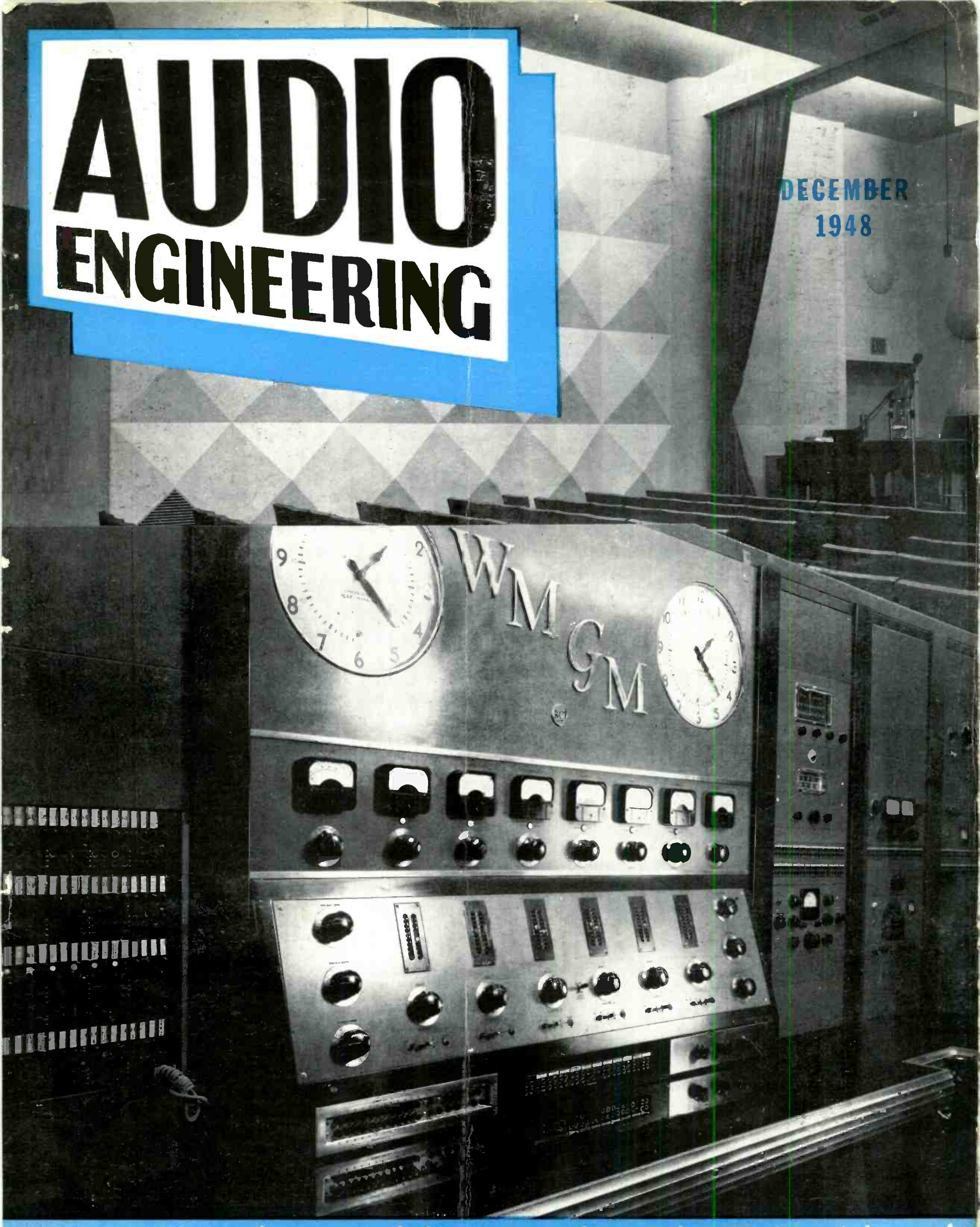
AUDIO ENGINEERING

DECEMBER
1948



THE JOURNAL FOR SOUND ENGINEERS

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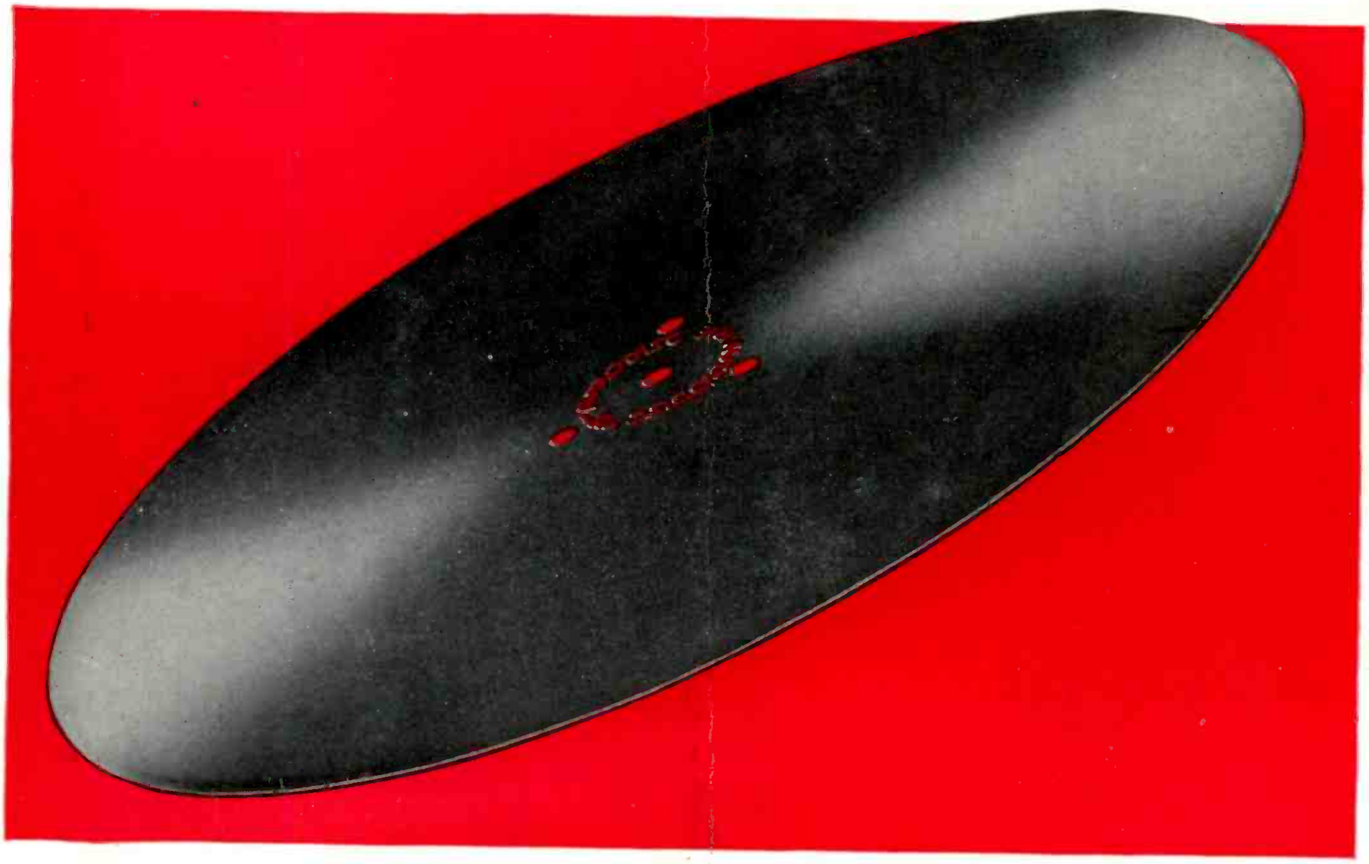

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COVER

Cover montage illustrates studio acoustic treatment and master console furnished by RCA to station WMGM, New York City.

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The Editors of "Audio Engineering"

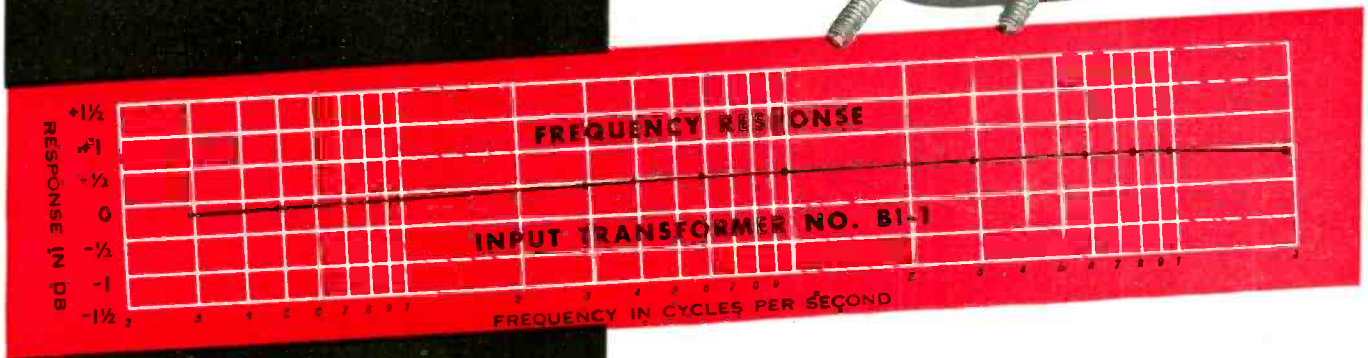
wish you a

Merry Christmas

and a

Happy New Year

LOOKING FOR HIGH FIDELITY IN AUDIO COMPONENTS?



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Catalog No.	Application	Impedance Primary—Secondary	Max. Power Level
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BI-3	Line bridging to P.P. Grids..........	*Pri.—8,000/6,000 ohms CT *Sec.—50,000 ohms CT....	+20 dbm.
BI-4	Line to line..........	*Pri.—600/150 ohms CT *Sec.—600/150 ohms CT..	+20 dbm.
BI-5	Line to line..........	*Pri.—600/150 ohms CT *Sec.—600/150 ohms CT..	+30 dbm.
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BO-3	P.P. Plates to Line.....	Pri.—5,000 ohms CT..... *Sec.—600/150 ohms CT..	+40 dbm.
‡BO-4	P.P. Plates to Line.....	Pri.—7,500 ohms CT..... *Sec.—600/150 ohms CT..	+43 dbm.
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What Constitutes High Fidelity Reproduction?

A review of papers presented at the Acoustical Society meeting in Cleveland Nov. 6, 1948.

The recent Cleveland meeting included the following panel discussion of high fidelity requirements by a group of distinguished engineers:

The Acoustic Facsimile as a Goal, by W. B. Snow

Subjective Considerations for High Fidelity Reproduction, by D. P. Loye

The Reproduction of Sound, by Harry F. Olson

High Fidelity vs. Subjective "Faithful" Sound Reproduction, by J. P. Maxfield

The Limitations Imposed by Sound Recording on High Fidelity Sound Reproduction, by S. J. Begun

W. B. Snow

• W. B. Snow reviewed Bell Laboratories' research of fifteen to twenty years ago: The first binaural system, with headphones; stereophonic transmission by wire, and by film. In these, equalization was used to provide flat response over a very wide frequency range. *High fidelity* requirements have been well known for years, and should not be determined by listener preference testing.

On the other hand, in most applications high fidelity is uneconomical, and listener preference tests could make a valuable contribution by determining the conditions under which a satisfactory *impression* of the sound could be produced, or the limit of degradation of quality which would be artistically acceptable. He noted that it would be desirable to revive interest in a comparison of a multichannel narrow range system with a single channel wide range system. Nevertheless, the ultimate goal should remain acoustic facsimile.

D. P. Loye

• The next paper discussed the problem of fidelity in motion picture reproduction. For the highest fidelity a system of adequate power, free from harmonic and intermodulation distortion, and with a frequency range of 40 to 15,000 cycles would be required. Even though commercial systems do not use this full bandwidth, they do attempt to produce a subjectively flat response from studio air to listener's brain. This presents problems which are peculiar to theater work. Theater reproduction must be at a high level to override audience noise. Since speech is then reproduced at a considerably

[Continued on page 36]

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Magnetic Field Distribution of a Ring Recording Head

S. J. BEGUN*

The magnitude of the magnetic field components acting on the recording medium is determined.

IN most of the prior discussions of the theory of magnetic recording, the assumption has been made that the recording medium is subjected in the recording process either to a longitudinal or to a perpendicular magnetizing field only. An inspection of the field distribution around the gap of a ring recording head, however, indicates that a perpendicular field component is always present and that in many cases the magnitude of the perpendicular component cannot be neglected. W. W. Wetzel[1] shows qualitatively the longitudinal and perpendicular field pattern around a typical magnetic ring head but does not evaluate the effect of the perpendicular component.

Furthermore, no proper allowances have been made for the fact that in many recording mediums the strength of the biasing and signal fields are not constant over the thickness of the sound track in the zone of the recording gap. The longitudinal field component in air has been experimentally determined by Clark and Merrill[2], but these measurements relate to the average field strength over a considerable cross section, since a relatively substantial air column was enclosed by the wire loop which was used to scan the field along the path of the medium.

Magnetic Field Analysis

In an effort to get a better understanding of the various factors which might affect the recording process, a graphical analysis was made of the magnetic field to which successive layers of the active cross section of the recording medium parallel to the surface of the pole pieces are subjected. In view of the small physical dimensions, it is difficult to obtain this field distribution by direct measurements even in air. In addition, it seems next to impossible to determine experimentally the field pattern in the presence of a typical recording medium. Fortunately, graphical methods supply a sufficiently accurate picture of the field distribution. *Figure* 1 shows the field pattern with a recording medium bridging the gap region of a ring-type head. Since the field pattern is symmetrical on both sides of the center of the gap, only one-half of the field pattern has been plotted[3]. The field lines were drawn for a gap length which is equal to the coating thickness and for a recording medium with a permeability 3. These assumptions approximate commercial conditions for powder-coated tapes.

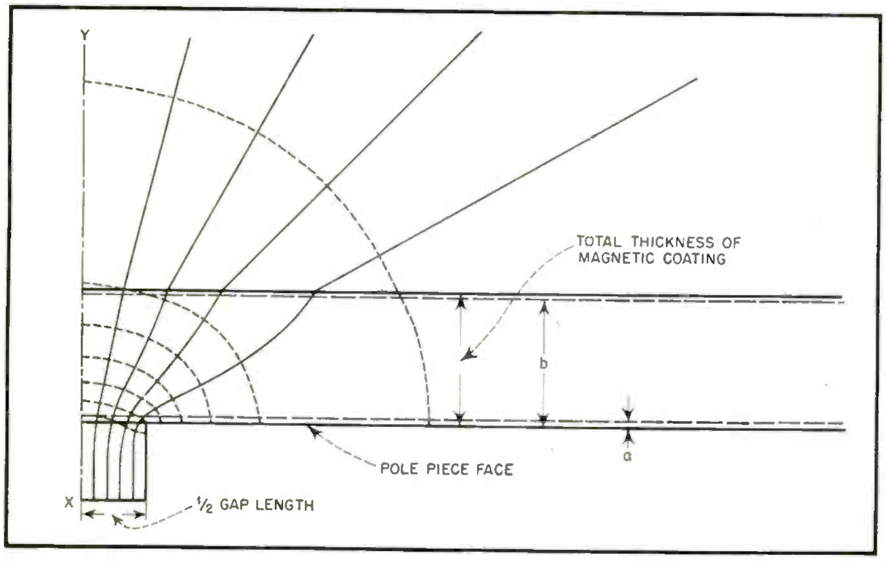
In *Fig.* 2 (plotted from the analysis of *Fig.* 1), Curve *A* shows the magnitude of the longitudinal field component and Curve *A'* the magnitude of the corresponding perpendicular field component as function of the distance from the center of the gap for a tape layer at a distance *a* (see *Fig.* 1) from the plane

**Brush Development Co., Cleveland, Ohio.*

[1] AUDIO ENGINEERING, *Dec.*, 1947.

[2] *Proc. of the I.R.E., Dec.*, 1947.

[3] *These plots were made by Prof. W. R. Smythe of the California Institute of Technology for The Brush Development Company.*



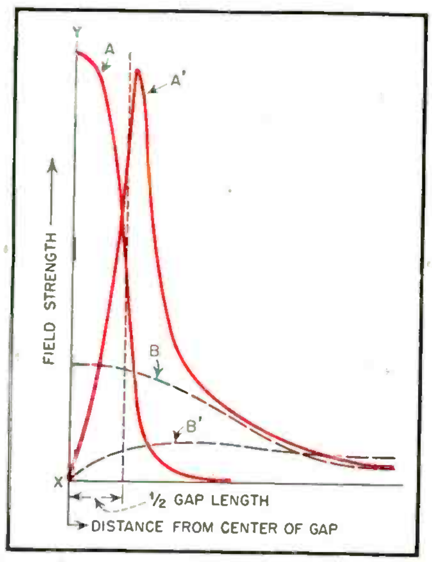


Fig. 1 (left). Magnetic field distribution from recording pole piece into and through coating of a powder-coated magnetic recording tape. Flux direction and density are represented by the direction and density of dotted lines. Field gradient is mapped by solid lines. Fig. 2 (right). Plot of the horizontal and vertical field components of the magnetic recording tape. See text.

