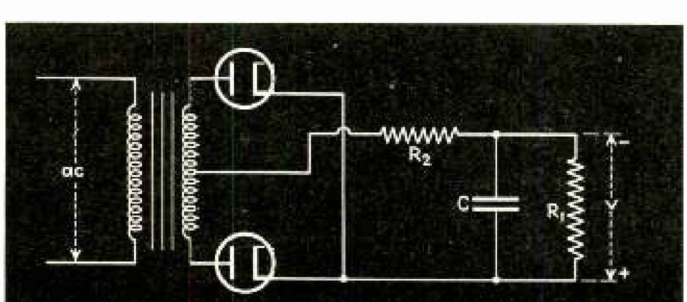


Fig. 7—A typical rectifier power supply. R_1 is the load and C and R_2 make up filter

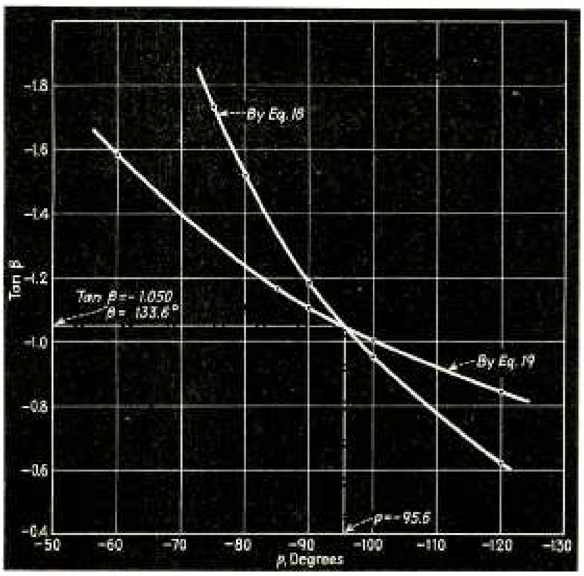


Fig. 8—Curves which determine the duration of current flow through the rectifier elements of Fig. 7 as calculated in Example 3

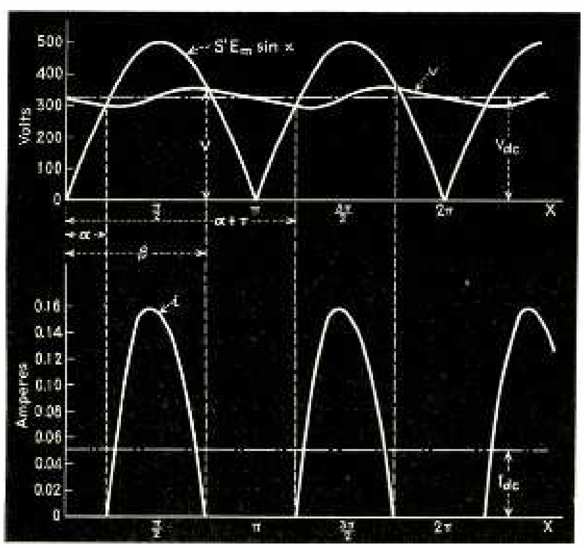


Fig. 9—Voltage and current curves of the circuit in Fig. 7 as determined in Example 3

If the terms involving the arc drop voltage (E_a) are neglected in Eqs. (14) and (15) the angles α and β may be determined. Negligible error results by this omission since the arc drop E_a is usually a very small fraction of E_m. By so doing Eqs. (14) and (15) reduce to

$$\epsilon^{\frac{\pi+\alpha-\beta}{A}} = \frac{\sin \beta}{\sin \alpha} \quad (16)$$

$$\epsilon^{(K/B)\,(\alpha-\beta)} = \frac{\sin(\beta+\phi-\theta)}{\sin(\alpha+\phi-\theta)} \quad (17)$$

By letting $(\alpha-\beta) = \rho$ Eqs. (16) and (17) can each be solved for β in terms of the angle ρ. Thus from Eq. (16)

$$\tan \beta = \frac{\sin \rho}{\epsilon^{-\frac{\pi+\rho}{A}} - \cos \rho} \quad (18)$$

and from Eq. (17)

$$\tan \beta = \frac{\sin \rho + [\tan(\phi-\theta)][\cos \rho - \epsilon^{\frac{K}{B}\rho}]}{\epsilon^{\frac{K}{B}\rho} + (\sin \rho)(\tan(\phi-\theta)) - \cos \rho} \quad (19)$$

The values of β and ρ which satisfy the above two equations can be found graphically by plotting tan β in each case against assumed values of ρ. The intersection of the two curves gives of course the correct values of ρ and tan β. These angles being determined, α and P may be calculated from preceding equations. The current and voltage functions may next be determined.

The d-c component of the load voltage v is

$$V_{DC} = \frac{1}{\pi}\left\{\int_{\alpha}^{\beta} (E_m(\sin x) - E_a - R_2\, i)\, dx + \int_{\beta}^{(\pi+\alpha)} V \epsilon^{-\frac{x-\beta}{A}} dx\right\}$$

Substituting in the value of i, integrating the result and simplifying, the above expression becomes.

$$V_{DC} = \frac{1}{\pi}\Big\{E_m(\cos\alpha - \cos\beta) - R_2 E_m M[\cos(\alpha+\phi-\theta) - \cos(\beta+\phi-\theta)] - \frac{E_a R_1}{R_1+R_2}(\beta-\alpha) - \frac{R_2 P B}{K}\Big[\epsilon^{-\frac{K}{B}\alpha} - \epsilon^{-\frac{K}{B}\beta}\Big] + VA\Big[1 - \epsilon^{-\frac{\pi+\alpha-\beta}{A}}\Big]\Big\} \quad (20)$$

The d-c value of load current is

$$I_{DC} = \frac{V_{DC}}{R_1} \quad (21)$$

The following problem is worked out to exemplify the use of the preceding equations.

Example 3. The full wave rectifier shown in Fig. 7 has anode voltage of $\pm$ 500 sin X. The resistance-condenser filter used is composed of a 1000 ohm resistance and a 4 μf condenser. The equivalent load resistance R_1 is 6000 ohms. Assume E_a = 10 volts

$K = (R_1 + R_2) = 7000$ ohms
$\phi = \tan^{-1} A = 83.7°$
$E_a/K = 0.00143$
$B = R_1 R_2 C\omega = 9050$
$\theta = \tan^{-1}(B/K) = 52.3°$
$K/B = 0.774$
$A = R_1 C\omega = 9.05$
$\tan(\phi - \theta) = 0.612$
$M = \sqrt{\frac{1+A^2}{K^2+B^2}} = 7.97\ (10^{-4})$
$E_m M = 0.3980$

The curves obtained by plotting Eqs. (18) and (19) for assumed values of ρ are shown in Fig. 8. By graphical solution $\alpha = 38.0°$ and $\beta = 133.6°$. From the boundary condition at $x = \beta$ and $i = 0$

$$P = \left[\frac{E_a}{K} - E_m M \sin(\beta+\phi-\theta)\right] \epsilon^{\frac{K}{B}\beta} = -0.622$$

The equation of the current pulse in the first half cycle is by Eq. (13)

$$i]_{\alpha \text{ to } \beta} = [0.398 \sin(X + 31.4°) - 0.622\,\epsilon^{-0.744X} - 0.00143] \text{ amperes}$$

$$V = E_m(\sin\beta) - E_a = 352 \text{ volts}$$

The value of the d-c output voltage by Eq. (20) is

$$V_{DC} = \frac{1}{\pi}\Big\{(500)(1.477) - (398)(1.318) - (8.51)(1.67) + (804)(0.4343) + (3185)(0.15)\Big\} = 331 \text{ volts}$$

The equation for the instantaneous load voltage between the limits of $x = \alpha$ and $x = \beta$ is:

$$v = [500(\sin x) - 398(\sin(x + 31.4°)) + 622\,\epsilon^{-0.744X} - 8.37] \text{ volts}$$

Between the limits of $x = \beta$ and $x = (\pi+\alpha)$

$$v = 352\,\epsilon^{-\frac{x-133.6°}{9.05}}$$

Current and voltage curves computed from the above equation are plotted in Fig. 9 for the first and successive half cycles. Since they are repeating functions, only those for the first half cycle need be computed.

[1] For a discussion of the general theorems of product waves as may be used in rectifier circuits the reader is referred to a paper "Rectifier Calculus" by W. M. Goodhue, presented at the A.I.E.E. Northeastern District meeting May 3–5, 1939.

[2] For the mechanics of solution of this equation the reader is referred to a previous paper by the author entitled, Half Wave Gas Rectifier Circuits in the 1938 October issue of *Electronics.*

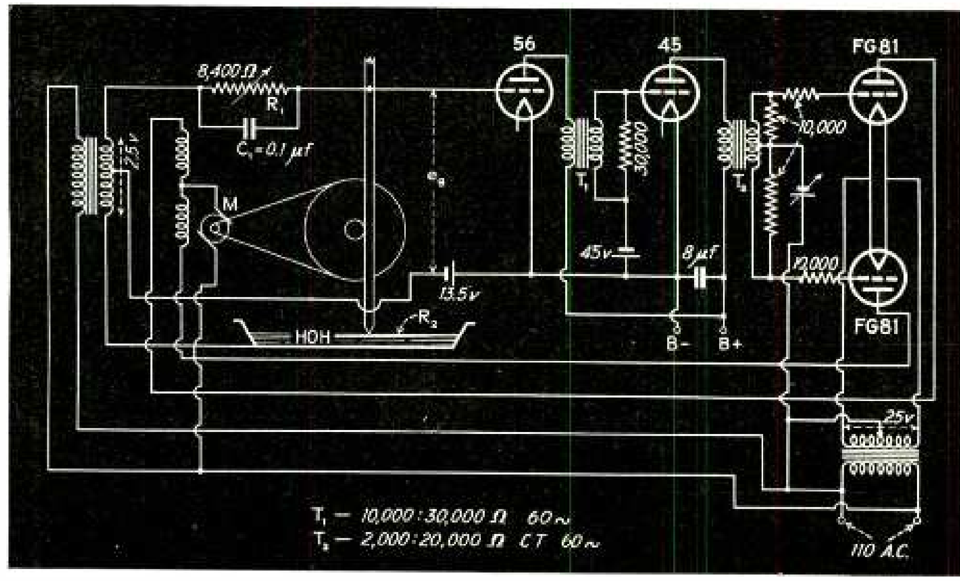


Fig. 1—Circuit diagram of the water level indicator. The resistance between the metal pointer and the liquid container is the variable element of a bridge circuit

WATER LEVEL INDICATOR

By L. A. WARE
The State University of Iowa

AN interesting application of a bridge-controlled thyratron follow-up system is an automatic liquid level indicator in which it is desirable to prevent as far as possible interference with the surface of the liquid. The instrument gives a direct reading and is also capable of driving a stylus to produce a permanent record.

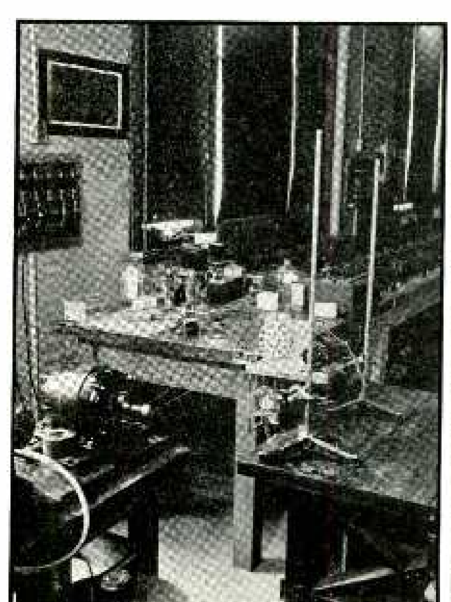
The equipment consists of three main parts: The bridge, in which the variable resistance arm consists of the resistance between the liquid and a metal pointer which dips into it, an amplifier, a rectifier and a driving motor. The circuit diagram of the complete unit is shown in Fig. 1 and of the bridge circuit alone in Fig. 3. The resistance between the liquid and the pointer is the controlling resistance of the circuit and the output voltage of the bridge resulting from any unbalance due to a change of this controlling resistance is amplified by the associated amplifier.

The output voltage of the amplifier is applied to the grids of a reversible rectifier. The rectifier in turn, operates a motor which moves the liquid contact point upward or downward, thus controlling the balancing resistance between the liquid and the point. This movement occurs in such a way as to maintain a condition of balance of the bridge. Each of these elements will be taken up separately for consideration.

The Bridge Circuit

The bridge is the usual type of resistance bridge in which R_2 represents the water contact resistance which, concentrated at the contact point primarily, varies over relatively wide limits as shown in Fig. 5. Here the resistance is plotted as ordinate against the depth of the point in water. This resistance arm is normally balanced by the resistance R_1. Reference to Fig. 3 will show that the bridge-unbalance output differs in phase by 180° depending upon whether R_1 is greater or less than R_2. Upon this reversal of phase depends the correct operation of the rectifier circuit.

The capacitance C_1 is added across R_1 for the purpose of making adjustments which will be described later. The presence of C_1 and C_2 is beneficial because these capacitances advance the phase of the bridge output voltage e_g in Fig. 3 which fires the thyratrons earlier in the cycle than otherwise would be the case (see Fig. 4). This lead of voltage on the grids of the thyratrons ahead of their plate voltage is a result of the lead due to the capacities and a



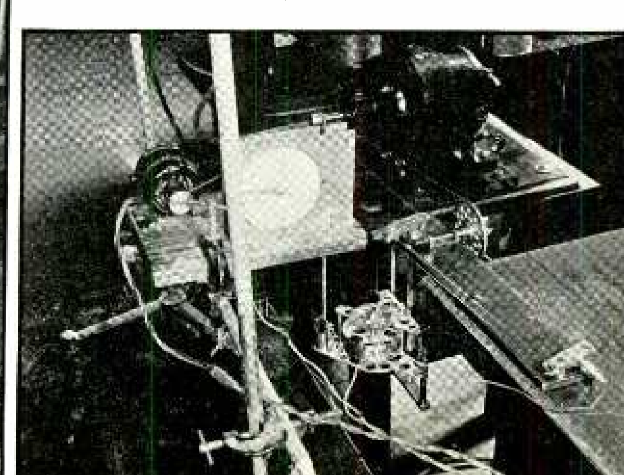


Fig. 2A—Left, general view of the experimental apparatus. Fig. 2B—Below, the motor shown on the left moves the liquid contactor to balance the bridge circuit

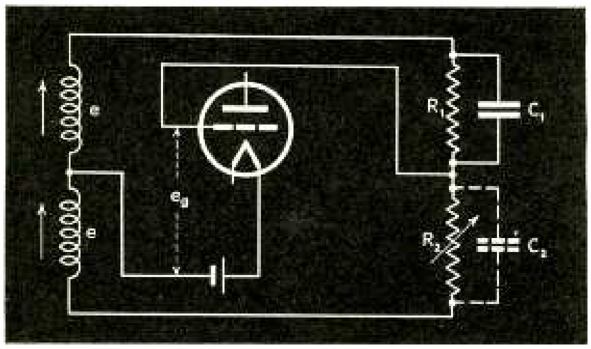


Fig. 3—The operation of the indicator depends upon the balance or unbalance between R_1 and R_2

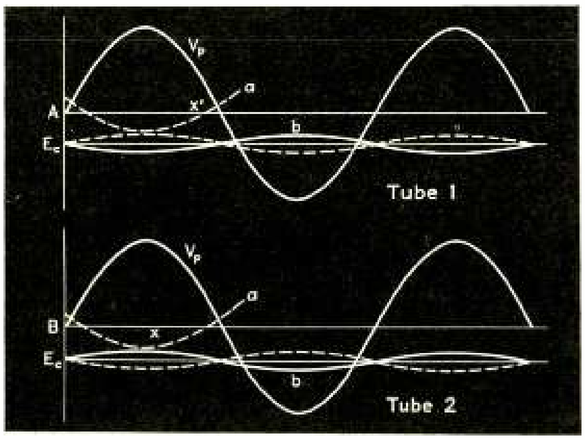


Fig. 4—Curves of the voltages which are applied to the thyratron rectifier

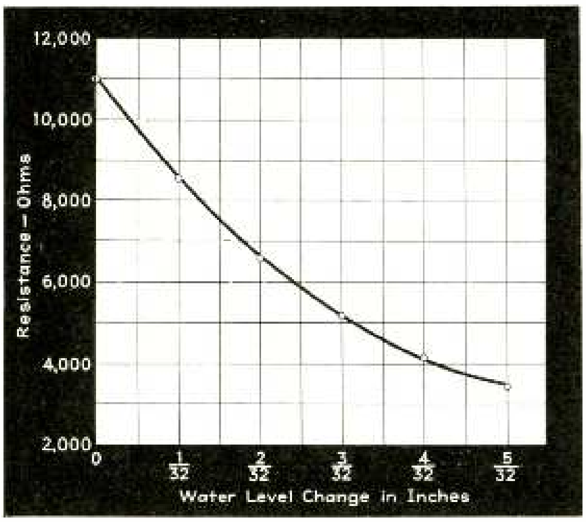


Fig. 5—Curve showing the change in resistance R_2 as the pointer is immersed in the water

lag through the amplifier circuit. Since the operation of the circuit does not depend critically upon this lead it is not necessary to attempt to set it at any particular value. Too much lead, however, is detrimental as will be shown later.

Amplifier and Rectifier

The circuit diagram in Fig. 1 sets forth the amplifier and rectifier, both of which are of the usual type. The rectifier tubes will fire depending upon the phase and magnitude of their grid voltages. Their plate voltages are in phase and the grid voltages are displaced 180° from one another. Thus, as may be seen by reference to Fig. 4, the output of the amplifier can fire only one thyratron at a time. A reversal of 180° in this amplifier voltage will fire the other tube. The bias E_c is so adjusted that with no amplifier output, i.e. with the bridge balanced, neither tube will fire. If a voltage appears as at b in Fig. 4B, which curve touches the thyratron firing threshold a at the point x, that tube will fire at about the midpoint of its half-cycle. Any increase in amplitude of the grid voltage will fire the tube correspondingly earlier. Too much lead of the grid voltage ahead of the plate voltage, as mentioned above, is likely to fire the opposite tube as at x' in Fig. 4A. However, though this should not occur, in normal cases it will not be of serious consequence since the opposite tube will come on only lightly and will not affect the motor operation appreciably.

Gear Train and Contactor Assembly

This assembly, shown in Figs. 1 and 2, is so constructed that one turn of the motor produces ⅛-inch travel of the rack. It is necessary that this distance per turn be neither too large nor too small. Too great a travel per turn produces excessive oscillation of the system and too low a travel decreases the speed of level variation which can be followed by the rack. The motor used in this assembly is a 1/100 hp double field, universal motor driven by two type FG81 thyratrons. As mentioned above the tubes drive the motor in either direction depending upon the phase of the amplifier output. The grid bias on the thyratron is adjustable thereby making it possible to decrease the "dead space", or distance of free travel of the rack to a very small value. The resistance R_1, though normally set at about 8400 ohms, can be adjusted to cause the indicator on the gear assembly to read correctly in the event of any changes in water conductivity or contact resistance. This provides a convenient means of calibration.

Summary of Operation

Assume that the entire apparatus is adjusted and energized and that $R_2 = R_1$. In this condition the voltage e_g is zero and neither thyratron is firing. In case a small decrease in the water level takes place R_2 will increase by a few hundred ohms thus throwing the bridge out of balance and causing a voltage e_g to appear on the first amplifier grid. This voltage, amplified, will fire the corresponding thyratron and will rebalance the bridge by raising the rack. The dial on the gear train can be calibrated to read in any units desired and the two adjustments, thyratron bias and R_1, provide means for calibrating, controlling accuracy and to a certain extent, preventing oscillations.

Tests

Three preliminary tests have been carried out on this equipment to determine the operating characteristics. The questions which arise are: Will the equipment maintain its calibration over at least the period of a day and how accurately can it follow variations in the water level? The first of these questions has been considered from two standpoints: Undisturbed action over a period of from 70 to 90 hours, and the effect of change in water conductivity. The first item was checked for three different contact points, brass, bronze and german silver. Since the german silver seemed to be the best material it was used in the other tests.

In Fig. 6 the curves are shown for the variation of reading of the dial as time elapsed in the test mentioned above. In all cases the readings were checked against a hook gauge reading to 0.01 inch. After each reading the metal point was allowed to remain in the water and at the end of the period an appreciable deposit had accumulated on the point. The water used was from the University water supply and it is assumed that the small amount of evaporation over the 3 or 4 days time during which the experiment was conducted was not enough to affect the water conductivity appreciably. It will be noted that the german silver point gave the best results, deviating from the true level by only about 0.024 ± 0.005 inches over the period of 70 hours.

The effect of change in water conductivity upon the reading of the dial is indicated in the following table:

Salt added to 16 ounces Distilled Water	Deviation from true reading
0 grains	∞
1	0.04 inch
2	0.02
3	0.01
4	0.00
5	0.00

The right hand column shows the deviation from the correct reading due to salt being added to distilled water on the basis of 5 grains per 16 ounces as normal.

The question as to how well the indicator can follow the variation of water level is considered in Fig. 8. Only four of the several records made are shown. The principle of the apparatus used for obtaining these records is shown in simplified form in Fig. 7. It is seen that as the frame work *A*, which is shown in the photograph Fig. 2B, is moved upward or downward the water surface moves similarly. The stylus *S* is mounted on a lever which is supported, at a point 2/3 of its length from *S*, by the frame work *A* itself. The other end of the lever is connected by a pin and insulating bushing to the rack of the indicator. It is seen that as long as there is no variation between the position of the point and the water surface a straight horizontal line is drawn around the paper drum by the stylus. However, any deviation of the point from this true reading will be marked on the drum. This trace produced on the drum is in general a wave and has twice the amplitude of the true deviation because the distance $bc = 2ab$. As the framework *A* is raised and lowered the drum is rotated uniformly and a record of this deviation is automatically made. The motion of the framework is not exactly a sinusoidal motion, due to the rather short eccentric which can be seen in the photograph of Fig. 2B. Also there is a slight deviation from sinusoidal motion produced by the fact that the supporting cord holding up the framework *A* is slightly longer during parts of the cycle than in other parts due to stretching. It is not considered that this deviation is serious.

Due to the faint trace made by the pencil stylus on the paper drum it has been necessary to retouch the records reproduced here in Fig. 8. It will be noted that these records are marked with the half-period, *T*, the maximum amplitude, the approximate maximum velocity, and the approximately maximum lag. The traces show directly to scale as marked by the 0.1-inch lines, the amount of lag of the german silver point behind the water surface at all parts of the cycle. It also clearly indicates the oscillation of the electro-mechanical system. In order to reduce the effect of the oscillations to some extent a brake was used on the motor, driving the rack, in all of these cases.

Conclusion

In conclusion the statement seems justified that, for slowly varying levels, the indicator gives acceptable results. Over a considerable period of time the point will come back repeatedly to the same depth in the water as indicated by Fig. 8 at the points marked by the vertical lines. If the variation itself is sufficiently slow the point will follow quite well as indicated in Figs. 8A and 8C. However, when rapid motion of the water level occurs the lag is correspondingly larger as in Figs. 8B and 8D.

The effects noted in Fig. 6 and the table above, when the 70 hour run and the effect of salt in the water are considered, indicate that if the apparatus is calibrated preferably every half day the measurements should be quite reliable. It is not thought that the conductivity of the water will vary enough over any 6-hour period to cause trouble. The german silver point should be cleaned every time the calibration is set.

The aid of the Institute for Hydraulic Research in providing equipment and help in this investigation is acknowledged with appreciation.

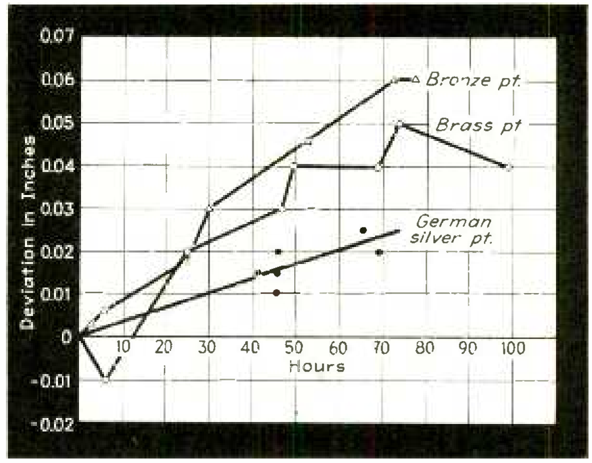


Fig. 6—Curves showing the variation in indication due to the use of different metals for the pointer

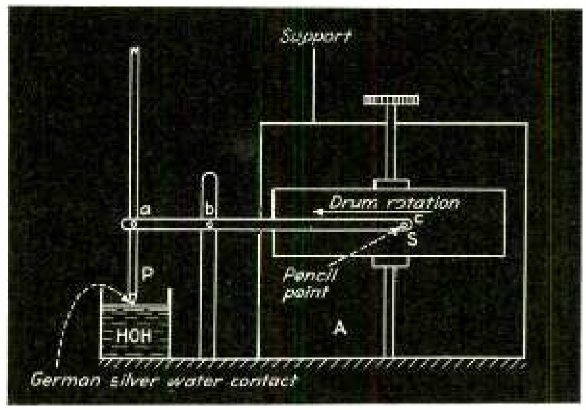
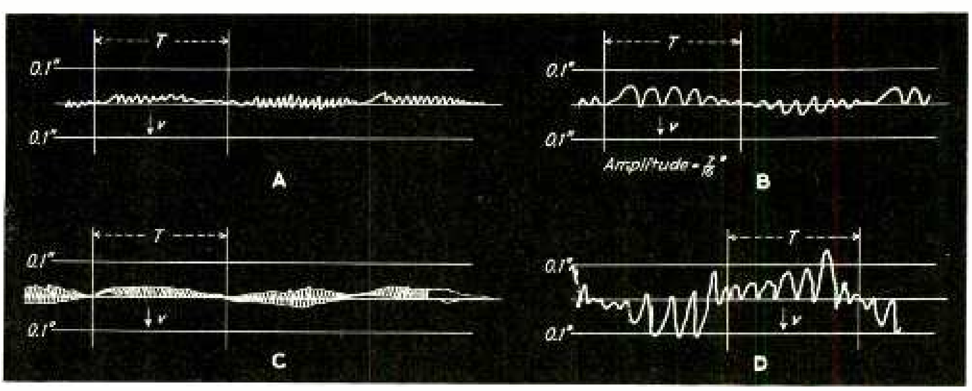


Fig. 7—As the water level changes the frame A also changes causing a deviation in the curve being drawn on the rotating drum

Fig. 8—Typical curves made with this water level indicator. For slowly varying levels this instrument gives very acceptable results



British Vision Receivers . . . II

ONE of the earliest British t-r-f receivers, which incidentally gave the best performance of all receivers on the market, three years ago, was available either with or without allwave sound reception, but for simplicity of comparison, the type without this feature has been chosen for description.

Price, 95 gns; 12 inch picture tube, 21 tubes.

T-r-f amplification was used for vision, and part t-r-f, part superheterodyne for television sound. Separate chasses were used for vision, synchronizing, sound, and power supply, four chasses in all, and in addition the picture tube was enclosed in a metal box structurally forming a fifth chassis. The picture tube was mounted vertically and viewed in a mirror mounted in the lid of the cabinet, which was arranged to rise to 45 degrees.

The circuit, which is shown in block schematic form in Fig. 1, started with a tapping from the antenna into a grid coil which was self-tuned by means of a "spade trimmer" adjustment, and applying the vision and television sound signals to the grid of an r-f pentode. A double-wound r-f transformer was connected in the plate circuit of this tube, also self-tuned by spade trimmers and having its secondary damped by resistance. This stage was followed by a succession of similar r-f amplifier stages, totalling six in all, the output of which was applied through a final double wound transformer to the plate of a low-capacity diode, the cathode of which was connected, through a potentiometer forming the load resistor, to ground. The slider of this potentiometer was connected to the modulating grid of the picture tube. Suitable r-f chokes and other circuit components were provided to filter out the r-f before application to the picture tube.

The full voltage across the diode load was conducted to the synchonizing chassis and applied through series resistors to the grids of two pentodes operated at low screen voltage and acting as limiters for horizontal and vertical synchronizing, respectively. These tubes are normally biased to —2 volts, and the picture signal acted to reduce the bias further, thus maintaining a condition of high plate current and low plate voltage, since high resistances are connected in the plate circuits. The synchronizing pulses acted to bias the tubes negatively and cause a sudden increase in plate voltage, which in the case of the horizontal sync was passed directly to the grid of the blocking oscillator through a coupling condenser, causing immediate triggering of the oscillator. The plate of the vertical sync limiter was connected through a condenser to ground, which built up its positive charge as the groups of vertical pulses were received. A diode was connected from the positive terminal of this condenser through a tertiary winding on the vertical oscillator transformer to a point of suitable positive voltage on a potential divider across the B supply, so that when the condenser voltage built up to this value, it started to discharge through the transformer winding and triggered the vertical oscillator.