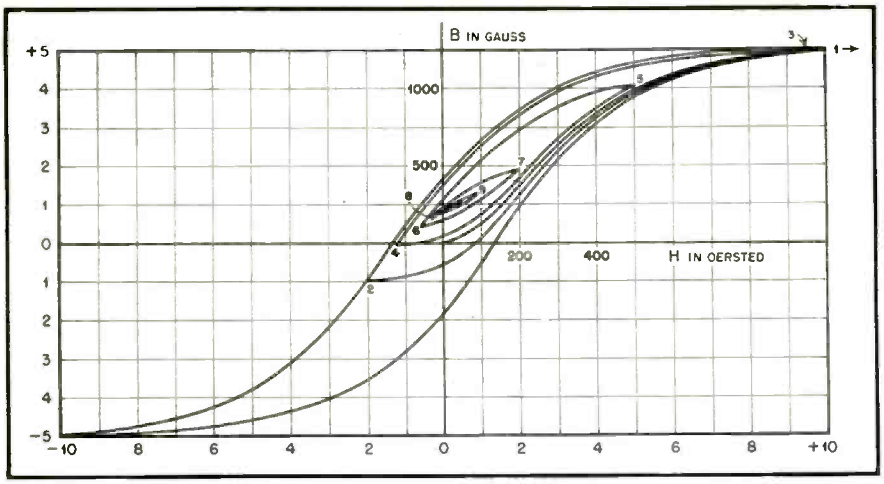


Fig. 3. The major hysteresis loop represents the magnetic properties of the coating. The minor loops, identified by 1, 2, 3, 4, etc., show the various steps through which an incremental part of a nearby layer passes when it moves away from the center of the recording gap and is subjected to decreasing field strengths of the combined d-c signal and high frequency a-c bias. The final induction reaches a value to the d-c signal.

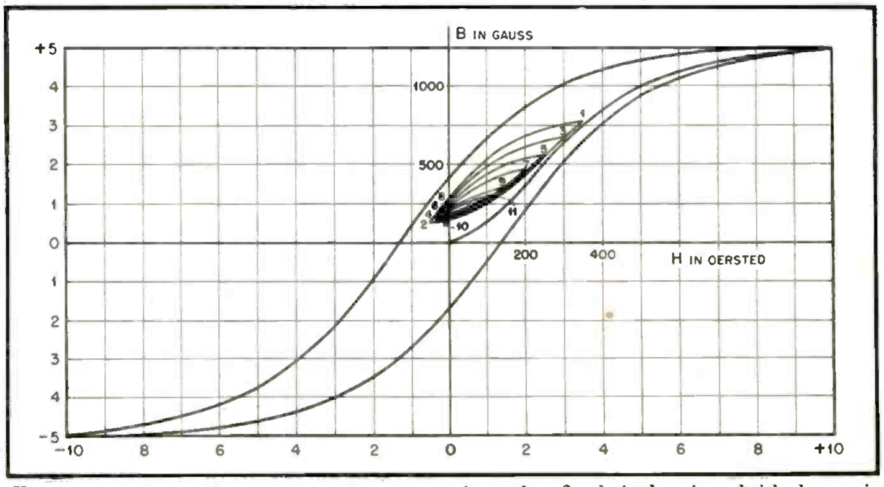


Fig. 4. Similar to Fig. 3, but showing the various steps through which an incremental part of a far layer passes when it moves away from the center of the recording gap and is subjected to decreasing field strengths.

of the pole-piece faces. Curve *B* and *B′* are plots of the longitudinal and perpendicular field components at a distance *b* (see *Fig.* 1) from the plane of the pole-piece faces. Distance *a* corresponds to a layer very close to the surface of the coating, and distance *b* to a layer which is separated for an average coating thickness from the plane of the pole faces. These curves show that at the center of the gap the longitudinal components of the induction for layers close to the pole faces are almost four times greater than for the deepest layers. They also show that the effect of the perpendicular field component is much more pronounced in layers adjacent to the pole faces.

Considering the tape moving to the right from the center of the gap, the longitudinal field is at a maximum at the center of the gap and decreases very rapidly for close-by layers and relatively slowly for remote layers. On the other hand, the perpendicular field is zero at the center of the gap, rises to a maximum beyond the gap, and then decreases again steeply for adjacent layers and more gradually for deep layers.

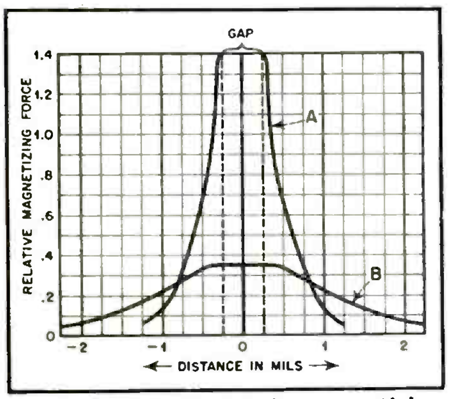


Fig. 5. Idealized total magnetizing forces as function of distance from center line of recording pole-piece gap. Curve A is for a layer close to the surface of the coating, and Curve B is for a layer well inside the coating.

Experience has shown that in a-c biasing the bias field strength must be of a certain magnitude to assure a linear transfer characteristic. In accordance with most theories explaining the mechanism of a-c bias, the peak value of the minimum bias field strength must be sufficient to produce induction values in the medium which lie beyond the instep of the normal magnetization curve. When applying such minimum bias field strength to the farthest layer at the center of the gap, the nearby layers are subjected to field strengths about four times greater, as shown by *Fig.* 2. Such large fields will cause saturation of the nearby layers in most recording materials. While the nearby layers are driven into saturation, no recording is effected. Only after the field strength has decreased to values below the saturation region will recording take place. Assuming that the bias field strength in the center of the gap was properly chosen to provide a linear transfer characteristic for the remote layers and assuming that approximately the same field strength will be most appropriate for recording in any layer of the material, it then becomes apparent from the field distribution curves of *Fig.* 2 that the final induction laid down in the farthest layers will be predominately longitudinal, whereas the final induction in the near layers will be mainly vertical. It is fortunate for this hypothesis that the ring head is an efficient pickup device for either component.

Graphical Analysis

It is of some interest to study the recording mechanism by means of a graphical analysis. It is assumed that the magnetic recording medium has the magnetic properties given by the hysteresis loop in *Figs.* 3 and 4. This is typical for a powder-coated tape. To simplify the problem, it is furthermore assumed that the signal is of such low frequency that it can be represented by a d-c value. In *Fig.* 5, Curve *A* shows in an idealized form the magnitude of the total magnetizing force produced by the d-c signal along the path of the motion of the tape across the gap of the head for a layer close to the pole faces. Curve *B* shows the magnitude of the total magnetizing force acting on far layers. No direction is associated in these plots with the magnetizing forces. Curves *A* and *B* were determined by vectorially adding the vertical and horizontal field components of *Fig.* 2. No attempt has been made to plot Curves *A* and *B* accurately, since the idealized curves as shown provide all information needed. If the d-c signal level is changed, the height of Curve *A* and Curve *B* will change correspondingly.

In a similar manner, the a-c bias magnetizing forces are plotted superimposed upon the d-c signal, giving the Wave Curves *A'* in *Fig.* 6 and *B'* in *Fig.* 7. The peak values 1, 2, 3, 4, etc., of Curves *A'* and *B'* were used to plot in the *B-H* diagrams of *Fig.* 3 and *Fig* 4 a series of hysteresis curves corresponding to the individual cycles of the magnetizing forces. The transfer of the wave pattern *A'* and *B'* to the B-H diagram takes only the decreasing magnetizing forces into consideration, starting from maximum values as they occur in the center of the gap. This simplifies the graphical representation without introducing any undue errors.

Induction Diagram

Points 1, 2, 3, of *Fig.* 3 and *Fig.* 4 are presented in an induction diagram in *Figs.* 6 and 7. Correlating the instantaneous magnetizing forces to the induction in the recording medium while it passes over the head, it is interesting to note that the remanent induction in this case is approximately the same for the nearby and far tape layers[4]. This, however, will not always be so. The remanent induction values left in different layers will depend upon the bias condition, the magnetic properties of the recording medium, and the recorded wavelength.

Making a sufficient number of plots for different conditions, namely different biasing and signal forces, the remanent induction can be obtained either as function of the bias magnetizing force for a constant signal or as function of the signal level for a constant biasing force. Such curves have been plotted and found to be in good agreement with experimental data.

This particular graphical representation, however, must be viewed with some caution since no attention has been given to the change of direction of the magnetizing force while the magnetic recording medium moves away from the center of the gap. For nearby layers, the remanent induction must be essentially perpendicular, since they are driven to saturation until the peak value of the magnetizing force is smaller than that identified by Point 3 in *Figs.* 3 and 6, which coincides with the position of the tape in the head where the perpendicular component is predominant. This conclusion can be properly drawn on the basis that a saturated ferromagnetic material shows no hysteresis losses when the field direction is changed[5].

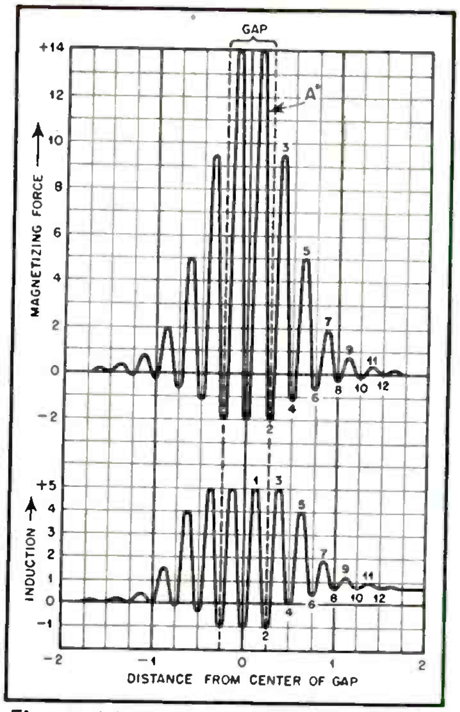


Fig. 6. Magnetizing forces on and resulting induction in an incremental unit of a magnetically coated tape layer as it passes across the recording gap of a magnetic recording head being excited with a d-c signal superposed on a-c bias. The layer is assumed to be one close to the surface of the magnetic coating.

For the remote layers, on the other hand, conditions are more complex and only additional studies can tell whether a graphical method describes the conditions properly.

After the recording medium leaves the pole pieces, demagnetization will take place mainly because of the perpendicular field in the surface layers. Would there be true longitudinal recording made with a d-c signal field, no demagnetization should be expected, since a magnet is formed under these conditions which is extremely long in relation to its cross section. No allowances have been made for effect of demagnetization.

The graphical analysis can be made to show also that a slowly tapering field, as shown by Curve B in *Fig.* 5, is unsuitable for recording high frequencies. The relatively fast varying signal intensity which is superimposed upon the bias field has a self-erasing effect. It is for this reason that short wavelengths will be retained much better by the nearby layers which are subjected to a sharply decaying field pattern. Experimental evidence confirms this explanation. When frequency curves are taken with tape coatings of different thicknesses, the playback level from these tapes in the lower frequency region is approximately proportional to the thickness, thus indicating that the complete sound track cross section contributes to the threading of flux lines through the reproducing head. In the high frequency region, on the other hand, the output level from these tapes does

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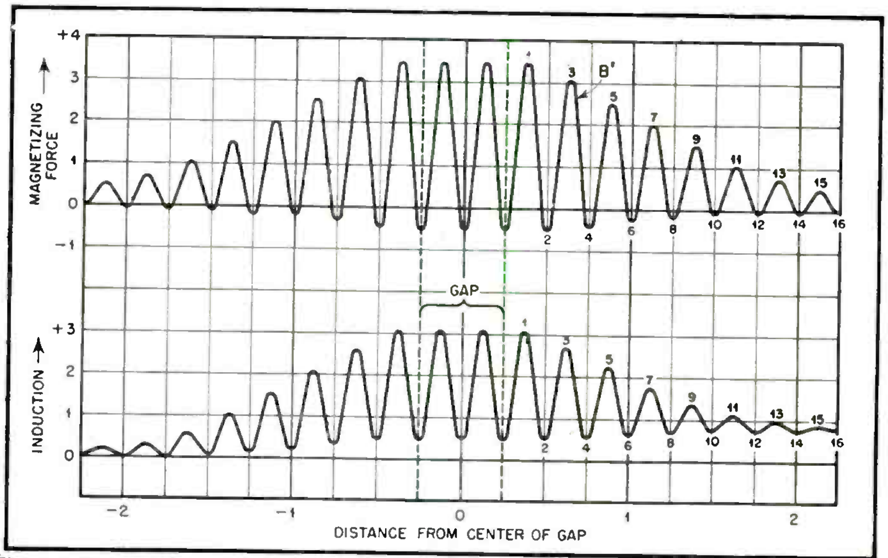


Fig. 7. Same as Fig. 6, except that the unit of magnetic powder coating is assumed to be located far inside the magnetic powder coating, away from the recording pole pieces.

[4]*These plots were prepared by J. E. Shomer of The Brush Development Company.*

[5]*Bozorth, R.M., "Magnetism",* Rev. of Mod. Phys., *Jan.,* 1947 *(Vol.* 19), *p.* 47.

[6]*Kornei, O., "Frequency Response of Magnetic Recording",* Electronics, *Aug.,* 1947.

Telephone Recording

E. W. SAVAGE*

Part III — Preliminary data on telephone recording apparatus.

AUGUST 2, 1948 telephone recording officially became available to the general public. Tariffs of the nation's telephone companies now allow the service on all types of calls—local, intrastate, interstate and foreign.

But it has taken over 60 years to translate the *idea* of this service into an actuality.

July, 1887, a slightly premature note of optimism was sounded by sponsors of the Bell-Tainter Graphophone who confidently expected that "the Graphophone can *soon* be used for recording telephone messages."

February 4, 1889, Edison demonstrated the practicability of recording for use both in transmitting and receiving telephoned speech and music. His showing was before the Franklin Institute. Transmission was long-distance, New York to Philadelphia. Playback of the recordings in Philadelphia was heard by an audience of 5,000—without the aid of vacuum-tube amplifiers.

1914, Telegraphone Corp. of America swung into action with high hopes of popularizing magnetic recording for telephone usage. This effort, though, died—almost while aborning.

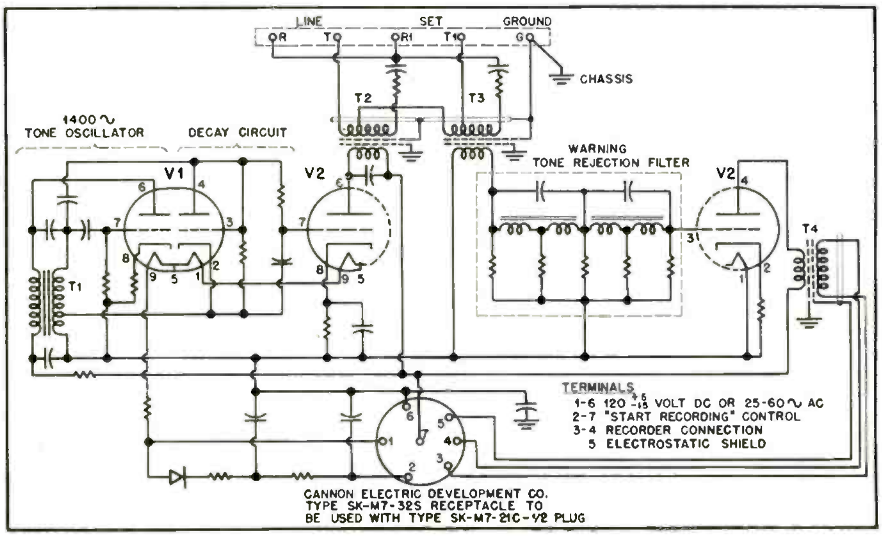
1925, Dictaphone Corp. made its first sale of a telephone recorder to Pennsylvania Power & Light.

So, throughout the years, recorder manufacturers have not lacked interest in telephone recording, even though their equipment may have been—and may still be—deficient in certain technical refinements desirable for telephone operation.

Chief obstacle to an earlier public offering of the service has been the long-standing granite wall of telephone company "policy". Keystone in that wall is the tenet that people's conversations should not be voice-recorded without their knowledge and consent. To an unbiased mind, this principle—whether considered as one of law or of etiquette—is a reasonable and justifiable protection of the telephoning public. Nevertheless, it was argument on this one point which consumed the greater part of the Federal Communications Commission's 2½ years' deliberations on telephone recording.

*Box 408, New Canaan, Conn.

Fig. 1. Western Electric 50-A recorder-connector unit, and (below) its schematic diagram.



What is regrettable is that it took 60 years, plus the intervention of a government agency, finally to join the telephone companies with the recorder manufacturers in deliberations that produced results.

The Tone Warning Signal

Once the Commission had ruled that notice must be given to all parties participating in a recorded call, the next problem was to devise practical and fool-proof means for giving that notice. Of the several plans proposed, the Commission chose the "tone warning signal". The heart of that system is the recorder-connector, which this article describes.

Other proposed plans included the Bell System's notification by operator; the writer's suggestion that recorder-equipped telephones be assigned numbers having the prefix "Recorder Exchange" or "RX"; and the recommendation of one State commission that the "scratch" of the recording stylus be fed into the line as a warning signal.

Operator notification was objected to as being costly to small telephone companies and cumbersome to telephone users. The writer's plan, which entered the competition a bit too late, would automatically forewarn persons calling Recorder Exchange numbers from ordinary telephones that they might be recorded. This would be achieved through the simple expedient of the prefix designation. Calls in the reverse direction were equally well safeguarded. Had the "needle-scratch" warning been chosen, there would obviously have been a few complications—such as what to do with the subscriber using a magnetic recorder.

The Commission made a few last-minute changes in details of the tone warning plan. Also, some newspaper stories announcing the service were confusing. Therefore, a re-statement of the plan's highlights is in order.

Recording from message toll circuits requires the use of a recorder-connector, furnished only by the telephone companies. (Originally, it was contemplated that recorder manufacturers, also, might supply the connectors.)

Inductive or acoustic couplings to the telephone line are unauthorized, as is any form of direct connection other than through the prescribed recorder-connector.

Installation charge for the recorder-connector ($5) and monthly rental ($2) are uniform throughout the nation. For several months, at least, these units may be in short supply. (There are already in the field over 20,000 recorders usable for telephone work, which will require connectors if their operation for that purpose is continued.)

The subscriber may use any recorder he wishes. Bell System is not offering any unit at this time. Independent telephone companies are recommending a modified Gray Audograph.

The recorder-connector, whose over-all size approximates that of the standard telephone bell-box, also contains the tone signal generator. The warning tone, itself, is a single beep of 1400 c.p.s. (tolerance plus or minus 10%), duration .20 second (tolerance plus or minus 20%), repeated once each 12-18 seconds (originally specified at 12-15 seconds), at a level equal to the average telephone talking signal strength.

For all concerned, the first few months of living with the new tone warning signal will be difficult. Telephone users outside the larger Metropolitan areas will have little opportunity actually to hear an advance sampling of the signal which they are asked to distinguish from the other buzzes, hums and clicks on their lines. Originally it was planned that the public might call or dial a special number and hear just how the tone warning sounds. This suggestion was later abandoned on the ground that it would cost the smaller telephone companies too much and would delay the availability of tone generators to the general public. Even after one has become familiar with the 1400 c.p.s. beep, there will still be occasions when its sounding will be masked out by speech on low-level circuits. The writer has already experienced such an instance.

For the recorder manufacturer's service department, the introduction of the tone warning will present difficulties. The thousands of machines now out in the field, which were sold with high-gain amplifiers and inductive coupling, must be adapted for operation with the new type connector which requires considerably less gain.

Recorder salesmen, too, are not cheered by the cumbersome plan for making telephone recording demonstrations. Not only must they sell the prospective customer on the general idea of recording and on a particular make of machine; they must also persuade him to lay out $5 for a recorder-connector and then wait for some time to get it.

The Recorder-Connector

These units will be manufactured by Western Electric for the Bell System, and by Automatic Electric for the independent telephone companies. Surprisingly, there are over 6,000 of these smaller non-Bell System companies.

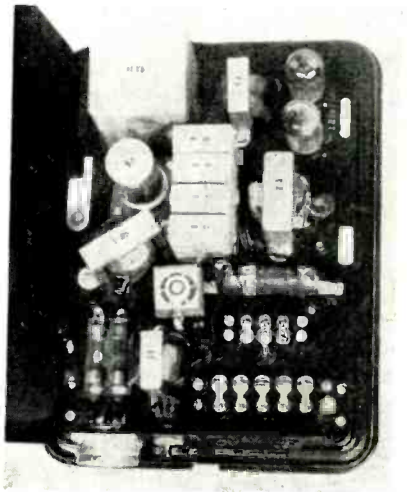


Fig. 2. Internal view of Automatic Electric type 31 recorder-connector.

Geographically, they are spread over about half the nation, and they handle about one-fifth of the total telephone business.

Principal difference between the Western Electric and the Automatic Electric connectors is that the former is all electronic, while the latter employs relays for its timing interrupter. Also, the Automatic Electric unit provides a choice of two levels of output to accommodate recorders either with or without automatic volume control.

The Western Electric 50A

This recorder connector provides the features specified by the Federal Communications Commission in its order prescribing the conditions under which telephone message recording is authorized.

The 50A Recorder Connector supplies:

(a) Means for the physical connection of a voice recorder to a telephone circuit
(b) A tone warning signal which is automatically applied whenever the voice recorder is in use
(c) An interlocking circuit arrangement such that the connection of the recorder is completed only when the tone warning generator is activated.

The circuit of the 50A Recorder Connector is shown schematically in *Fig.* 1. The oscillator *V1* and associated circuits provide the 1400-cycle tone, the duration and decay characteristics of the tone and the timing of the repetition of the tone. The output of the tone generator is fed through a conventional amplifier (½ of *V2*) to the hybrid coil *T2*. The associated resistance-capacitance network is so adjusted that the level of the tone delivered to the local telephone set is reduced considerably below that delivered to the line, thereby limiting the tone in the local receiver to a tolerable level. The tone level on the line is about —4 vu. The insertion loss of the 50A Recorder Conector is about 1 db.

The hybrid coil *T3* is used to derive the recorder connection and is arranged to reduce the difference in level between the speech from the local station and from the distant station by about 10 db. The warning tone rejection filter reduces the level of tone introduced into the recorder input connection. This suppression is provided so that the tone will not reduce the gain of the recorder amplifier by operating its automatic gain control, thereby avoiding possible loss of a syllable or two during the recovery of the a-v-c circuit. The transformer *T4* provides for electrical isolation between the recorder and the telephone line. By means of the amplifier derived from the other half of *V2*, the speech level incoming from a distant point is slightly less in a 600-ohm recorder connection as at the local telephone set. This amplifier also functions as a relay in the recorder input circuit, since connection to the telephone line is completed only when plate power is applied to vacuum tube *V2*.

Power supply required for the 50A Recorder Connector is nominal 120 volts d. c. or 25-60 cycle a. c. It is contemplated that power will be provided by the subscriber. The power can be controlled directly from operation of switches on the voice recorder. The circuit provides for maintaining the tubes in a standby condition so that the recorder connection can be completed and recording started immediately on operation of the recorder control switch. The power control and recorder leads are terminated in a seven-prong receptacle mounted on the recorder connector. The corresponding plug and cord are to be provided by the customer as an accessory to his privately owned voice recorder.

Automatic Electric-Recorder Connector

This unit provides facilities for interconnecting a telephone line, a local telephone instrument and a recorder, under conditions which will meet all of the requirements of the FCC. The equipment is mounted in a slightly modified version of the standard metal

[Continued on page 39]

Suggested Wiring Standards for

Motion Picture Recording Equipment

GINO RUDOLFI*

Practical technical data on the wiring of high-grade recording apparatus.

THE TECHNICAL PERFORMANCE requirements of manufactured motion picture recording equipment are among the highest in the sound industry. Because of the expense of picture, production, this equipment must not fail during the shooting of scenes, or during scoring sessions. The journeyman technician (or wireman, as he is usually classed) employed for this work must not only be a precision wireman of the highest caliber, but must have a thorough foundation in basic engineering practices peculiar to the recording of sound on film.

The number of units of a given type of motion picture recording equipment is necessarily limited, each studio usually having special requirements dictated by its individual recording technique and system. Because of this the studio wireman usually finds himself presented with a rather brief draft of what is wanted, the fundamental plan being laid out by the chief engineer. It is then up to the wireman's background and "know-how" to come up with a completely wired system that is foolproof and wired without the ever-present danger of ground loops, and with a set of harnesses constructed to perfection and approaching workmanship at its best. In a complex rack-and-panel job, a soundtruck, or master control panel using many shielded wires and jack bays, this can become quite bewildering to the uninitiated. The end result of a studio wired job is a work of art pleasing to students of perfection in workmanship.

The following methods are applicable in many respects to other branches of the sound industry to increase the reliability (and sales appeal) of their products. This information has been gathered from data supplied by men in the industry and from corporations active in the design and manufacture of motion picture recording systems —Western Electric. RCA Bardwell & McAlister, and others.

**P.O. Box* 1310. *Hollywood, Calif.*

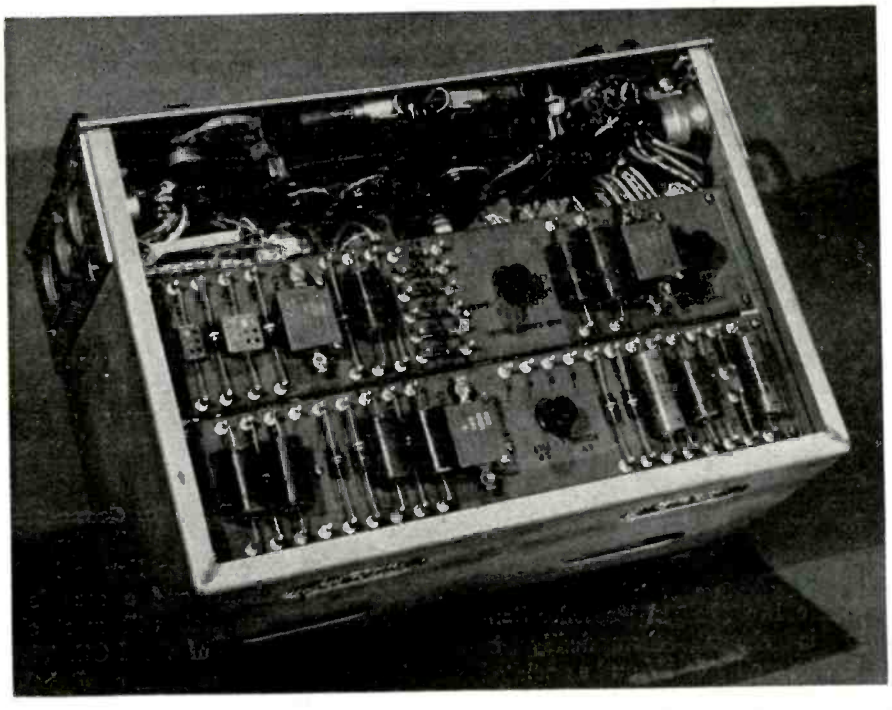


Fig. 1. Example of proper layout of resistors and capacitors.

Good Wiring Practice

1. Bus wire and sleeving should be used as interconnections up to lengths of 2½": over this length use standard hook-up wire.

2. In wiring bus-wire and sleeving, about 1/32" spacing should be maintained between terminal and sleeve of exposed bus-wire.

3. All stripping of leads should be 5/16", except where insulated leads go to ground lances. in which case it should be ¾" strip.

4. Shielding on cables or wires, when stripped, should be clean cut and mechanical means provided to prevent strands of shielding from protruding in-or-outside of shield. Mechanical means should be provided for sliding of shield back over wire without damage to insulation of wire. Maximum length of wire exposed from shield, ¾". Where possibility of stray pickup or cross-talk exists. shields should be carried as closely as practical to terminal connections.

5. External wires to terminals of component parts having internal wiring (transformers. reactors, capacitors, etc.) should be soldered to opposite side of terminal from side to which internal connection has been made (where terminal shape makes it feasible).

6. External wires to terminals of transformers, capacitors, reactors. and other parts requiring replacement in service. are not to be threaded through eyelet of terminal. but given one-half turn around top of terminal before soldering. This does not apply to tube sockets. where wire should be threaded through eyelet of terminal contact.

7. No more than 3 connections per terminal. and each connection should be arranged. where possible. to permit its removal without disturbing other connections. Jumper wires between terminals on the same terminal board should not be considered a connection—provided that jumper wire does not interfere with other connections.

8. Capacitors in power supply circuits should be individually wired for easy replacement.

9. In wiring of key-switches, push-button switches, relays. etc., use inside connections where possible to permit easier access to extra terminals for later uses.

10. Loops of external wires to transformers, reactors, capacitors, etc., should be made in the same direction to present symmetrical balance.

11 Wires to be soldered to terminals to be given from ½ to 1 turn around terminal before soldering.

12. Leads of carbon resistors. tubular capacitors, micas, etc., should not be shorter than 3/16" to soldered connection. These leads should also be so dressed that no tension is placed upon the component (see *Fig.* 1). Where possible clamps or brackets should be provided to hold these parts to prevent weight tension or vibration. Sharp bends in the leads of these components should be made no closer than 3/16" to the body of the component. Where possible, soldered points on leads of carbon resistors used in circuits where current flows through them and where the application is critical with respect to noise, should not be shorter than ½".

13. Shields on grid wires should be carried close enough to grid cap to allow grid shield to cover both the grid cap and end of wire shield. Grid cap terminals should be protected from grid shield by varnished cambric tubing.

14. Where necessary, use hi-flex rubber wire for rubber-mounted tube sockets, etc. The terminations of the hi-flex should be made in auxiliary fixed terminals.

15. Wiring to jack bays and terminal blocks should be as follows:

a. The red colored wire of a pair (black and red) should be connected to the odd numbered terminals or jacks, and to the left-hand jack as seen from the front of the panel. The red-colored wire represents the "high" side of an unbalanced circuit.

b. The black colored wire of a pair should be connected to the even-numbered terminals or jacks, and to the right-hand jack as seen from the front of the panel. The black colored wire represents the "common" or grounded side.

c. Cables formed behind jack bays should be formed and so located to permit easy access to jack terminals.

16. Adjacent wires or cables, properly shielded, should have no more than 60 db difference in level. Wider level differences should require complete separation of wires and cables from one another.

17. Cable runs to all components should be routed so replacements can be made without disturbing wires or components.

18. Mechanical grounds of electrical circuits should be connected to shakeproof terminal-lugs on bare metal or plated surfaces. Beware of painted or specially treated surfaces.

19. Splices of primary circuits should be covered with rubber tape and friction tape and shellacked. The new plastic tape is also permissible. Varnished cambric tubing may be used over splices, provided mechanical means are employed to prevent cambric from sliding off splice.

20. Foolproof Soldering Methods:

a. Use minimum heat without inducing a "cold-joint". Solder with heat and *not* with pressure!

b. Use minimum amount of solder necessary to cover connection and wire-joint. Flow solder over top and bottom of connection.

c. High resistance-producing holes or gaps in solder joints should be picked clean and hole or gap solder-filled.

d. Where practical, wire joint and ensuing solder joint should be planned to allow rapid *visual* inspecion.

e. Feeding of stripped portion of wire through eyelets and crimping should conform to natural direction of wire approach, preventing sharp wire-bends at joint.

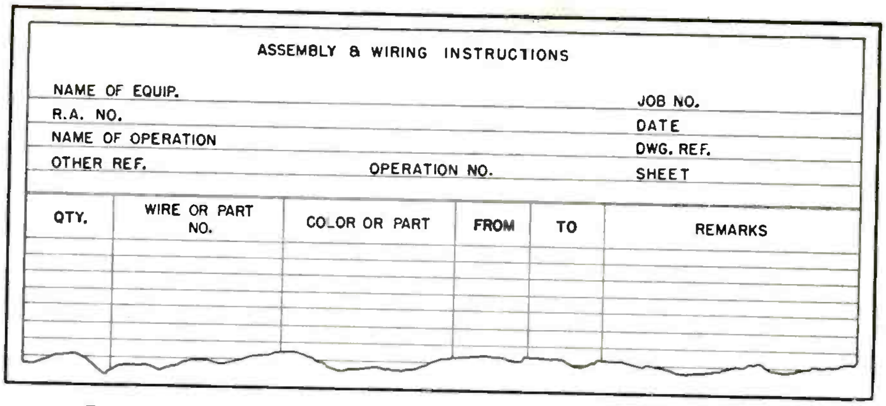
f. Post-type solder terminals should carry from ¾ to full turn of lead with care taken for a smooth and symmetrical joint.

g. Sharp points of solder, bulges and blobs should be removed and joint feathered smoothly.

h. *All* strands of stranded-wire should be crimped and anchored before soldering. Sharp protrusions of a strand from joint should be removed. Solder *all* exposed copper.

i. Solder joint should be boiled free of flux, insulation or other trouble-breeders. Clean with carbon tetrachloride and stiff bristle brush.

j. Only rosin, or rosin and alcohol, should be used for flux (and as little as possible).



ASSEMBLY & WIRING INSTRUCTIONS

NAME OF EQUIP. — JOB NO.
R.A. NO. — DATE
NAME OF OPERATION — DWG. REF.
OTHER REF. — OPERATION NO. — SHEET

QTY.	WIRE OR PART NO.	COLOR OR PART	FROM	TO	REMARKS

Fig. 2. Shop order form for assembly and wiring of apparatus.