The scanning oscillators each comprised a tetrode having its screen fed through a transformer winding, while a second winding on the transformer was connected through a condenser to the grid. An adjustable leak was provided from grid to cathode to control the rate of discharge of the condenser. Each oscillator tube was resistance coupled to a pentode output tube, and thence to a shunt-fed output transformer. A waveform correction circuit was connected across the secondary of the horizontal output transformer. The secondaries were then connected to the saddle-type deflecting coils on the picture tube, which was of the magnetically-deflected, electrostatically-focussed type.

The sound signal was taken out from the vision channel by a tapping on the secondary of the r-f transformer feeding the grid of the third r-f amplifier tube. This was taken over to the sound chassis and tapped into a self-tuned grid coil feeding a triode-hexode converter tube, the oscillator of which had its grid tuned by a manually controlled variable capacitor. The converter was

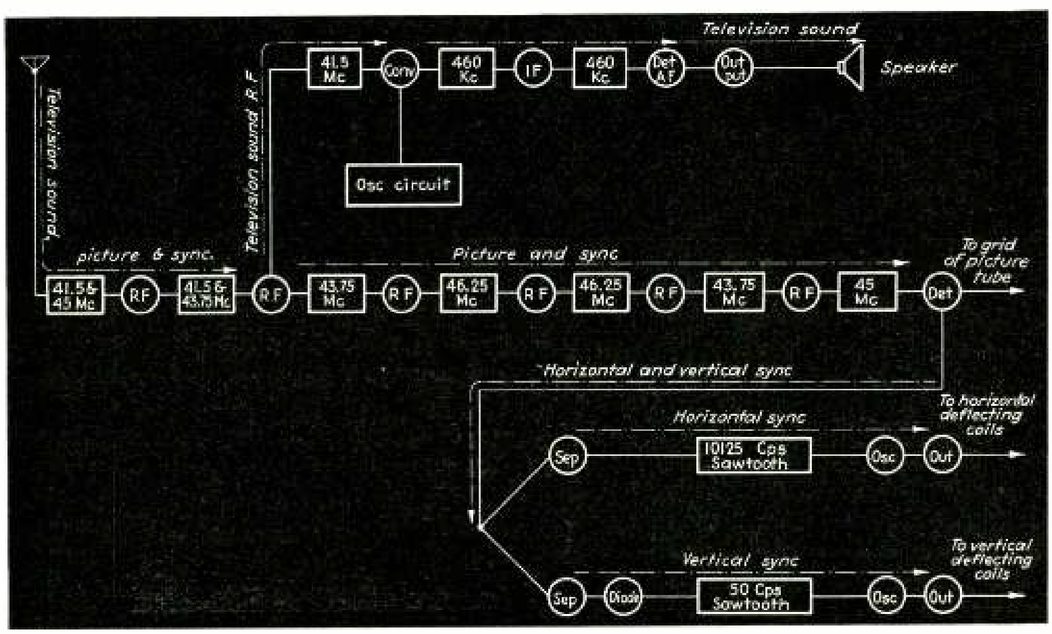


Fig. 1—Block diagram of an early British television receiver. Four chasses were used plus a metal container for the picture tube

By W. J. BROWN

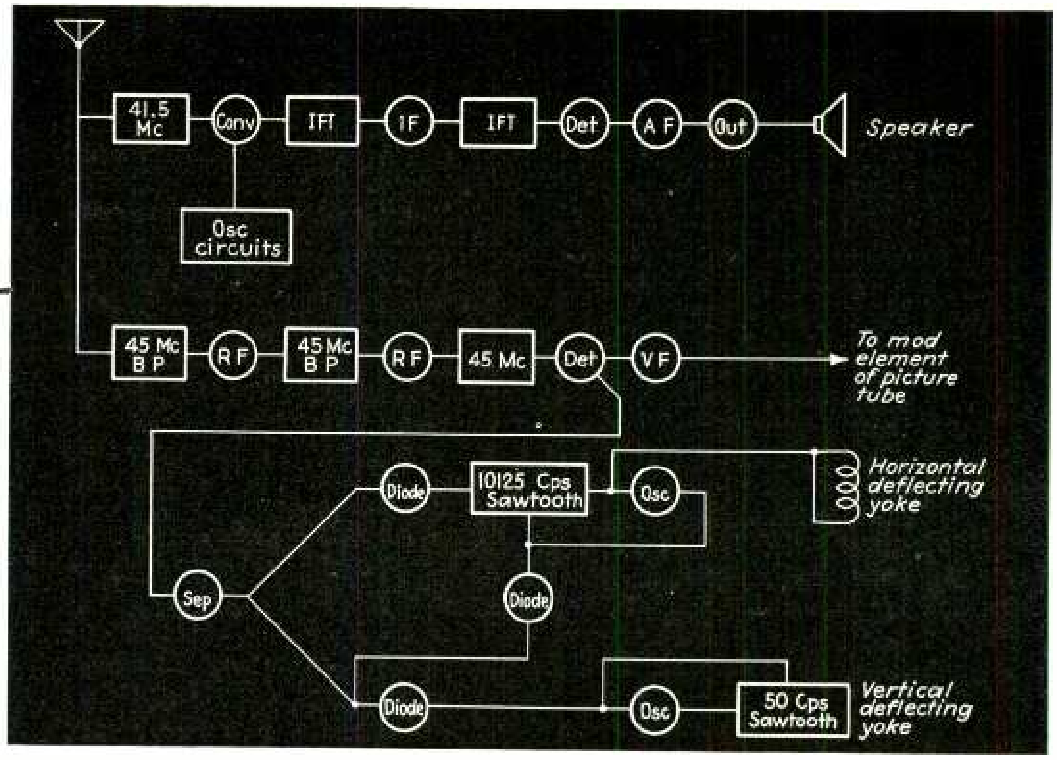


Fig. 2—Block diagram of a typical modern British television receiver. T-r-f circuits are used for vision and superheterodyne circuits for sound

followed by a flatly tuned i-f transformer, double wound, feeding a pentode i-f amplifier and thence through a further double wound i-f transformer to the diode of a conventional double diode-triode circuit, resistance coupled to an output pentode. Avc was provided on the i-f stage only. The separate power-pack chassis was equipped with a single, half-wave high-voltage rectifier and with a pair of parallel-connected low-voltage rectifier tubes.

The performance of this receiver was exceptionally good, even when judged by modern standards, and the controls were notably easy to handle, in that they were non-critical and substantially independent of each other. Interlacing was particularly good and occurred automatically, even with the most casual adjustment of the controls. Definition was also very good, and the range of brightness and contrast control provided was adequate.

The controls were: sensitivity (vision), by screen voltage potentiometer on the first four r-f amplifier tubes; contrast, by potentiometer in diode detector load circuit; brightness, by voltage applied to picture tube cathode; frame hold, by variable grid leak in the vertical scanning oscillator; line hold, by variable grid leak in horizontal scanning oscillator; sound volume, by diode fed potentiometer; sound tuning, by manually controlled oscillator condenser.

The very earliest receivers of this type, and also of the superheterodyne type, had the additional complication of requiring a duplicate set of synchronizing circuits with changeover switch to suit either the Marconi—E.M.I. system with 405 lines interlaced, or the Baird system of transmission with 240 lines non-interlaced. Fortunately this complication, which was only introduced to give the two transmission systems a fair trial, was eliminated after a very few months, when the Baird system was abandoned and the Marconi—E.M.I. system was adopted as the one standard system.

Modern T-r-f Receiver

T-r-f receivers still hold a considerable sway in England, and at least three prominent manufacturers used them in their 1939–40 line. A brief description is given, therefore, of the simplest of these types in order to show the great reduction in circuit components which has been brought out, in this case, by the use of secondary emission amplifier tubes, of the electron multiplier type in the r-f stages.

Price, 38 guineas; 9-inch picture tube; 17 tubes; console; sound for television only.

The antenna transmission line is tapped into a pair of bandpass vision input circuits, using a rather unorthodox form of mixed coupling. A branch is taken from the antenna input terminal via a series resistor to the sound channel. The grid of the first vision r-f amplifier tube is tapped off from the second bandpass circuit, and the plate of this tube, which is of the single stage electron multiplier type, feeds into an unusual type of interstage coupling. This comprises adjustable inductances directly in series with the plate and with the succeeding grid, together with a series-feed plate resistor, a bypass condenser connecting the "cold" ends of the two coils, and a fixed coupling inductance from the cold end of the grid coil to ground. The plate and grid tuned circuits are completed by the interelectrode capacities of the tubes, and are individually tunable by adjustment of the coil inductances.

The second r-f amplifier tube feeds from its plate through a similar circuit into a diode detector, the resistance load circuit of which supplies a single stage video amplifier, the plate of which feeds the modulating element of the picture tube through a bypass condenser in the conventional way.

The synchronizing signal is taken from one of the auxiliary electrodes of the video amplifier, which is supplied with B voltage through a series resistor, and is applied through a condenser to the grid of a triode separator. Pulses are passed on through resistance-capacity coupling from the triode plate to a diode which is connected so as to short circuit partially the grid of the horizontal blocking oscillator and suppress the starting of a blocking oscillation. On arrival of a synchronizing pulse, the short circuit is removed and the blocking oscillation immediately starts. The grid quickly returns to a negative voltage which establishes itself across a condenser in series with the grid and leaks away through an adjustable grid leak at the appropriate rate to produce the forward stroke of the sawtooth waveform. The vertical timing is performed by a second diode also fed with pulses from the separator plate resistor, but which is also controlled by a third diode associated with a resistor-capacitor time lag circuit, in such a way as to delay removal of the short circuit until sufficient pulses have been integrated. The third diode is also connected back to the plate of the horizontal oscillator, to ensure correct timing of the vertical oscillator with respect to the line scanning.

The vertical and horizontal blocking oscillators are triodes operating in conjunction with iron-cored transformers having windings in the plate and grid circuits. The blocking circuit is in series with the grid in the case of the horizontal oscillator, and the cathode in the case of the vertical oscillator. The line scanning coils of the magnetically deflected picture tube are connected across a section of the grid winding of the transformer, in series with a condenser. The frame scanning transformer is wound on a specially shaped yoke which itself forms the magnetic circuit for deflecting purposes. The use of separate scanning output tubes or output transformers is thereby eliminated.

The equipment is mounted in a console cabinet with the picture tube mounted almost horizontally for direct viewing, and it is notable that only two controls are brought out to the front of the cabinet.

Multiplier R-f Tubes

Further mention should be made of the tubes which have made it possible to increase the gain per stage so much as to make it possible to obtain a useful working range of vision reception with only two r-f stages and one video stage. These tubes were first released in England in September 1938. The outstanding point of interest in the characteristics of these tubes is the exceedingly high mutual conductance of 12000 to 14000 micromhos, which is obtained by the use of a single stage of electron multiplication by secondary emission.

The geometry of this tube is shown in Fig. 3; K^1 is the indirectly heated primary cathode; G_1 is the control grid, to which the signal is applied to modulate the electron stream; G_2 is the accelerator or screen grid; G_3 is an earthed screen which, in conjunction with a second earthed shield not shown, concentrates the electrons into beams bombarding the secondary cathode; K_2 is the secondary cathode, which is bombarded and releases electrons in larger numbers than, but similarly modulated to, the primary stream; G_4 is a grid, connected to the plate, which accelerates the secondary stream towards the plate, and P is the plate.

This tube was introduced in two alternative forms, one having a conventional pin type base, while the other has a ring type glass seal with projecting pins rather like the American Loktal base.

Summary of Design Trends

Reverting to the general question of receiver design, the various principles which have been adopted to simplify or to improve receiver design in the last three years should be summarized. An attempt will be made to evaluate the effect on cost and performance of each contribution.

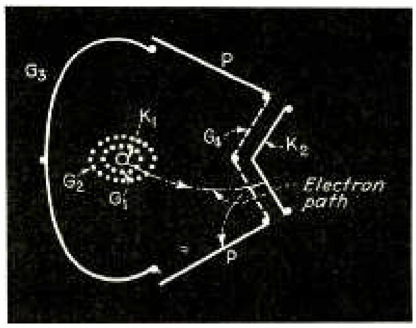


Fig. 3—High mutual conductance tube which makes use of secondary emission and permits the high gain necessary in television receivers

1. Direct reviewing of the screen is used, in most receivers, even including those in the higher price brackets. The development of short tubes with large diameter screens has contributed materially to this trend. The directly viewed screen is not quite so attractive or convenient as the older mirror arrangements, but it does effect a very real saving in cost, both of cabinet and mirror.

2. The number of individual chasses has been reduced concurrently with reduction in total number of components, effecting a small saving in assembly labor as well as eliminating inter-chassis wiring. In some cases the picture tube has been mounted on, or through the chassis.

3. Careful circuit design has reduced the number of manual controls required, and has resulted in economical positioning of controls, eliminating long drives through flexible or solid extension shafts as was necessary in some early receivers.

4. Circuit components and tubes have been eliminated by the use of higher conductance tubes, of which the outstanding example is the t-r-f receiver comparison described above, in which two r-f stages and one video stage give virtually the same result as was previously obtained with six r-f stages. The sensitivity loss is understood to be only of the order of two to one.

5. In superheterodyne receivers, tubes have been eliminated by utilizing a single amplifier system for two or even three channels. The saving in components due to this is usually offset to some extent however by extra switching, wavetrap circuits, etc. While one method has been described in Part I under the title "Modern Superheterodyne", there are several other circuit combinations which have been successfully employed. Illustrative of one such combination is a receiver introduced in 1938 having an r-f stage, a converter and four i-f stages. The complete chain was used for the vision channel, while the whole of the chain up to and including the second i-f was used simultaneously for television sound, by the use of wideband r-f circuits and two sets of series-connected i-f transformers, operating respectively at 4.5 Mc for sound, and over the band 7 to 9 Mc for vision. For allwave broadcast reception, these two sets of transformers were switched out of circuit and a third set of i-f transformers introduced at a frequency of 465 kc while the r-f and converter circuits were simultaneously switched to appropriate tuned circuits.

6. Some economy in number of vision r-f or i-f amplifier stages has been obtained in a number of cases by increasing the gain per stage and sacrificing bandwidth, and while this naturally tends to spoil definition, it is again tolerable in the lower priced receivers, especially those using small picture tubes.

7. An economy in number of components per stage has been made in some cases in conjunction with (6), by utilizing single-wound i-f transformers throughout the vision channel and staggering the tuning of these to get the required bandwidth.

For instance in the receiver mentioned in (5) above, there were two single circuit i-f transformers tuned to 8 Mc, one tuned to 7.3 Mc and one to 8.7 Mc.

8. The development of high current rectifier tubes for medium voltage B supply has made it no longer necessary to use two separate medium voltage rectifiers in addition to the high voltage rectifying tube.

9. While the above list has referred entirely to simplification, the synchronizing circuits have tended if anything to become rather more complete in the attempt to obtain reliable interlacing, but, as already mentioned, this is largely due to a problem of transmitter waveform which does not exist in the American standard waveform and need not seriously concern the American designer.

10. Economy of maintenance has been improved by the increasing tendency to use magnetic deflection and focussing for the cathode ray tube, thus decreasing the tube replacement cost, although adding something to the original cost of the permanent equipment of the receiver. Originally, the majority of tubes used either or both electrostatic deflection and focussing, but the balance has now swung in favour of magnetic.

Large Screen Television

Having considered at length the steady trend towards simpler and cheaper receivers, it is felt that this article would not be complete without reference to the equally steady progress towards satisfactory and reliable receivers of the projection type.

In the first instance, it should be said that one of the greatest steps forward in bringing the possibilities of television home to the British public was the showing of a championship fight on the television screen at two or three large movie theaters in London, early in 1939. This program was shown simultaneously in different theaters using two entirely different systems, the Baird system using cathode ray projection tubes, and the Scophony system using mechanical projection.

The Baird apparatus, which was in duplicate, used a projection type tube with black and white screen, operating at approximately 36000 volts. The image was projected through a wide aperture lens system onto a specially prepared picture screen, approximately 15 ft x 12 ft, the projector being mounted in the auditorium about 30 ft in front of the screen.

The Scophony apparatus used a regular cinema arc as the light source, together with a mechanically driven optical projection system mounted behind a 15 ft x 12 ft screen. The success of this theater performance was so complete as to increase the demand for home receivers, even during the spring season, for several weeks to the point at which sufficient home type cathode ray tubes could not be produced to meet the demand.

Projection Type Receivers for the Home

Reverting to projection type receivers, smaller units for use in the more luxurious homes, clubs or hotels, were introduced on the market in the fall of 1938 including three makes employing projection tubes, and one employing a mechanical system, and the latter in particular met with particularly favourable public comment during its second year of exhibition at Radiolympia, in 1939. As this system differs so widely from anything seen in America and has perhaps the most interesting future possibilities, some reference should be made to its method of operation.

Light from a powerful source is focussed through a lens system and a slit onto the flat wall of a special light control cell, and after passing through this cell it impinges on an opaque rod which is of such diameter and so mounted as to just intercept the full width of the light beam which falls onto it. The light control cell is filled with liquid, and is terminated at one end by a piezo-electric crystal surface which is arranged to be set in vibration in accordance with an impressed high frequency voltage, which is modulated in the picture signal received. A train of pressure waves is thus generated in the liquid and this train is propagated from one end to the other of the cell. The light passing through the cell, at right angles to the line of wave propagation, is diffracted to an extent depending upon the amplitude of the pressure wave, and therefore to the intensity of picture modulation. The diffraction fringe of light thus produced passes round the opaque rod mentioned above and is then focussed by another lens onto a rotating mirror drum. The amount of light falling onto the mirror drum is thus proportional to the picture signal.

Since the pressure waves take a finite time to travel from one end to the other of the light control cell, however, the amount of light escaping past the opaque rod is not the same at all points along the axis of the rod; in fact, while the light intensity at the "driving" end of the cell corresponds to the picture intensity at the same instant, the light intensity at the remote end of the cell corresponds to the picture intensity that *did* exist a short time previously, this time factor being equivalent to the scanning time of almost a whole line of the picture.

The mirror system is arranged to scan the screen in the form of the typical television scanning pattern, but instead of projecting only a single spot of light, it projects approximately a whole line of the picture, and the dimensions and relative velocities are so arranged that this line of light, which carries with it some of the "previous history" of the picture point intensity leaves each picture point at its correct location on the screen. In this way, the intensity of the picture thrown on the screen is made some 200 times greater than with the older forms of mechanical projection utilizing only a single spot. This has made it practicable to project a picture 15 ft x 12 ft of adequate brilliance, using a conventional cinema arc as light source, and a picture 24 inches x 19 inches using a very small 300 watt high pressure mercury vapour lamp.

The horizontal scanning system comprises a small mirror drum having 20 facets, rotating at 30,375 rpm. As the drum is only about 2 inch diameter and 5/32 inch wide, cut from a single piece of glass, the induction driven, synchronously controlled motor is quite small enough in size to be a practical proposition, and sufficient synchronising power is obtainable from 6L6 tubes to hold it in step. Vertical scanning is obtained with a larger mirror drum of sectional construction, rotating at the relatively low speed necessary to obtain 50 interlaced frames per second.

ACOUSTIC LINE LOUDSPEAKERS

By WILLIAM D. PHELPS
RCA Manufacturing Co.

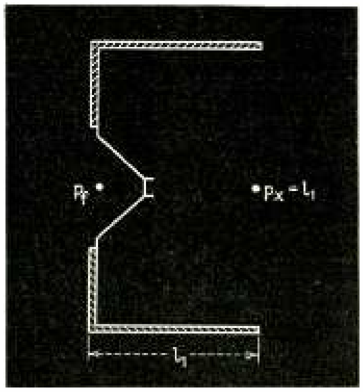
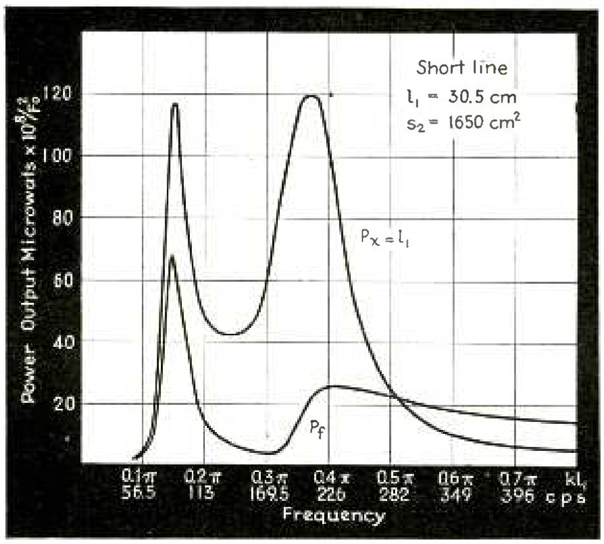


Fig. 1—Sound chamber of a conventional radio cabinet



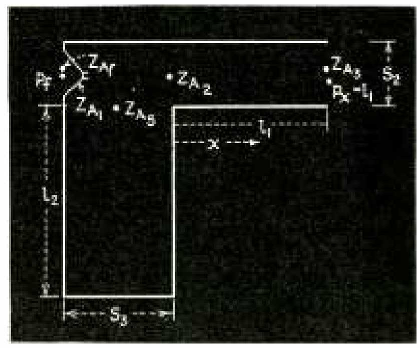


Fig. 3—Above, diagram of an acoustic line with a shunt line

Fig. 2—Left, computed curves of power output at the front and back of the acoustic line

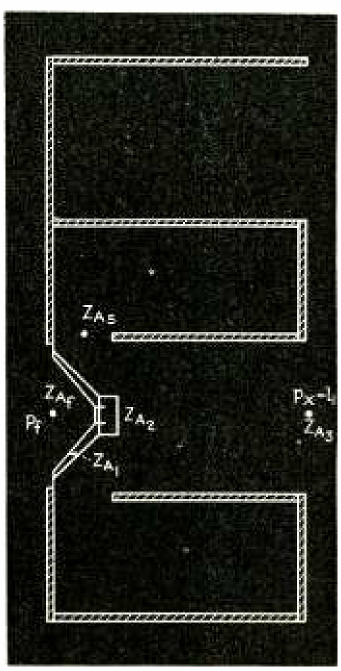
RESONANCE has long been a problem in radio cabinet acoustics. It occurs over a relatively narrow frequency band and peaks the low frequency characteristics in that region. The enhancement of the low frequency components affects the intelligibility and naturalness of the reproduced sound, and is particularly noticeable on male speech.

During the past few years attention has been given to various acoustic means for eliminating the effect of cabinet resonance and extending the low frequency range of the cabinet. For example, the effect of tubes in the bottom of a back-enclosed cabinet has been shown by Caulton, Perry, and Dickey.[1, 2] The effect of an absorbing labyrinth has been shown by Olney.[3] It is the purpose of this paper to describe a loudspeaker system which eliminates cabinet resonance and increases the efficiency at the low frequency end of the audio spectrum.

Theory of Operation of the Acoustic Line

The sound chamber of a radio cabinet may be represented by a short acoustic line driven by a loudspeaker as shown in Fig. 1. The computed power output characteristics at the front and back of the system at constant voltage are shown in Fig. 2. The second peak in the power output by the back is due to cabinet resonance. It is seen to control easily the total output characteristic of the system in this region. If a shunt line of length l_2 is combined with the system as shown in Fig. 3, two desirable results are obtained. First, the output by the back may be made negligible over a wide frequency band in the region of cabinet resonance, thereby eliminating its effect on reproduction. Second, the low frequency range is extended. The system is shown incorporated in a radio cabinet in Fig. 4.

Fig. 4—Radio cabinet incorporating the acoustic line with shunt line



Neglecting inertance in the entrance to the shunt line, it may be shown that the pressure output p of the system is given by the relation

$$p_{x=l} = \frac{S_1 \quad \xi_S Z_{A5} \qquad Z_{A4} Z_{A3}}{Z_{A2} + Z_{A5}\, j Z_{A3} \sin kl + Z_{A4} \cos kl} \quad (1)$$

where $S_1 \xi_S = \dfrac{F/S_1}{Z_{A1} + Z_{Af} + \dfrac{Z_{A2} Z_{A5}}{Z_{A2} + Z_{A5}}}$,

$$k = \frac{2\pi}{\lambda}$$

$$Z_{A4} = \frac{\rho c}{S_2},$$

$$Z_{A5} = \frac{\rho c}{S_3} \cot kl_2, \text{ and}$$

$$Z_{A2} = Z_{A4} \frac{Z_{A3} \cos kl_1 + j\dfrac{\rho c}{S_2} \sin kl_1}{j Z_{A3} \sin kl_1 + \dfrac{\rho c}{S_2} \cos kl_1}$$

and where the Z_A's are the acoustic impedances, and l_1, l_2 S_2 and S_3 are dimensions shown in Fig. 3. Computed curves of $p_{x=l}$ showing the effect of the shunt line on a 12-inch stock speaker at constant voltage

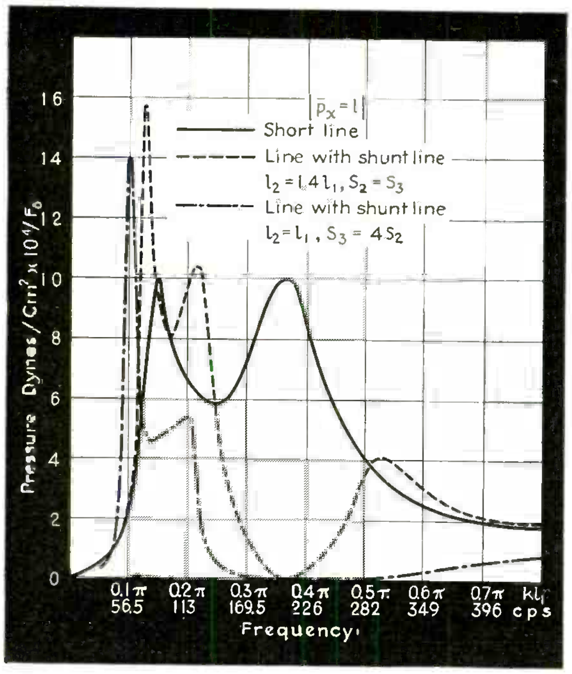


Fig. 5—Computed pressure curves for an acoustic line, and an acoustic line with a shunt line

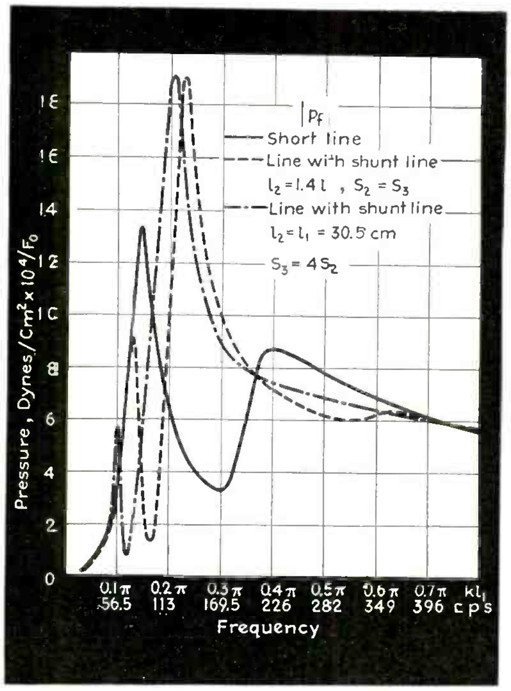


Fig. 6—Computed curves of the pressure at the speaker for an acoustic line, and a line with a shunt line

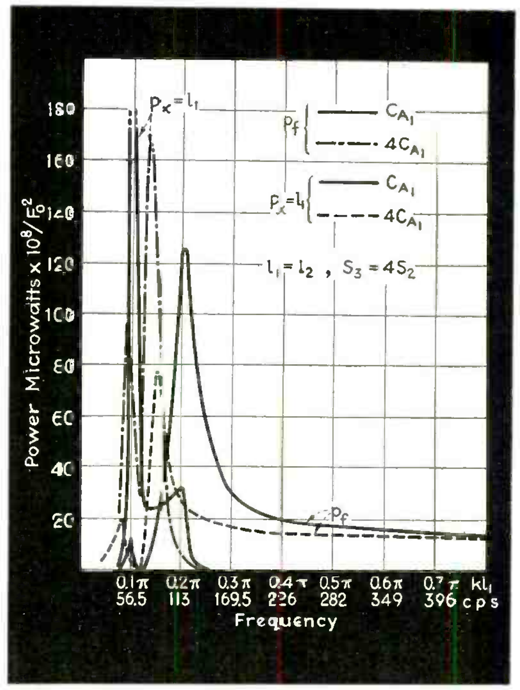
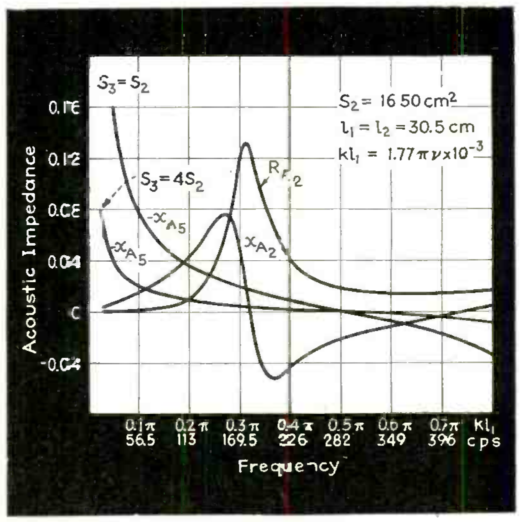
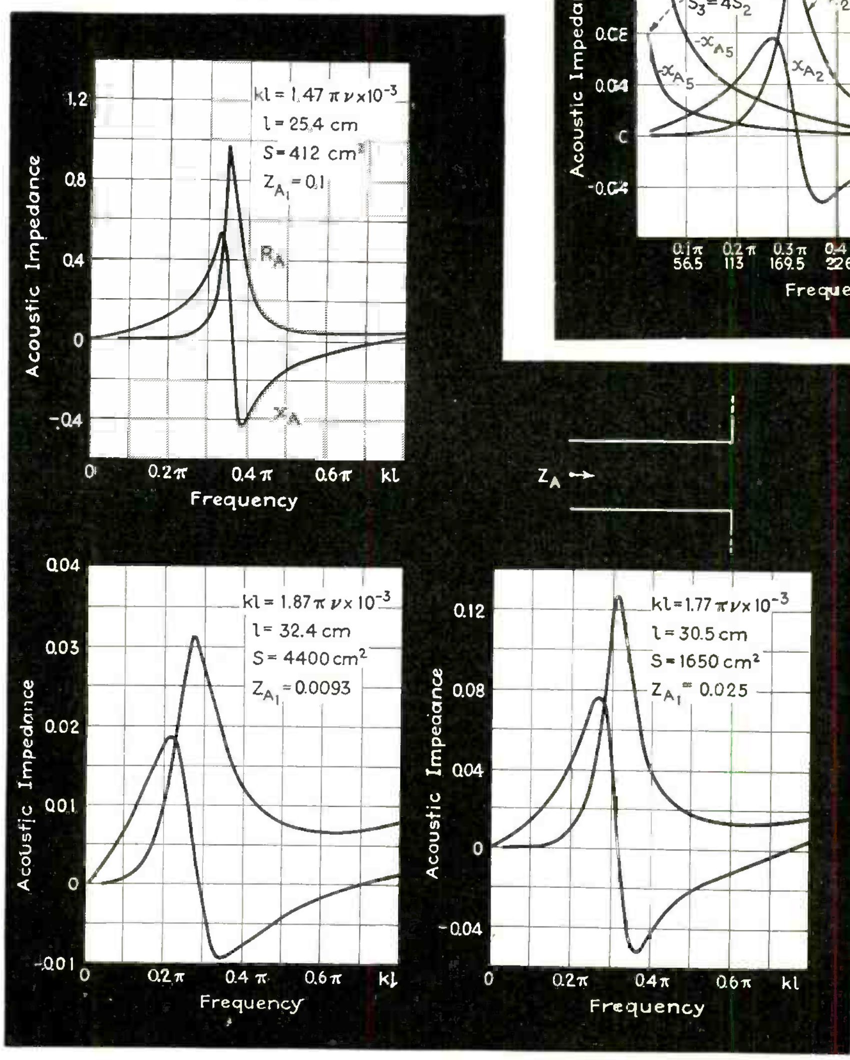


Fig. 7—Computed power output at front and back of the line with shunt line for two values of speaker compliance

Fig. 8—Right, Impedance components of the acoustic line and the shunt line

Fig. 9—Below, Impedance components of open pipes terminated in a large baffle





are shown in Fig. 5. It is noted that by proper choice of length of the shunt line the resonance peak is eliminated with lines of equal areas but the output in the neighborhood of 113 cycles per second remains. Making $l_2 = l_1$ and $S_3 = 4S_2$ the output is essentially eliminated over a wide frequency band. The curves in Fig. 6 show the effect of the shunt line on the pressure output, p_f, at the front. The cone resonance frequency is raised since the shunt line removes the air load at the back of the cone in this region.

Whether or not the power output from the line unduly distorts the frequency characteristic of the system naturally depends on the relative power outputs of the line and the speaker. As shown in Fig. 2, the output by the line completely overshadows the speaker output not only at line resonance but at lower frequencies as well. The power outputs by the speaker and the line with shunt line are given in Fig. 7. It is noted that the power output by the speaker completely overshadows that by the line above 100 cycles per second over a wide frequency range. The peak in the p_f curve is reduced in frequency and magnitude by making the cone acoustic impedance inertive at lower frequencies as shown by the

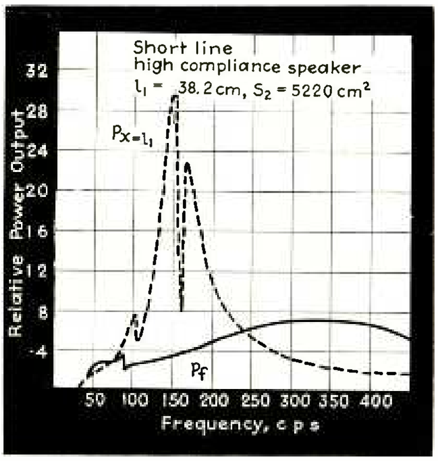


Fig. 10—Observed power output at front and back of acoustic line (Fig. 1) using a high compliance speaker

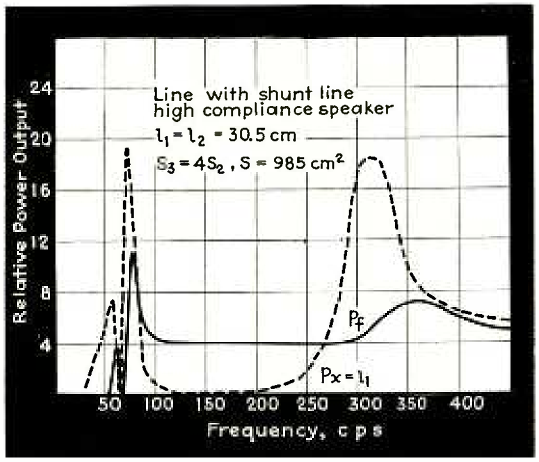


Fig. 11—Observed power output at front and back of acoustic line with shunt line using a high compliance speaker

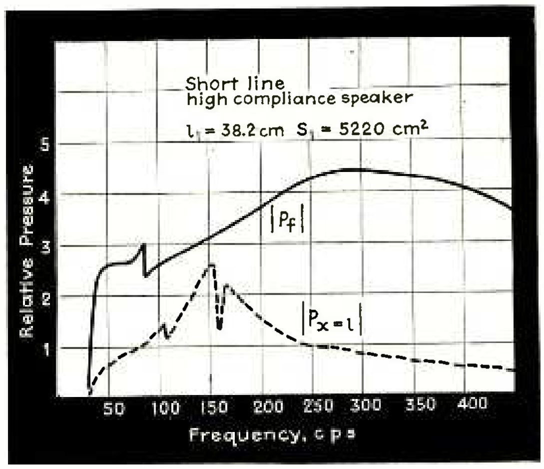
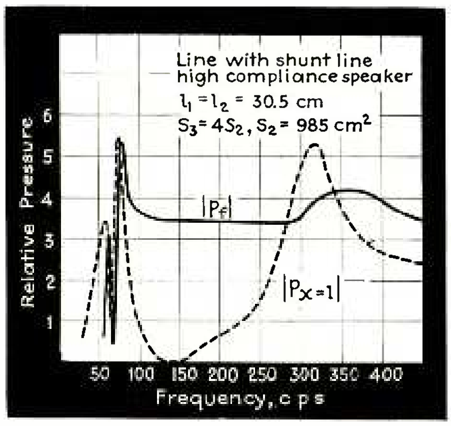


Fig. 12—Observed pressure at front and back of acoustic line using a high compliance speaker

Fig. 13 — Observed pressure at front and back of acoustic line with shunt line using a high compliance speaker



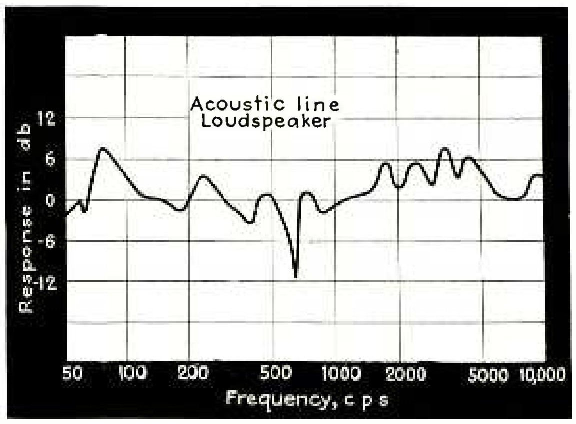


Fig. 14 — Frequency characteristic of the acoustic line loudspeaker

dotted curves for p_f. This curve is obtained by increasing the cone compliance by a factor of 4. If the entrance to the shunt line contains inertance, the band over which p_f is eliminated is lowered in frequency and narrowed.

The approximate frequency limits of the region over which the output by the line is reduced by the shunt line may be obtained simply by comparing the relative magnitude of their impedance as shown in Fig. 8. The intersection of the curves X_{A2} and negative X_{A5} gives the position of anti-resonance near the low frequency limit. In Fig. 9 are shown input impedance curves of open pipes terminated in an infinite baffle.

Measurements

Measurements were made on the acoustic line and the acoustic line with shunt line of the same overall dimensions shown in Figs. 10 and 11. A high compliance 12-inch speaker unit was used in the measurements. The outputs by the front and back were completely isolated by a large baffle.

The power outputs by the front and back of the acoustic line are shown in Fig. 12. It is noted that the output by the back predominates in the region of 150 cycles per second due to resonance of the line. At 150 cycles per second the power ratio is 8.5. By eliminating the output by the back in this region the effect of cabinet resonance on reproduction may be obviated. Figure 13 shows how effectively the acoustic line with shunt line eliminates the power output by the back from 100 to 250 cycles per second. The resonance at 80 cycles per second is desirable from the standpoint of low frequencies while the resonance at 320 cycles per second does not appear to be objectionable. In Figs. 14 and 15 are pressure curves taken at the front and back of the line and the line with shunt line.

The way in which the outputs by the front and back of the acoustic line speaker combine into the overall frequency characteristics in a room is shown in Fig. 16. The amplitude and phase are right to extend the response down to 50 cycles per second. Negligible output by the back in the region of 150 cycles per second keeps the response down in this region and eliminates cabinet boominess.

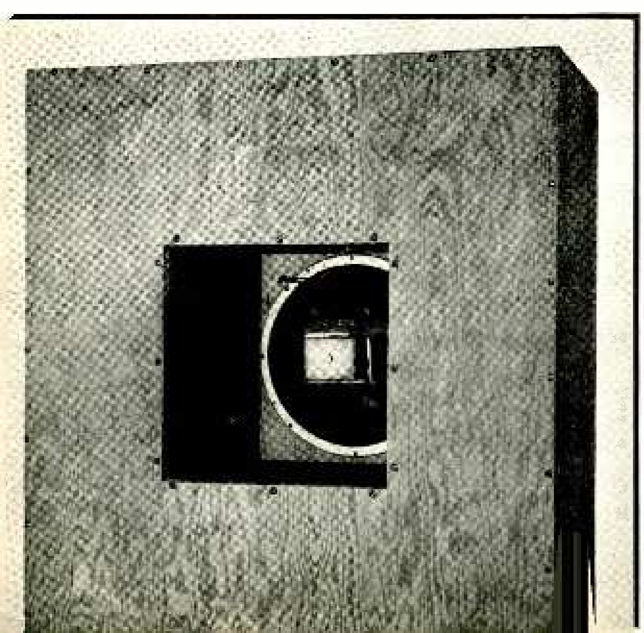


Fig. 15—Back view of speaker cabinet incorporating an acoustic line with a shunt line

References

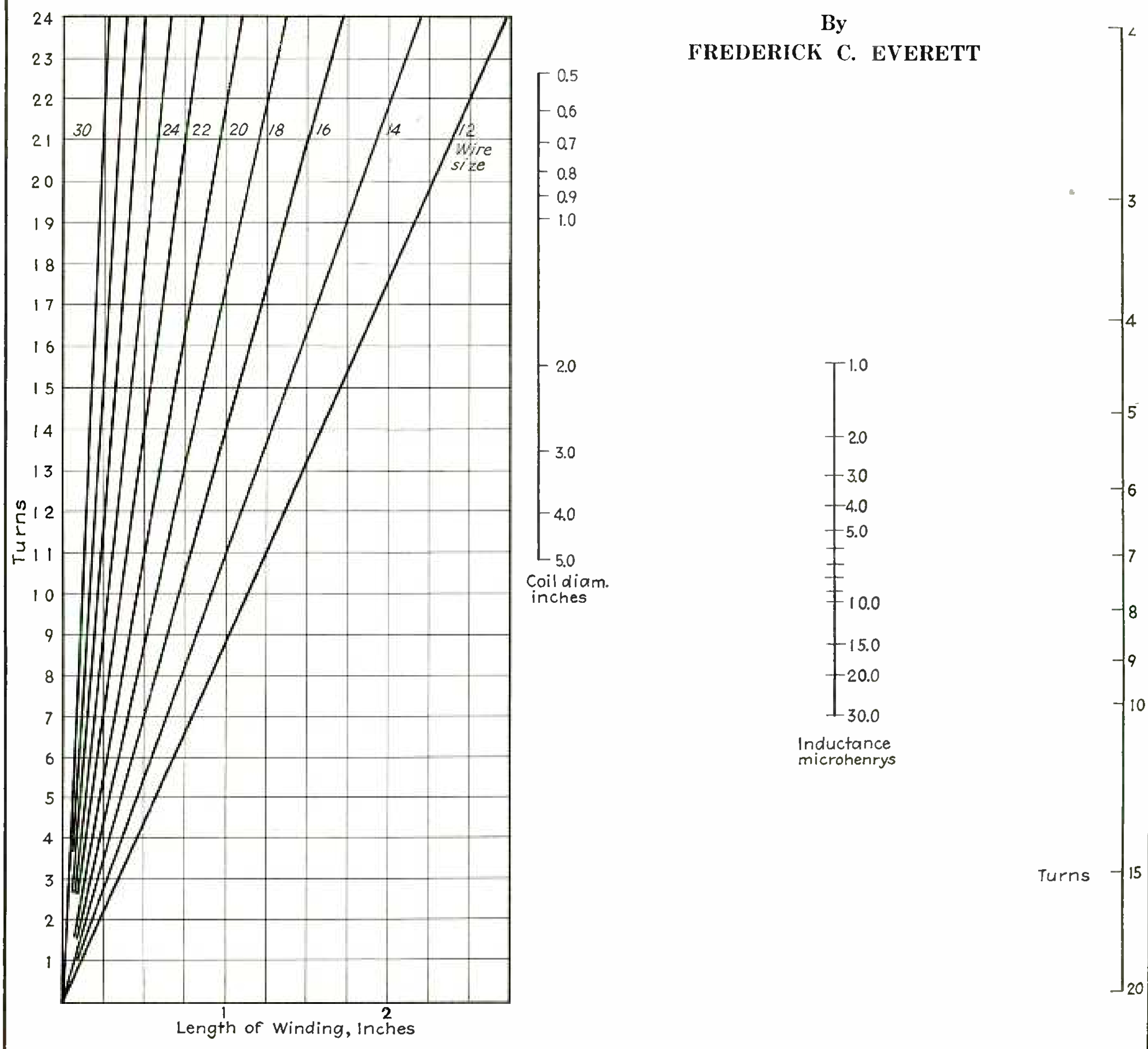
1. Caulton, Perry, & Dickey, Radio Engineering, 1936.

2. Thuras, U. S. Patent No. 1,869,178.

3. Olney, J.A.S.A. 8, 104 (1936); High, U. S. Patent No. 1,794,957.

SHORT WAVE INDUCTANCE CHART

By
FREDERICK C. EVERETT



Charts in various forms have been available for the design of short-wave inductances, but there has been nothing to insure that the highest possible Q had been obtained in the design. By utilizing the information produced by Pollack[1] it has been possible to make the entire computation without "cut and try."

These charts are suitable only when the length of winding is equal to half of the diameter, which is the optimum proportion. The number of turns for any desired inductance can be obtained at once from the chart on the right. Using half the diameter for the length, the optimum size of the wire can be obtained from the chart on the left. The coil should be wound so that the wire occupies the length of winding used in the computation. [1]*Inductances for frequencies—4 to 25 Mc Dale Pollack,* Electrical Engineering *Sept., 1937.*

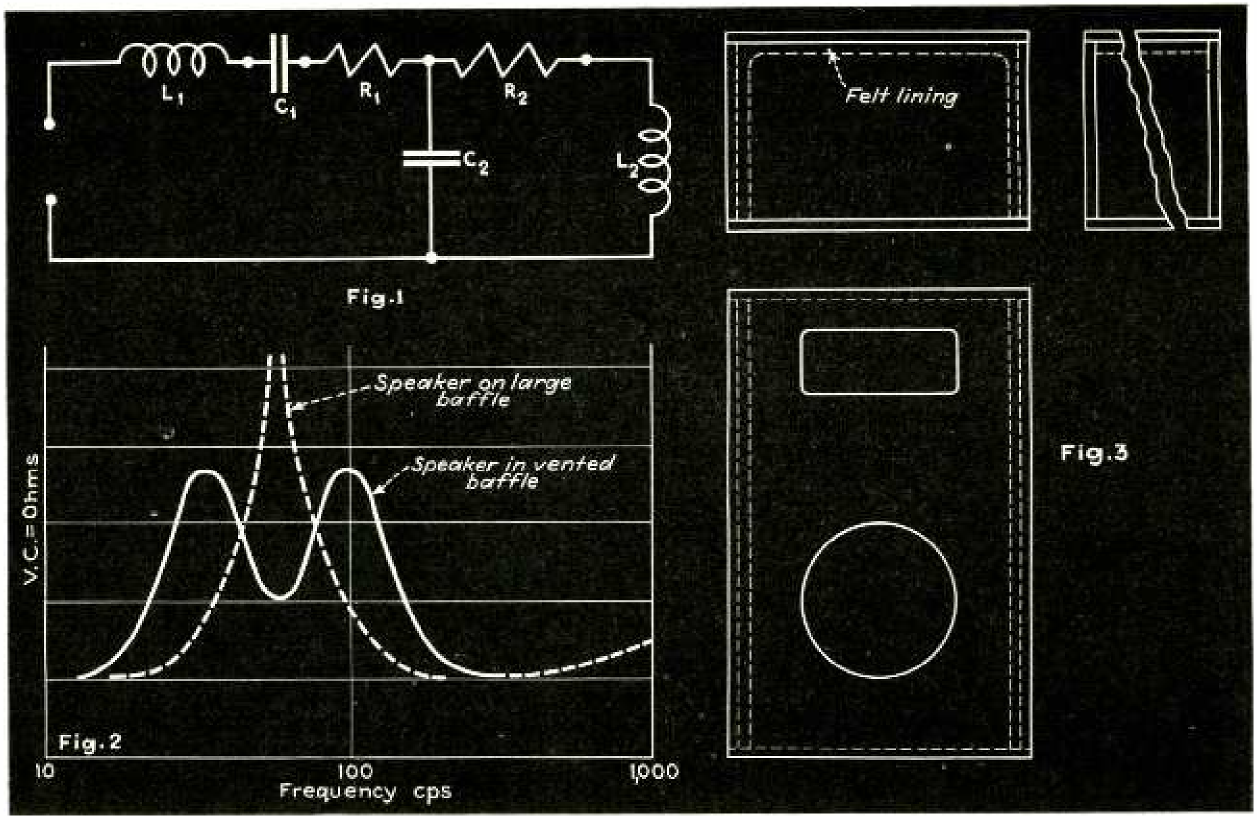


Fig. 1—Equivalent electrical circuit of the mechanical operation of the speaker diaphragm in the vented enclosure. Fig. 2—Impedance-frequency characteristic of the vented enclosure using a 2-ohm voice coil. Note the peaks on either side of the speaker resonant frequency. Fig. 3—The enclosure is lined with material to reduce internal reflections

VENTED SPEAKER ENCLOSURE

By C. E. HOEKSTRA

The Magnavox Company

THE vented speaker enclosure uses a conventional cone type dynamic speaker mounted in a box lined with sound absorbent material which has in addition to the hole for mounting the speaker certain additional holes which serve to couple acoustically the air enclosed in the box to the atmosphere. The device is used to control the radiation from the rear of the diaphragm, to improve the speaker's low frequency impedance characteristic and to extend the low frequency response of the system.

It is difficult to make an accurate analysis of such a baffle. There are certain second order effects which are difficult to evaluate. At the same time, however, it is possible to make an analysis neglecting these second order effects which is sufficiently accurate for engineering purposes and which will serve as a guide in development work. In Fig. 1, letters L_1, C_1 and R_1 represent the moving system of the speaker modified by the atmospheric load on the diaphragm. R_2 and L_2 represent the radiation resistance and reactance of the vent areas. C_2 is the acoustic capacitance of the enclosure. In general the values of L_1 and C_1 and L_2 and C_2 are such that the resonance of the independent systems are at about the same point. Thus, at some point below the speaker's mechanical resonant frequency the capacitive reactance of the speaker circuit goes into resonance with the inductive reactance of the box circuit. At some other frequency above the speaker's mechanical resonant point the inductive reactance of the speaker circuit goes into resonance with the capacitive reactance of the box circuit.

A series resonant circuit is capacitive below resonance and inductive above resonance. A parallel resonant circuit is just the reverse or inductive below resonance and capacitive above resonance. Thus, in an impedance-frequency characteristic (Fig. 2) of the speaker mounted in such a baffle there will be two peaks, one on each side of the resonant frequency of the speaker. In the conditions outlined here one peak or the other will be the greater in amplitude. If the speaker resonant frequency is lower than the box-vent resonant frequency, the first peak will be the greater and if the box-vent resonant point is lower than the speaker resonant point, the second peak will be higher.

An analysis of Fig. 1 will show that the current in L_2 is in the region of the resonant points 180 degrees out of phase with that in L_1. Thus,

(Continued on page 54)

TUBES AT WORK

Coordination of aircraft instruments using a cathode ray tube, introducing reverberation in electronic organ music, and a long-distance television link

Cathode-Ray Tube Used As Aircraft Instrument Indicator

At a recent meeting of the Institute of the Aeronautical Sciences, P. R. Bassett and Joseph Lyman of the Sperry Gyroscope Co. described a new application of cathode ray tubes for the simultaneous indication of several instruments on the panel of an airplane in flight. The connections between the indicator and the various flight instruments are shown in the accompanying sketch. It will be noted that six separate indicating instruments are connected to the device: A blind landing receiver, an artificial horizon instrument, the directional gyro, the altimeter, the air speed meter, and the radio compass. Indications of four of these devices are made to appear on the screen of the cathode-ray tube simultaneously. Furthermore, the indications are so coordinated that the pilot has a continuous indication of the position of the plane with respect to the ground and its attitude in flight.

The front surface of the cathode-ray tube screen is shown in the figure. There are four traces indicated on the screen. At the top a short vertical trace is the indication for the directional gyro compass, used in conjunction with the scale in degrees just above it. At the center of the screen is a long horizontal line which is controlled by the artificial horizon instrument in such a way that the line always maintains the position on the true horizon. The central circle of light is controlled by the blind landing receiver when landing, or by the altimeter when in level flight. Finally, the short horizontal bar below the center line is controlled by the air speed indicator.

These four indications are produced on the cathode-ray screen by a commutating connection between the several instruments and the control grid and deflection plates of the cathode-ray tube, at a rate of 60 cycles per second. As a result of this high commutation rate, each trace of light appears to be continuously illuminated without flicker although actually each of the indications is laid down in succession. The electrical connection between the several operating instruments and the cathode-ray indicator is made through small Selsyn remote metering devices. These are extremely delicate magnetic pick-up devices which operate over a three-phase system to transmit an indication of the rotation of each of the instruments named.

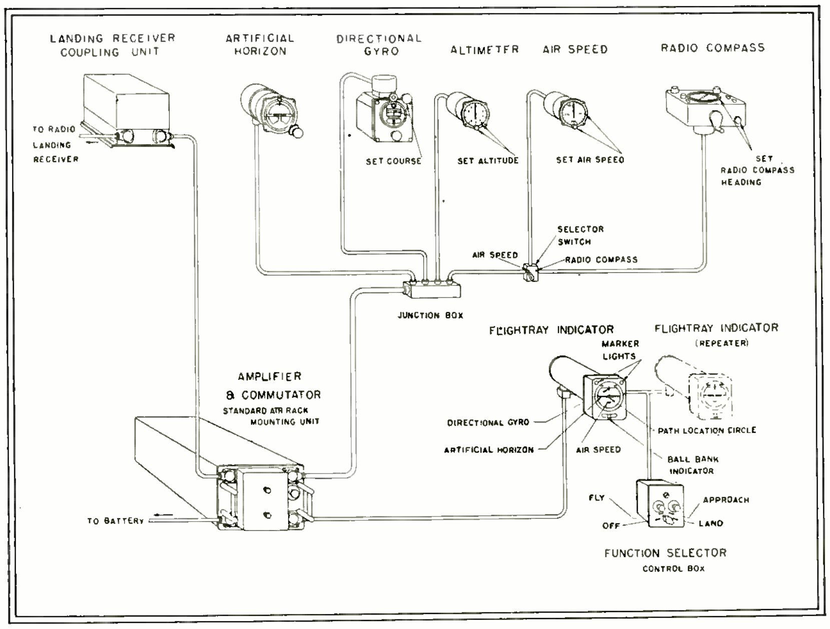
Thus when the plane changes direction, the indicator of the directional gyro compass moves with respect to its case. A small magnetic element attached to the compass member moves also and in doing so it moves past a three-phase winding of the Selsyn device which is attached directly to the case of the instrument. This Selsyn transmits over a three-wire system the indications which produce a corresponding change in the position of a receiving Selsyn motor associated with the commutator. The receiving Selsyn rotates in such a way as to produce a change in the direct voltage applied to the horizontal deflecting plate from the cathode-ray tube. In this way, the short vertical line at the top of the screen is moved to the left or right in direct proportion to the motion of the directional gyro compass. Similar connections are used between the blind landing receiver (whose output consists of direct voltages giving the position of the plane as above or below and to the left or to the right of the landing beam).

The commutating device is rather involved since it must not only apply a wide variety of varying potentials to the cathode-ray tube deflecting plates and control grid, but it must also be responsive to small rotational changes transmitted to it from the several controlling instruments.

In addition to the cathode-ray indication, there are two lamps in the upper corners of the face of the instrument which light when the plane passes through the radiation pattern of two marker transmitters, one two miles from the airport (which lights a green light in the upper left-hand corner) the other at the airport edge (which lights the red light in the upper right-hand corner). Also, a ball indicator is used to show the shift to the center of gravity of the plane relative to the vertical.

The commutating device is mounted directly on the shaft of the rotary converter instrument which produces all of the necessary voltages, including the high voltage for the cathode-ray tube from an input of 12 volts from the plane's storage battery. Required input power is about 100 watts. The entire device weighs about 60 lb exclusive of the controlling system.

In flying the plane the pilot considers that the indications on the cathode-ray tube screen are stationary, and that the small figure of a plane which is painted on the base of the instrument is capable of motion. That is, "he flies the plane toward the marks" as though they were stationary references or on the ground. All of the controls of the plane are coordinated with this type of indication. Thus, for example, when making a blind landing

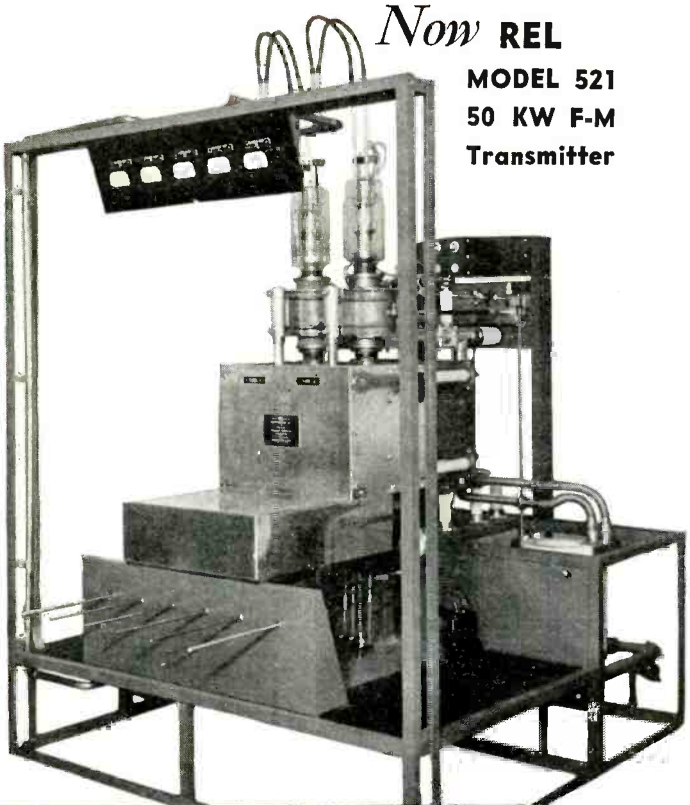


The "Flight-Ray" aircraft instrument indicator, which applies the readings of four instruments simultaneously to the face of a cathode-ray tube

FREQUENCY MODULATION

(ARMSTRONG SYSTEM)

Now **REL**
MODEL 521
50 KW F-M
Transmitter



First to Develop

Original equipment at W2AG (Yonkers, N. Y.) and at W2XMN (Alpine, N. J.) was developed at REL in collaboration with the inventor, Major E. H. Armstrong.