Grounding Systems

1. Use only one chassis ground for audio circuits.

2. In networks and audio amplifiers, locate chassis ground as close as possible to lowest audio level point of circuit.

3. In power supply circuits, locate chassis ground as close as possible to minimum ripple point.

4 Separate ground wires from various levels of gain or attenuation stages may be run to common chassis ground. This may complicate wiring of units by increase in number of required wires. For simplicity, a common wire ground may be used, provided following rules are observed:

a. Common ground bus wire should be continuous and other leads soldered to it. Common ground bus wire should not consist of a series of separate leads.

b. Common ground bus wire should start at the highest audio level in audio amplifiers and each point in circuit should be grounded successively as the lower levels of unit are approached (with exception of ground of input transformers).

c. Input transformer ground should be made by short, separate connection direct to chassis ground. Exception to this is the alternative connection of ground on input transformers to —*B*.

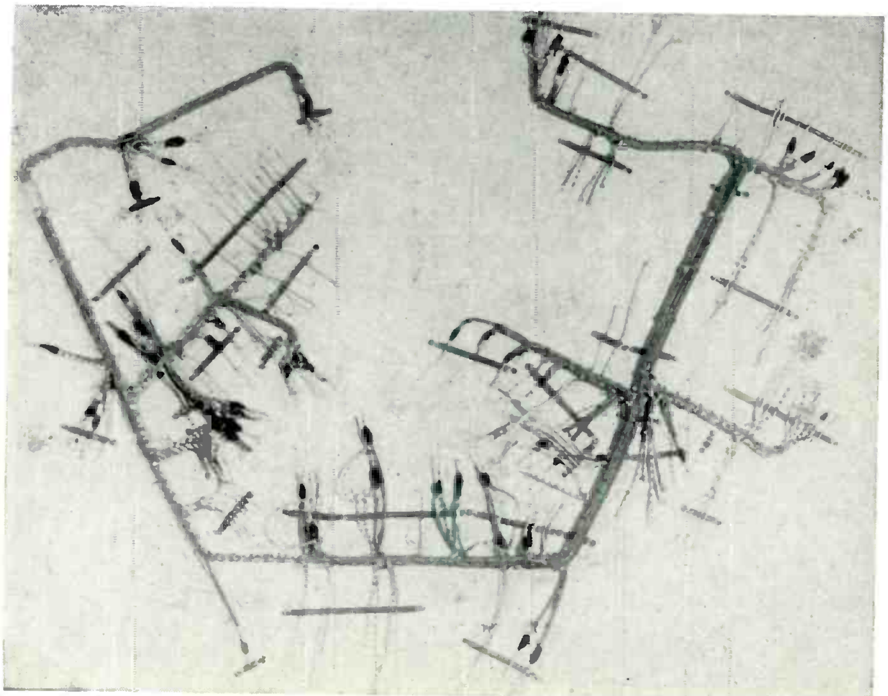
d. Common ground bus wire should be grounded to chassis at lowest level point of circuit.

e. Same steps should be followed in attenuation networks as outlined in *a*, *b*, and *c*, except that mixer circuits using variable pads should have separate ground wires to a common ground point.

f. Same steps should be followed in power supply systems as in *a* and *c*, with common ground wire starting at highest ripple point and being grounded to the chassis at the lowest ripple point.

5. For some systems, it is required to keep

Fig. 3. Example of completed cable ready for installation.



the electrical circuit separate from the mechanical chassis grounds. In this instance, the common electrical circuit ground terminal is insulated from the chassis and is carried out to a terminal lug. Another terminal lug is provided with connection, if so desired, to the mechanical or chassis ground. The mechanical grounding system should include:

a. Chassis.

b. Shield cases of tubes, transformers, reactors, capacitors*, relays, switches, etc.

c. Shields of cables where in no way connected to electrical circuits.

d. #1 Pin of metal tubes.

6. Ground systems of several amplifiers, neworks, transmission lines, or power supplies in combinations should be considered the same as for single units.

7. No common ground bus to be used to carry current.

General Cable Layout and Cabling Procedure

The methods to be outlined are readily applicable to large production as well as to limited or "custom" production; the only difference is that in larger production runs more detailed work sheets are justified because of the added operations.

The first step (and one which, if not followed, leads many to grief) is a thorough and complete analysis of drawings . . . schematic, wiring diagram, assembly drawings, mechanical detail drawings and an objective survey of the unit or a system in its entirety.

From the schematic, a wiring diagram should be made showing the general routing of all wires and jumpers.

**Except when capacitor cases are above or below chassis potential, and insulated from chassis by wafers or other means.*

Marking this drawing is the next step, as to cable numbers (cable *a*, *b*, etc.). The wire numbers can start 1, 2, 3, etc., using your own sequence arrangement directly on the wiring diagram. Next, a wire list (a sample of which is shown in *Fig.* 2) is prepared coinciding with the number and cable markings of the wiring diagram. The wire list will show the approximate length of each wire, cable number, gauge, color-code, and its route from terminal number: for example, *"Wire #6, 19", Cable B, 18 G., blk-blue, from V1 pin 2 to T2 Term. 4"*. When this has been completed, a careful check is made to insure no errors as to above details.

Each established cable in the wiring diagram should follow the procedure outlined below:

a. Locate all main cable breaks and cable bends and mark on cable board, in inverted form, by measurement from chassis limits and channels of cable. At this time no attempt should be made to fix over-all width of cable. The reason for the inverted procedure is that all stitching hitches, when the cable is finally installed, should be hidden from view. It is much simpler to stitch with the stitches facing you while cable is being made in the form board.

b. Next, establish approximate lengths of all wires, adding a few inches to allow for final adjustment, and cut wires per established color code.

c. Make a preliminary "rough" cable of the above wires, spotting only where absolutely necessary, not paying too much attention to sequence of wires in cable.

d. Lay this rough cable into chassis and continue shaping and working wires to gradually form the over-all cable layout. Then re-trim the wires for proper length of loops and dressing with respect to wherever these wires will eventually be soldered. As you proceed in this manner, be sure to install additional spotties wherever necessary to keep the final cableform in shape.

e. Strip ends of all wires and temporarily mechanically connect them to their proper terminals and/or locations. *Do not solder.*

f. Observe over-all appearance of cable, dress of wires, neatness of bends, crossovers, and breakouts. Make any necessary corrections of wire lengths.

g. Remove cable from chassis and lay out on cable-board, in inverted form, marking terminations on board of all wire-lengths in the flat and on one plane. Now, drive nails into the board parallel to the cable to establish over-all cable width. Too many nails make lacing difficult, while too few will fail to hold the shape of the cable while lacing. Mark board as to wire number, wire color, gauge and any other pertinent information necessary for production.

h. The next step is to establish the cabling sequence and to proper laying in of individual wires so that a neat-appearing cable will result, always bearing in mind that the cable is on the board in an *inverted* position, so that when cable is finally soldered to components in chassis, there will be a minimum of cross-overs, and so that the shortest wires appear at the bottom of cable and the longer wires fan out on top of the cable.

i. Lay in wires according to the above sequence established, removing each wire (after it has been laid in its proper position and routing) and measure the exact length. Correct the temporary wire list to show the actual *net* length of each wire. Also, be sure to include in the wire-cutting list the *net* stripping length for each ending of wire, bearing in mind that in many cases a different stripping length will be required on one end from the other.

j. Install necessary springs and other hold-down gadgets to hold wires in place on board for proper lacing so that slippage will be kept to zero.

k. Make final lace of cable.

l. Install in chassis, prove cable and make any final minor adjustments if required.

m. Revise the wire-cutting list (if the production warrants) to facilitate ease of production on the wire-cutting machine by consolidating wire guages, wire colors, and listing wires of light gauge and light color progressively as to length.

n. First *production* model should be completely explained and detailed to wireman or supervisor in charge of production.

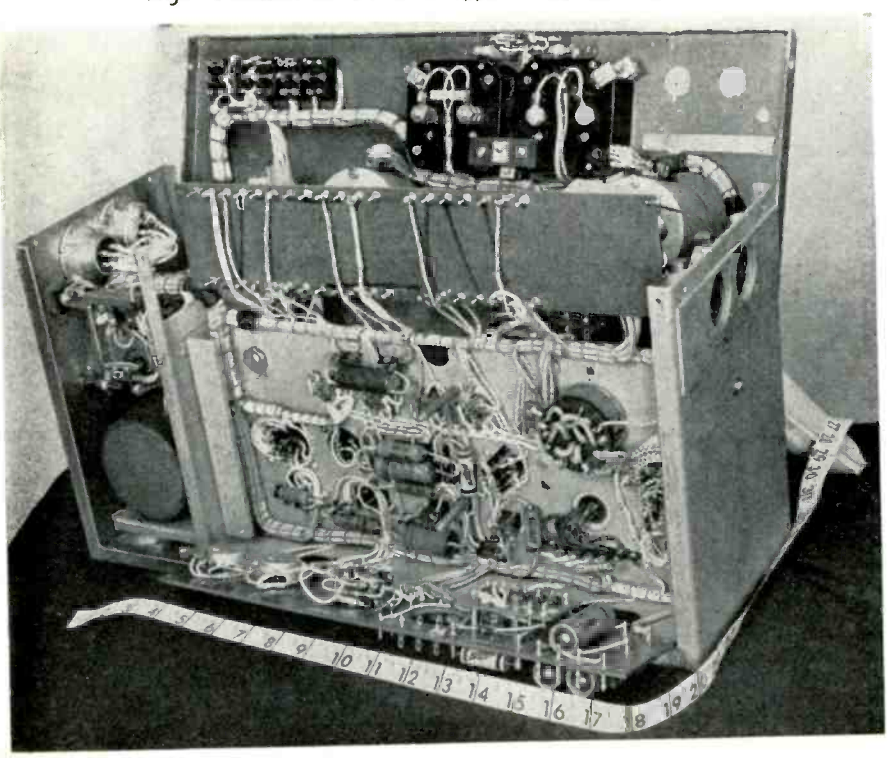
o. Careful spot inspection of first few models to determine that *all* facts and details have been absorbed and are being followed.

p. Pointers for a Neat Cable

1. Stitches pulled as tightly as possible.
2. Space stitches evenly.
3. Stitches *no* closer than *diameter*

[Continued on page 44]

Fig. 4. Cable installed in typical high-grade unit.



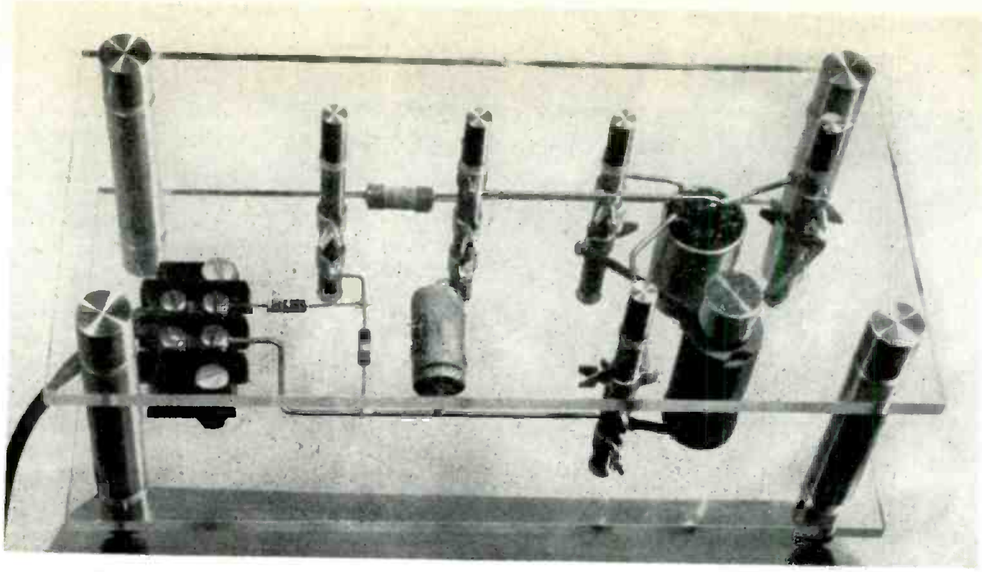


Fig. 4. A-c/d-c test and demonstration unit for making measurements on germanium triodes, and providing accessibility to all circuits.

Clarification of Germanium Triode Characteristics

S. YOUNG WHITE*

A resume of the information collected to date by the author in his investigation of this new component.

The articles on transistors that have appeared in Audio Engineering for the last three months have reflected a goodly amount of confusion in the mind of the writer, and a word of explanation is due the reader. It is hoped this article will mark a transition from a state of chaos to one of "disciplined confusion."

When something of the great potentialities of the transistor appears in the technical world, it is the writer's policy to make a quick, independent survey of the limits of all parameters, and by thousands of measurements, to establish the nature of the problems involved in production and application. It is felt that by keeping an open mind until this survey is complete we run less risk of jumping to conclusions that subsequently have to be modified. So our previous articles were merely our day-to-day notebook, and while all the statements were based on facts, they were of necessity poorly organized.

We feel we are now ready to give a reasonably clear general picture. We have visited a factory or two, had access to patent search, and contacted the people who developed the process of obtaining purified germanium.

History

The general idea of having two contacts of limited area closely adjacent on some conductor of peculiar properties is apparently quite old, according to Patent Office records. By passing a current through one contact, the conductivity of the other is affected in some way. It is easy to see how this can occur, since if the current on the grid were made heavy enough, there would obviously be considerable local heating, which, with the formation of oxides and the like, would cause a change, no matter how minute, in the conductivity at the plate contact. In selenium and copper oxide barrier layers, the effect is apparently quite pronounced. But no actual power gain is of record before Bell Laboratories scientists combined the purified germanium crystal and a special type of etch which formed a type of barrier layer which gave amplification.

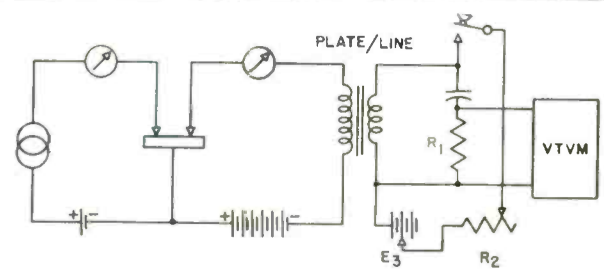
Let us analyze the word amplification in this connection. It is a characteristic of limited-area contacts that they quickly overheat and tend to burn out. Another characteristic in the transistor type of action is that the μ and G_m of the unit tend to increase, often quite rapidly, as the voltages applied to it are increased. This often means that it is impossible to run full direct-current curves on the device, in the same way we can never run d-c curves on a hundred-kw triode—it burns up on the upper readings. However, in oscillators for pulse or peak modulation, where the duty cycle is low, it operates with long life. So we often have a transistor of no power gain which oscillates readily. The basic germanium crystal with merely a diode etch will often oscillate at a thousand cycles, but as an amplifier has a distinct power loss.

It is thought that the term "germanium triode", as suggested by Sylvania, is a better name for the device than "transistor", as it covers the cases where no actual power gain is involved as well.

Germanium

Because, for the present, we must have a specially etched germanium to produce these useful effects, we are in-

Fig. 1. Method of of burning contacts. Battery E_3 and rheostat R_2 adjust peak voltage and energy of "shots." R_1 is matched to the secondary of the transformer.



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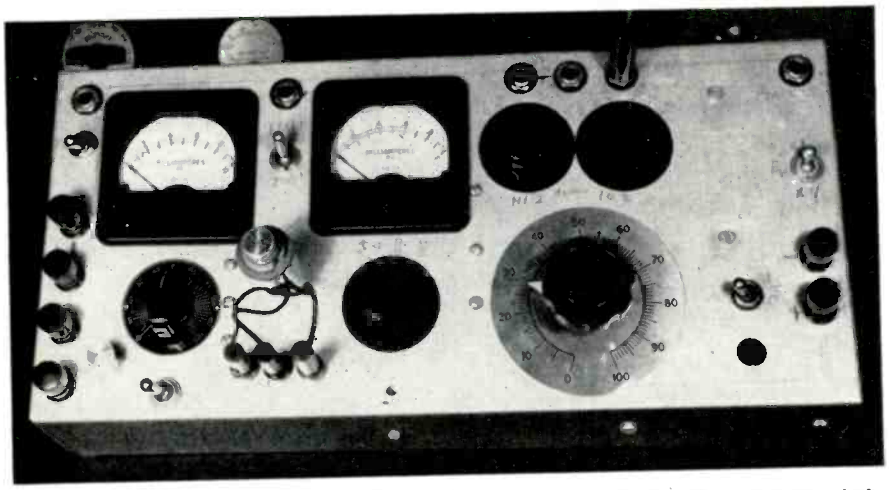


Panel view of apparatus set up to make measurements on the characteristics of germanium triodes with all parameters variable.

terested in its commercial history. It is an odd material not occuring free in nature, and little general work has been done on it. So, in 1926, Purdue University took this orphan up as a pure research project. In order to study it, they had to develop a purification method, which they pioneered, and which is used today by everyone in the field.

During the last war, it was intensively investigated as a detector in radar, mainly for its ability to withstand strong signals, and was produced in small amounts by the General Electric Company, somewhat more by Bell Laboratories, and in large quantities by Sylvania.