First to Produce

F-M Equipment for the following:

15 W Portable Mobile Transmitter.	1000 W High Fidelity Broadcast Transmitter.
50 W Portable Broadcast Relay.	2000 W High Fidelity Broadcast Transmitter.
50 W High-Fidelity Studio-Station Relay.	5000 W High Fidelity Broadcast Transmitter.
200 W High-Fidelity Studio-Station Relay.	50000 W High Fidelity Broadcast Transmitter.

Now in Daily Service

REL F-M Transmitters are no longer in the experimental stage, as proved by the following list of stations which are now servicing the public daily:

STATION	LOCATION	OWNED BY
W2XMN	Alpine, N. J.	Maj. E. H. Armstrong
W2XAG	Yonkers, N. Y.	C. R. Runyon, Jr.
W1XOJ	Paxton, Mass.	Yankee Network
WEOD	Boston, Mass.	Yankee Network
W3XO	Washington, D. C.	Jansky & Bailey
W8XVB	Rochester, N. Y	Stromberg-Carlson
W2XQR	Long Island City, N. Y	J. V. C. Hogan
W9XAO	Milwaukee, Wisc.	The Journal Company
W8XAD	Rochester, N. Y	WHEC, Inc.
W2XOR	Newark, N. J	Bamberger Broadcast Service

and the following are now being built by REL:

STATION	LOCATION	OWNED BY
WGAN	Portland, Me.	The Portland Broadcast. Sys. Inc.
WWJ	Detroit, Mich.	The Evening News Ass'n.

A large percentage of the construction permits now on file with the FCC calling for F-M equipment specify REL transmitters.

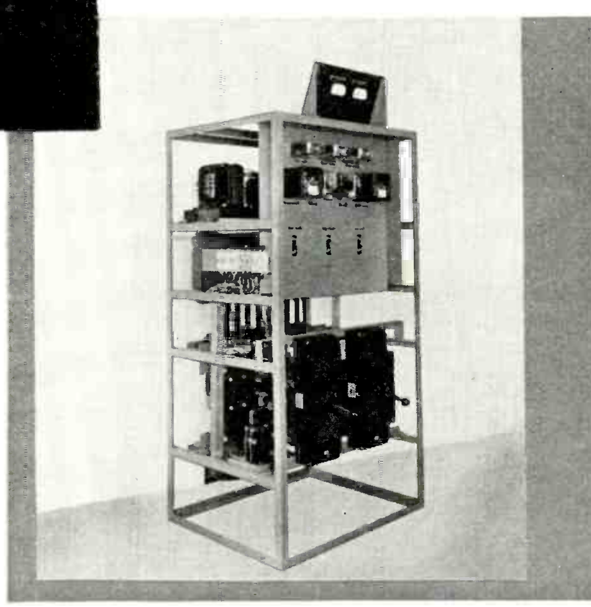
We invite engineers and executives to profit from our experience as the pioneer builders of successful F-M Transmitters.

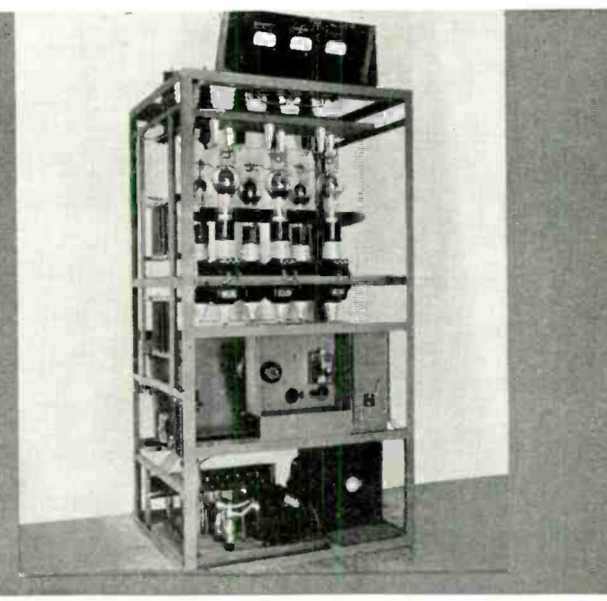
Various components of the REL 50 KW F-M Transmitter are here illustrated.

Above—top—shows the power amplifier unit before it is mounted in its shielded room. Immediately beneath is the central control desk, which contains all monitoring equipment.

To the right—
1st—Power control.
Next—Rectifier Unit.

These units are only part of the complete station. All units are assembled in a building particularly designed for the purpose.





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National Association of

Forty-seven members of RCA among 572 industrial engineers and scientists given awards as "Modern Pioneers on American Frontiers of Industry."

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Research is the keystone of every operation of RCA. RCA Laboratories are the fountain head of many of the spectacular radio and electronic developments of the past twenty years.

Back of these developments...back of the term *Research*, in fact...are men. Men make discoveries. And we at RCA are extremely proud of the man-power which has elevated RCA *Research* to a position of leadership.

We wish to add our own congratulations to the public recognition these men have already received. And, in addition, we extend equally warm congratulations to the many other RCA engineers and scientists whose brilliant work is contributing so much to the progress of their industry.

RCA Manufacturing Company, Inc.
National Broadcasting Company
RCA Laboratories
R.C.A. Communications, Inc.
RCA Institutes, Inc.
Radiomarine Corporation of America

Manufacturers Honors RCA Scientists

Of the 572 industrial engineers and scientists chosen by the National Association of Manufacturers to receive awards as "Modern Pioneers on American Frontiers of Industry," forty-seven were members of the RCA organization. The awards were given for original research and inventions which have "contributed most to the creation of new jobs, new industries, new goods and services, and a higher standard of living."

Special national awards were given by the National Association of Manufacturers to nineteen of those receiving honors. Dr. Vladimir K. Zworykin of the RCA Manufacturing Company was chosen to receive one of these national awards.

47 RCA "Modern Pioneers on American Frontiers of Industry"

Randall Clarence Ballard	Glenn Leslie Dimmick	Humboldt W. Leverenz	Terry M Shrader
Max Carter Batsel	James L. Finch	Nils Erik Lindenblad	Browder J. Thompson
Alda Vernon Bedford	Dudley E. Foster	Loris E. Mitchell	Harry C. Thompson
George Lisle Beers	Clarence Weston Hansell	Gerrard Mountjoy	William Arthur Tolson
Harold H. Beverage	O. B. Hanson	Harry Ferdinand Olson	George L. Usselman
Rene Albert Braden	Ralph Shera Holmes	Richard R. Orth	Arthur Williams Vance
George Harold Brown	Harley A. Iams	Harold O. Peterson	Arthur F. Van Dyck
Irving F. Byrnes	Ray David Kell	Walter Van B. Roberts	Julius Weinberger
Wendell LaVerne Carlson	Edward Washburn Kellogg	George M. Rose, Jr.	Irving Wolff
Philip S. Carter	Winfield Rudolph Koch	Bernard Salzberg	Charles Jacob Young
Lewis Mason Clement	Fred H. Kroger	Otto H. Schade	Vladimir Kosma Zworykin
Murray G. Crosby	E. Anthony Lederer	Stuart W. Seeley	

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Radio City, New York

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

Wing Nuts-Cap Nuts-Thumb Screws

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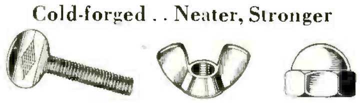
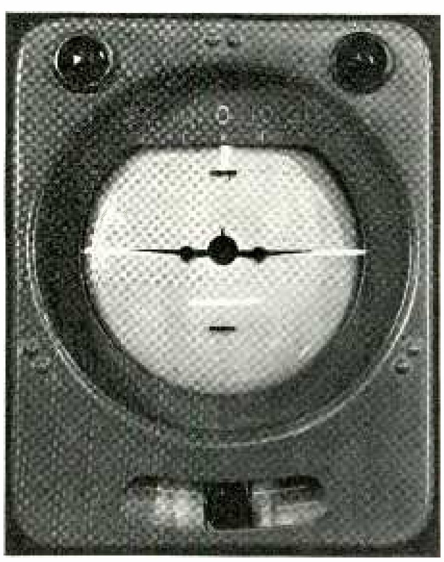


SOLD ONLY THROUGH RECOGNIZED DISTRIBUTORS

Quality-Controlled **PARKER-KALON Fastening Devices** the pilot sees to it that the wings of the figure at the plane are maintained parallel to and on the line which indicates the horizon, and at the same time that the fuselage (central portion of the plane) is maintained directly within the circle of light which operates under the control of the blind landing receiver. If the plane follows through this "tunnel" it will come to the surface of the airport at the proper landing angle. On the other hand, if it gets above or below the beam, the figure of the plane moves correspondingly above or below. The short line at the bottom which indicates air speed is maintained so that its position is almost directly under the airplane, which indicates that landing speed is being maintained. If the line drops lower the speed of the plane

Position of flight-ray indicator on airplane instrument board. The indications coordinate as many as four instruments simultaneously, doing so without confusing the pilot



Details of luminous traces which show plane's direction and speed. The traces from top to bottom are gyro compass indication, artificial horizon, blind landing (or altimeter, in center) and air speed

is dropping in proportion, and when the line approaches the small black marker, it is a warning that the stalling speed of the plane is being approached. In level flights the landing receiver is disconnected and the altimeter is switched in position. The altimeter then controls the central circle of light causing it to move above or below the plane as the plane moves below or above the reference altitude which is set on the altimeter itself.

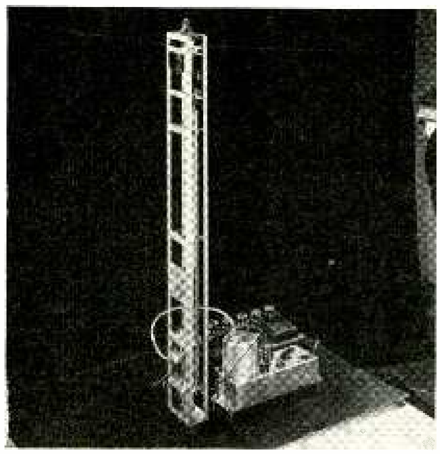
The new flight ray indicator can be used exclusive of all the other instruments while making a landing as well as during level flight, although its function is simply to repeat the indication of instruments located elsewhere in the plane. The flight ray indicator may be installed in duplicate at several positions on the plane so that not only the pilot but the other members of the operating crew of a large ship may be apprised of the flight movement.

• • •

Artificial Reverberation for Electronic Organ Music

The "traditional" tone of the pipe organ resides not only in the structure of its pipes and the manner of blowing them, but also in the acoustics of the church or hall in which the organ is heard. Since most organs are heard in large stone churches where the degree of reverberation is high, the echo effect has come to be an important part of conventional organ tone. In the electronic organ, the same effects arise if the organ is played in a large, acoustically "live" hall, but when the organ is played in a small room or an acoustically treated broadcast studio, reverberation is so small that it is virtually absent and the tone, although it may approach the harmonic content of the pipe organ tone very closely, seems to be quite different to the ear.

The recreation of reverberation effects artificially has recently been accomplished by Laurens Hammond, of the Hammond organ interests. The reverberation unit is about three feet long, and it may be mounted in the output cabinet (loudspeaker enclosure) of the conventional Hammond organ.



Reverberation device which uses a spring for sound transmission

Part of the electrical output of the organ proper is fed directly to the loudspeaker in the usual manner, thus supplying the basic tone output. The remainder of the output is fed to a driving unit resembling the voice coil of a dynamic loudspeaker. This unit produces practically no audible output, but it is coupled mechanically to a group of coiled springs which transfer the mechanical vibration from the driving coil to a group of Rochelle salt piezo-crystal elements. These pickups in turn transform the mechanical vibration back to electrical energy, which is then fed after amplification to the loudspeaker. The passage of the sound energy through the springs introduces a calculable delay, corresponding to that which would occur in a large hall, between the direct and reflected components.

The natural reverberation effect which occurs in large halls results from the reflection of the sound from many wall surfaces simultaneously. The reflected sound reaches the ear of the listener at corresponding different times, and the result is an undefined echo which has the effect of prolonging and enriching the original tone. In the Hammond reverberation device, the effect of simultaneous reflect[illegible]n from several surfaces is obtained by

• • •

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Two New York policemen wearing complete radio transmitting and receiving equipment, having a range of several hundred feet, which is used for obtaining evidence. The complete radio equipment is worn as a wide belt, with the microphone under the carrier's vest

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INSULATORS

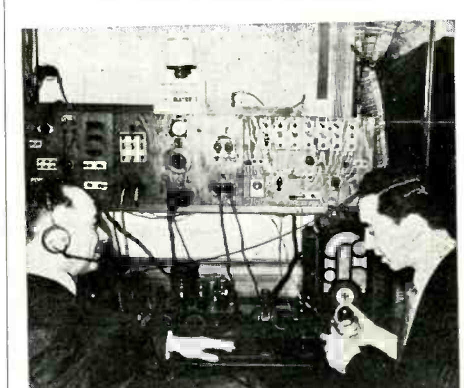
using several springs of different lengths, each of which drives a separate piezo pickup element. Where direct reflection is desired the spring is terminated in a solid support, which reflects the energy back toward the source. Total absorption of the mechanical vibration is accomplished by terminating the spring in an oil column which absorbs the motion. A partial reflection is achieved by connecting the ends of two springs of different size. At the junction between the two a partial reflection occurs, part of the energy traveling on, the remainder being reflected back to the source. The direct attenuation of the energy is small in the springs, so that the amount of energy passed or reflected can be calculated accurately.

The rate of propagation of sound in air is somewhat in excess of 1,000 feet per second, whereas that in the coil springs is about 40 to 50 feet per second. Accordingly long delay intervals may be obtained in springs of convenient length. When the length of spring required exceeds the length of the unit, two parallel springs are coupled at their upper ends by a small rocker-arm lever of aluminum which transfers the motion from one spring to the other. By combining several total reflection points, partial reflection points and absorption points in the spring system, each with different delay times, it is possible to build up within the system a very large number of reflected waves which are transformed by the crystal elements to a combined reflection signal which is combined with the original signal at the output power amplifier. The unit contains, in all, five lengths of spring, four tubes filled with oil, and two rocker arms.

Beside the effect of reverberation produced by the device, several secondary effects are produced which add to the naturalness of the tone compared with that of the pipe organ.

• • •

COLLEGE HAS ITS OWN RADIO NETWORK



David Sarnoff listening as his son, a sophomore at Brown University, makes an announcement over the campus radio frequency distributing system

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20 Units, 175 MMF.	Test Frequency 1000 Kc.
Average Power Factor	.030%
Maximum Power Factor	.045%
Average Temp. Coef. (20° to 80°C.)	+.000022
Maximum Temp. Coef. (20° to 80°C.)	+.000036
After 5 Complete Cycles of 5 Hrs. at —30°F. and 15 Hrs. at 180°F. Returned to Room Temperature	
Average Power Factor	.031%
Maximum Power Factor	.048%
Average Capacity Change	±.113%
Greatest Capacity Change	+.135%
After 100 Hours in 100% Relative Humidity at 104°F.	
Average Power Factor	.032%
Maximum Power Factor	.048%
Maximum Capacity Change	.05%
Lowest Leakage Resistance (at 1000 Volts D.C.)	over 10,000 Megohms

The above figures will vary slightly for different nominal capacities.

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MOLDED BEZELS
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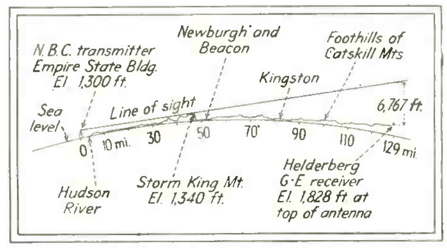
POLYSTYRENE COIL FORMS

Schenectady Television Station Joined to New York Outlet

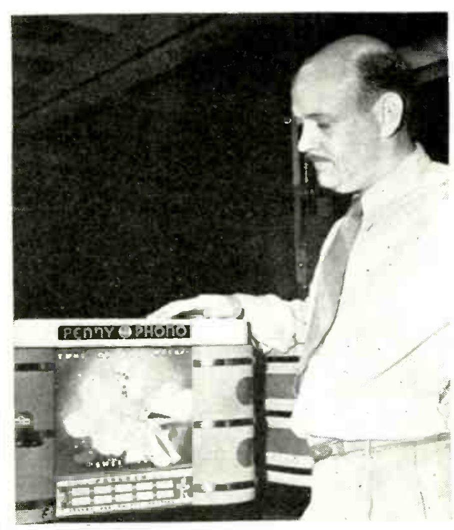
MEMBERS OF THE Federal Communications Commission were given a demonstration on Feb. 1 of television rebroadcasting over a direct path of 129 miles, when the General Electric station Helderberg Mountains near Albany was used to relay programs originating in the N.B.C. transmitter, New York City. The horizon distance, commonly considered to be the limit of reliable reception, from the Empire



Profile of the earth over which New York-Schenectady signals travel

State Building is about 40 or 50 miles. The fact that a signal is received at 129 miles and of sufficient strength to allow high quality rebroadcasting, can be explained on several counts. In the first place, the presence of the Hudson River, which represents a higher conductivity than the surrounding terrain, results in a smaller can-

MODERN VERSION OF PENNY ARCADE



Dr. Gordon K. Woodward, Los Angeles physician, recently developed this automatic phonograph which sells tunes to the public at a rate of a penny a tune, instead of the customary nickel now required. The device was made practical through the development of a new type of record which is 16 inches in diameter and contains 10 separate songs on each side. Each side of the record contains more than one hour of tunes

ALWAYS READY

to measure

★ RESISTANCE

★ INDUCTANCE

★ CAPACITANCE

RANGES

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RESISTANCE
1 milliohm to 1 megohm

INDUCTANCE
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CAPACITANCE
1 micromicrofarad to 100 microfarads

IN ANY LABORATORY where measurements of inductance, resistance or capacitance have to be made, this bridge has become as invaluable as an ohmmeter or a voltmeter.

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ized instruments take care of unusual applications. All must conform to Westinghouse standards of accuracy, precision and long life.

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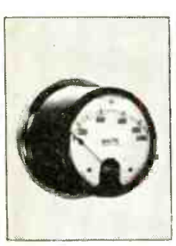
SOCKET INSTRUMENTS

r Economical Analysis



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ontained — ares up to mperes. Accuracy within 1%.	Single-phase or polyphase, 115 volts—5, 10, and 20 amps capacity. Accuracy within 1%.	Circular chart voltmeters up to 750 volts and ammeters to 125-ampere capacity —1, 3, or 7-day chart. Accuracy within 3%.	Convenient means of connecting any conventional instrument for test purposes.

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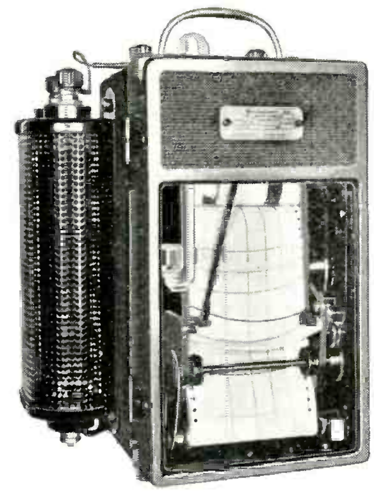
RECORDING INSTRUMENTS



TYPE U

Voltmeters and ammeters, both portable and switchboard. Easy to install and operate, light in weight. Records continuous 8-day operation. Minimum friction. Accuracy within 3%. Permits assembling of data which otherwise would not be available without considerable expense.

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Circular chart voltmeters and ammeters, switchboard or portable. For measuring load curves, station curves and for a wide range of industrial applications. Accuracy within 3%.

TYPE G-40

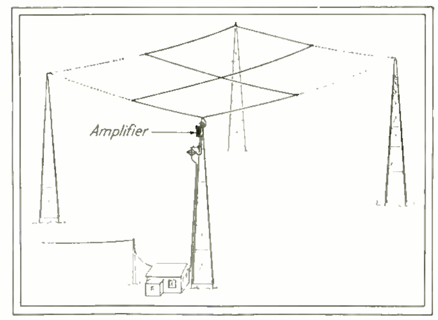
Direct-acting, strip-chart voltmeters, ammeters, wattmeters, and varmeters for 35, 17, 8, or 3-day records. Chart speeds — ¾, 1½, 3 and 6 inches per minute or inches per hour. Accuracy within 1%.

J-40230

Instruments

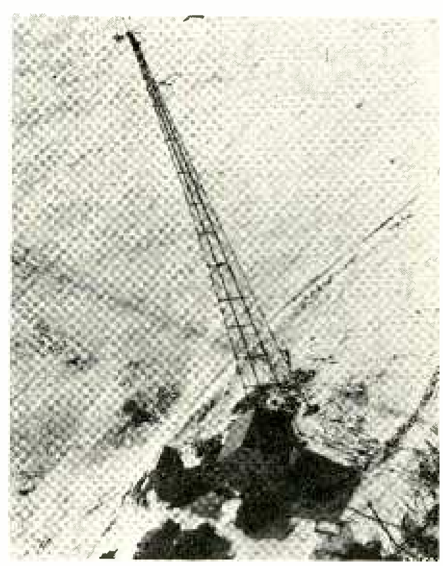
WESTINGHOUSE ELECTRIC

cellation of the reflected and direct components of the waves. In the second place, the receiving location is quite fortunate, being on a hill which slopes in the direction of New York City. At this location four 128-ft towers have been erected to support a rhombic antenna which resembles two diamonds placed end to end. This antenna is tuned for the 44-50 megacycle band on which the N.B.C. station operates.



Rhombic receiving antenna and relay amplifier (on tower)

The main axis of the diamond structure points directly toward the Empire State Building. Inasmuch as the receiving location is some 6,000 ft below the line of sight to the Empire State Building, all of the signal energy received must arrive by means of refraction or diffraction. Nevertheless, the rhombic antennas develop sufficient signal strength so that it can



Relay station which transmits sight signal around mountain

be amplified without too great interference from noise. The initial amplifier is mounted directly at the top of one of the towers of the antenna. This amplifier introduces a gain of twenty times, after which the signal is sent down to a small jack located at the base of the tower where sound and picture signals are amplified separately and demodulated. Demodulated signals are then used to modulate the output

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"A" COATING . . . An organic cement coating designed for domestic, medium- and high-range applications where low cost and good protection from abnormal humidities are required. Has a temperature rise limitation of 130 degrees C. from 30 degrees C. ambient in free air.

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Only in IRC Power Wire Wound Resistors do you have a choice of three protective coatings developed to help you make an intelligent, economical choice. Each of these is designed to provide maximum dependability at minimum cost for the different types of service which power type resistors are called upon to meet. Time and again these specialized IRC coatings have proved their value. They have proved that freedom from costly resistor failure can only be achieved by giving full consideration to the protective coatings of resistors, and thus guarding against the possible effects of salt air, heat, humidity and corrosive atmospheric conditions.

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Fixed ________ Adjustable ________ Tapped ________
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Actual wattage load (normal) ________ (max.) ________
Max. ambient condition ________
Type of Service: ________ Domestic ________ Tropical ________ Coastal ________
Is resistor in fully enclosed and sealed equipment? ________
If tapped, state resistance and wattage per section. ________

Company ________ Title ________
By ________
Address ________

of a 10-watt transmitter operating on a channel 156-162 megacycles. This 10-watt transmitter is used simply to relay the program to the main television transmitting station on the opposite side of the mountains, somewhat more than one mile distant. The transmitting antenna for this unit is also of rhombic shape, but is only 10 ft across, as compared with 400 ft across for the receiving antenna.

At the main transmitter in the Helderbergs, a dipole antenna is used to pick up a picture signal relay from the receiving station. Here the received signal is converted to 66-72 megacycle channel used by the main transmitter and amplified to a carrier level of 10 kw. The sound part of the program is carried by wire line from the receiving station to the main transmitter where it modulates a similar 10-kw ultra-high-frequency transmitter.

The receiving station, 129 air line miles from New York City, is located 1700 ft above sea level. The main transmitter is at an altitude of 1520 ft. When regular operation of the G-E station begins, it is expected that the N.B.C. programs will be rebroadcast on regular schedules, interspersed with programs originating locally in Schenectady. No date has been announced for the opening of the station, however.

• • •

SPEECH DEVICE MAKES INANIMATE OBJECTS TALK

A device which makes inanimate objects "talk" is being demonstrated by Gilbert Wright. Two sensitive "biscuits" capable of picking up the slightest sound and recording it are applied to the throat of the subject and pick up the vibrations of the vocal cords. The person does not even have to open his mouth for the microphones to pick up the words. The device will also synchronize dialogue with the sounds of inanimate objects, and it is expected to find wide application in animated movie cartoons, since words may be synchronized with the actual sounds of animals

Vented Speaker Enclosure

(Continued from page 34)

acoustically the radiation from the vent is in phase with that from the front of the diaphragm. The radiation from the front of the diaphragm is 180 degrees out of phase with that from the rear of the diaphragm.

A rigorous analysis points out that the vent areas are radiators much in the same manner as is the diaphragm. Thus, the vent areas should be of the same order as the piston diameter of the speaker.

The vent should be located near the speaker and it may be shown that two radiating surfaces work better together when spaced close together (in terms of wavelengths) than when spaced far apart.

The relation between the box volume, vent area, and speaker resonance frequency may be determined in the following manner.

$$C_V = \frac{V}{\rho C^2} \qquad (1)$$

ρ is the density of the transmitting medium and C_V is the capacitance of the box, C is the velocity of sound in that medium. (In this case, air.) V is the volume of the box

Rayleigh[1] states that the acoustic reactance of a circular orifice placed in a wall of infinitesimal thickness is

$$X_A = j\frac{\rho\,\omega}{2\,R} \qquad (2)$$

where

$\omega = 2\pi f$
f is frequency and
R is the radius of the orifice

So, since $X_A = X_C$ for resonance

$$\frac{\rho C^2}{V\omega} = \frac{\rho\,\omega}{2\,R} \text{ so that}$$

$$R = \frac{V\omega^2}{2\,C^2} \text{ or} \qquad (3)$$

$$V = 2\,C^2\,R/\omega^2 \qquad (4)$$

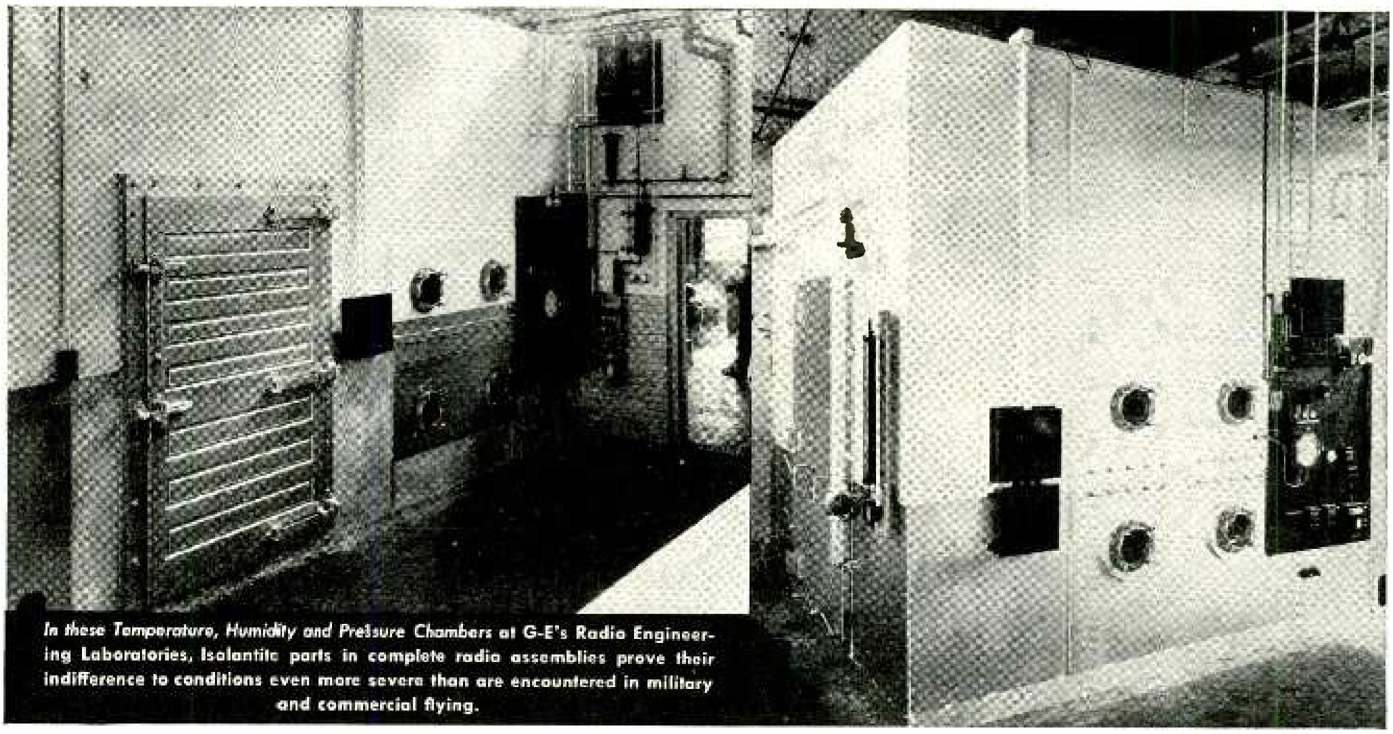
The vent areas need not necessarily be circular. Their area is

$$\pi R^2 = A \text{ and } R = \left(\frac{A}{\pi}\right)^{\frac{1}{2}} \quad \text{thus}$$

$$V = \frac{2\,C^2\left(\frac{A}{\pi}\right)^{\frac{1}{2}}}{\omega^2} \text{ etc.} \qquad (5)$$

The second order effects modify V and the value of X_A in this manner.