Apparently germanium can be found as a by-product in many places, but at present the usual source is from lead and zinc mines. It is sold as an oxide by the Eagle-Pitcher Company, who work closely with Purdue. The purity is about 99.8%. It is not known what these impurities are in a given batch.

As it comes, the material has insufficient conductivity, so nitrogen, boron, or tin (about 0.1 per cent) are added and we have a platform on which to build barrier layers by electrolytic etching. Usually a hydrofluoric etch is given first to provide diode characteristics, then the triode etch is applied.

Germanium is produced in ingot form and sawed with diamond saws to form the tiny blanks that are required. The crystal blanks undoubtedly could be smaller and still work well, but it is impracticable to saw them into smaller pieces.

The Barrier Layer

This is the all-important element. At the present time, there is divided opinion as to the importance of the massive crystal body itself. One school of thought tends toward the opinion that it is merely a platform on which to build the barrier layer, and that at some time we may be able to paint the whole thing on a copper plate. The other school believes the effect is produced in the massive body of the crystal. Let us hope the first view is correct, as the crystal is a heat insulator and if we could place the barrier on copper we could handle more energy. We can also visualize a hundred to the square inch in calculating machine work, with printed circuits.

The barrier layer is substantial in thickness, being from half to two thousandths of an inch, so it is not of molecular dimensions. If a desired characteristic is found with a given etch at one-thousandth thickness, it can be built up to two-thousandths in production. The contact can then be "burnt" down into the body of the etch to any desired amount, including burning right through the barrier layer to the crystal body. This is done with controlled pulses.

These pulses can be produced experimentally in a simple manner. Set up the unit for gain measurements, as in *Fig. 1*, with meters in all circuits, and with an output transformer in the circuit with a step down voltage ratio, such as a plate-to-line transformer. A battery of 10 or 20 volts, a series resistance, and a key may be arranged to key the battery across the secondary, whereupon pulses will appear across the primary. By trial and error you can find a combination that produces proper burning-in pulses, and the limit is easily gauged by watching the plate meter.

For instance, with a very thick etch, you may find it only passes a plate current of 100 microamperes at 100 volts, when the catwhisker is first engaged. A "shot" will increase this to 200 microamperes, and so on. So if you wish to operate at 45 volts and three milliamperes, set the plate voltage at 45, and keep pulsing until you reach this value. This is very promising for production, as these "shots" or pulses can be given automatically, and stopped when the parameter chosen, such as gain or plate current, reaches the desired limits.

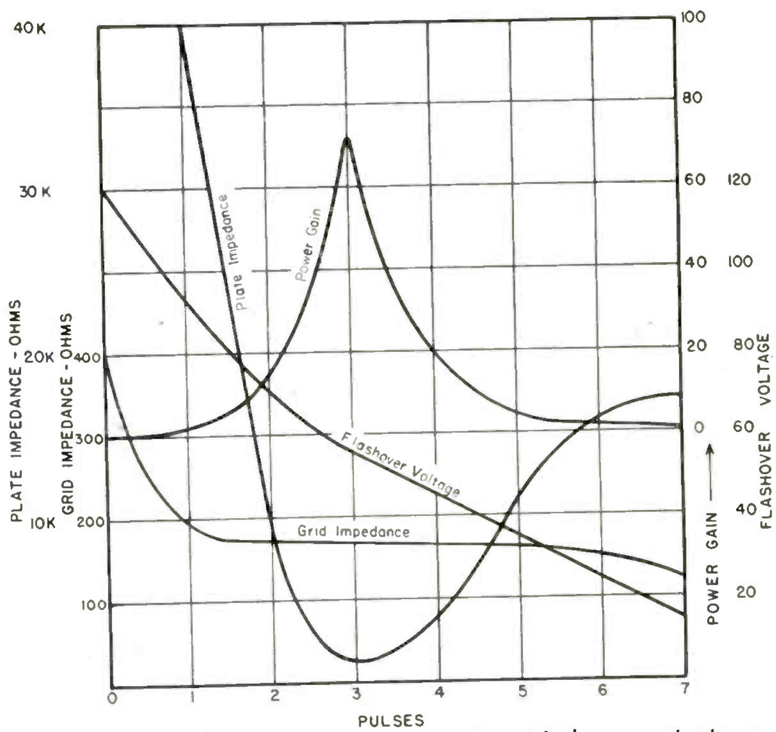


Fig. 2. Change in performance of the germanium triode as contacts are burnt down into deeper layers of the barrier. This is a generalized curve based on about 10,000 readings on hundreds of active spots, and is of great importance in understanding the amplifying action.

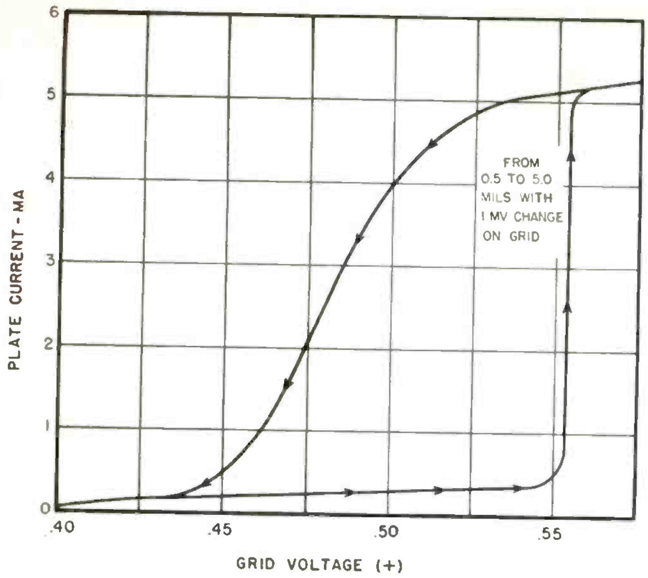


Fig. 3. Curve showing d-c G_m of 4.5 Mho.

In many cases, if you etch too thick and pulse down, the layer will behave as though it were built up to that thickness originally. Remember, in any case, we must always pulse a little to obtain a firm, welded contact, so continuation of the process is a natural development.

It is important in any theory to account for the fact that when this barrier is formed, even very thinly, the pervious history of the crystal disappears—that is, whether the diode and triode action before etching is good or bad, has little influence on the action as an etched triode. Also bear in mind, we apparently must have a diode etch before the triode etch, so we have a double barrier.

Three Separate Control Effects

Before we discuss the various characteristics that exist in the various thicknesses of the barrier, let us separate out some effects that show up when taking curves in the usual d-c fashion.

There seems to be a slow heating effect that takes several seconds to stabilize. This gives a d-c power gain in almost all crystals, but does not mean that there is gain at 1 kc, for example.

The next effect is a fast control action, also due to heat. This may carry up to six or twenty cycles, and seems to be different than the slow heat. We are not too sure on this point, but sometimes we obtain both at once.

The third effect is the true triode action, which goes up to above a megacycle, at least.

These three effects in combination make the d-c curves valueless for a-c calculations. The family of grid and plate curves must be made dynamically, or on an oscilloscope at 1 kc, for example, to be sure no heating is involved. We are building such a supply with 6AS7G tube driven from the linear sweep of the oscilloscope so we can see the curves by using the drop across the cathode resistor as our plate voltage.

If we obtain a highly active crystal with an etch that is deliberately made too thick, but uniform over the surface, we can give it literally hundreds of different characteristics. We must use catwhiskers or plated-on contacts of limited area, but the behavior with beryllium copper is quite different from tungsten, and stainless steel is still different. We can operate with spacings of a half-thousandth to about 4 thousandths, with any pressure. Then as we burn in the contacts we change all parameters markedly, and in a different manner, with each type of contact and each pressure. We must run accurate curves of each contact as a diode for each condition we set up, including forward and backward characteristics. Then we must make d-c curves, slowly, to obtain the slow-heat-plus-fast-heat-plus-transistor-control, redraw at 1 kc for the transistor alone, and then differentiate out on the fast heat effect, or take another set at about 5 cps. You must also plot increase in grid current with applied plate potential, and plot input and output impedances, and then make measurements of gain values, as well as of distortion and noise.

If you chose values of shots that burn down to the crystal in six or eight applications, you have done quite a job, and you must then repeat with several catwhisker materials, different point sizes, various pressures, and certainly at four or more spacings.

It is seldom you can make such a uniformly etched crystal, so you may be investigating an incompletely etched portion of the face. Also there are numerous etches possible, and all degrees of each etch. So in all seriousness, we can make a million measurements, and still have something to learn. And all these curves will differ in almost all particulars.

Another source of confusion is in the mind of the experimenter—what is his conception of a "vacuum tube?" Depending on his present work he unconsciously thinks of specific tubes, as for hearing-aid equipment, an AM receiver, or a high-fidelity audio channel; and he would like a germanium triode or pentode, perhaps, to plug in the same socket and watch it operate. There is little hope of that—we have a highly special device with plenty of odd features to necessitate circuit re-design from the ground up. The reverse is also true, that the germanium triode is showing some effects that are beyond the ability of any vacuum tube, a case in point being a d-c G_m of 4.5 million, which we shall describe.

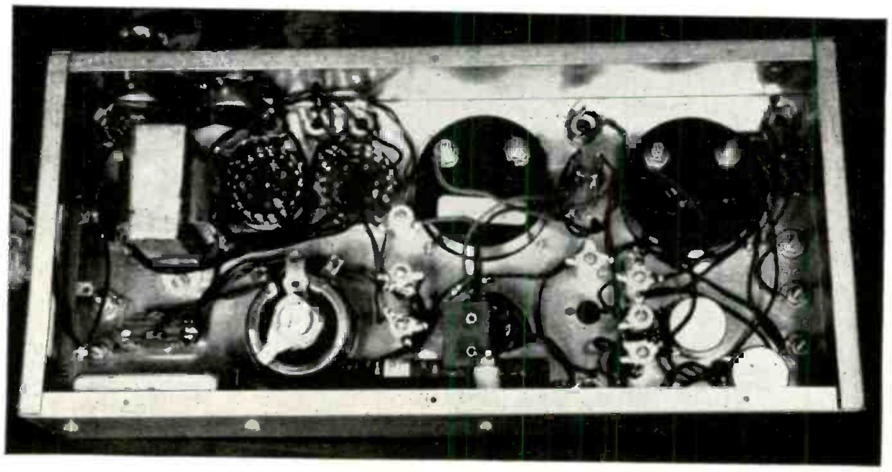
Transistor Life-Temperature Effects

A promising feature is the indefinite life promised by the germanium triode. This is somewhat marred by its very short life when used experimentally.

We all agree there is nothing in the body of the crystal to suffer deterioration, so we must think in terms of the life history of other electrical barrier

[Continued on page 40]

Underside view of chassis shown on opposite page. This apparatus permits a wide range of measurements to be made.



Elements of

RESIDENCE RADIO SYSTEMS

C. G. McPROUD*

PART IV

Continuing the description of a high-quality home reproducing system comprising several unique features

IN ANY SYSTEM for radio and phonograph reproduction, there are a number of individual circuit entities which may or may not be physically separate units. The system being described in this series happens to be built in unit form—each section being essentially a separate unit—which has certain advantages for an experimenter's installation. It also has some disadvantages.

The principal advantage of unit construction lies in its flexibility. Suppose, for example, that a complete system were constructed on a single chassis. The wiring is simpler, no plugs or cables are necessary, and it is more economical, both of chassis space and of cost. But if the builder or owner should happen to want a major change in some specific section—and what experimenter is satisfied to leave well enough alone?—he must rebuild completely, or must try to adapt the new design to an already-cut chassis. However, with the unit system, a single section can be replaced easily, without the necessity of disturbing those portions which are working to the owner's complete satisfaction.

In the system being described, there are five separate units: the FM tuner; the AM tuner assembly; the control amplifier consisting of the phonograph preamplifier and equalizer, the noise suppressor, and the volume control; the main amplifier, and the power supply. The first three have already been discussed; this article covers the last two, also built as separate units.

The Main Amplifier

The final amplifier in this system provides the voltage gain and output power to raise the signal level from the control amplifier sufficiently to drive the loudspeaker. Since the entire system is used only for home entertainment, and the loudspeaker itself is quite efficient, the power requirements are relatively low. The general design of the amplifier follows closely that of the 6AS7G amplifier previously described by the writer.[1] The output is approximately 6 watts at one per cent harmonic distortion, and the average power used with the present speaker is less than one watt.

It will be remembered that the control amplifier terminates in a tube-to-line transformer, and that a 600-ohm line is used to feed the signal to the main amplifier. Thus an input transformer is required for the latter. Briefly, the main amplifier consists of a step attenuator, the input transformer, two stages of amplification using 6J7's as triodes, and employing 17.5 db of feedback, the push-pull interstage transformer feeding the 6AS7G, and the output transformer. The complete schematic is shown in *Fig.* 2.

The input transformer, T_1, is designed to work across a terminated line, which means that the apparent source impedance is one-half the nominal line impedance. Referring to *Fig.* 3, (*A*) shows a transformer working from a 600-ohm line, without a resistive termination. This arrangement does not terminate the line correctly for many circuits, and often results in a frequency response of the preceding equipment which differs from that measured into a resistance load. Some transformers, especially those at the input of a microphone preamplifier, are designed to operate from an open circuit, and similarly most microphones are intended to work into an unloaded transformer winding. Other transformers are designed to work with a resistance termination on the secondary, as at (*B*), but this often causes a reduction in high-frequency response. The transformer used in this amplifier was designed to work across a resistive termination, so the apparent source impedance is one-half the line impedance, as shown at (*C*).

This permits the use of a simple arrangement for a step potentiometer, since the transformer offers no load to the line, and it is not necessary to use a T-pad. The main requirement is that the transformer "looks back" at 300 ohms. In order to adjust the gain of the main amplifier to a value which

*Managing Editor, AUDIO ENGINEERING

[1] "High Quality Amplifier with the 6AS7G", AUDIO ENGINEERING, March, 1948

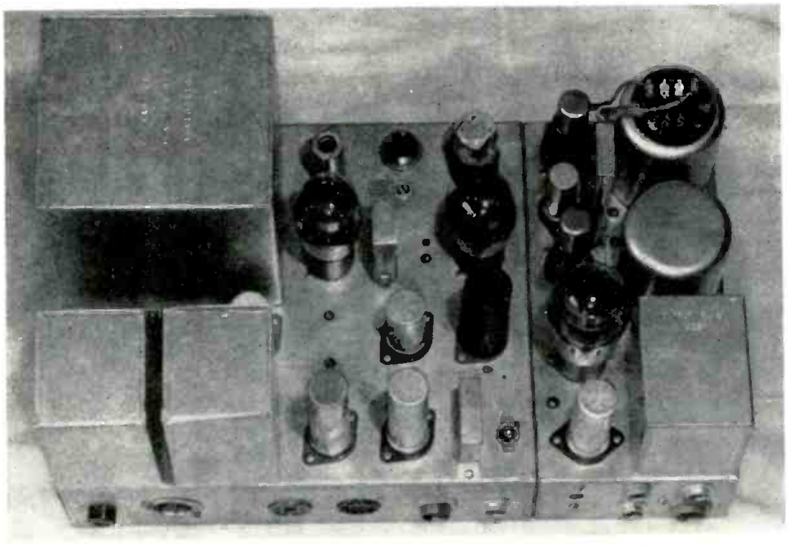


Fig. 1. Top view of the main amplifier and power supply units bolted together as a single chassis.

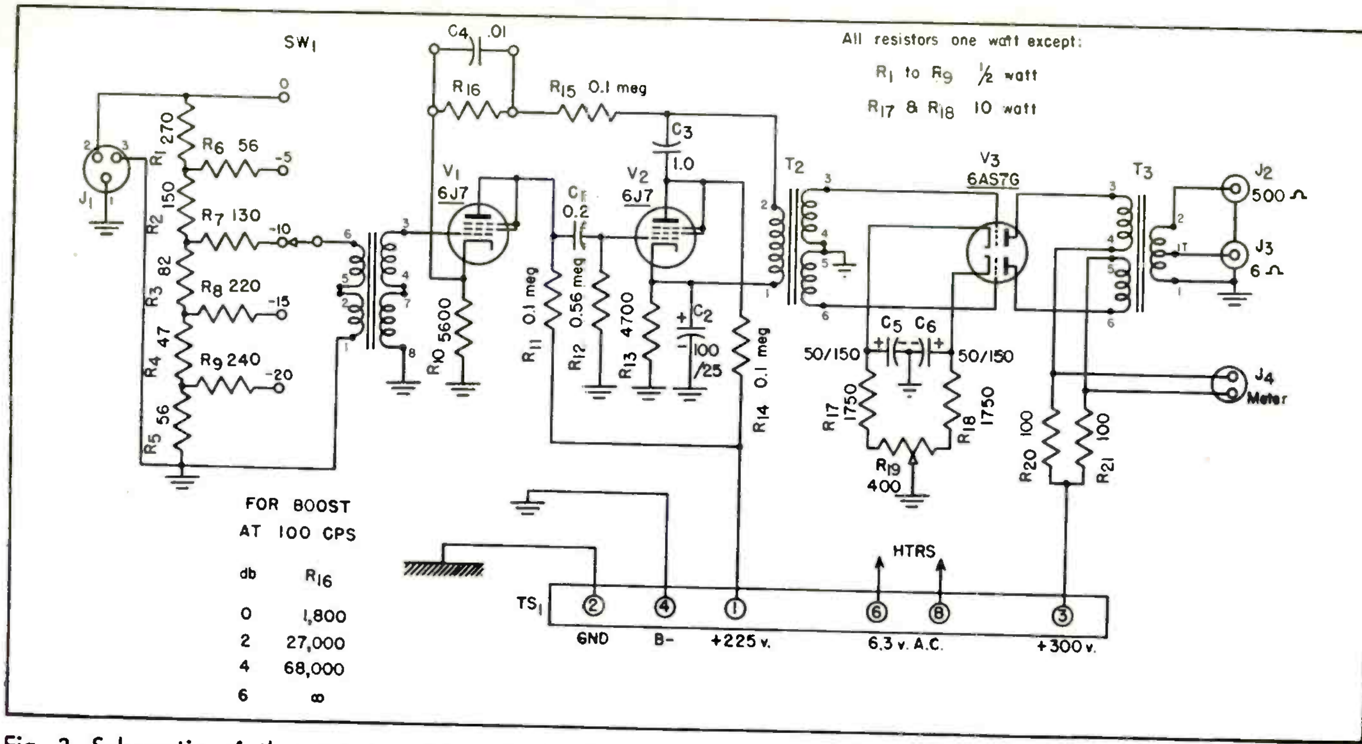


Fig. 2. Schematic of the main amplifier, closely following the original 6AS7G amplifier described in the March issue.

permits the compensated volume control (in the control amplifier) to operate over its optimum range, it is desirable to have discrete steps of attenuation, and 5 db is a suitable value for these steps. Thus the input attenuator consists of an L-pad designed to offer a constant 600-ohm load to the line, and to offer a 300-ohm source to the transformer when the 600-ohm line is connected. The entire attenuator is assembled on a Centralab #1404 switch, with one of the rotor contacts removed, and with the lugs bent back so as to provide a number of tie points for the resistors as shown in *Fig.* 4. The shunt resistors, R_1 to R_5, are selected from RMA values to provide a total resistance of approximately 600 ohms (actually 605) with 5-db steps. The resistance at point *X*, for example, is equal to (150 + 82 + 47 + 56) in parallel with (605 + 270), or 242 ohms; 300 less 242 equals 58 ohms for R_6, and the 56-ohm RMA value is sufficiently close. The same type of calculation is used to determine the values for R_7, R_8, and R_9.

Input Transformer

The input transformer has an impedance ratio of 300:90,000 which represents a voltage step-up ratio of 17.3. The secondary feeds the grid of V_1, a triode-connected 6J7, which is resistance coupled to a second 6J7, also triode connected. The choice of 6J7's was dictated by two conditions: it permitted mounting the selected input transformer in its normal position, with the terminal board on top and with a short lead to the grid cap, thus keeping the grid connection well removed from the heater leads; and according to the amplifier tables in the RCA Tube Handbook, the triode-connected 6J7 is capable of a higher output voltage than the 6J5, which would appear as a logical choice. The 6J7 also appears to be better than the 6N7 previously employed, both with respect to distortion and for a lower hum level.

Inverse feedback is employed on the first two stages, since the requirements from the second 6J7 are rather severe, and since the output tube has low gain and a low plate impedance and thus does not actually need feedback. Applying feedback around two transformers is also likely to introduce troubles which are difficult to eliminate, unless the transformer is designed specifically for such use. Parallel feed is used to keep d.c. out of the transformer primary, with the capacitor C_3 isolating the plate voltage from the transformer. Normally it is considered more desirable to place the capacitor between the low end of the primary and the cathode, as shown at (*A*) of *Fig.* 5, since this arrangement constitutes a bridge which balances out hum components in the plate supply. Referring to (*B*), R_p represents the plate resistance of the tube, R_L the shunt-feed resistor, C_c the coupling capacitor, and C_f a decoupling capacitor. The hum component of the

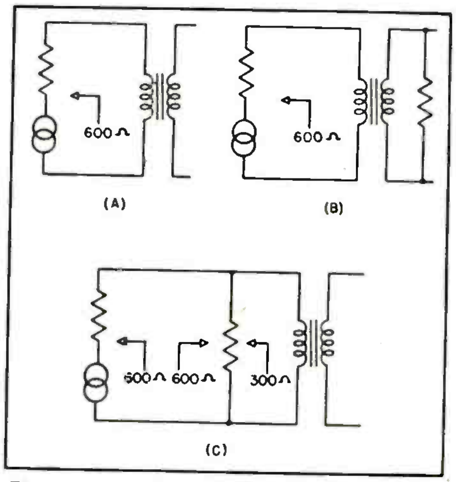


Fig. 3. Differing methods of operating transformers: (A) across an unterminated generator of 600 ohms impedance; (B) with a termination across the secondary; and (C) across a terminated line. Note that the transformer "sees" an impedance equal to one-half the nominal line impedance.

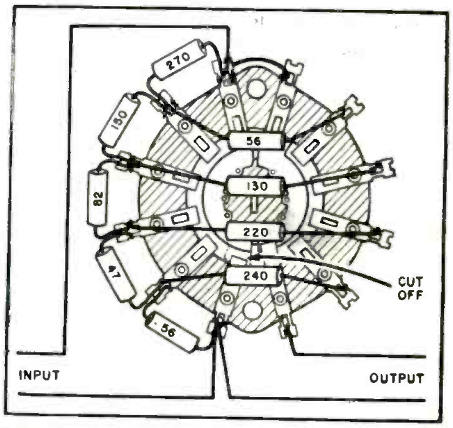


Fig. 4. Method of constructing input attenuator on a single switch deck. The contact fingers on one half are bent back or cut off, and the lugs serve only to mount the resistors.

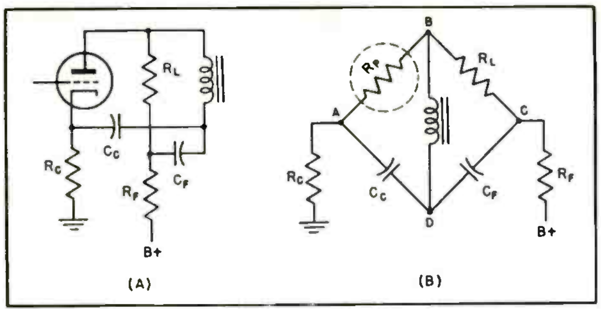


Fig. 5. Bottom-connected isolating capacitor (A), and rearrangement of elements in bridge form (B) to show hum balancing effect.

plate supply appears between *A* and *C*, and if C_c and C_f are chosen so their reactances are proportional to R_p and R_L respectively, the bridge will be balanced, and no hum voltage from the plate supply will appear between points *B* and *D*, to which the primary of the transformer is connected.

However, the plate voltage for this stage is practically humless, since it comes from a regulated supply, so this connection was not considered necessary. Therefore, the coupling capacitor C_3 is top-connected, and also serves to isolate the plate voltage from the feedback circuit. Feedback is applied to the cathode of the first stage through the network consisting of the resistor R_{15} in series with the capacitor C_4 across which is shunted R_{16}. This connection provides a quick means for varying the low-frequency response readily. The entire amplifier is flat with 1,800 ohms across C_4. For boosts of 2, 4, or 6 db at 100 cps, the value of R_{16} is 27,000, 68,000, and ∞, respectively. This is not intended as a variable tone control, but is a fixed adjustment which is set for a given speaker system. In general, this method of varying low-frequency response is not desirable, since it reduces the feedback at the low frequencies where it is most useful. However, the amplifier is in use with the 1,800-ohm resistor across C_4, so this problem is not encountered in practice. Even with 6 db of boost, the effect is not particularly important with program material, since there is a falling off in peak power requirements below the most probable peak at 350 cps[2]. It would, however, show up on constant-frequency measurement methods.

Output Stage

The output stage is conventional for the 6AS7G, using separate cathode resistors for each of the triode sections, and by-passing them heavily. The potentiometer R_{19} serves as a balance for the plate currents. The output transformer has a split primary, and a 100-ohm resistor is connected in series with each. A 150-0-150 microammeter is connected to the two junction points. When the plate currents in the two halves of the primary are balanced, the drops across the two 100-ohm resistors are equal, and the meter indicates a balance with no current through it. For initial adjustments of R_{19}, it is suggested that a resistor be used in series with the meter, to avoid possible overloading. The connections for the meter appear on a receptacle, as do the 6 and 500-ohm outputs of the amplifier.

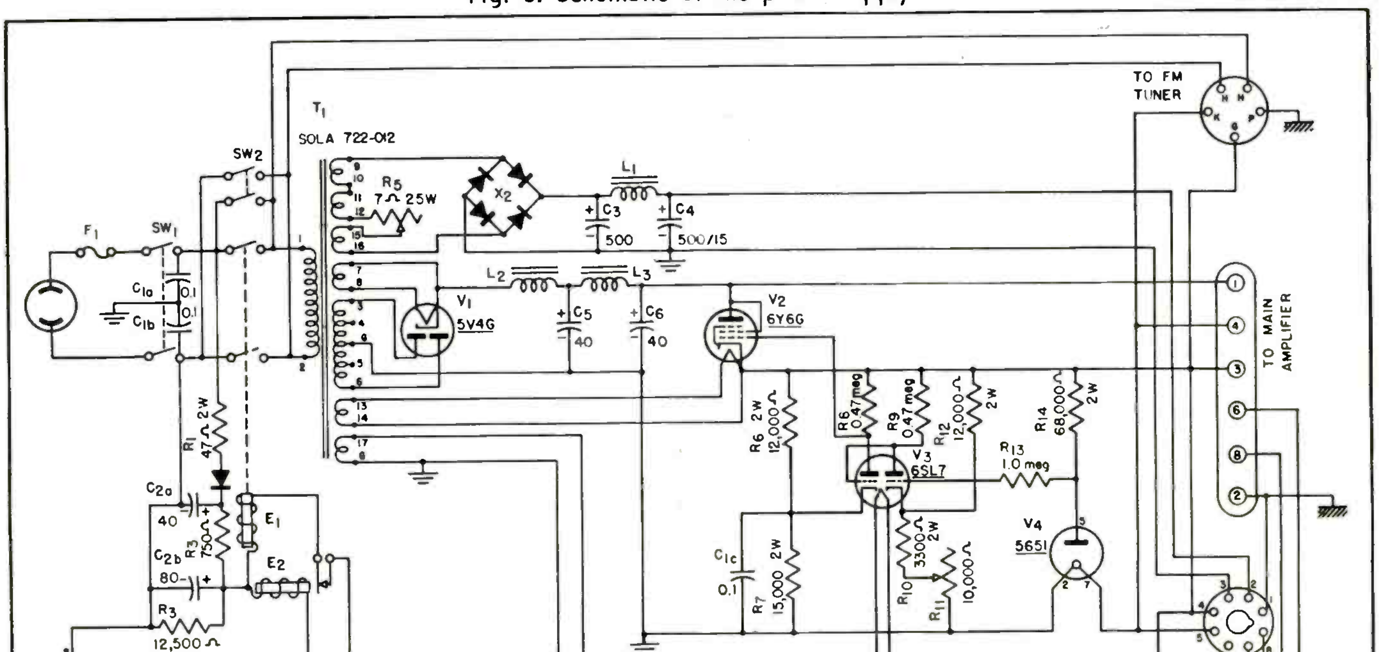
The overall gain of this amplifier is 50 db, with the input attenuator providing additional gain settings of 45, 40, 35, and 30 db. Power output at one per cent harmonic distortion is 6.2 watts, and the response is flat within ±1 db from 24 to 17,000 cps. The output stage works with a plate supply of 300 volts, and the bias is 87 volts. The first two stages are fed from a regulated supply at 225 volts, and the filaments are heated from a 6.3-volt winding on the power transformer.

The Power Supply

Aside from the relay system and the d-c filament circuits, the power supply is conventional. Surplus parts were used when their characteristics were suitable for the purpose, and no similar units are available from jobber stocks.

2"Powers Produced by Musical Instruments", John C. Steinberg, 9-23, Electrical Engineers Handbook, Pender & McIlwain, (Wiley)

Fig. 6. Schematic of the power supply unit.



However, equivalent voltage and current ratings may be obtained by using an additional filament transformer with a heavy-duty power transformer. Referring to the schematic of *Fig.* 6, it is seen that the a-c line first passes through a fuse and the main power switch Sw_1 thence to the contacts of the ON relay, E_1, which are paralleled by another switch, Sw_2, which permits the use of the unit without relay operation if desired.

The relay system, described in Part I of this series, consists of a 100-ma selenium rectifier and an RC filter system. Whenever any of the station selector relays is actuated by depressing its corresponding push button, the current flows through the relay circuits, first passing through E_1, and the normally closed contacts of E_2. The selector relays have holding contacts, and as long as any one is actuated, E_1 remains closed, applying power to the transformer primary. Depressing the OFF button energizes E_2, which operates and breaks the holding circuit; E_1 releases, and disconnects power from the transformer primary.

The power transformer has a total of six filament windings, of 6.3 and 5 volts. Two of the 5-volt windings and one of the 6.3-volt windings are connected in series, and feed a 1-amp bridge-connected selenium rectifier, with R_5 being used to adjust the d-c output voltage. The filter consists of L_1, C_3, and C_4, and the output is adjustable from 10 to 14 volts at 1-amp drain.

The high-voltage supply uses a 5V4G rectifier with a two-section choke input filter, furnishing 300 volts to the 6AS7G. The regulating circuit consists of a 6Y6G as the series tube, with a 6SL7 as the control amplifier and a 5651 for the voltage reference. The circuit is that recommended by RCA, and the output voltage is adjustable from 180 to 240 volts. It is normally set at 225 volts, and the regulation holds the ouput constant within two volts over a current range from 10 to 75 ma.

The metering circuit for balancing the 6AS7G output stage is fed to the power supply, and with another circuit consisting of ground and a series resistor from the regulated B+ bus is fed to a four-terminal receptacle for the meter. Either of these two circuits is selected by a 3PDT switch, not shown on the schematic, with the third position connecting to a jack on the front panel. This jack is used when aligning the FM tuner by inserting a patch cord between it and the jack on the tuner chassis. The discriminator balance is read directly on the meter, and the job of alignment is made as simple and accurate as possible.

Power for the control amplifier appears on an octal socket, and that for the main amplifier appears on a terminal block, mounted under the chassis. The FM tuner requires plate supply and 115-volts a.c. for the primary of the filament transformer, and this fed through a 5-p socket. The AM tuner obtains its power through the FM tuner, as indicated on the block schematic, *Fig.* 7.

Construction

The main amplifier is built on a 5"x10" chassis, and the power supply is on a 12"x10" chassis. As shown in the photos, *Fig.* 1 and *Fig.* 8, these two chassis are bolted together, with short leads connecting their terminal blocks. These two sizes were chosen so that they could be used together as a single unit, 10"x17", and thus fitting on a standard relay rack; or so they can be used separately if desired. The use of terminal blocks for each section permits interconnection with short leads when the chassis are used together, or with a cable as long as necessary when

[Continued on page 38]

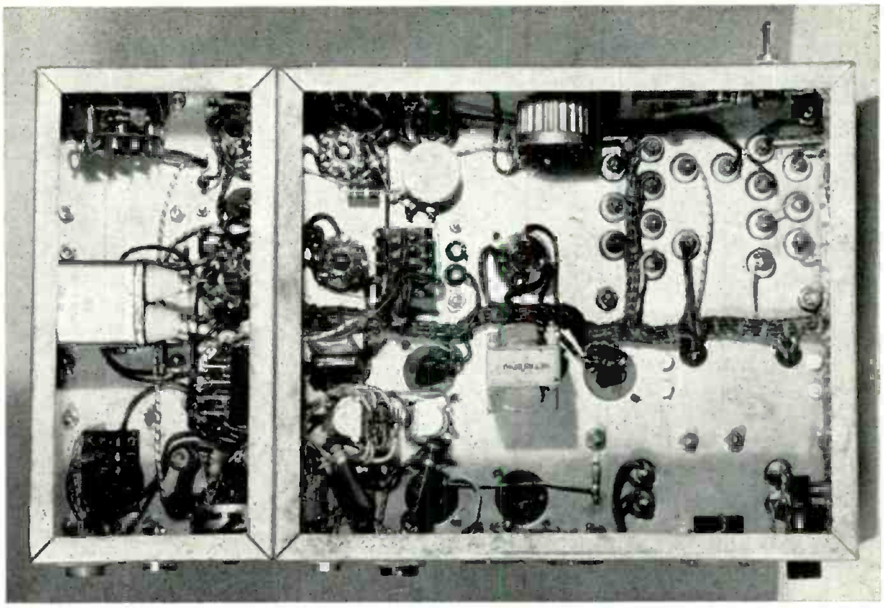


Fig. 8. Bottom view of two units bolted together, showing cabled wiring and use of resistor mounting strips.