FRIGID OR TORRID..



In these Temperature, Humidity and Pressure Chambers at G-E's Radio Engineering Laboratories, Isolantite parts in complete radio assemblies prove their indifference to conditions even more severe than are encountered in military and commercial flying.

Grueling Climatic Tests in These Weather Chambers Prove Isolantite Insulators Can Take It

ISOLANTITE* Insulators prove their qualities through daily use in every part of the world. And in these test chambers at General Electric's Radio Engineering Laboratories — as components of complete, operating radio equipment — they demonstrate how they withstand controlled conditions worse than those encountered in military and commercial flying: temperatures from tropic heat to sub-zero arctic cold . . . barometric pressures from below sea level to those found in the stratosphere . . . humidities from 0 to 100%.

Under such arduous conditions, does Isolantite retain all its advantages? Indeed it *does*. While in these torture chambers it still maintains its unusually low dielectric loss, high surface resistivity, and great mechanical strength. All its characteristics as a superb insulator remain unimpaired.

Isolantite is adaptable in many other ways, too. New and precise forms and unusually-shaped parts may be economically manufactured to meet requirements — whether in the widely used Isolantite body or in Iso-Q, a ceramic with still lower losses. The Isolantite engineering staff, with long, specialized insulation experience, will be glad to cooperate with you in their design. For *your* needs in high-efficiency, rugged and thrifty insulators, consult us at all times.

**Registered trade-name for the products of Isolantite, Inc.*

ISOLANTITE

CERAMIC INSULATORS

ISOLANTITE INC., FACTORY: BELLEVILLE, NEW JERSEY
SALES OFFICE: 233 BROADWAY, NEW YORK, N. Y.

It is difficult to make the enclosure walls solid. Their movement increases the box capacitance and introduces a dissipative element in this leg of the circuit. The box sides and back must be lined with hair-felt or other sound absorbent material to eliminate the reflections which would otherwise be set up at higher frequencies. Thus it is difficult to measure accurately the enclosure volume.

The value of X_A is approximate. A second method of calculation[2] states that

$$Z_A = \frac{2\rho C}{\pi R^2}\left(1 - \frac{J_1(2kR)}{kR} + j\frac{\omega\rho}{\pi R^4 k^3}\, k_1(2kR)\right) \qquad (6)$$

where $k = 2\pi/\lambda$ and Z_A is the usual acoustic impedance of a circular orifice in a wall of infinitesimal thickness.

At low frequencies the reactance term of this equation becomes

$$X_A = j\frac{16}{3\pi^2}\,\frac{\omega\rho}{R} = \frac{0.56\ \omega\rho}{R} \qquad (7)$$

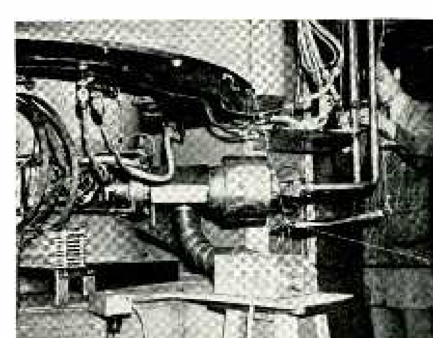
The value of X_A is in error also because the wall is not infinite, but has a finite thickness.

A typical enclosure using a twelve inch speaker whose natural period when loaded in an infinite flat baffle is sixty cps would be 30 cm deep, 50 cm wide and 125 cm high. The vent would be a single circular hole 22.5 cm in diameter, or a rectangular hole 10 x 40 cm.

(1) Rayleigh: "Theory of Sound," Vol. II, Page 306, Macmillan.
(2) Olson and Massa: "Applied Acoustics," Page 33, Blakiston.

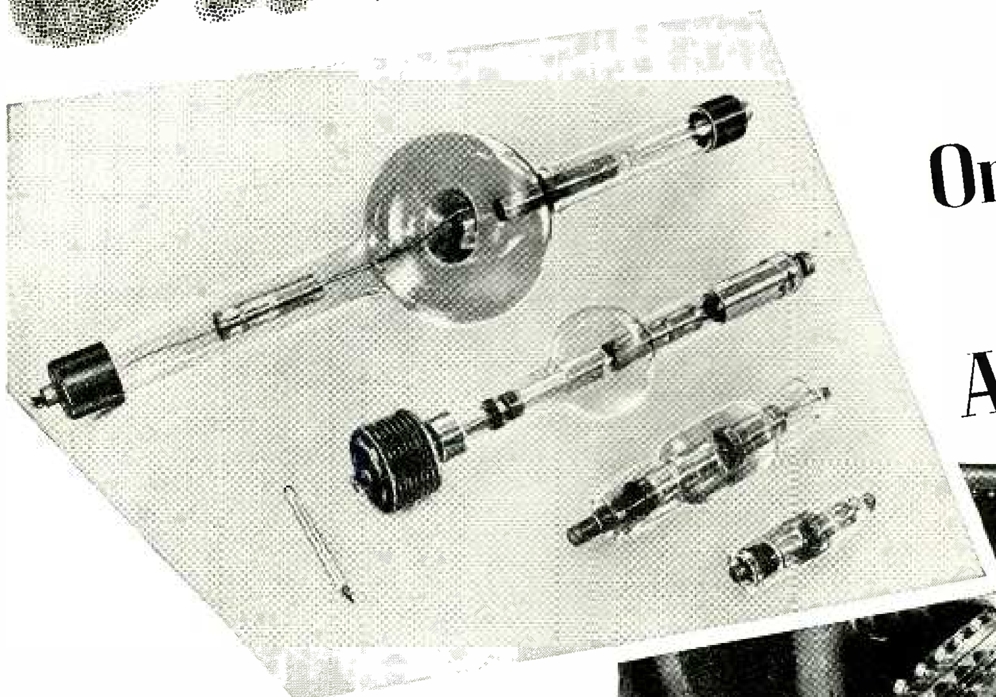
• • •

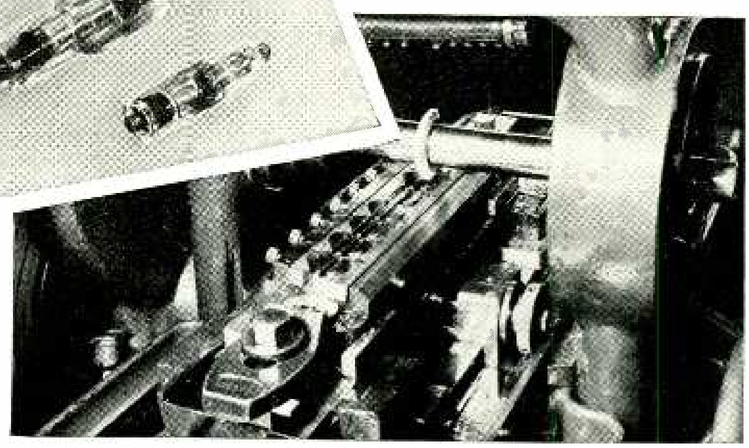
SCIENTISTS HELP SOLVE RADIUM PROBLEM



A scientist in the Royal Society Mond Laboratory of Cambridge University is making adjustments on a cyclotron machine. Neutrons, produced by the cyclotron, may be used as a substitute for radium

Out-Gassed to One Billionth of an Atmosphere





Representative types of X-ray tubes produced by Machlett Laboratories, Inc., Springdale, Conn. At right is shown machining of cathode heads...which must be accurate to 0.0001 of an inch.

Critical requirements of X-ray tubes are met by pure Nickel

Low gas content and high strength, as you know, are required in metals for radio tubes. Consider, then, the more critical needs of makers of X-ray tubes:

Operating voltages range from 70,000 to upwards of 200,000 volts. A vacuum in the order of 10^{-7} mm. of mercury must be *created and maintained.* Furthermore, cost of completed tubes is far in excess of that of radio tubes. All of which adds up to one fact...that makers can *take no chances* with metals they use in X-ray tubes.

What metal *do* they use? Says Mr. T. H. Rogers of Machlett Laboratories, Inc., "For important metal units inside the tube we have found pure Nickel to be the most satisfactory of many tried. Its gas content is low, and Nickel sheets, rods and bar stock, though tough and strong, are readily fabricated and welded."

Economical production, and uniform, dependable operation of radio, television, X-ray and other electronic tubes result from the use of Nickel. For further information read "Nickel in the Radio Industry." This booklet available free on request. Address:

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street New York, N. Y.

NICKEL

TUBES

In addition to the list of tubes registered by the R.M.A. Data Bureau, there is presented an index of all the tubes already listed in this department

INDEX

JAN 1939 . . . JAN 1940

Filament Types for use with Dry Batteries or Equivalent Power Supply

Type Number	See Footnote	Structure or Function	Salient Characteristic	Issue		Page
1A5GT		Power Amplifier Pentode	P_o = .1	Feb	40	52
1A7GT		Pentagrid Converter	g_c = 250	Feb	40	53
1B7G*		Pentagrid Converter	g_c = 350	Feb	40	54
1B7GT*		Pentagrid Converter	g_c = 350	Nov	39	73
1B8GT*		Diode Triode Beam PA	P_o = .21	Nov	39	72
1C5GT*		Power Amplifier Pentode	P_o = .24	Feb	40	52
1D8GT*		Diode Triode PA Pentode	P_o = .2	Dec	39	57
1E4G		Triode	μ = 14	Mar	40	65
1G6G*		Twin PA Triode (B)	P_o = .675	Mar	40	68
1G6GT*		Twin PA Triode (B)	P_o = .675	Nov	39	69
1G4G		Triode	μ = 9	Mar	40	69
1G4GT		Triode	μ = 9	Nov	39	69
1H5GT		Diode-Triode	μ = 65	Feb	40	52
1LA4	(GL)	Power Amplifier Pentode	P_o = .115	Jan	40	66
1LB4	(GL)	Power Amplifier Pentode	P_o = .2	Nov	39	72
1LH4	(GL)	Diode Triode	μ = 65	Jan	40	66
1LN5	(GL)	R-F Pentode	g_m = 800	Jan	40	64
1LA6	(GL)	Pentagrid Converter	g_c = 250	Jan	40	64
1N5GT		R-F Pentode	g_m = 750	Feb	40	52
1N6G		Diode PA Pentode	P_o = .1	Feb	40	50
1N6GT		Diode-Power Amplifier	P_o = .1	Dec	39	57
1P5G		R-F Pentode, rco	g_m = 800	Feb	40	53
1P5GT		R-F Pentode, rco	g_m = 800	Dec	39	55
1Q5G*		Beam Power Amplifier	P_o = .27	Mar	40	66
1Q5GT*		Beam Power Amplifier	P_o = .27	Feb	40	53
1R5	(GB)	Pentagrid Converter	g_c = 250	Jan	40	58
1S4*	(GB)	Power Amplifier Pentode	P_o = .065	Jan	40	58
1S5	(GB)	Diode Pentode	g_m = 525	Jan	40	58
1T4	(GB)	R-F Pentode, rco	g_m = 750	Jan	40	58
1T5GT		Beam Power Amplifier	P_o = .17	Jan	40	62
3A8GT**		Diode-Triode Pentode	g_m = 750	Nov	39	74
3C5GT**		Power Amplifier Pentode	P_o = .26	Dec	39	53
3Q5GT**		Beam Power Amplifier	P_o = .27	Dec	39	56

All filament ratings are 1.4 volts, .05 amps except as indicated by * = 1.4 volts, .10 amps. ** = 1.4 volts, .10 amps or 2.8 volts, .05 amps.

Filament Types for Use with Power Supplies Other Than Dry Batteries

Type Number	See Footnote	Structure or Function	Salient Characteristic	Issue		Page
2V3G		Half-Wave Rectifier	i_{dc} = 2	Mar	40	69
2W3GT		Half-Wave Rectifier	i_{dc} = 55	Dec	39	54
2X2/879		Half-Wave Rectifier	e_{ac} = 4500	Nov	39	70
5W4GT		Full Wave Rectifier	i_{dc} = 90	Nov	39	73

Unipotential Cathode Types

Type Number	See Footnote	Structure or Function	Salient Characteristic	Issue		Page
6AB7	(M)	R-F Pentode, rco	g_m = 5000	Feb	40	55
6AC5GT		Triode Power Amplifier	P_o = 3.7	Feb	40	54
6AC7	(M)	R-F Pentode, sco	g_m = 9000	Feb	40	55
6AE5GT		Triode	μ = 4.2	Nov	39	73
6AF5G		Triode	μ = 7.4	Feb	40	52
6AF7G	fs	Tuning Indicator	....	Feb	40	51
6AG7	(M)	Beam Amplifier	g_m = 7700	Feb	40	51
6AL6G		Beam Power Amplifier	P_o = 6.5	Nov	39	71
6C5GT		Triode	μ = 20	Dec	39	53
6E8G	fs	Triode-Hexode	g_c = 630	Dec	39	53
6H4GT		Single Diode	....	Jan	40	66
6H8G	fs	Double Diode Pentode	g_m = 2400	Dec	39	57
6K8GT		Triode-Hexode, rco	g_c = 350	Feb	40	55
6M8GT	fs	Diode, Triode, Pentode	g_m = 1900	Nov	39	72
6P5GT		Triode	μ = 14	Feb	40	54
6R7GT		Double Diode Triode	μ = 16	Dec	39	53
6SA7GT		Pentagrid Converter	g_c = 425	Feb	40	55
6SF5GT		Triode	μ = 100	Jan	40	64
6SJ7GT		R-F Pentode, sco	g_m = 1650	Jan	40	60
6SK7GT		R-F Pentode, rco	g_m = 2000	Jan	40	60
6SQ7G		Double Diode Triode	μ = 100	Nov	39	73
6SQ7GT		Double Diode Triode	μ = 100	Jan	40	60
6T6	fs (GM)	R-F Pentode	g_m = 5500	Nov	39	73
6V6GT		Beam Power Amplifier	P_o = 4.25	Nov	39	69
6W6GT		Beam Power Amplifier	P_o = 3.3	Dec	39	55
6Y6GT		Beam Power Amplifier	P_o = 3.6	Jan	40	62
7A4	(GL)	Triode	μ = 20	Feb	40	54
7A5	(GL)	Power Amplifier Pentode	P_o = 1.9	Jan	40	66
7A7LM		R-F Pentode, rco	g_m = 2000	Nov	39	75
7B5	(GL)	PA Pentode	P_o = 3.4	Mar	40	69
7B6	(GL)	Double Diode Triode	μ = 100	Mar	40	67
7B8	(GL)	Pentagrid Converter	g_c = 550	Mar	40	66
7C5	(GL)	Beam Power Amplifier	P_o = 4.25	Mar	40	66
7C7	(GL)	R-F Pentode	g_m = 1300	Feb	40	56
7E6	(GL)	Double Diode Triode	μ = 16	Feb	40	51
7E7	(GL)	Double Diode Pentode	g_m = 1300	Dec	39	55
7F7	(GL)	Double Triode	g_m = 2(1600)	Dec	39	55
7J7	(GL)	Triode-Hexode	g_c = 310	Nov	39	69
7Q7	(GL)	Pentagrid Converter	g_c = 450	Nov	39	71
12A6	(M)	Beam Power Amplifier	P_o = 2.5	Dec	39	51
12A8G		Pentagrid Converter, rco	g_c = 550	Jan	40	62
12A8GT		Pentagrid Converter, rco	g_c = 500	Mar	40	69
12B7	(GL)	R-F Pentode, rco	g_m = 2000	Dec	39	55
12B7	(ML)	R-F Pentode, rco	g_m = 2000	Nov	39	71
12B8GT		Triode-Pentode	g_m = 1800	Mar	40	65
12C8	(M)	Double Diode Pentode	g_m = 1325	Mar	40	65
12E5GT		Triode	μ = 14	Nov	39	70
12F5GT		Triode	μ = 100	Mar	40	66
12G7G		Double diode triode	μ = 70	Feb	40	51
12J5G		Triode	μ = 20	Feb	40	53
12J7GT		R-F Pentode, sco	g_m = 1225	Mar	40	67
12K7GT		R-F Pentode, rco	g_m = 1450	Mar	40	67
12K7G		R-F Pentode, rco	g_m = 1650	Jan	40	67
12K8GT		Triode-Hexode	g_c = 350	Nov	39	75
12K8	(M)	Triode-Hexode	g_c = 350	Dec	39	52
12Q7GT		Double Diode Triode	μ = 70	Mar	40	68
12Q7G		Double Diode Triode	μ = 70	Mar	40	68
12SA7	(M)	Pentagrid Converter	g_c = 450	Mar	40	64
12SA7GT		Pentagrid Converter	g_c = 450	Feb	40	51
12SC7	(M)	Twin Triode	μ = 70	Mar	40	64
12SF5GT		Triode	μ = 100	Jan	40	64
12SF5	(M)	Triode	μ = 100	Nov	39	75
12SQ7	(M)	Double Diode Triode	μ = 100	Mar	40	64
12SQ7GT		Double Diode Triode	μ = 100	Jan	40	60
12SR7	(M)	Double Diode Triode	μ = 16	Dec	39	51
12SK7	(M)	R-F Pentode, rco	g_m = 2000	Mar	40	64
12SK7GT		R-F Pentode, rco	g_m = 2000	Jan	40	64
12SJ7	(M)	R-F Pentode, sco	g_m = 1650	Mar	40	64
12SJ7GT		R-F Pentode, sco	g_m = 1650	Jan	40	60
14J7	fs (GL)	Triode-Hexode, rco	g_c = 310	Nov	39	71
20J8	fs (GM)	Triode-Heptode	g_c = 270	Nov	39	75
25AC5GT		Power Amplifier Triode	P_o = 2.0	Nov	39	72
25B8GT		Triode, Pentode	g_m = 2000	Feb	40	54
25C6G		Beam Power Amplifier	P_o = 6	Jan	40	66
25D8GT		Diode, Triode, Pentode, rco	g_m = 1800	Feb	40	56
25X6GT		Rectifier Doubler	i_{dc} = 60	Feb	40	56
25Y4GT		Half-Wave Rectifier	i_{dc} = 75	Dec	39	54
25Z4GT		Half-Wave Rectifier	i_{dc} = 125	Dec	39	54
32L7GT		Rectifier Beam PA	P_o = 1	Mar	40	69
35A5LT		Beam Power Amplifier	P_o = 1.5	Nov	39	74
35L6G		Beam Power Amplifier	P_o = 1.5	Jan	40	67
35Z3LT		Half-Wave Rectifier	i_{dc} = 100	Nov	40	74
35Z5GT		Half-Wave Rectifier	i_{dc} = 100	Mar	40	66
35Z5G		Half-Wave Rectifier	i_{dc} = 100	Jan	40	62
45Z5GT		Half-Wave Rectifier	i_{dc} = 100	Feb	40	53
40Z5/45Z5GT		Identical with 45Z5(GT)	....	Feb	40	50
50C6G		Beam Power Amplifier	P_o = 6	Dec	39	51
50L6GT		Beam Power Amplifier	P_o = 1.75	Feb	40	56
50Y6GT		Rectifier Doubler	i_{dc} = 85	Dec	39	56
50Z7G		Rectifier Doubler	i_{dc} = 65	Dec	39	56
70A7GT		Rectifier Beam PA	P_o = 1.5	Dec	39	57
70L7GT		Rectifier Beam PA	P_o = 1.8	Feb	40	56
117Z6G		Full Wave Rectifier	i_{dc} = 60	Jan	40	62
117Z6GT		Full Wave Rectifier	i_{dc} = 60	Nov	39	68
117L7GT		Rectifier Beam PA	P_o = .55	Nov	39	74

Picture Tubes

Type Number	Deflection	Issue	Page
3AP1	Electrostatic	Jan 40	67
3AP4	Electrostatic	Jan 40	67
5AP1	Electrostatic	Feb 40	55
5A4	Electrostatic	Feb 40	55
5BP1	Electrostatic	Jan 40	67
5BP4	Electrostatic	Jan 40	66
7AP4	Magnetic	Dec 39	52
9AP4	Magnetic	Jan 40	66
12AP4	Magnetic	Jan 40	66

Withdrawals

Registration of the following tube types was withdrawn on the dates shown:

7D7	(G)	September 8, 1939
21A7	(GL)	September 8, 1939
2Z3		December 18, 1939
83V		December 18, 1939

NATIONAL RESEARCH CREATES NEW PRODUCTS ★ NEW MARKETS

Hot dogs!

Now Cooked Better.. Electrically

..thanks to

PHENOLITE
REG. U.S. PAT. OFF.
Laminated BAKELITE

THE "Miracle Grill" made by Miracle Appliance Co., Cressona, Pa., cooks hot dogs electrically in 45 seconds. A current is passed through them which cooks the frankfurter from the inside out, sealing in the flavor and making them far more delicious than when cooked by the ordinary method.

The facings of the grill are made of black mirror-finish Phenolite, which not only acts as electric insulation, but greatly adds to the appearance of the product. The Phenolite facings are easy to keep fresh and clean. Steam and other vapors from the cooking frankfurters do not damage this surface and may be instantly wiped away. To protect and insulate the metal prongs which hold the hot dogs, little sleeves of National Vulcanized Fibre are used.

Here, again, a new product - doing an old job better - is created - thanks to the unusual combination of qualities of Phenolite and National Fibre. Our technical staff's broad experience in the application of these versatile materials is available to you on any problem. Call or write us.

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PHENOLITE
Laminated BAKELITE

Attention is called to the increasing use of a suffix appended to the conventional tube type number to indicate some of the mechanical characteristics of the tube type. The significance of these suffixes is given below. It should be noted, however, that where in the above the suffix appears under the heading "Type Number" the suffix will be commonly found to be included in the labelling and branding of all tubes of the type described. Where the suffix appears in the next column it may not appear in the tube labelling but is so shown in the records and publications of the Data Bureau and others.

Octal Base Types
- (M) Metal Envelope and Octal Base
- G Glass Envelope and Octal Base
- (GM) Metal Coated Glass Envelope and Octal Base
- GT Short (T-9) Glass Envelope and Octal Base

Locking Base Types
- (GL) Integral (T-9) Glass Envelope and Base (loktal)
- (ML) Integral (T-9) Metal Envelope and Base
- LM (MT-8) Metal Envelope and Octalox Base
- LT (T-9) Glass Envelope and Octalox Base
- (GB) Integral (T-5-½) Glass Envelope and Base

In addition to the indication of the mechanical characteristics of the tube

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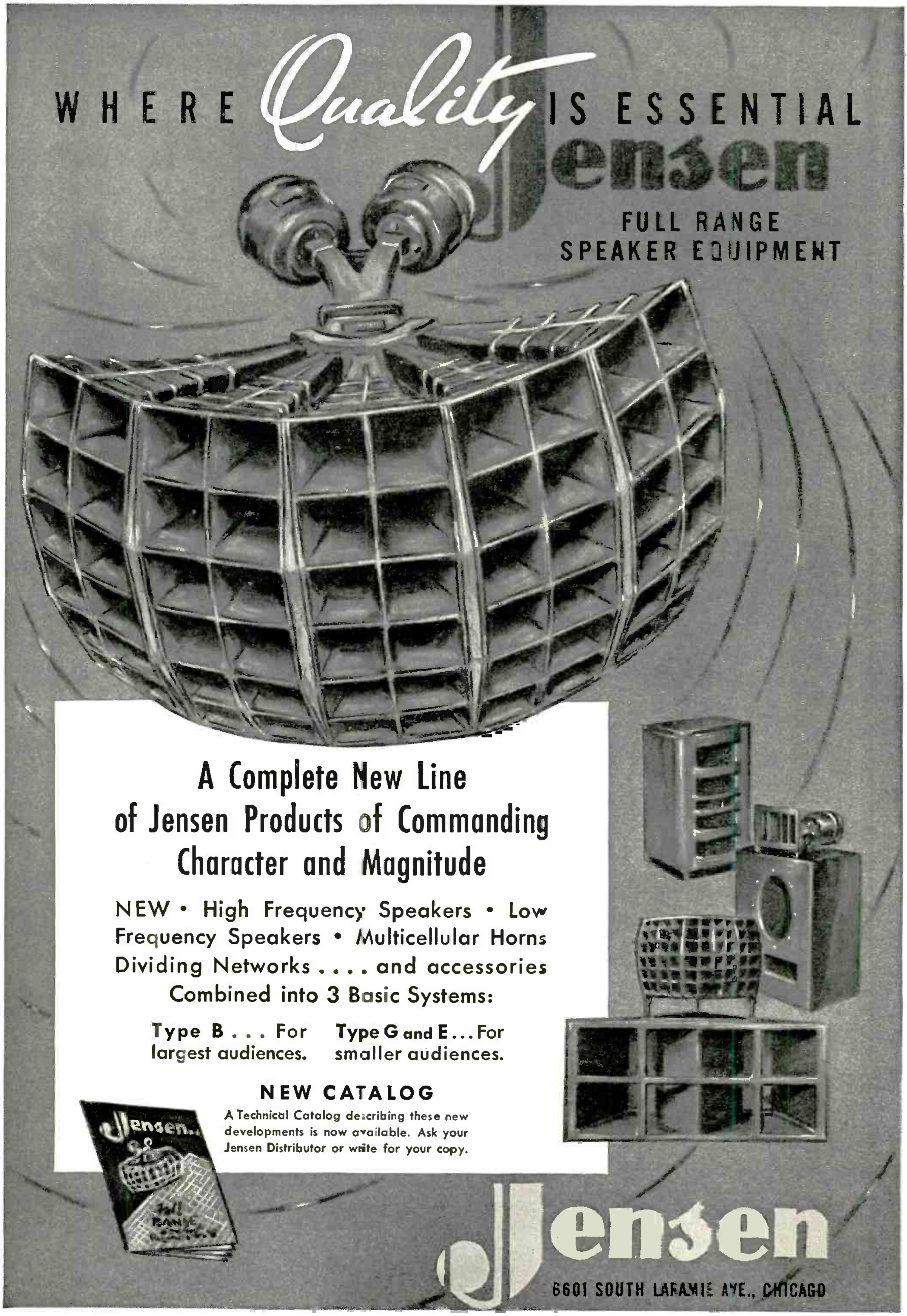
RADIO RUNS ON GAS

Natural gas drives an electric generator to power the radio receiver shown above. This experimental unit, sponsored by H. Carl Wolf, Natural Gas Company executive, has not yet been developed to a point of practical use in the home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types, there is indicated in the second column by the symbol "fs" the fact that the tube type is registered for foreign service, either by a foreign or a U. S. manufacturer.

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Tube Registry

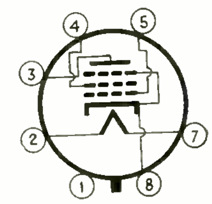
Tube Types Registered by R.M.A. Data Bureau During January 1940

Type 6F6 (GT)

Prototype 6F6

POWER amplifier pentode; heater type; (T-9) glass envelope; seated height $2\frac{7}{8}$ inches (max); 7 pin octal base.