TABLE I

Transformer	Thordarson	Audio Dev. Co.	UTC
Input	T2A68	214A or 215A	LS-10
PP Input	T2A40	214H or 215C	LS-21
Output (VC only)*	T3S21		LS-57
Output (Line and VC)	T3S22	314C or 315C	LS-55

*If amplifier is to be used only to feed a voice coil, a transformer without a line winding is recommended

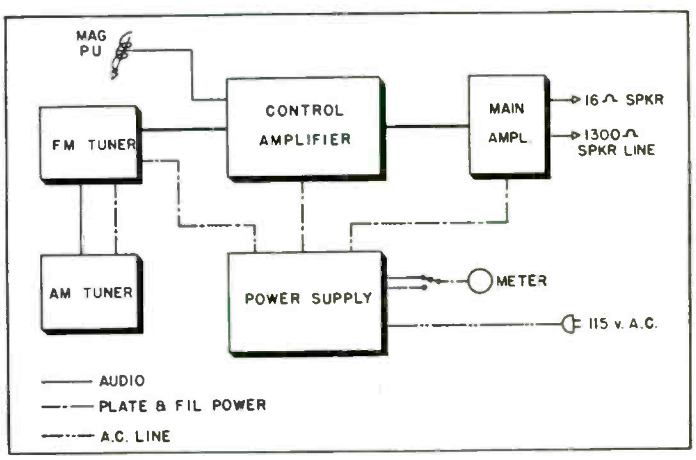


Fig. 7. Block schematic of the entire system described in this series.

EDWARD TATNALL CANBY*

IT WASN'T until negotiations with the Union broke wide into print that the light dawned upon this department. For the last two months an overwhelming flood of new recordings has been coming in that has aleady built up a backlog of impressive proportions. Instead of the nice 4" packages that used to arrive very respectably every so often (the kind of package you *can* carry home from the P.O. when the postman has found you out and left a slip. . .) suddenly great foot-wide monsters began arriving from the big companies. It took two people to get 'em upstairs. One had fourteen albums in it, and none of them pint-size either. Nor were these albums that could be safely ignored—far from it. The quality stayed high.

The explanation was simple (or *you* find a better one). With the (privately) approaching end of the recording ban the big companies had begun to unload. To dehoard. Enough albums, say, to last at least another full year had to be launched all at once upon the unprepared dealers (and reviewers), as fast as they could be set up.

I don't suppose we can find much fault—what else, after all, could be done? Obsolescence raised its ugly mug. Yet in the face of persistent reports of poorish record sales it seems rather a remarkable invitation to deflation to dump this vast quantity of goods upon an already satiated market. However, business is business and no doubt the record companies know what they are up to. As for us buyers of records, it's hard to know whether to be pleased or annoyed; better double your record budget, borrow willy-nilly from future expectations and try to keep afloat on the flood! Obsolescent or no, there is plenty of stuff you can't afford to miss in this hoard. As for this department, on account of it has such a stack of new records and, coincidentally, on account of it'll be almost Xmas by the time this is in print, we hereby promote a double-barrelled attack on the mountain of unreviewed stuff. Consider this as two months' worth, in one, and file away for future reference if need be. The remainder of the flood will be mopped up as best as Canby in the January issue, with profound hopes that we'll be reasonably dried up, come Ground Hog Day.

* * *

Note: I thank Mr. H. S. Scott for pointing out a couple of factual aberrations in the Noise Suppressor comparative diagrams in the September issue. In the H. H. Scott 210-A suppressor-amplifier the 10 kc resonant circuit whistle filter operates of course not on the 10 kc, but on the 5 and 8 kc positions of the range switch, for use in AM listening. The gate sensitivity is varied "automatically" *along with* the "floor" in the left hand (continuously variable) control and—I did not know this—also in the range control settings. See schematic for details. (This happily, falls into line with my own aurally-derived suggestions of last month, that some degree of control over gate sensitivity (beyond the input adjustment) is clearly necessary, but should be moderate, and removed as much as possible from the listener's primary attention. Could be done either by inconspicuous location of the control or by combination with some other function, as here.)

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*279 *W. 4th St., New York* 14, *N. Y.*

Recent Recordings

Beethoven, Symphony No. 7 in A.
National Symphony Orch. (Engl.), Fistoulari.

Decca London EDA 55 (5)

Debussy, Images No. 2: Iberia; Berceuse Heroique (1914).
Paris Conservatory Orch. Meunch.

Decca London EDA 51 (3)

These two albums, in quite different areas of orchestral music, are sensationally fine examples of what the recording art has come to, at least in England, where the ban has never been. The Beethoven is a good performance, not outstanding, musically; but the recording is so extraordinarily clear in detail, the big liveness so suitable to the music, the high highs and low bass so natural and clean, that I would rather listen to this, played on top quality equipment, than to any other current version. Beethoven is notoriously hard to record; this is about the best treatment he'll ever get . . . The Debussy, except for the soft parts, is a recording engineer's dream, with color, atmosphere, tinkly highs for that extra-wide range, etc. Performance here is unbeatable and the album may sound technically superior to the Beethoven, thanks to all of this, though I suspect the technique was very similar.

Prokofieff, March, Op. 99. Shostakovitch, Waltz from "Les Monts d'or" (film music).
N.Y. Philharmonic, Efrem Kurtz.

Columbia 12881-D (1)

One more product of what must have been a memorable series of recording sessions, pre-ban, when the now famous "Gayne" suite was waxed (should one say, lacquered). Brilliant, but when played next to the above Deccas this shows up as a relatively course-grained offering, in spite of wide range, lack of distortion and all the rest. Matter of acoustics and mike placing, I'd say. The Prokofieff is a nice, sassy bit well worth a try; the Shostakovitch is thoroughly weak-tea.

Ravel, L'Enfant et les Sortiléges (1925).
Chorus, Orchestra, Soloists of French National Radio.

Columbia MOP 29 (6)

The prize recording of the fall season as far as I'm concerned—a heretofore little known opera-ballet, with singing, semi-talking in radio style, based on a child fantasy, a sort of French "Alice". If you know a bit of French, the words are very easy to catch, the recorded diction superb, the accompanying notes most helpful. Full of sensuous Ravel music, gracefully humorous, plus some extraordinary satire—a duet between two back-fence cats that is incredibly realistic, yet still real music; a fine take-off of 1925 U.S. jazz, with a jargon of meaningless Americanese as it must sound to a good Frenchman. Full of fun, laughs and art—and one of the finest recordings to come out of Europe (made, I undestand, on British equipment). Performance is absolutely tops, both as to singing and as to liveliness and naturalness.

Beethoven, Diabelli Variations, Opus 120.
Leonard Shure, pianist.

Vox 636 (7)

On a different musical plane, here is one of the supreme late-Beethoven pieces, a set of over thirty variations on a tinny little waltz tune by the music publisher, Diabelli. This has all the subtlety, the violence, the sudden strange changes of harmony and mood of the last Beethoven quartets and piano sonatas, but the music is far easier to listen to, and in fact rates as fairly easy Beethoven (as Beethoven goes). The recording is one of those strikingly natural products that Vox turns out, with a big, full sound, especially in loud passages, a minimum of percussive effects; again, this is the best piano recording to have been done in the U.S. at ban-time, in spite of minor imperfections such as too-high peaks, enforced surface noise in the very low passages (Beethoven's fault). If you are at all partial to B. aside from the symphonies, you can spend weeks enjoying this album, especially with a big speaker and *plenty* of power. The bigger the noise the better this sounds!

Dvorak, Symphony No. 4.
N.Y. Philharmonic, Bruno Walter.

Columbia MM 770 (4)

For those who enjoy the "New World" Symphony, same composer, this is a work to try and to get to know—it is generally

[Continued on page 33]

NEW PRODUCTS

"MUSIC IN FOCUS" AMPLIFIER

● Langevin announces its new "Music in Focus" Amplifier, Type 127-A, which has been designed especially for music lovers.

The new amplifier is equipped to operate with a radio tuner and a phonograph pick-up, either variable reluctance type, crystal cartridge, or the new LP micro-groove pick-up cartridges.

This amplifier is designed to meet the demand for quality in the medium price range.

It provides ten times the power required to supply ample volume in a large living room using a loudspeaker of average efficiency (4 watts with less than 5% total rms harmonic distortion over the range 50 to 15,000 cps).

Independent bass, treble and volume controls are provided so that the amplifier can be adjusted to various record and pick-up characteristics. It is described in detail in Bulletin 1055, available from the Langevin Manufacturing Corp., 37 West 65th St., New York 23, N. Y.

TINY RESISTORS

● Wilkor Products, Inc., 3835 West 150th Street, Cleveland 11, Ohio, is now producing a complete line of extremely small Carhofilm Resistors, specially designed for use in the

manufacturing of all types of miniature electronic units. They are available in sizes from 1/4 to 1 watt, in values fro 20 ohms to 5 megohms and with tolerances of 1/2 to 1%. The smallest resistor in the line measures 1/16" diameter over caps, 3/8" over-all length, with 1 1/2" diameter over caps, 3/8" over-all length, with 1 1/2" tinned copper leads. They can be supplied insulated. The company is planning to manufacture a hermetically sealed type in the near future.

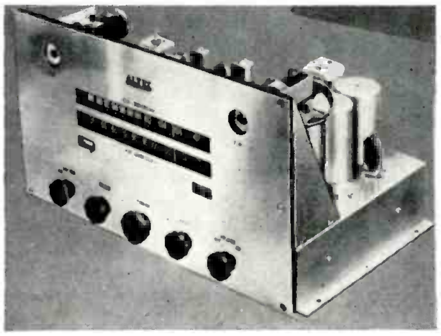
AM-FM TUNER AND AMPLIFIER

● Designed especially for home use, a new FM-AM tuner, coded ALC-101, and an associated high fidelity amplifier (A-323C) are now being shipped to distributors, according to an announcement by A. A. Ward, vice president of Altec Lansing Corporation.

Notable feature of the new tuner is the use of tuned r.f. in the AM side, in order to make AM reception comparable in quality to the FM. A ratio detector is used in the FM section.

Besides AM and FM input the tuner also has provision for television sound input and for phono input. The latter incorporates a preamplifier with special built-in equalization to permit operation direct from any of the new magnetic pick-ups.

A stepped low-pass filter for noise suppression and elimination of phonograph record



scratch is provided in both the phono and radio circuits. On step one the frequency response is flat within one db from 20 to 20,000 cycles. When step two of the scratch or noise filter is cut into the circuit a sharp 8,000 cycle cut-off becomes effective; on step three a sharp 6,000 cycle cut-off is provided, and step four provides a 4,000 cycle roll-off. This noise suppressor is not of the simple radio type "tone control" roll-off but instead consists of a resistance-capacitance-inductance combination low pass filter so as to permit reproduction of all usable frequencies, and provide a very sharp cut-off for elimination of scratch and noise above the cut-off point.

A sharp 10 kc dip filter is provided on the AM audio output of the tuner so as to remove the heterodyne whistle of adjacent channel AM stations. A dual wave trap is provided at the input of the AM section to prevent cross-modulation interference from nearby high power stations.

The A-323C Amplifier utilizes the same basic circuit as the Altec Model A-323B Amplifier. The technical features of the amplifier are stated to include: flat frequency response within 1 db from 20 to 20,000 cycles, full power delivery within 1 db from 35 to 12,000 cycles, hum and noise 30 db below 6 mw, less than 8% intermodulation of 2% total harmonic content at full 18 watt output.

SLOW SPEED RECORDER

● Chase Engineering & Manufacturing Company, Baltimore, Md., is now in production on their new slow speed, single channel, magnetic tape handling mechanism operation at a speed of 3.75 inches per second, giving one hour of continuous recording or playback from a standard 1200 foot roll of tape.

This new unit is priced for the mass market, and is being manufactured only for radio and television manufacturers for incorporation with their various amplifiers, radio or television combinations.

CEMCO has incorporated many key features in their new product, such as a turntable for record playing that does not interfere with the use of tape, but also can be operated simultaneously with the tape, or independently as the occasion requires. If desired, the turntable may be removed completely. For further data, please write the manufacturer.

CERAMIC CARTRIDGES

● Two of its microphone models and a phonograph pickup cartridge now are available with ceramic elements, it has been announced by The Astatic Corporation, Conneaut, O.

A variety of applications now have given final proof to the extensive advantages previously anticipated for microphones and pickups employing ceramic elements, according to an Astatic spokesman. The quality of reproduction of the devices has been com-

[*Continued on page 30*]

PROFESSIONAL DIRECTORY

Thousands of Soundcraft discs are leaving the factory daily to find their way into the broadcasting stations and recording studios of the world as mediums for reproduction of the programs people listen to.

Twenty-five Soundcraft types and sizes are job-proven for every need from transcribing a spot announcement to originals for micro-groove record releases. Twenty-five prices run the gamut from the premium super disc, the 'Broadcaster', and the professional quality, competitive 'Playback' to the budget-saving 'Auditions' and single face types.

Soundcraft's recording surface, due to micro-filtering of the "acetate" and electrostatic dust elimination in the drying air, can be counted on for quiet, sure-fire cutting free from mysterious noisy patches, grey rings and stylus failures. Thanks to complete weather making equipment and scientific controls Soundcraft manufacturing operations are independent of seasons. Because Soundcraft discs are uniform, the recordist can *predict* results.

Clip the coupon for your copy of "How Soundcraft discs are made", names of your nearest distributors, and a sample disc to meet any requirement of quality and price you may wish to outline.

To: REEVES SOUNDCRAFT CORP.
10 E. 52nd St., N. Y. 22, N. Y.
Please send story, distributor list, and free sample Soundcraft disc to

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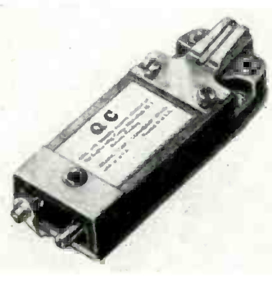
The 'Broadcaster' The 'Playback' The 'Audition' The 'Maestro'

NEW PRODUCTS

[from page 28]

pletely unaffected by exposure to extreme climatic and artificial heat, it was stated. The widest humidity range has left the ceramic products similarly unchanged in performance and physical condition. Comparatively low impedance of the microphone has permitted their use under many circumstances where, previously, only costly, heavy units were suitable. The ceramic pickup cartridges have been adapted successfully to standard circuits without making additional changes.



REGULATED D-C POWER SUPPLY

● A d-c power supply with output voltage regulation better than 0.01% and ripple less than 0.1% is announced by the Hasting Instrument Company, Inc., of Hampton, Va.

The precision-regulated power supply is adjusted by the manufacturer for optimum regulation at any specified load of from 5 to 30 milliamperes and for any output voltage from 0 to 100 volts. Regulation is thus obtained within ±0.1% for input line voltages varying from 75 to 135 volts a-c at frequencies from 50 to 400 cycles per second.

The unit pictured measures 4 x 5 x 6 inches and weighs 6 pounds. It is well designed for laboratory use and is small enough to be readily adapted as a built-in power supply component for large instruments.

NEW BFO

● The new Type 1304-A Beat-Frequency Oscillator supersedes the older General Radio Type 913-C. Identical in over-all size with its predecessor, the new oscillator has greater accuracy, better stability, and lower distortion.

Over-all frequency range is 20 cycles to 20 kc, with an accuracy of (±1% + 0.5 cycle) after the dial zero has been set in terms of the a-c line frequency. The gear-drive dial has a logarithmic scale. A frequency increment dial with a range of ±50 cycles is provided.

Output impedance is 600 ohms, balanced or unbalanced. Normal maximum output is 0.3 watt with total distortion of less than 0.25% over most of the range. Distortion is slightly higher below 100 cycles and above 7500. With distortion of 1% between 100 and 7500 cycles, a maximum output of 1 watt can be obtained. A-C hum is less than 0.1% of output voltage.

Open-circuit output voltages for the two output levels are 25 volts and 40 volts, respectively. Output voltage varies less than ±0.25 db over the entire frequency range.

Frequency drift from a cold start is less than 7 cycles in the first hour, and is essentially completed after two hours.

Power supply is 105 to 125 (or 210 to 250) volts, 50 to 60 cycles. Total power consumption is 100 watts.

The 19-inch relay-rack panel is 7½ inches high, and the depth behind panel is 14¼ inches. Net weight is 41½ pounds.

HI-FI TRANSPOWERS

● The new Stancor "HF" and "WF" series of high fidelity audio transformers include a complete range of commonly used ratings for amplifier circuits, speakers, microphones and pickups, including low impedance to grid, push-pull input, mixing, output and input.

Special coil and core construction results in the reduction, to a miniumum, of hum pickup, leakage reactance as well as harmonic and intermodulation distortion.

The "HF" series, except for the HF-65 output transformer, has a wide range frequency response of 20-20,000 cps, within ± 1 db. The HF-65 has a response of 30-20,000 cps within ± 1 db. The "WF" series, except for the WF-21, has a frequency response characteristic of ±2 db from 30-20,000 cps. ±2 db. The WF-21 input transformer has a response of ±2 db from 50-10,000 cps.

Both series are potted in gray enameled cast cases with four tapped holes on both top and bottom for flush mounting. Stud-type terminals are provided on a phenolic panel. Standard Transformer Co., Dept. B, Chicago 18, Ill.