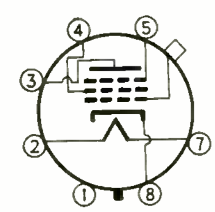
E_f = 6.3 v
I_f = 0.7 amp
E_p = E_{c2} 250 v
E_{c1} = −16.5 v
I_{po} = 34 ma
I_{so} = 6.5 ma
r_p = 80,000 ohms
g_m = 2,500 μmhos
R_l = 7,000 ohms
P_o = 3.2 watts (8%)
Basing 7-S



Type 6M7 (G)

FOREIGN service, r-f pentode, remote cutoff; heater type; (ST-12) glass envelope; seated height $3\frac{7}{8}$ inches (max); 7 pin octal base.

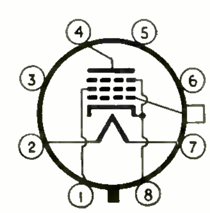
E_f 6.3 v
I_f = 0.3 amp
E_p = 250 v
E_{c2} = 125 volts
E_{c1} = −2.5 v
I_p = 10.5 ma
I_{g2} = 2.8 ma
g_m = 3400 -mhos
r_p = 0.9 megohm
C_{in} = 6.3 μf
C_{out} = 11 μμf
C_{gp} = 0.001 μμf
Basing 7-R



Type 6S6 (GT)

R-F pentode, remote cutoff; heater type; (T-9) glass envelope; seated height $3\frac{1}{8}$ inches (max); 5 pin octal base.

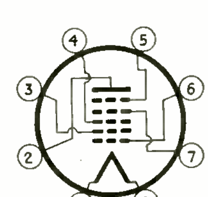
E_f = 6.3 v
I_f = 0.45 amp
E_p = 250 v
E_{c2} = 100 v
E_{c1} = = 2 v
I_p = 13 ma
I_{c2} = 3 ma
g_m = 4000 μmhos
r_p = 0.35 megohm
C_{in} = 7 μμf
C_{out} = 6.4 μμf
C_{gp} = 0.01 μμf
Basing 6-AV



Type 1LB6 (GL)

FOREIGN service, heptode-converter; filament type; (T-9) glass envelope-base; seated height $2\frac{1}{4}$ inches, (max); 8 pin loktal base.

E_f = 1.4 v
I_f = 0.05 amp
E_p = 90 v
E_{c5} = 0 v
$E_{c2,4}$ = 67.5 v
E_{c1} = 0 v
I_p = 0.4 ma
$I_{c2,4}$ = 2.2 ma
g_c = 100 μmhos
r_p = 2 megohms
C_{rf} = 3.8 μμf
C_{ifout} = 7.0μμf
Basing 8-AX

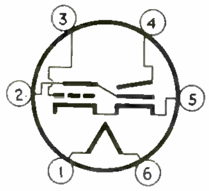


Type 6AB5/6N5

Originally 6AB5 and 6N5

TRIODE-tuning indicator; heater type; (T-9) glass envelope; seated height $3\frac{9}{16}$ inches (max); 6 pin base.

$E_f = 6.3$ v
$I_f = 0.15$ amp
$E_p = E_T = 135$ v
$I_p = 0.5$ ma
$E_c = 0$ v
$I_T = 2$ ma (approx)
Shadow Angle = 0° @ −10 v (approx)
Shadow Angle = 90° @ 0 v (approx)
Basing 6-R

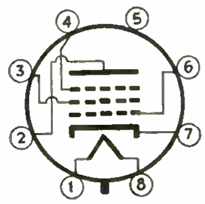


Type 7G7/1232 (GL)

Originally 1232

R-F pentode, sharp cutoff; heater type; (T-9) integral glass envelope-base; seated height $2\frac{1}{4}$ inches (max); 8 pin loktal base.

$E_f = 7.0$ v
$I_f = 0.48$ amp
$E_p = 250$ v
$E_{c2} = 100$ v
$E_{c1} = -2$ v
$I_p = 6$ ma
$I_{c2} = 2$ ma
$r_p = 0.8$ megohm (approx)
$G_m = 4{,}500$ μmhos
$C_{in} = 9.0$ $\mu\mu$f
$C_{out} = 7.0$ $\mu\mu$f
$C_{gp} = 0.007$ $\mu\mu$f
Basing 8-V

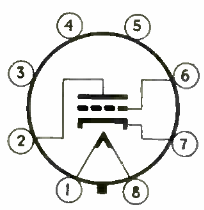


Type 7B4 (GL)

Prototype 6F5 (M)

HIGH mu triode; heater type; (T-9) integral glass envelope-base; seated height $2\frac{1}{4}$ inches (max); 8 pin loktal base.

$E_f = 7.0$ v
$I_f = 0.32$ amp
$E_p = 250$ v
$E_c = -2$ v
$I_p = 0.9$ ma
$r_p = 66{,}000$ ohms
$\mu = 100$
$G_m = 1{,}500$ μmhos
$C_{in} = 3.6$ $\mu\mu$f
$C_{out} = 3.4$ $\mu\mu$f
$C_{gp} = 1.6$ $\mu\mu$f
Basing 5-AC



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FCC MEMBERS SEE FIELD TELEVISION EQUIPMENT

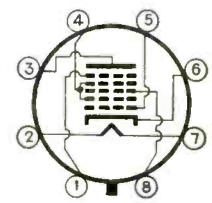
Ralph Beal, James L. Fly, and Dr. Charles B. Jolliffe, inspecting recently developed light-weight, portable television field equipment

Tube Types Registered by R.M.A. Data Bureau During January and February 1939

Type 12SA7 (M)

PENTAGRID converter, heater type metal envelope, octal base, 8 pins.

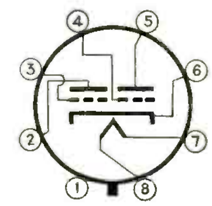
E_h = 12.6 v
I_h = .15 amp
E_p = 250 v
$E_{c2,4}$ = 100 v
E_{c3} = −2 v
I_p = 3.4 ma
$I_{c2,4}$ = 8 ma
G_c = 450 μmhos
R_p = .8 megohms
Basing 8-R



Type 12SC7 (M)

TWIN triode, heater type metal envelope, octal base, 8 pins.

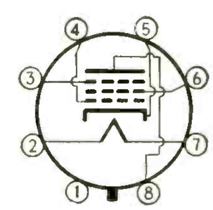
E_h = 12.6 v
I_h = .15 amp
E_p = 250 v (max)
E_c = −2.0 v
I_p = 2.0 ma (per plate)
G_m = 2 (1325) μmhos
R_p = 53,000 ohms
Basing 8-S



Type 12SJ7 (M)

PENTODE, sharp cut-off, heater type, metal envelope, octal base, 8 pins.

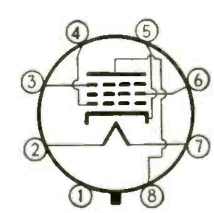
E_h = 12.6 v
I_h = .15 amp
E_p = 250 v (max)
E_{c2} = 100 v (max)
E_c = −3 v
I_p = 3.0 ma
I_{c2} = 0.8 ma
G_m = 1650 μmhos
R_p = 1.5 megohms
Basing 8-N



Type 12SK7 (M)

PENTODE, remote cut-off, heater type, metal envelope, octal base, 8 pins.

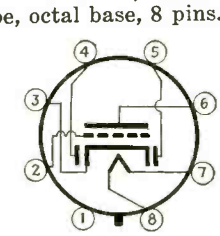
E_h = 12.6 v
I_h = .15 amp
E_p = 250 v (max)
E_{c2} = 100 v (max)
E_c = −3 v
I_p = 9.2 ma
I_{c2} = 2.4 ma
G_m = 2000 μmhos
R_p = 0.8 megohms
Basing 8-N



Type 12SQ7 (M)

DOUBLE-DIODE, high mu triode, heater type, metal envelope, octal base, 8 pins.

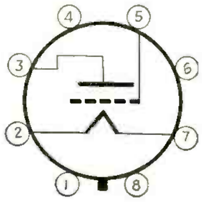
E_h = 12.6 v
I_h = .15 amp
E_p = 250 v
E_c = −2 v
I_p = 0.9 ma
G_m = 1100 μmhos
R_p = 91,000 ohms
Basing 8-Q



Type 1E4 (G)

TRIODE, filament type, glass envelope, octal base, 8 pins.

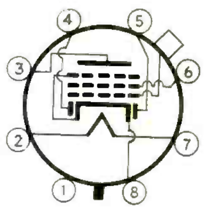
E_f = 1.4 v
I_f = .05 amp
E_p = 90 v
E_c = −3 v
I_p = 1.5 ma
g_m = 825 μmhos
r_p = 17,000 ohms
Basing 5-S



Type 12C8 (M)

DOUBLE-DIODE pentode, heater type, metal envelope, octal base, 8 pins.

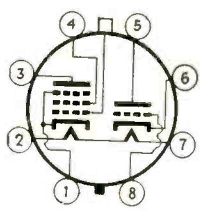
E_h = 12.6 v
I_h = .15 amp
E_p = 250 v
E_{c2} = 125 v
E_c = −3 v
I_p = 10 ma
I_{c2} = 2.3 ma
g_m = 1325 μmhos
r_p = .6 megohms
Basing 8-E



Type 12B8 (GT)

TRIODE-PENTODE, heater type, bantam glass envelope, octal base, 8 pins.

E_h = 12.6 v
I_h = .3 amp
TRIODE
g_m = 2400 μmhos
r_p = 37,000 ohms
PENTODE
g_m = 1800 μmhos
r_p = 0.2 megohm
Basing 8-T



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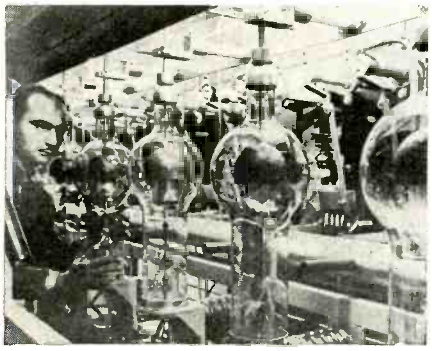
KDKA CHANGES TUBES AUTOMATICALLY

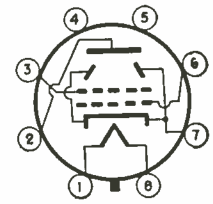


The new 50-kw transmitter of KDKA, at Allison Park, Pa. includes among its many features, an automatic relay shift which banishes interruptions of broadcasts due to rectifier tube failures. In the foreground, above, are rectifier tubes which are cut into the circuit, as required, by automatic tube changing relays shown in the background. Manual changing of tubes is thereby eliminated

Type 7C5 (GL)

POWER amplifier tetrode, heater type, glass base envelope, loctal base, 8 pins.

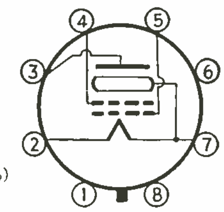
E_h = 7 v
I_h = .48 amp
E_p = 250 v (max)
E_{c2} = 250 v (max)
E_c = −12.5 v
I_p = 45 ma
I_{c2} = 4.5 ma
g_m = 4100 μmhos
R_l = 5000 ohms
P_o = 4.25 watts (6%)
Basing 6-AA



Type 1Q5 (G)

BEAM power amplifier, filament type, glass envelope, octal base, 8 pins.

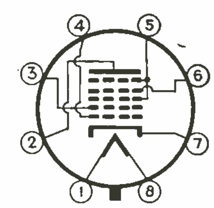
E_f = 1.4 v
I_f = .1 amp
E_p = 90 v
E_{c2} = 90 v
E_c = −4.5 v
I_p = 9.5 ma
I_{c2} = 1.6 ma
g_m = 2100 μmhos
R_l = 8000 ohms
P_o = .27 watts (7½%)
Basing 6-AF



Type 7B8 (GL)

PENTAGRID converter, heater type, glass base envelope, loctal base, 8 pins.

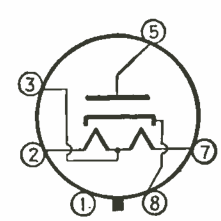
E_h = 7 v
I_h = .32 amp
E_p = 250 v (max)
$E_{c3,5}$ = 100 v (max)
E_{c2} = 250 v (max)
E_{c4} = −3.0 v (min)
I_p = 3.5 ma
$I_{c3,5}$ = 2.7 ma
g_c = 550 μmhos
r_p = .36 megohms
Basing 8-X



Type 35Z5 (GT)

RECTIFIER-BALLAST, heater type, bantam glass envelope, octal base, 6 pins.

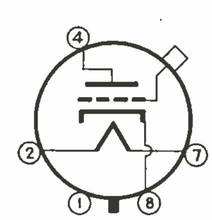
E_h = 35 v
I_h = .15 amp
RECTIFIER
E_{ac} = 125 v (max)
I_{dc} = 100 ma (max)
BALLAST
E_{pilot} = 6.3 v
I_{pilot} = 150 ma
Basing 6-AD



Type 12F5 (GT)

HIGH mu triode; heater type; (T-9) glass envelope, seated height 2⅝ inches; 5 pin octal base.

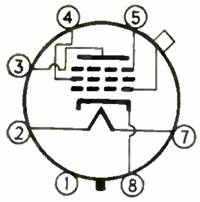
E_h = 12.6 v
I_h = 0.15 amp
E_p = 250 v (max)
E_c = −2.0 v
I_p = 0.9 ma
r_p = 66000 ohms
μ = 100
Basing 5-M



Type 12J7 (GT)

R-F pentode, sharp cutoff; heater type; (T-9) glass envelope; 7 pin octal base.

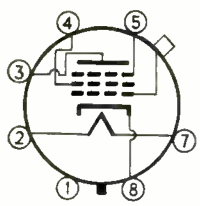
E_h = 12.6 v
I_h = 0.15 amp
E_p = 250 v (max)
E_{c2} = 100 v
E_c = −3.0 v
I_p = 3.0 ma
g_m = 1650 micromhos
r_p = 1.5 megohms
Basing 7-R



Type 12K7 (GT)

R-F pentode, remote cutoff; heater type; (T-9) glass envelope; 7 pin octal base.

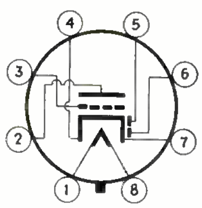
E_h = 12.6 v
I_h = 0.15 amp
E_p = 250 v (max)
E_{c2} = 100 v
E_c = −3.0 v
I_p = 7.0 ma
r_p = 0.8 megohm
g_m = 1450 micromhos
Basing 7-R



Type 7B6 (GL)

DOUBLE-DIODE triode, heater type, glass base envelope, loctal base, 8 pins.

E_h = 7 v
I_h = .32 amp
E_p = 250 v (max)
E_c = −2.0 v
I_p = 0.9 ma
g_m = 1100 μmhos
r_p = 91,000 ohms
Basing 8-W



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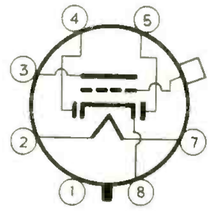
AIRCRAFT ENGINE SHOWN ON TELEVISION PROGRAM

An NBC camera man is shown training the television camera on an electrically operated, cutaway 1110 hp Wright Cyclone engine in a recent telecast marking the first television broadcast of its kind in the United States

Type 12Q7 (GT)

DOUBLE diode, high mu triode; heater type, (T-9) glass envelope, 7 pin octal base.

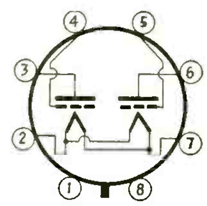
E_h = 12.6 v
I_h = 0.15 amp
E_p = 250 v (max)
E_c = − 3.0 v
I_p = 1.1 ma
μ = 70
r_p = 58000 ohms
Basing 7-V



Type 1G6G

CLASS B amplifier, filament type, (T-9) glass envelope, seated height $3\frac{7}{16}$ inches (max), 8 pin octal base.

E_f = 1.4 v
I_f = 0.10 amp
E_p = 90 v
E_c = 0 v
I_p = 1.0 ma (per triode)
r_p = 45000 ohms
g_m = 675 μmhos
Basing 7-AB



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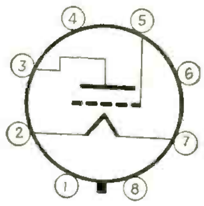
FOG-PIERCING EYE FOR PLANES

Guy Ball, exhibiting a newly invented instrument which, it is claimed, will enable aircraft pilots to see through fog. The device operates as a miniature television system to provide a picture of the terrain below the plane, on the screen of a cathode ray tube. Demonstrations have been given showing the effectiveness of the device to "see through" infrared filters, but field tests under actual operation are still to be made

Type 1G4G

TRIODE voltage amplifier, filament type, (T-9) glass envelope, seated height $3\frac{7}{16}$ inches (max) 7 pin octal base.

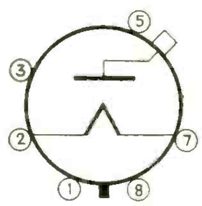
E_f = 1.4 v
I_f = 0.050 amp
E_p = 90 v
E_c = −6.0 v
I_p = 2.3 ma
g_m = 825 μmhos
μ = 8.8
Basing 5-S



Type 2V3 (G)

HALF-WAVE high-vacuum rectifier; (ST-12) glass envelope, 6 pin octal base.

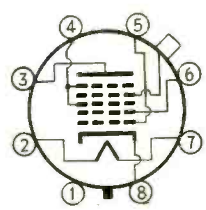
$E_{peak\ inverse}$ = 16500 v
$I_{p\ peak}$ = 12 ma (max)
$I_{p\ ave}$ = 2 ma (ave)
Basing 4-Y



Type 12A8 (GT)

PENTAGRID converter, remote cutoff; heater type; (T-9) glass envelope, seated height $2\frac{3}{4}$ inches (max), 8 pin octal base.

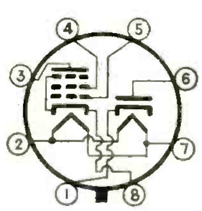
E_h = 12.6 v
I_h = 0.15 amp
E_p = 250 v
g_c = 500 micromhos
r_p = 0.36 megohms
Basing 8-A



Type 32L7 (GT)

RECTIFIER-BEAM power amplifier, heater type, bantam glass envelope, octal base, 8 pins.

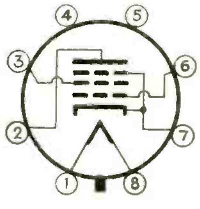
E_h = 32.5 v
I_h = .3 amp
BEAM POWER AMPLIFIER
g_m = 4800 μmhos
R_l = 2600 ohms
P_o = 1 watt (9%)
RECTIFIER
E_{ac} = 125 v (max)
I_{dc} = 60 ma (max)
Basing 8-F



Type 7B5 (GL)

POWER amplifier pentode, heater type, glass base envelope, loctal base, 8 pins.

E_h = 7 v
I_h = .43 amp
E_p = 250 v (max)
E_{c2} = 250 v (max)
E_c = −18 v
I_p = 32 ma
I_{c2} = 5.5 ma
g_m = 2200 μmhos
R_l = 7600 ohms
P_o = 3.4 watts (10%)
Basing 6-AE



THE ELECTRON ART

Loudspeaker testing, automatic electronic synchronization of large generators and the propagation of two and three meter waves are the subjects discussed in this month's review of the technical literature

Loud Speaker Testing

IN THE DECEMBER, 1939 issue of the *Philips Technical Review* there appears an article which should prove interesting to a large number of radio engineers. It is "The Testing of Loud Speakers," by R. Vermeulen. The article discusses the methods used in the Philips laboratory for the rapid determination of the factors which have to do with the quality of a loud speaker and also the fundamental problem of the conditions under which measurements on the loud speaker must take place.

There are two factors which determine the quality of a speaker. They are distortion and the frequency characteristics which indicate the sound intensity produced by the loud speaker when alternating voltages of different frequencies are applied to its terminals. For ideal reproduction, the distortion should be zero and the frequency characteristic must be flat, that is, the sensitivity of the loud speaker must be the same for all frequencies. It is important to note at this point that any deviations from these conditions found in practical cases, while they do not permit the drawing of any conclusion about their effect on the reproduction without the aid of listening tests, do however make possible a comparison of different loud speakers and particularly an estimate of the influence which may be expected from any change in the construction.

The simplest method and the one frequently applied for the determination of sound intensities makes use of a calibrated microphone introduced into the sound field. If a pure sinusoidal voltage is fed to the loud speaker, any overtones which appear in the microphone voltage and whose intensity can be measured separately with a suitable analyzing instrument, must be ascribed exclusively to the distortion in the loud speaker.

In order to record the frequency characteristic, the voltage of the measuring microphone is measured while the frequency of the signal on the loud speaker is varied. The voltage measured will at any frequency be proportional with the electrical energy supplied to the loud speaker. It would be well, therefore, to keep this energy constant during the recording of the characteristic. This, however, requires rather elaborate measures, since the impedance of the loud speaker changes with the frequency. In practice, therefore, either the amplitude of the voltage or that of the current is kept constant during the measurements, and the two frequency characteristics which will be obtained will generally be different. This should be kept in mind when interpreting the curves.

The voltage applied to the loud speaker is produced by a tone generator, the frequency range of which is from 25 to 16,000 cps. The voltage of the tone generator is supplied to the loud speaker via an amplifier. The amplifier must not of course falsify the loud speaker measurement and must therefore have a flat frequency characteristic and only very slight distortion. Furthermore, it must be able to give, as desired, a practically constant output voltage or output current.

In order to avoid the time-consuming operation of the point-by-point determination of a frequency characteristics, there has been developed in the Philips Laboratory an instrument which automatically records the required frequency characteristics.

In the determination of the distortion and the frequency characteristic of a loud speaker there are many factors to be taken into consideration. The sound radiation from the front and back of a speaker are different. In addition to the direct sound of the loud speaker there is also the indirect sound which reaches the microphone only after one or more reflections from the walls and other obstructions. How must the measurements be arranged in order to obtain results which really do form a measure of the usefulness of the loud speaker?

It would seem obvious that the measurements should be carried out under the same conditions as those under which the loud speaker is used in practice, for instance, in an ordinary living room. However, due to the numerous irregularities and the many different sizes and shapes of an ordinary living room, the resulting diagram is more a measurement of the properties of a room rather than of the loud speaker. In order to gain information about the speaker itself, it is necessary to measure the direct sound alone. All reflecting objects must be removed from the sound field. When the speaker is moved out of doors only the ground remains which might still cause unwanted reflections. This difficulty can be met by placing the loud speaker and microphone high

HARVARD CHECKS TONES OF STRADIVARIUS VIOLINS

Tones of rare Stradivarius violins are shown being checked on a harmonic analyzer and are compared with those produced by modern violins in the Jefferson Physical Laboratory of Harvard University under the direction of Prof. Frederick A. Saunders. The violin whose tones are being analyzed is played in another room and cannot be seen by the observers shown above. Seated in front of the machine is Jack Cunningham., and at the left is Robert Watson, both assistants to Prof. Saunders who stands at the opposite end of the analyzer. Three members of the Curtis String Quartet, whose violins are being tested, are shown at the right

above the ground, for instance, projecting over the edge of a high roof.

For a complete measurement of a loud speaker, the frequency characteristic and distortion must be measured not only at the axis of the speaker, but also in directions at different angles to the axis. This, however, becomes extremely elaborate and it is generally considered sufficient to take a measurement on the axis of the loud speaker and one in a direction at 45 degrees to the axis. This is supplemented by a measurement of sound intensity with the frequency constant and the direction varying continuously. A diagram is thus obtained of the directional distribution of the sound intensity which may be compared with light distribution curves such as are customarily recorded for sources of light.

Measurement out of doors has two objections, extraneous noise and weather. There have been numerous attempts made to imitate out-of-doors conditions in a sound-absorbent room, a so-called "soft chamber". This is a room in which the walls are completely covered with sound-absorbent materials. A soft chamber has been constructed at the Philips Laboratory which has an absorption coefficient of about 97 per cent. This gives deviations of about 2 db too much or too little but it is nevertheless permissible for many measurements.

Because an ordinary loud speaker is not a point source, interferences may occur between the waves which are radiated by different parts of the cone. Therefore, the microphone should be placed at a point which is two or three times the diameter of the radiator from the speaker. The author also discusses the total sound radiation of a loud speaker which is important when the question arises of "filling a room with sound," namely, when the indirect sound contributes a considerable portion to the formation of the sound field.

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Electronic Synchronizers for Large Power Generators

A PAPER DESCRIBING the application of electronics to the synchronization of large generators in an electric power generating station was presented at the A.I.E.E. winter session at New York in January. It was "Synchronizing Transients and Synchronizers for Large Machines," by R. D. Evans, F. H. Gulliksen and C. B. Myhre. An investigation is reported of the transients accompanying synchronizing operations performed under practical conditions which include some departures from the ideal conditions as to voltage, phase position, and frequency of the incoming machine. A typical long-distance transmission system is selected for the study of the transients arising from connecting a generator to a loaded line. The body of the paper shows the variations in initial and maximum swing currents in voltage, in frequency, and in angular relations which may be produced by synchronizing under unfavorable conditions. The results of this study are then examined from the standpoint of automatic synchronizers and criteria for defining their performances are developed. A new electronic automatic synchronizer which fulfils the required conditions is described.

Previous automatic synchronizers have employed electrically-interlocked relays which operate each time the phase angle between the machine and line voltages becomes zero. These instruments have given excellent service in a variety of applications. However, it has become evident that faster and more accurate synchronizing could be obtained if the interlocking relays were eliminated and their functions performed by electronic means.

The circuit of this synchronizer comprises two thyratron tubes, transformers and several rectifiers, condensers, resistors and a breaker-closing relay. Voltage-checking relays, apart from the automatic synchronizer, prevent synchronizing operations until contact *I* is closed to denote that the machine and line voltages are approximately equal. Figure 1A illustrates

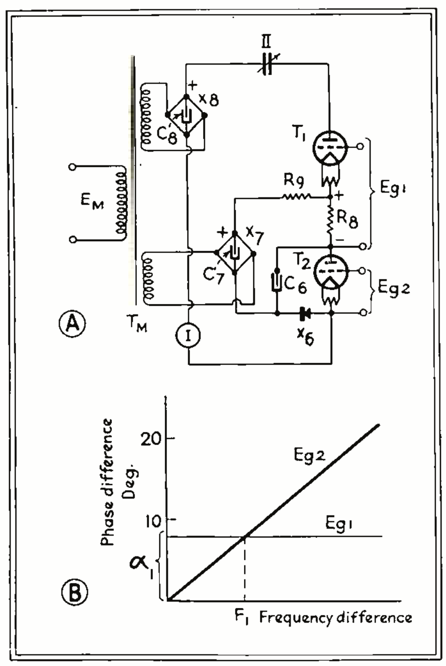

Fig. 1—Electronic interlocking circuit for generator synchronization and its grid control voltage requirements

the two thyratron tubes, T_1 and T_2 which are electrically interlocked so that relay *I* will become energized to close the circuit breaker only when both tubes pass current in series from rectifier X_8. The tube-interlocking circuit is arranged to prevent operation of tube T_1 if tube T_2 has already started to pass current. Current flowing through resistor R_8 from rectifier X_7 causes the voltage across resistor R_8 to become sufficiently negative as to bias tube T_1 and prevent its operation.

The operation of these tubes will respond to the grid-control voltages E_{g1} and E_{g2} as shown in Fig. 1B, tubes T_1 and T_2 will operate to close relay *I* only when the frequency difference is less than F_1. When the frequency difference exceeds F_1, tube T_2 operates before the prase angle a_1, is reduced to that for which tube T_1 is set to operate. Consequently relay I cannot operate.

Figure 2A illustrates the method for obtaining grid-control voltage E_{g1} for tube T_1. A constant direct potential E_{p3} is obtained from rectifier X_9. A variable direct potential E_{c10} is obtained from the beat-frequency voltage rectifier X_{10}. By varying the adjustment of rheostat P_3, the voltage E_{g1} can be made to become positive at a definite angle of advance, as indicated by the curve in Figure 2B. This angle of advance

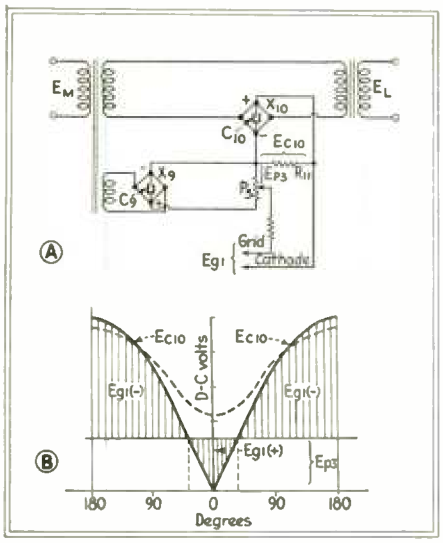

Fig. 2—Grid control circuit for tube T_1 and the grid voltage phase difference characteristics

is practically independent of the frequency difference so long as it does not exceed the usual synchronizing limits of ¼ to ⅛ cycle. If the frequency difference is high, the capacitor C_{10} introduces a delaying action so that voltage E_{c10} does not become zero when the phase angle is zero but follows the dotted line shown in Fig. 2B. This characteristic prevents synchronizing when the frequency difference is too high. However, it does not affect the accuracy of synchronizing at the normal synchronizing frequency differences.

Figure 3A illustrates the method for obtaining grid-control voltage E_{g2} for tube T_2. Voltage E_{g2} consists of four components, E_{P2}, E_{R2}, E_{C4} and E_{P1}. Voltage E_{P2} is a constant value taken from rheostat P_2. Voltage E_{R3} is obtained from the beat frequency voltage rectifier X_1. This is a variable voltage that is high for large phase angles, low for small phase angles, and zero when the machine and line voltages are exactly equal and exactly in phase. Voltage E_{C4} is taken from rectifier X_2 and X_3 through rectifier X_4 to obtain compensation against differences between the machine and line alternating voltage magnitudes, within the range set by an external overall voltage difference checking relay.

Rheostat P_1 and capacitor C_{11} are connected across resistor R_4 which receives voltages from the beat frequency voltage rectifier X_1. When the phase angle decreases from 180 degrees toward zero, capacitor C_{11} discharges through rheostat P_1. This produces a voltage drop E_{P1} which is approximately proportional to the frequency difference and which has a polarity as indicated in Fig. 3, with the result that the grid of tube T_2 tends to become more positive if the frequency difference is high.

The curves in Fig. 3B show the various component voltages E_{P2}, E_{R3} and E_{P1}. Voltage E_{C4} is not shown for it is assumed that the machine and line voltages are equal in magnitude. E_{R3} is highly negative at 90 degrees phase angle and decreases to zero at zero phase angle. Voltage E_{P2} is adjusted so that when E_{P1} is zero (when the frequency difference is zero), the grid voltage E_{g2} becomes zero at approximately 2 degrees. As the frequency difference is increased, voltage E_{P1} increases proportionally so that the grid voltage E_{g2} becomes zero at an advanced phase angle, for example, at α_1 as shown in Figure 3B. By manipulating rheostat P_1 the magnitude of voltage E_{P1}, for any given frequency difference, can be adjusted so that the advance angle at which voltage E_{g2} becomes zero will suit any circuit breaker with closing times from 0.3 seconds to 0.8 seconds.

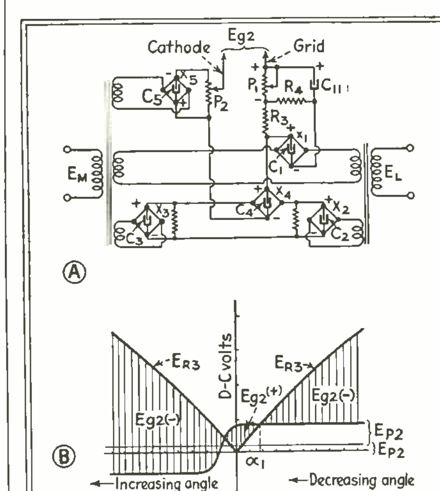

Fig. 3—Grid control circuit for the tube T_2 and the grid control voltage phase difference characteristics

The internal diagram for the electronically-interlocked automatic synchronizer is shown in Fig. 4, which is complete except for the voltage difference checking and other auxiliary relays.

For synchronizing the larger units at the Boulder Dam Power Plant, operating results show that the electronically-interlocked synchronizer performance is far superior to that of the interlocked relay type. The synchronizing performance is more consistently accurate because the electronic inter-

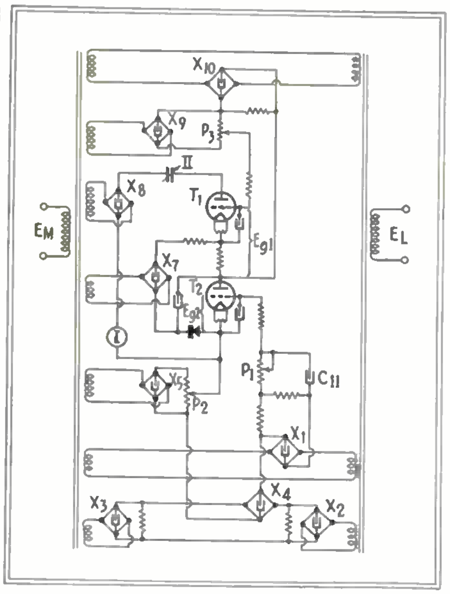

Fig. 4—Circuit diagram for the complete electronic synchronizer for power generators

locking feature is coordinated with the actual speed circuit breakers involved with the result that the current swings are reduced. Of equal importance to the peace of mind of the operating personnel is the relatively smooth synchronizing of the incoming machine and the almost complete elimination of grunt as the generator circuit is closed.

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RADIO EQUIPMENT FOR SCHOOLS

Vice Principal Estelle Phillips, of the Woodrow Wilson High School in Washington, D. C., is shown here speaking through the new radio loudspeaker system recently installed at the school. The equipment enables Miss Phillips to speak or send radio programs from her office to each classroom and also to hear what goes on in the various rooms

Propagation of Two and Three Meter Waves

THE RADIO DEPARTMENT of the National Physical Laboratory (England) is making an investigation of the propagation of radio waves of the order of two and three meters in wavelength. A brief report of the investigation to date is given in a paper in a preprint of the *Journal of The Institution of Electrical Engineers* by J. S. McPetrie and J. A. Saxton entitled "An Experimental Investigation of the Propagation of Radiation Having Wavelengths of Two and Three Meters." It is shown that for a receiver at a height h_R meters the field strength in volts per meter at a distance d meters from a half-wave radiator at a height h_T is given by

$$\epsilon = \frac{90\sqrt{P}\, h_T h_R}{d^2}$$

in which P is the power (watts) radiated at a wavelength λ meters. Within the optical range of the transmitter the fading was less than 3 db.

The results shown were obtained with a transmitter of about 200 watts output operating on wavelengths between 2 and 3 meters. The antenna is located on top of a wooden mast about 60 ft above the ground. The region of test is mostly level, and except for trees and houses is free from major obstructions. Figures 1 and 2 show the field strength plotted against distance, the first on square coordinates and the second on logarithmic coordinates.

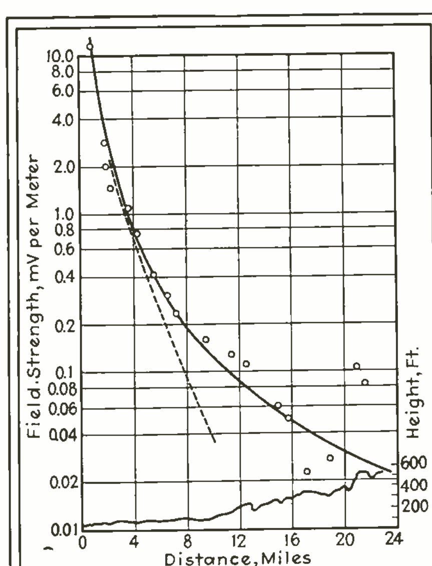

Fig. 1—Field strength vs distance for three meter waves. The wavy line is the contour of the land between the transmitter and receiver

The wavy line at the bottom of Fig. 1 shows the contour of the ground between the transmitter and the receiver. Over at least the level portion of the run the experimental points lie close to the full line which gives the field strength computed from the equation given above. Figure 2 shows that

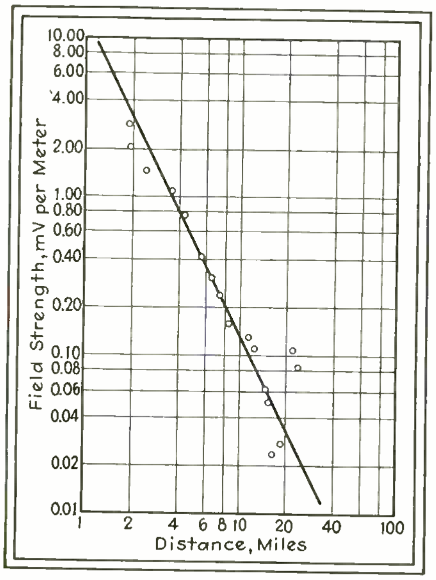

Fig. 2—Field strength vs distance for three meter waves plotted on logarithmic coordinates

the field strength is approximately inversely proportional to the square of the distance between the transmitter and the receiver.

The results show that an increase in the receiver elevation produces a correspondingly large increase in received signal. It was also found that if the receiver is located in a large open space, the passage of the signal over densely populated areas causes no large increase in attenuation. For distances up to the optical range of the transmitter and over a reasonably smooth portion of the earth's surface, the propagation characteristics of vertically and horizontally polarized waves are identical.

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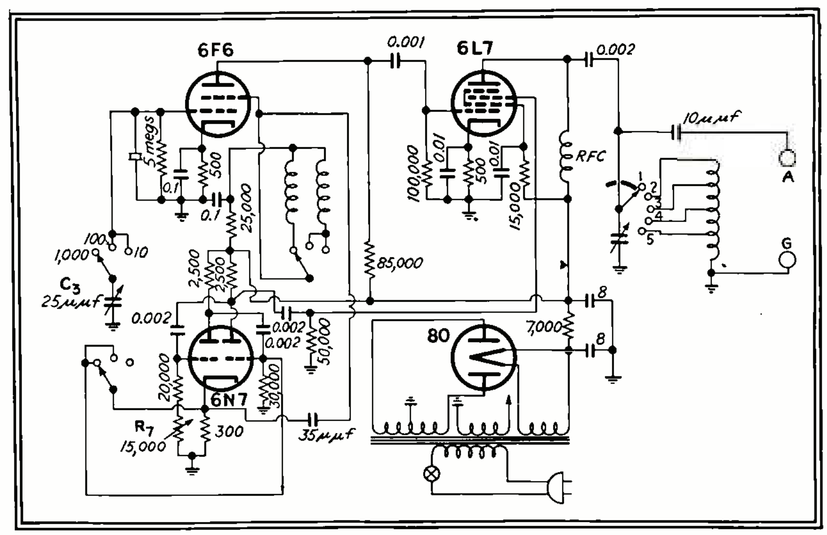
SAILPLANE HAS RADIO EQUIPMENT

Two-way radio communication for this unusual two place sail-plane enables the pilot to broadcast his position as he flies along, thereby enabling the ground crew to follow him on the ground, out of sight, by automobile. This close-up shows the complete radio equipment, which weighs only 12 pounds, complete. The unit operates at about 60 Mc

THE INDUSTRY IN REVIEW

Wide Utility Crystal Frequency Standard



Circuit diagram of the Hallicrafters crystal controlled frequency standard which provides signal of a wide variety of frequencies and is easily calibrated

A NEW crystal frequency standard which offers a number of interesting features is shown in the schematic diagram in the accompanying illustration. It is a refined type of the more conventional 1000-100 kc units which have come into popular use among laboratory technicians and servicemen. Like them it utilizes a Bliley type SMC-100 crystal which oscillates at 1000 kc or at 100 kc, the changeover being accomplished by switching coils in the oscillator tube circuit.

This Hallicrafters HT-7 Frequency Standard offers three outstanding features in that: (1) A 10-kc multivibrator is included, locked in with the 100-kc oscillator, (2) the 100-kc position of the oscillator provides for varying the crystal frequency over a small range to permit its adjustment to precisely 100 kc against any available standard such as the standard frequency transmissions from station WWV and (3) a tuned harmonic amplifier stage is built in which not only boosts the output at the higher harmonics but also provides for mixing the 100-kc and 10-kc outputs so that the 100-kc points serve as markers to facilitate identification of the 10-kc harmonics.

The 6F6 oscillator circuit differs from the conventional in the fact that the screen circuit is tuned, rather than the plate circuit. The plate is utilized for output coupling to the 6L7 harmonic amplifier. The capacity C_3 is located on the front panel of the instrument and is utilized in adjusting the crystal frequency. As indicated in the circuit diagram, this capacity is in the circuit only in the 100-kc and 10-kc positions. There is no provision for varying the 1000-kc oscillator frequency as any attempt to do so by means of shunt capacity results in unstable and sluggish operation of the crystal.

The 6N7 multivibrator circuit is adjustable by means of the variable grid resistor R_7 and locks in with the crystal circuit by virtue of the common coupling in the cathode circuit of the multivibrator tube. For most purposes the most desirable low-frequency output is 10 kc and the HT-7 units leave the factory adjusted for this frequency. However, the control knob of R_7 is located at the rear of the case, for use where some other multivibrator output frequency is desired, corresponding to other sub-harmonics of the 100-kc output of the oscillator.

The gang-switching arrangement is such that the 6N7 is operative only when the fundamental frequency selector switch is in the 10-kc position. In this position the 100-kc output is also present, to provide "marker" points as mentioned above. The multivibrator output is fed into the injector grid of the harmonic amplifier tube for electronic mixing with the 100-kc crystal output.

The coil switch in the output circuit provides for tuning the harmonic amplifier in the higher frequency ranges from approximately 4.0 to 40.0 Mc. Below 4.0 Mc there is little need for the additional amplification that would be provided by tuning this circuit. In position (1) of the switch, therefore, the inductance is out of the circuit. It is an interesting fact that if the tuned circuit is switched in, it serves as an effective variable attenuator at the lower frequencies. This is likewise true at the higher frequencies, allowing the output voltage to be varied over a wide range depending on how close to (or far from) resonance at the desired harmonic frequency this circuit is tuned.

The drift tendency of the HT-7 is that of the crystal itself and this is rated by Bliley at approximately 10 cps per megacycle per degree Centigrade for the 100-kc crystal position and 23 cps per megacycle per degree Centigrade for the 1000-kc position. Once the crystal is warmed up, the frequency becomes extremely stable. Checks of one of these instruments showed variations of less than 4 cps per megacycle for the 100-kc crystal position during a period of two hours (this was after the crystal had been allowed to reach stable operating temperature).

The HT-7 was produced primarily for the "ham" to enable him to check accurately his transmitting frequency and to calibrate his receiver bandspread dial. For such applications modulation of the frequency standard is not required and was therefore not included. Should a user require modulation it could probably be obtained by supplying one or more of the tubes directly from the rectifier output, but through a resistor capable of maintaining the original voltages applied to these tubes in the design of the HT-7.

The frequency range over which the harmonic outputs of this instrument are useful depends on the sensitivity of the receiver or other device into which it is worked. Checks of modern communications receivers show the 10-kc harmonics usable for calibration purposes up to over 15 Mc, the 100-kc harmonics to 60 Mc and the 1000-kc harmonics well beyond 60 Mc.

No attempt will be made here to point out the many applications for a device of this kind. It is not intended to replace signal generators, test oscillators or other similar equipment. It can, however, directly serve many of the purposes of such equipment. In addition it should find extensive use as a standard against which to check frequency calibrated equipment of all kinds.

News

✦ **Western Electric Co.** is prepared to manufacture frequency modulated radio broadcast transmitters. Under an agreement recently made with Major E. H. Armstrong, these transmitters will make use of the wide swing frequency modulation system developed by him; and will include also several important features which have been developed by Bell Telephone Labs. An initial experimental transmitter of 1 kw capacity is now in operation. The installation of the station was made with the cooperation of WOR to study the transmission characteristics of this new system which will carry the programs of the Mutual network on an experimental frequency allocation. Further development work is being carried on by Bell Telephone Labs., at the Western Electric Company's Kearny, N. J., Works and at the radio laboratory at Whippany, N. J. . . . Messrs. J. B. Parker and R. A. Mahler have severed relations with Harvey Radio Labs., Inc., of Cambridge, and, in conjunction with Mr. John M. Wells, have incorporated a new concern, **Harvey-Wells Communications, Inc.**, organized for the manufacture and sale of radio communication equipment of all types . . . The manufacture and sale of selenium rectifiers in the United States has been placed in charge of Mr. George Lewis as Manager of the Rectifier Division, **International Telephone Development Co.**, with factory and sales headquarters at 137 Varick St., New York City . . . Two contracts have been signed between **The Gray Mfg. Co.**, and **Electrical Research Products, Inc.**, a subsidiary of Western Electric Company. Under one contract The Gray Mfg. Co. retains the services of the technical consulting staff of Electrical Research Products with respect to certain design phases of the Gray Audograph. The other contract is an agreement for the exchange of patent rights . . . Ralph Layman, Jr., has joined the Fabricating Division of **William Brand & Co.**, Willimantic, Conn., as Chief Chemist. Mr. Layman was for several years engaged in the laboratory department of the American Cyanamid Corp., specializing in insulating varnish research . . . Due to a demand for its line of electronic devices, the **Worner Products** Co., has moved to larger and more modern headquarters at 1019 W. Lake St., Chicago . . . **Clarostat Mfg. Co.,** Brooklyn, N. Y., announced that Glasohms, or fibreglass power resistors and heating elements are now available to the radio trade generally. These Glasohms were described on page 64 of December *Electronics* . . . Mr. Robert Adams is now the new Sales Engineer for the **Oxford-Tartak Radio Corp.**, Chicago. Mr. Adams was previously associated with Stewart Warner Corp., as Superintendent of the radio division, and also with the G.E. and R.C.A. companies.

Literature

Transmission Line Fittings. Bulletin No. 101-D contains illustrations, diagrams and descriptive matter of solderless fittings for small copper tube transmission lines. Isolantite Inc., 233 Broadway, New York City.

Radio's Master Encyclopedia. The 1940 edition of the encyclopedia is now available. It consists of 800 pages and contains illustrations, prices and specifications of radio parts and accessories. The price of the book is $2.50 and it is available from United Catalog Publishers, Inc., 230 Fifth Ave., New York City.

Receiving Tube Manual. Technical Series RC-14 manual has been prepared to assist radio servicemen, radio technicians, experimenters, radio amateurs, and all others technically interested in radio tubes. 237 tube types are covered in numerical-alphabetical sequence for quick reference. The price of the book is 25 cents and can be obtained from any RCA tube distributor or from the Commercial Engineering Section, RCA Mfg. Co., Harrison, N. J.

Molding Machines. Catalog No. 906 contains information on completely automatic equipment for molding plastics and also catalogs of other machines available from F. J. Stokes Machine Co., Tabor Road, Philadelphia, Pa. Case histories are included as well as a material production conversion table.

Phano-Charger. Bulletin GEA-3179A describes Model CR7 501-K phano-charger, an adjustable, self-regulating battery charger for maintaining storage batteries by the floating method of charge. Characteristic data are included in the bulletin. General Electric Co., Schenectady, N. Y.

Insulator Data. A new 24-page indexed booklet recently issued by General Ceramics Co., 30 Rockefeller Plaza, New York City, contains complete data on Steatite and Ultra-Steatite low-loss insulators, coil forms, bases, etc. This catalog, No. 1000, covers mechanical tolerances, dielectric factors, electrical stability, etc.

Supplementary Listing Information. Supplement No. 4 to the 3rd edition of the Mallory-Yaxley Radio Service Encyclopedia is now available from P. R. Mallory & Co., Inc., Indianapolis, Ind. The Monthly Technical Service was more thoroughly described in the January issue of *Electronics*.

Home Study Course. A new 1940 information booklet describing a practical radio and communication engineering course designed for home study is now available from Smith Practical Radio Institute, 1311 Terminal Tower, Cleveland, Ohio.

Audiodiscs and Audiopoints. Several bulletins are available on products of Audio Devices, Inc,. 1600 Broadway, New York. One 9-page booklet tells about audiodiscs and audiopoints and how to test them. This information includes chemical, physical and sound properties, a frequency response chart, a chart showing the response vs. diameter, etc. Other bulletins are entitled "Cutting & Playback Audiopoints for Instantaneous Recordings"; "How to Make a One-Man Recording" and "Audiodiscs."

Photoelectric Products. "Fotolectric" products such as light relays, burglar alarm systems, and an experimenter kit are described in a bulletin called Worner Fotolectric Products distributed by Eastern Sales Office, released by Worner Fotolectric Products, 671 W. Ohio St., Chicago. Model 601 Announcer is described in another bulletin. Either of these pieces of literature may be obtained from either Worner or Eastern Sales Office, 265 West 14th St., New York City.

Transmitting Tubes. Bulletin GEA-3315 contains new prices and other characteristic data of high-vacuum air-cooled and water-cooled radio transmitting tubes, as well as mercury-vapor rectifiers and gaskets for water-cooled types. Radio & Television Dept., General Electric Co., Schenectady, N. Y.

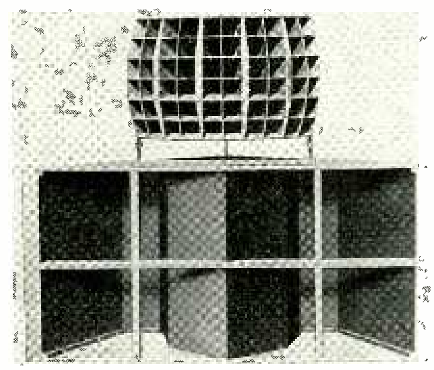
Microphones and Equipment. A new 8-page catalog, No. 60, illustrates and describes all the microphones and equipment of Turner Co., Cedar Rapids, Iowa. The catalog includes a description of the new Model U-9 Multi-Flex microphone.

Recording Blanks. An 8-page booklet gives information about the Gould-Moody Co., (Recording Blank Div., 395 Broadway, New York City) and its process in manufacturing recording blanks.

Rotary Converters. A new bulletin, No. 13-25, supplies information on rotary converters to be used for changing d-c to a-c for loads of 85 to 100% power factor for use with radio receivers, amplifiers, phonographs, sound pictures, electric organs, PA systems, musical instruments, etc. Janette Mfg. Co., 556 W. Monroe St., Chicago.

Ward Leonard Equipment. A new series of bulletins describing equipment of Ward Leonard Electric Co., Mount Vernon, N. Y., are now available.

Tin. The fourth issue of "Tin and Its Uses" is available from International Tin Research and Development Council, Fraser Road, Greenford, Middlesex, England. This new issue announces a new "white bronze" plating which competes with chromium in its resistance to tarnish and is almost similar in color and reflecting power to polished silver. A new thick tin lining is also described.



Jensen Type B Speaker System

Alloys Data Book. R-40 Data Book contains information on electrical heat and corrosion resisting alloys. Driver-Harris Co., Harrison, N. J.

F-M Transmitters. Bulletin GEA-3327 includes technical information as well as a general description of the G.E. 1 kw frequency modulation transmitter which incorporates the 250 watt exciter (Model 4GG1A1) and the 1 kw amplifier (Model 4AF1A1).

Speaker Equipment. A catalog describing the entire new line of full range speaker equipment is available from Jensen Radio Mfg. Co., 6601 S. Laramie Ave., Chicago.

Steel Cutting Needles. American made, Bragshaw steel cutting needles are described in a leaflet issued by H. W. Acton Co., Inc., 370 7th Ave., New York City.

New Products

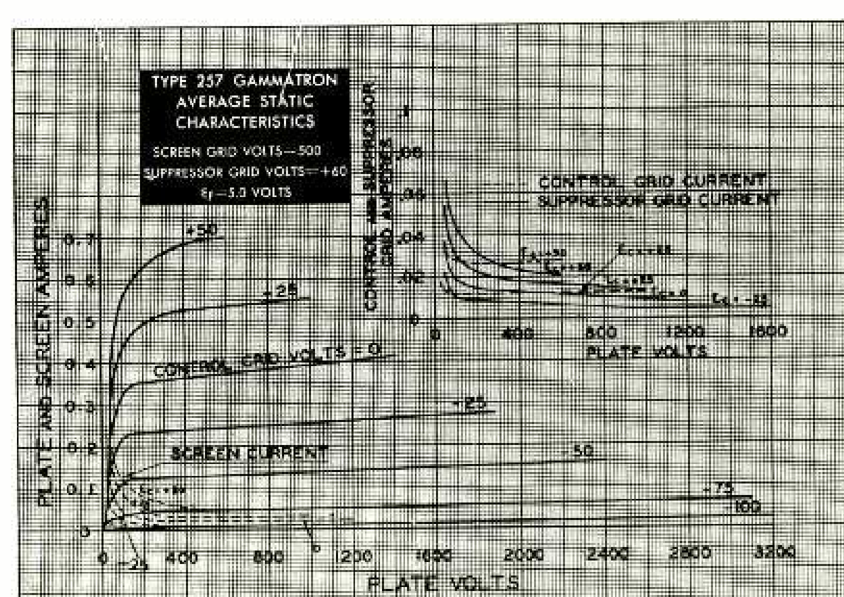
Gammatron

HEINTZ & KAUFMAN, LTD., South San Francisco, Cal., announce Type 257 Gammatron, which offers a number of features in a multi-element transmitting tube. The elements which are constructed entirely of tantalum and are mounted directly on a molded base without the use of internal insulators make it possible to pump this tube under extreme temperature and to maintain a vacuum under operating conditions without the use of a chemical agent or "getter." The elimination of insulators and the unique construction of this tube provide feedback capacity from plate to grid of approximately ⅓ of that in other tubes. Thus the tube will operate on higher frequencies without fear of self-oscillation. Dual screen grid and suppressor grid leads result in very low inductance drop.

Signal Generator

THE NEW LOW-COST RCA "Signalyst", is a signal generator designed for increased efficiency in radio and television receiver alignment work. Simple to operate, the Signalyst is useful for r-f and i-f alignment of radio broadcast receivers and special receivers operating in the u-h-f bands, for television overall tests when modulated by square waves of composite picture signals, and for direct calibration of television receiver local oscillator when used in conjunction with the Piezo electric calibrator. The Signalyst has a fundamental frequency range of 100 kc to 120 Mc on 10 bands. It is accurate to within plus or minus 1% scale calibration. Output is available at the end of a coaxial cable. This new service instrument is an important companion to the Rider Chanalyst and the Rider VoltOhmst recently acquired by RCA.

Heintz & Kaufman Ltd. Type 257 Gammatron described above



Another device available is a robot electronic switch, known as the RCA Electronic Control, which is a capacity-operated relay. No photocell or light beam is utilized. Instead, the relay responds to the change in electrical capacity which takes place when a person approaches. The new device has many uses for advertising displays and for unique lighting effects.

RCA's New Signalyst

Model 64-B is a new monitoring loudspeaker employing a newly designed permanent magnet mechanism. It is housed in a modernistic cabinet which permits an unusually wide angle of sound distribution. Frequencies between 60 and 10,000 cycles are faithfully reproduced with very low distortion through the coordinated design of speaker and cabinet.

All three products mentioned above are available from RCA Mfg. Co., Camden, N. J.

Air Vise

A NEW PNEUMATICALLY OPERATED vise designed for production work where time in handling is an important factor in manufacturing costs is available from The Larkin Air Vise Co., Portland, Conn. This vise is applicable to drill press work, bench work, shaping, etc., and comes in five sizes ranging from 4 to 8 ins. in jaw width. It is supplied with hardened and ground jaws, flanged base and hand operated control valve. Special jaws to fit any work, swivel and universal bases and foot operated valves are also available.

Cornell-Dubilier Products

NEW COMPACT CAPACITOR decade boxes (size 3⅝x5x3 ins.) provide a wide variety of capacity standards. The CDA-5 box, for instance, provides values of .0001 to .011 μf in steps of .0001 μf or a total of 100 different capacity combinations through the medium of its two 10-position switches. The Model CDB-5 is similar except that its range is .01 to 1.1 μf. The CDC-5 with a range of 1.0 to 10.0 mfd has a single switch which provides steps of 1 μf. These boxes may be used singly or in combination. The three in combination provide a range of .0001 to 11.1 μf in steps of .0001, or a total of 100,000 different capacitor values. Each switch position is directly calibrated and the values are accurate within $\pm 5\%$ of the actual values. In addition each box is accompanied by an individual chart giving the exact values for each switch position. Model CDB-3 and CDC-3 boxes are similar to the CDB-5 and CDC-5 models except that they provide the narrower tolerance of 3%.

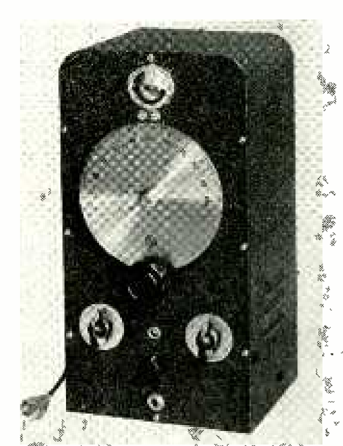
MICA CAPACITORS for heavy-duty commercial services such as high-frequency C. W. furnaces or bombarders are available in a wide variety of capacity and current handling ratings in the Cornell-Dubilier Type 75A units. The capacity range is from .001 to .05 μf. Maximum current ratings are from 7 to 100 amps at 100 kc and 45 to 80 amps at 3000 kc. At 300 and 1000 kc currents up to 125 amps can be safely handled.

Soldering Irons

HEXACON ELECTRIC Co., 161 W. Clay Ave., Roselle Park, N. J., announce a new number to their line of electric soldering irons, which is a screw-type tip, with a diameter of 1⅝ ins. 700 watts, catalog No. 700. The new iron is suitable for extra heavy soldering jobs and due to its hexagon shape can be held in a vise when replacing or filing tip, without danger of denting outer housing and damaging element.

Frequency Monitor

THE BROWNING LABORATORIES, Winchester, Mass., have a custom-built laboratory calibrated frequency monitor (Type S-1) for checking frequencies from 1.5 to 60 Mc. A 100 kc crystal is used as a secondary standard. This may be readily checked against WWV. Stable electron coupled oscillators are used to cover a band of frequencies from 50 to 100 kc wide. The transmitter frequencies which it is desired



to check are included in this narrow band. The circuit is so arranged that the oscillators can be accurately checked at numerous points by means of the 100 kc crystal. Transmitter frequencies are checked by the zero beat method which is indicated visually on a cathode ray tube and aurally by means of phones plugged into a jack. The accuracy of this monitor is better than .01%.

Porta-Power

A NEW ADDITION TO the Porta-power family of General Transformer Corp., (1250 W. Van Buren St., Chicago), is the "Twin-power" Model "P" which was designed to solve the problem of eliminating batteries in six volt sets. By providing separate sources of supply to the filaments and to the vibrator, the vibrator disturbance is eliminated and high fidelity performance is assured.

Pocket-size Battery Tester

A POCKET-SIZE BATTERY tester has been announced by Weston Electrical Instrument Co., (Newark, N. J.) to meet the need for a compact, inexpensive unit for correct testing of dry batteries under load. The tester will provide positive data about new batteries as well as batteries in service without the need for duplication of any existing test equipment. For the sake of a layman, the scale consists simply of a "Replace-Good" indication. Pin jacks are provided for the different battery voltages encountered.

Experimental Set

A NEW LOW COST, COMPLETELY assembled photoelectric and capacity relay experimental set is available from Rehtron Corp., 2159 Magnolia Ave., Chicago. This simplified, multi-purpose apparatus consists of a photoelectric Robot relay, a long range light source with infra-red filter, and a signal switchboard equipped for both audible and visible signal demonstrations. It operates on 115 volt, 50-60 cycle outlet. The Robot relay and light source may also be used for other permanent practical installations (no batteries are required). The unit is designated as Model E-77.

Hole Piercing Machine

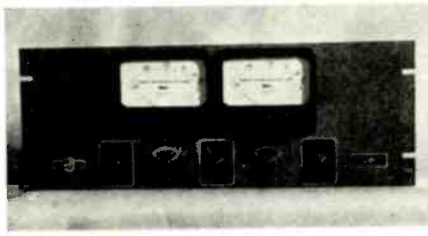
AUTOMATIC MFG. CO., INC., 850 Passaic Ave., Harrison, N. J., have available a multiple hole piercing machine (Model 1001) which will punch holes in paper, bakelite, or similar tubes, also in small zinc or aluminum cans. Practically any number of holes within reasonable limitations can be punched in one operation. The size range is from ⅜ in. to 2 ins. inside diameter. These holes may be spaced in practically any position around the tube and for a length of approximately 6 ins. Additional information may be obtained from the manufacturer.

D-C Motors

KATO ENGINEERING CO., Mankato, Minn., have designed a line of d-c motors which in addition to driving a piece of equipment also furnish 60 cycle a-c current for the operation of an auxiliary function.

Phase Monitor

A NEW TYPE 798 PHASE Monitor for rack and panel mounting has been announced by Victor J. Andrew, 6429 S. Lavergne Ave., Chicago, for adjusting and aiding in the maintenance of the phasing networks of a three element directional antenna. The unit consists of two complete monitors built as a single rack and panel instrument, al-



lowing simultaneous monitoring of phase between a center and two outside towers. Each phase angle is continuously indicated directly in degrees, between 0 and 180 by a large panel d-c meter which is also usable for third and fourth quadrant angles. Phase angles may be read at a glance.

Phenolic Molding

A NEW, EASILY PREFORMED, high-impact phenolic molding material, known as Durez 1900 Black, has been announced by Durez Plastics & Chemicals, Inc., North Tonawanda, N. Y. This molding material will flow through hoppers and automatic feeding devices easily, and is suitable for parts requiring a high-impact material.

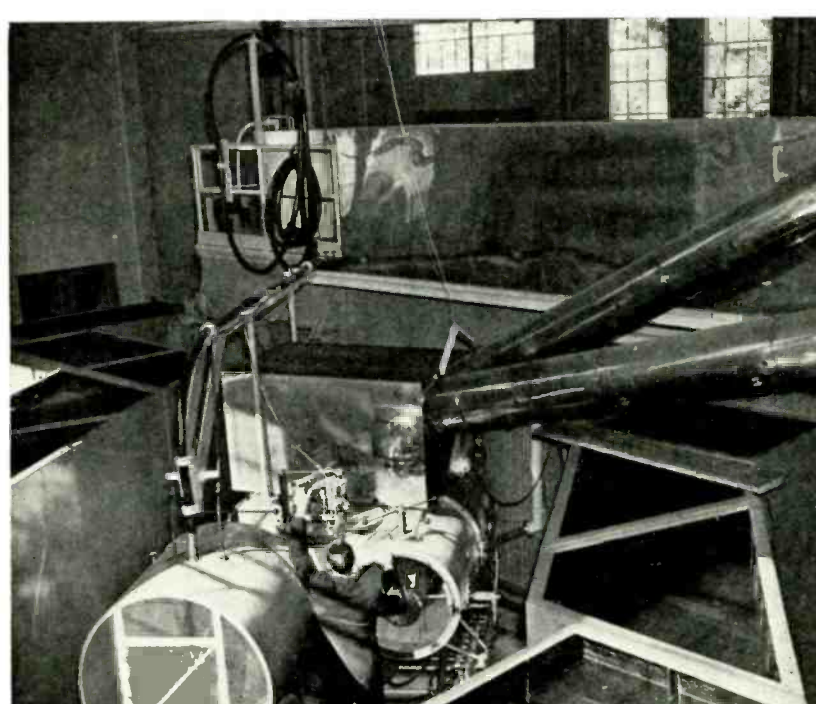
Dry Battery Tester

A NEW POCKET-SIZE TESTER, (Model 245), for testing dry batteries under load, has been introduced by Simpson Electric Co., 5216 Kinzie St., Chicago. An artificial load is introduced into the circuit, within the meter. A toggle switch is provided to switch the load off and on, providing a comparison between readings with load off and load on. The tester is available in six voltages, covering the popular sizes of "A" and "B" batteries.

Volt-Ohm-Milliammeter

JUMBO, MODEL 4922-S, is a new Hickock Instrument (419 Erie Bldg., Cleveland) with a 9¼-in. rectangular meter which is easily read at any angle and from a distance. There is a potentiometer adjustment for change in ohmmeter circuit battery voltage. Change in battery voltage does not affect the accuracy of the ohm readings. This instrument incorporates a new type rectifier circuit designed to withstand more overload. The ranges have been extended to cover practically all applications of electrical measurements.

220 TON CYCLOTRON



A view of the huge 220 ton cyclotron at the William H. Crocker Radiation Laboratory of the University of California. The vats of water surrounding the machine are for radiation protection for the workers. The tubes above lead from the oscillator

Marine Radiophone

A NEW AND COMPACT 25-watt radiophone for small boats is the Model HT-8 announced by Hallicrafters, Inc., Chicago. It provides 2-way communication with other boats, land telephone and Coast Guard stations. Any one of five crystal-controlled frequencies is selected by a rotary switch and another switch gives choice of five corresponding receiving frequencies plus an extra weather report channel. All circuits are internally pre-tuned during installation of the equipment.

The transmitter and receiver are inclosed in a single cabinet designed either for table or bulkhead mounting. The power supply is separate and connects to the main unit by plug and cable. Power is drawn from the boat's battery but by inter-changing one plug provision is made for operation from any 110-volt a-c line.

ALSO ANNOUNCED by Hallicrafters is a 12 tube amateur communications receiver, the Super Defiant, which features an overall range from 540 kc to 42 Mc. Every function is controlled from the front panel. It operates on 110 volt 50–60 cycle and may be adapted to d-c operation, if desired.

• • •

"DESIGN COMPUTER" FOR AIRPLANES

Lewis L. Imm, formerly with the Bureau of Air Commerce is shown here with his "Librascope", a design computer which engineers use to obtain maximum aeronautical efficiency from airplanes in the making. It will also correlate meterological reports from all parts of the country, as well as enable the designer to compute maximum speed, climb, altitude, etc. merely by properly operating the several dials. The device is a type of calculating machine which shows the results of several variables in a series of simultaneous equations.

Narrow Band Transmission

(Continued from page 17)

ϕ_s (q) of Equations (7) cause the frequency response characteristic of the output to be approximately as shown in Fig. 5.

The amplitude of any distortion frequency in Equation (8) is given by

$$B\ J_o\ (x) \cdot Js\ (x) \cdot \phi\ (q)$$

or

$$B\ [J_s\ (x)]^2 \cdot \phi\ (q)$$

where s is the particular value chosen for n.

It is known that when the argument $x = \frac{\omega_o h}{p}$ becomes very large, the value of the term J_o (x) becomes very small. The maximum value of any term of J_n (x) $(n = 1, 2, \text{etc.})$ also becomes small. For $\frac{\omega_o h}{p} > 70$, these values are all less than 0.1, so that the product $J_o\ (x) \cdot J_n\ (x)$ or $J_n\ (x) \cdot J_n\ (x)$ is always less than 0.01. Since the amplitude factor $\phi\ (q) \leqq 1$, the distortion frequencies can be disregarded for all practical purposes.

The above analysis is applicable only when the oscillator frequency is changing. Let it be arbitrarily assumed that for one-third of the time the oscillator frequency remains constant at its maximum value, and that for another third of the time it remains constant at its minimum value. In this case, the total reproduced frequency range, as perceived by the ear, will correspond to that provided by a transmission channel having the frequency response characteristics shown approximately in Fig. 6.

A simplified block schematic diagram of the entire demonstration system is shown in Fig. 7. The signal source was a broadly-tuned radio receiver set to station WJZ. The automatic volume control was operated from the audio output of this receiver and was used to maintain a fairly constant long-time average volume level. When the throw-over switch S was placed in the dotted position the carrier frequency was kept constant at 10,000 cps so that only those signal frequencies ranging from 1500 to 3000 cps were transmitted and reproduced.

Extended listening tests were

made using numerous observers, all of whom chose the new system as giving the best quality, the usual report being "a vast improvement." None of these observers reported noticing any loss of the high frequencies when the transmission was changed over to the new system, and no distortion was perceived at any time either in speech or in music. The loud speaker was operated at comfortable room loudness.

Although listening test reports such as these are necessarily subjective, they nevertheless indicate that the desired result was satisfactorily accomplished.

References

1. E. H. Colpitts and O. B. Blackwell, *Carrier Current Telephony and Telegraphy, Trans. A.I.E.E.*, Vol. 40, pp. 205–300, 1921.
2. G. A. Campbell. U. S. Patent 1,671,143, "Wave Translator."
3. J. C. Steinberg, U. S. Patent 1,836,824, "Wave Transmission with Narrowed Bands."
4. W. T. Wintringham, U. S. Patent 1,821,997, "Compression of Frequency Range".
5. B. von der Pol, *Frequency Modulation, Proc. I.R.E.*, Vol. 18, pp. 1194–1205, July, 1930.

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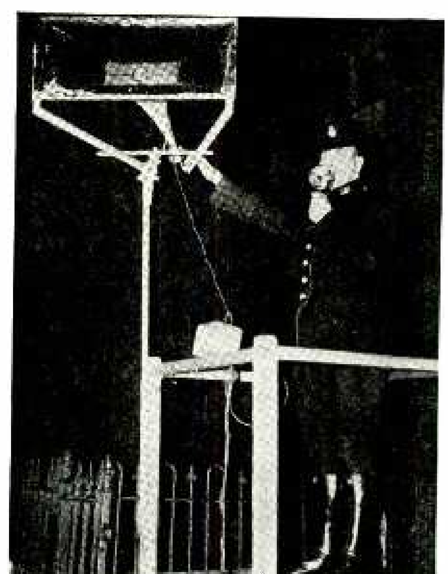
LOUD SPEAKER SOLVES BLACKOUT PROBLEM



The problem of traffic control at Trafford Bar, Manchester, England, where five roads meet has been solved as a result of recent blackouts. White-coated policemen, using red and green lamps, co-operate with the officer on a look-out platform who directs traffic through the speaker

Business of Television

(Continued from page 13)

grams, and the number of program hours have been steadily increasing.

2. Considering the fund of experience and experienced personnel being accumulated month by month, each dollar can be spent more wisely and effectively.

3. Basing one version of "Efficiency" on the average cost per program hour on the air gives the story month by month as shown in accompanying Figure.

It can be seen that the cost per hour in November was 45 per cent of that in May. Of course, there are many reasons for this, besides the one of getting more experience and knowledge of operation. For instance, one other factor is that of utilizing a given "Unit Crew" for the maximum number of hours possible in a work-week, etc.

Of paramount importance is the question, "How is television doing in respect to possibilities of supporting itself as a business venture?" More than five years of active analysis and nine months practice in operation have established certain data. Theorizing for the future, once nebulous but now being nurtured by experience and time, is becoming clearer and more practical.

N.B.C. operated during the past nine months, as did all television stations in the country, on an experimental license. However, for three and one-half years, prior to public service in April, 1939, a considerable amount of research was conducted on the advertising aspects of television. In fact, programs thought suitable for advertising purposes, involving products of many different industries, were tried, using both live-talent studio shows and regular commercial film. A considerable number of manufacturers and advertising agencies cooperated in the production of these shows.

All this, naturally, was done anticipating that television would eventually become an advertising medium. N.B.C. could not plan an immediate sale of its television time as is done in sound broadcasting.

In the meantime it busied itself creating as much program variety as possible in order to build a fund of experience which, it is hoped, will be of much value at such a time when television broadcasting is commercial in the same sense that sound broadcasting is at present.

A point has been made to keep advertisers and advertising agencies constantly informed on the progress of television broadcasting. This service is and has been in the form of lectures, letters, monographs, personal meetings, and an open invitation to all qualified advertising men to visit the television plant. This policy reaped excellent response, with the result that there is now a considerable file of information on the advertising potentialities of television broadcasting.

One phase of cooperation with the advertising industry was to issue an invitation to all advertising agencies to appoint a liaison post in each agency to act as a clearing house for the agency on television matters with N.B.C. There is now quite a long list of agencies who have responded and have been working with the N.B.C. in this manner.

Along with this open policy with the advertising industry, any and all were invited to work with the N.B.C. in putting on shows using facilities at no cost. The results of this offer are self-evident from the facts that 73 different advertisers have cooperated with N.B.C. on 148 individual programs in the first eight months. The 73 advertisers represent seventeen of the major industries. The experimental advertising shows have been broadcast using all three types of program facilities and accounted for about 12 per cent of the total program time.

A word might be said here for the wisdom of permitting a more or less unhampered experimental activity, because by allowing the technique of presenting advertising programs to grow hand in hand with the technique of presenting sustaining programs, the development of a rounded program service for the public is created, instead of a patched-together program fare, which could have been the case if television were suddenly to become commercial without the actual experience in advertising show building over the same length of time as that devoted to the study of sponsored show building.

Patents

Telemetering System. Method involving frequency variations, means for isolating the supply current carried by the conductor from the frequency varying voltage, etc. No. 2,172,918. E. G. Watts, Pittsburgh Equitable Meter Co.

Measuring Apparatus. An electron tube recorder, for example, one recording variations in temperature in a furnace. A voltage variable in phase in accordance with the deflection of a controlling element including a light sensitive device is utilized. No. 2,172,064. T. R. Harrison, Brown Instrument Co.

Balancing Machine. Means for supporting the part to be balanced so as to permit it to perform a gyratory movement, means for rotating the part, means for correcting the part for unbalance, etc., involves a vacuum tube. H. O. Fuchs, G. M. Corp. No. 2,171,927.

Electrotherapeutic Device. An oscillation generator for electro-therapy comprising two pairs of two vacuum tubes each, input and output circuits connecting the tubes in said pairs symmetrically with respect to each other. H. W. Parker, Rogers Radio Tubes Ltd. No. 2,171,670.

Welding Apparatus. Method of controlling the space gap between an electrode and a work piece during arc welding comprising impressing a welding current made up in part of a high frequency high voltage arc maintaining current across the gap, bypassing a portion of the high frequency current around the gap and utilizing the voltage fluctuations in the by-passed portion incident to variations in the break-down voltage in the gap to actuate means advancing the electrode towards the work piece when the voltage approximates a determined maximum and to retract the electrode when the voltage approximates a determined minimum. K. Heindlhofer. United States Steel Corp. No. 2,173,446.

Burglar Alarm. Apparatus for detecting the movement of metals permeable to magnetic lines of force through a zone of detection. Several coils positioned laterally and at the opposite sides of the zone of detection have between them an alternating current field which is disturbed and thereby affects an amplifier when metal permeable to magnetic lines of force pass through the field. J. C. Becker, Everett Experimental & Development Co., Shanghai. No. 2,181,648.

Cardiograph. Contact members adapted for drawing an action voltage from a human body including means for amplifying the voltages and for recording them. H. E. Hollmann, Radio Patents Corp., No. 2,150,223.

Headlight Control. Use of phototube and amplifier for automatically dimming the lights of a vehicle in response to the approach of an oncoming vehicle. R. E. Alley, Austin, Minn. No. 2,150,-900.

Message Detector. Use of phototube in connection with an endless moving belt for controlling the rate of flow of messages on the belt. R. W. Stain, Western Union Tel. Co., No. 2,150,467.

Automatic Cutting Machine. System of control for a milling machine. Wilhelm Chladek, W. E. & M. Co. No. 2,151,743.
See also No. 2,150,430 and 2,150,431 and 2,150,440, all to the Western Union Tel Co. on conveyor systems.

Communication System. An inter-office type of communicator system, using a single double-purpose tube. H. J. Nichols, I. B. M. Co. No. 2,150,-241.

Motion Control. Phototube means for controlling the operation of several motor-operated traveling devices such as cranes, etc. H. W. Ball, Morgan Engineering Co., Alliance, Ohio. No. 2,-181,778.

Traffic Analysis. Vacuum tube circuit arranged so that a first closer circuit operates when a traffic unit crosses a given point, a second circuit closer operates when the traffic unit crosses a second more advanced point, etc. C. D. Greentree, G. E. Co. No. 2,181,728.

Motor Control System. Means of controlling the direction of motor rotation by means of light sensitive devices. Britton Chance, Mantolooking, N. J. No. 2,182,717.

Therapeutic Apparatus. Method of producing alternating current, pulsating direct current, oscillating current, galvanic current, thermionic means for periodically varying the current amplitude, etc. J. H. Dobert, Millvale, Pa. No. 2,182,223.

British Patents

Tabulating Machine. Statistical record cards, etc., are duplicated by optically scanning each column in turn, the receiver operating in synchronism with the scanning means. The device is photo-electrically controlled. British Tabulating Machine Co. Ltd. No. 502,692.

Headlight Adjustment. Photo-electric means of adjusting a beam of light. British Thomson-Houston Co. No. 501,712.

Broaching Machine. A hydraulic broaching machine is provided with a photo-electric relay which operates a valve controlling the movement of the main ram to operate the broach on its return upward movement. Lapointe Machine Tool Co., Ltd. No. 502,326.

Calculating Machine. Photo-electric means and rotable perforated plates for producing the light impulses. A. Lannert. No. 502,560.

Copying Apparatus. Apparatus for duplicating three-dimensional objects comprises an optical unit having means for projecting a beam of light towards an object or pattern to be scanned, to produce an image on the surface of the object with a sharply defined contour line, and having a light-sensitive cell system supported in fixed angular relation to the projector with the line of sight of the cell intersecting the contour line of the image. L. M. Jackson. No. 507,235.

Precipitation Apparatus. Patents Nos. 502,999; 504,901, and 506,896 to Lodge-Cottrell.

Exposure Meters, etc. Patents Nos. 504,203 and 504,211 to Zeiss Ikon. Nos. 504,786 and 504,805 to H. F. Tonnies. No. 505,195 to S. F. Warren and No. 506,219 to J. M. Bing.

Ammonia Tester. Liquids to be tested photo-electrically are first subjected to temperature conditions in a chamber in communication with an observation chamber in which the liquid passes between a source of light and a light sensitive element. No. 509,061. V. H. Gilbert.

Exposure Control. No. 509,108 British Thomson-Houston Co. on a photo-electric exposure meter, and No. 509,-260, an apparatus for adjusting the speed of operation of the shutter or the size of aperture of photographic apparatus by the use of a phototube and galvanometer. I. G. Farben.

Electrode Materials. A secondary-electron-emissive material consists of one or more of the sulphides, oxides or selenides of the alkaline earth metals mixed with not more than 0.1 per cent of a finely divided heavy metal such as copper, bismuth, lead, manganese, nickel or antimony. The material is similar in composition to known Lenard phosphors, but with two or three times as much heavy metal. Preferably, there is added not more than 10 per cent of a fusible flux, for example lithium, sodium or potassium phosphate, sodium or potassium chloride or magnesium, sodium or calcium fluoride or mixtures of these; if the alkaline earth oxide is added as hydroxide, the flux may be dispensed with. The emissive material may contain up to 50 per cent of alkaline earth sulphates, carbonates or nitrates as dilutents. The mixture is prepared in aqueous or alcoholic solution, any insoluble compounds being ground up or precipitated so as to be capable of suspension or reduced to colloidal form; for example, a colloidal solution of calcium carbonate is prepared by passing carbon dioxide through a suspension of calcium oxide in menthyl alcohol. The layer may be not more than 10^{-4}mm in thickness, preferably applied to a base of nickel or iron sintered on to the electrode in hydrogen. No. 507,589. Siemens & Halske.

Fluorescent Material. Red-fluorescent material, more particularly for use with discharge lamps, comprises heat-treated magnesium oxide, silica, and an activator such as manganese, prepared by mixing the finely-divided oxides in molecular proportions, with addition of less than 2 per cent of a manganese compound, e.g., oxide, nitrate or carbonate, and firing at about 1250°C or lower for an hour or longer. The material may be applied to the interior of the envelope of a low-pressure discharge tube filled with rare gas such as argon, krypton, neon orxenon, at a pressure of 1-10 millimeter of mercury. It may be attached by a bond such as glycerine, a mixture of glycerine and boric acid, potassium silicate, castor oil, or phosphoric acid; or may be embedded in the glass by heating this to the softening temperature. No. 507,639. British Thomson-Houston Co.

Tube Operation. The working point of a tube is arranged to be on a part of the grid-voltage/anode-current characteristic where the curve can be represented by the equation $I_a = KU^n$ where I_a is the anode current, U the grid potential, K a constant and n is less than unity so that the effective input capacity is less than the cold capacity and may be negative. The tube may be used in a short-wave tuned amplifier or a wide-band resistance coupled amplifier. The variation of input capacity with grid bias may be utilized to frequency modulate oscillations produced by the tube by virtue of its negative input capacity or a feed-back circuit, or to vary the frequency of oscillations produced for automatic tuning in a radio receiver. No. 508,043. Telefunken.

Light Modulator. In a light modulator the mechanical wave generator consists of several portions, the natural resonant frequency of one portion or a number of portions being different from that of other portions. In one embodiment, two piezo-electric crystals of different natural frequencies are mounted side by side to produce two trains of waves, and both are supplied at a carrier frequency midway between their resonant frequencies so that the overall frequency response curve of the device exhibits a band-pass characteristic. The electrode nearest the liquid may carry a layer of substance known as "Cellophane" which serves to broaden the frequency response curves of the crystals. In another embodiment, a number of small pieces of crystal may be mounted on a suitable carrier, e.g. crystal chippings of required frequency left over when cutting quartz crystals to required shapes, may be cemented into a mosaic, and by choosing their natural frequencies and relative proportions the device may be given almost any desired characteristic. No. 508,065. J. Sieger and F. Okolicsanyi, Scophony, Ltd.

Electrical Depositions. In a process for metallizing metal articles, the cathode is cooled, and the input of energy is such that the articles, which may form the anode or may not be connected to any potential source, acquire a temperature of 300°C. A copper article, for example, is degassed, cleaned and heated, for five minutes, to a temperature of 950°C by cathodic bombardment in hydrogen. A slight deposition of silver from the cathode accompanies the heating. Subsequently, the gas pressure is increased, e.g. to 2–3 mm, and the loading is adjusted so that the article is heated to 800°C and silver is deposited; the silver alloys with the copper. After half an hour, the temperature of the article is reduced to 600°C and is then slowly reduced to 400°C to form a layer of pure silver. In another form, the silver is deposited at a temperature at which the silver only diffuses into the surface and the alloy is not formed, the article being heated subsequently to form the alloy. A number of intermediate layers of different metals may be produced. The energy input may be at least one watt per sq. cm. of cathode surface. No. 508,278. B. Berghaus.

Floating Carrier Transmitter. A controlling bias is required to decrease with increase in modulation level, the bias potential including the voltage drop across a resistance in the anode-cathode circuit of an anode bend rectifier which, in the absence of modulation, is biased approximately to cut-off. No. 508,515. Marconi Co.

Cathode-ray Tubes. A screen for a cathode-ray tube, either of the luminescent or the iconoscope type, is so arranged that only a small portion of it is scanned, and is rotated by the impact of the ray so that that portion is continually charging. For this purpose it may be formed with impressed wings on its edge or oblique blades like a turbine rotor. In a gas-filled tube the rotation may be aided by the radiometer effect, for which purpose appropriate portions of the wings are blackened. The screen may be formed with blackened cooling-rings cooperating with other members on the envelope of the tube, which may be of metal. No. 508,712. Scophony, Ltd.

INDEX TO ADVERTISERS

SEARCHLIGHT SECTION
(Classified Advertising)

Package Control. In packing oval cigarettes so that the imprints are all on one side, the cigarettes are fed in rows through a sorting device in which each cigarette is placed on a movable support, and those which require to be turned are lowered into a mechanism for turning them and then restored to their normal position, after which the feed of the row is continued. This sorting is controlled by photoelectric cells. F. Lerner. No. 503,142.

Boiler Supply Controller. Water supply to lavatory fittings, etc., is automatically controlled by the user crossing a light ray. Gummers, Ltd. No. 504,185.

Sorting Apparatus. This patent relates to apparatus for sorting objects according to their effects on a light beam by means of an air jet controlled by photo-electric device. E. T. Both. No. 504,683.

Recording Device. A system for optically reading printed, stencilled, etc., records in which an image of the original character is compared with a standard character so as to obtain coincidence between the two when they are of similar nature, the image of one character is formed in the plane of the other a number of times, each time in a different position relating to the second character. British Tabulating Machine Co. No. 504,719.

Printing Control. In feeding sheets, especially in color printing machines, the sheets are registered to lay marks thereon in such a manner that any error in registration due to humidity or other cause is distributed about a predetermined point on the sheet, the registration of the sheet being controlled automatically by photoelectric devices influenced by the lay marks. Waterlow & Sons, Ltd. No. 504,818.

Engraving Machine. Engraving tools are moved to and from the work under the control of a light-sensitive cell controlled by the shading on a record. L. M. Jackson. No. 505,081. See also No. 505,437 to J. W. Dalton on copying by scanning. This patent relates to apparatus for obtaining relative motion in two dimensions between an object, such as a metal plate and a device such as an engraving tool. See also No. 506,259 (The Interchemical Corp.) on a method of color reproduction using a color separation image in which the effect of light in one spectral region is subtracted from that in another spectral region.

Radiation Thermometers. Apparatus responsive to heat radiation comprises two photo cells of the polarized vacuum type arranged in opposition so that ambient temperature affecting both cells equally is balanced out and the apparatus responds only to radiation received by one cell, the other cell being enclosed in a heat-screening enclosure. Foster Instrument Co. No. 506,596.

GIVE YOUR TABLE MODEL CABINETS

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WITH COLORFUL BAKELITE PLASTICS

A PRACTICAL METHOD of adding sales-winning variety to table model receivers can be achieved, at low cost, by molding cabinets from colorful Bakelite Plastics.

These versatile molding materials are available in a complete range of colors that retain their original lustre indefinitely. The colors are self-contained and therefore cannot wash-off or wear-off, despite constant handling.

Bakelite Plastics offer, also, important savings in radio cabinet manufacture, by the simplified mass production methods they afford. Costly, time-consuming polishing and other hand finishing steps are eliminated. Since cabinets of Bakelite Plastics are formed completely in the one molding process, assembly operations are reduced to a minimum.

Obtain additional information on these sales-winning, cost-cutting materials by writing for illustrated booklet 13P, "New Paths to Profits". It describes, in non-technical terms, the benefits obtained through the use of versatile Bakelite Plastics.

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