MONTGOMERY TIMERS

● Montgomery Mfg. Company, 549 West Washington, Chicago 6, Ill., announce their new line of synchronous program timers

that are particularly suited for accurate control of public address, radio, chimes or any system of wired or direct reproduction. These units can be set exactly for the time of day programs are to be switched on and off with any desired interval as low as 2½ minutes. As many as 288 operations per day can be set on the program disc. A calendar switch is provided which can be set to silence the program through as many twelve or twenty-four hour periods as desired in any week.

Thus a single operation or a full week's program can be set up on the timer which will be continuously repeated until reset.

For further data, please write the manufacturer.

STUDIO CONTROL CONSOLE

A new type of cabinet construction in this custom-built studio control console, designed and built by the RCA Engineering Products Department for Radio Station

KOMO, in Seattle, Wash., gives the operator an unobstructed view of program action through the window between control room and broadcast studio. M. E. Gunn (left), RCA audio speech input engineer, is shown demonstrating features of the console to R. A. Elliott, Manager of the RCA Broadcast Audio Sales Section. Console height was minimized by mounting the terminal block and line transformers on a panel below the work surface of the control desk. The unit is one of seven, including a master control, supplied by RCA to Station KOMO.

— News —

WARD LEONARD NEWS

● Mr. Dawson J. Burns of the Ward Leonrad Electric Co., Mount Vernon, N.Y., who resigned the office of President of the Company at a meeting of the Board of Directors held September 28, 1948, was elected Chairman of the Executive Committee. Mr. Burns has been a member of the Board of Directors since 1903, serving the Company as Vice-President from 1908 to 1944, at which time he was elected President.

Mr. Arthur A. Berard, Executive Vice President and General Manager of the Company since 1944, was elected President and General Manager. Mr. Berard, who joined the Company in 1920, has been a member of the Board of Directors since 1927 and has served as Factory Manager and General Sales Manager.

RECORD REVUE

[*from page* 26]

rated as the best of Dvorak's symphonies in spite of the "New World's" big rep. The Walter interpretation is unsurpassable. Recording evidently was done a good while before the ban; the acoustics, in common with several other Walter recordings, not quite as good as Columbia later achieved with same orchestra; but the difference is minor and technically the recording is excellent, with current wide-range standards.

Saint-Saens, Piano Concerto No. 2.
Benno Moiseiwitsch; Philharmonia Orchestra, Cameron.
RCA Victor DM 1255 (3)

Those who fell for the splendid Saint-Saëns 3rd symphony (AUDIO ENGINEERING, Sept.) may want to investigate this opus, though they will not find here the unique physical combination of very low lows (organ) and high highs that made the Symphony recording technically so remarkable as a demonstration recording. This one is musically similar, though I'd say windier and more bombastic. The playing, by the man who did some of the finest Rachmaninoff piano ever recorded, years ago, is wonderful, as is the usual British piano recording. Piano plays much here, orchestra relatively little.

Stravinsky, Symphony of Psalms (1930).
London Philharmonic Orch. and Choir, Ansermet.
Decca London EDA 52 (3)

This severe, imposing work for chorus and orchestra was one of those impossible "modern" pieces, back in the early 1930s. Now, in this splendid new recording, it's quite listenable—partly because music of this sort is far easier for all of us to understand than it was then; but also because the new and better recording makes the listening enormously easier than the old version did. (C MM 162, dating from soon after the work appeared and itself a model of good recording in its day.)

Stravinsky, Danses Concertantes, (1942).
RCA Victor Chamber Orch. Stravinsky.
RCA Victor DM 1234 (3)

This is another in the unprecedentedly long series of first-rate recordings of Stravinsky by Stravinsky, dating back to the early 1930s. For years Columbia carried on the series, first in imports, then recently in U.S. recordings; now Victor has Stravinsky on its list, and has set him to conducting the House Orchestra in his own works. This is a recent-style work, and if you know the recent type of Stravinsky you may judge ahead of time whether you will like this. But somehow whenever S. turns to ballet his music takes on extra color and life and this is no exception. The first section, as always, is the most imposing and most difficult; once that is over, the rest is relaxed, humorous, full of fine rhythms and wonderful noises. For many listeners this kind of music is already irresistable, especially those who are hot jazz enthusiasts; it is utterly unlike the big, romantic "classical" music of Carnegie Hall, but, taken on its own terms, you'll find it made for today and as good a product as you'll get in any sphere of music-making right now. Try it. Excellent recording, Victor's latest and best.

Strauss, Elektra (final scene) 1909.
Soloists, chorus, Royal Philharmonic Orchestra, Beecham.
RCA Victor DM 1247 (4)

If you want a contrast to the above Stravinsky, then sample this! Elektra was a "modern" (as of 1909) opera that shocked and horrified the then musical world; today it is unbelievably dated. To our ears, considering the song and dance that it raised, it sounds just plain old fashioned, notably the huge orchestra, the hefty wailing and screaming in the best Wagnerian style, gone mad! Today, this once-modern music shows up as a powerful and final exaggeration of all the familiar Wagnerian effects, and in truth it was the last gasp of that sort of thing—a mighty one-before a complete reaction that led to the casual, non-emotional utterances of more recent days, and to the brassy, jazzy horseplay of much other later music . . . Still, this is a remarkable piece, wonderfully performed and recorded, and a first on records. If you are partial to Strauss, or to Wagner, give it a try. It's potent stuff, whatever the style; more to it than the familiar (and earlier) Strauss tone poems for orchestra.

Genesis Suite. (Shilkret, Tansman, Milhaud, Castelnuovo-Tedesco, Toch, Stravinsky, Schoenberg.)
Janssen Symphony of L.A., chorus. Edward Arnold, Narrator.
Artist JS 10 (5)

This was an interesting musical undertaking—Shilkret conceived of a setting with narrator, chorus and orchestra of the biblical story of Genesis, somehow managed to get the imposing list of composers above, each to contribute an entirely independent movement, the whole to be related only through the story continuity and of course the same narrator and performers. Done in semi-radio style and not unlike much in films, the often-dissonant music is very easy to take; but unlike most such background music, this has a lot to it; some of it I'd say was of considerable importance. Interesting contrast between musical styles of the various composers, but the whole runs along surprisingly consistently, as drama. Recording is West Coast style, wide range, dry, ultra-clear, lacking in liveness.

Poulenc, Concerto in D minor for Two Pianos (1932).
Whittemore and Lowe, duo-pianists; RCA Victor Symph. Mitropoulos.
RCA Victor DM 1235 (3)

Witty, very French music, most of it in the light, hard, satirical style of France in the 20s, with a bit of just about everything incorporated, from Bach and Chopin to Paris Music-Hall stuff. Clever and good listening, but not very important music, played in a hard, superficial way. The recording itself is one of the finest from Victor to date, evidently one of those just previous to the ban, with improved tonal range, less distortion in loud passages. Excellent piano tone, fine balance between pianos and orchestra, rather close, dead acoustics. Good demonstration record for this type recording.

Telemann, Fantasias.
Edith Weiss Mann, harpsichord.
Allegro 2 (2)

Sweelinck, Variations on "Est-ce Mars?"; Fantasia Chromatica.
Putnam Aldrich, harpsichord.
Technichord T-12 (2)

Two excellent harpsichord albums from two smaller companies both much interested in wide-range, distortion-free recording of older music. These harpsichords are recording "naturals", with fine, twangy highs, the instrument's absolutely even dynamic range (no sudden, unpredictable peaks), absence of difficult heavy bass (as in the piano). The two artists are both scholar-musicians with sure knowledge of the old music and the complexities of "realizing" it on the harpsichord; result is a naturalness of sound in both albums that the music never has in "modernized" versions for piano or even orchestra. Telemann was a vigorous, prolific contemporary of Bach, now making a quick come-back; Sweelinck was a splendid old Dutchman, 16th century, his solid music closely related to the English late 16th c.—"Est-ce Mars?" sounds like a swaggering English tune.

RECORD LIBRARY

In this spot a continuing list of records of interest will be presented. This list specifically does not suggest "the" best recordings or versions. It will draw predominantly but not entirely from postwar releases. All records are theoretically available, directly or on order; if trouble is experienced in finding them Audio Engineering will be glad to cooperate. Records are recommended on a composite of musical values, performance, engineering; sometimes one, sometimes another predominates but records unusually lacking in any of the three will not be considered. Number of records in album is in parenthesis.

The string quartet—it's nothing to be scared of in these fine recordings. (*Pre-war)

***Mozart, "Hunt" Quartet, K. 458.**
Budapest Quartet.
RCA Victor DM 763 (3)

Haydn, Quartet Op. 74, No. 3 "Horseman".
Budapest Quartet.
Columbia X 274 (2)

***Haydn, Quartets Opus 50, No. 3; Op. 76, No. 3 ("Emperor"), Op. 20, No. 5.**
Pro Arte Quartet.
RCA Victor DM 526 (7)

Beethoven, Quartet op. 59, No. 1. ("Rasoumovsky).
Paganini Quartet.
RCA Victor DM 1151 (5)

***Beethoven, Quartet op. 131.**
Budapest Quartet.
Columbia MM 429 (5)

Brahms, Quartet No. 3, op. 67.
Guilet Quartet.
Vox 208 (4)

Debussy, Quartet in G Minor, op. 10.
Paganini Quartet.
RCA Victor DV 17 (4 pl.)

***Hummel, Quartet in G Major, Op. 30, No. 2.**
Coolidge Quartet.
RCA Victor DM 723 (2)

***Schubert ,Quartet in B flat, Op. 168.**
Busch Quartet.
RCA Victor DM 670 (3)

Mozart, Piano Quartet in G minor, K. 478.
George Szell, members of the Budapest Quartet.
Columbia MM 773 (3)

A sequel to the recording of the Piano Quartet in E flat, K. 493, by the same group (Audio Engineering, March). Szell is well known as a conductor but in this and the companion Mozart album he turns out to be a first rate Mozart pianist—a rare bird today, since many top piano virtuosi find themselves at a loss when playing the misleadingly—oh-so-misleadingly—simple music of Mozart. Like the other album (MM 669) this is beautifully and naturally recorded, with excellent balance, wide range but unharsh. A notable Mozart item.

Viennese Waltzes. (Johann Strauss, Josef Strauss, Josef Lanner.)
Alexander Schneider String Quintet.
Columbia MM 766 (4)

A surprising album, containing a group of "unknown" waltezes from the huge collection that has turned up in, of all places, our own Library of Congress. These are played in original form, quintet of three violins, a viola, a double bass, a piquant combination that, with these top rank players and unusually fine recording, makes for a lot of good casual listening. Most curious of the Waltzes is one based on familiar operatic themes of Mozart—converted to waltz tempo! The full sound of this recording should serve as a model for the type—small groups recorded to sound big, round, with "presence", perspective. An excellent job.

Glazounoff, From the Middle Ages (1903).
Indianapolis Symphony, Sevitsky.
RCA Victor DM 1222 (3)

Rimsky-Korsakoff, Sadko (Symphonic Poem).
San Francisco Symphony, Monteux.
RCA Victor DM 1252 (2)

Dvorak, Husitska Overture. Smetana, The Moldau.
Boston Pops Orchestra, Fiedler.
RCA Victor DM 1210 (3)

A brace of good, solid, old-fashioned orchestral pieces, comfortable, ample, even colorful; their only unusual feature—the Moldau aside—is their complete unfamiliarity! But the style, in each case, is so familiar that you'll be quite at home from the note. Glazounoff's piece is a cross between Brahms and Tchaikowsky with a touch of Rimsky—Rimsky himself is as you might expect, but less so. Dvorak's Husitska is a bit unexpected, a big, tragic overture, reminiscent of the "Tragic" of Brahms, and highly dramatic, impetuous. If your taste is towards the Tchaikowsky era, these will please. All are good, big recording, best seems to be the Indianapolis (Glazounoff).

Beethoven, Violin Sonatas, Opus 12, No. 1 and No. 2.
Jascha Heifetz, violin, Emanuel Bay, piano.
RCA Victor DM 1254 (4)

An old and well-seasoned team of performers; thanks be, that this album of simple early Beethoven is played simply, without the pretentiousness that we often get when stars of the Heifetz variety are paraded in album form. These two sonatas are in the Mozart tradition still (with inevitable Beethoven touches), not the epochal, heroic Beethoven of the later sonatas ("Kreutzer", for instance) and plenty other works. Recording is unusually nice, wide range, mellow, straightforward, well balanced.

HIGH FIDELITY REPRODUCTION

[*from page* 8]

higher level than originally, the low frequencies must be attenuated in accordance with the shift in level along the Fletcher-Munson curves. It is also necessary to use *effort equalization* to compensate for the change in voice quality due to sound stage conditions. On a quiet sound stage the actor lowers his voice, which then acquires excessive lows and highs. A declamatory voice, as Mr. Loye showed, lacked lows and highs. Effort equalization in recording then will raise or lower the mid-frequency response so that the reproduced sound is subjectively correct. Originally developed empirically, laboratory studies provide the basis for present effort equalization practice.

He also discussed stereophonic reproduction, mentioning its use for sound reinforcement systems for orchestras. As applied to film in a 1940 demonstration, it added naturalness.

Harry F. Olson

● This proved to be the most informative and original paper of the symposium, and discussed listener range preference, analysis of typical present set performance, and analysis of tolerable faults. The first matter touched on was his well-known series of listener range preference tests using an acoustical filter. These indicated 69% preferring full range, and 31% preferring a 5000 cycle low-pass system cutoff. Not all of the 31% were actually against the wider range—they were often voting against a program that was disliked. In narrow bandwidth this would be less forcibly called to the ear's attention, and hence be less objectionable.

Tests using electronic systems often produce the opposite result, due to the many forms of distortion which may be present. He showed actual performance data on three typical sets in the $300 price class. All had very irregular acoustical response and a cutoff between 3000 and 4000 cycles. Directivity effect was high, even though reduceable at microscopic cost. Harmonic distortion reached 100% at 40 cycles because of the use of a pentode output tube without negative feedback, and the use of a 60 cent output transformer. In the middle range distortion was very great due to poor detector design.

Loudspeakers are often unjustly accused of responsibility for this intermodulation distortion. His data showed that the total set intermodulation was about five times that of the speaker alone.

Irregularity in the response curve is accompanied by poor transient response. Oscillograms of the speaker response to a 150 millisecond tone burst indicated this. Quick buildup and decay of tone are needed for more reproduction of instruments such as the piano and guitar, and receiver loudspeakers often fail in this important respect—as the tone burst tests showed.

Amplifier distortion is more objectionable than older tests have indicated. ½ to 1% was just perceptible in a wide range system, and 4 to 5% was highly objectionable.

The public would like better sound, but few will pay very much extra for it. Furniture is very important, and a great deal of set cost lies in the cabinet. If two sets have equivalent cabinets, the public will pick the better sound; but if both cabinets and sound quality differ in opposite directions, prediction of the customer's choice is difficult.

Radio set and phonograph quality has improved in the last ten years without significant increase in price as a result thereof. Frequency range has increased at the rate of 100 cycles per year, representing slow but definite progress.

J. P. Maxfield

The author being absent, Frank Massa read a summary of Mr. Maxfield's paper. He distinguished between high fidelity, faithful reproduction, and pleasing reproduction. The difference between high fidelity and faithful reproduction lay chiefly in the latter's use of a certain amount of high end droop. The amount of droop needed depends on the amount of distortion present. If distortion is very low, the public will find that this procedure has made wide range reproduction quite acceptable. If distortion is marked, the public will not accept wide bandwidth.

S. J. Begun

Dr. Begun began by stating that economic considerations prevented high fidelity results from a sound recording system. He enumerated various well-known sources of distortion in disc, film, and tape systems, showing that each had faults. It was indicated that these could be minimized.

Nevertheless, faithful reproduction has been attained by all recording means. At the present time, other elements of a reproducing system require much more improvement than does the recording-reproducing element.

Discussion

The discussion was opened by F. V. Hunt, who commented that in his experience with wider range systems, the addition of an octave of bandwidth was accompanied by a listener demand for about 5 db more level. In discussing Dr. Begun's remarks he noted that the present NAB pre-emphasis curve effectively guarantees excessive transcription distortion. There had been insufficient attention to the difference between transient response tests and the steady state. Finally, there was too great a difference between generally available reproducing system components and what had been used in the laboratory.

Pat Norris remarked that, with radio sets improving at the rate of only 100 cycles per year, and his hearing decreasing at the rate of 200 cycles per year, the future sounded dark. He emphasized that modern apartment construction severly limited the usable volume range for many listeners, and that the use of full orchestral volume would quickly lead to a visit from the gendarmes. He also discussed his experiments in accustoming the non-technical to wider frequency range in small steps.

Harvey Fletcher noted that the discussion had not even touched on high fidelity, which had been available for many years, but rather on more practical systems. The problem is how to define the loss from ideal for any given set of system characteristics by a single number—a quality scale. It was interesting to recall that Pupin had said that if he had known the actual frequency spectrum of speech, he would never have developed the loading of telephone lines, for the cutoff of the first loaded lines was 1500 cycles.

Harold Burris-Meyer protested the limitation of high fidelity to the audible range. Sub-sonic tones (10 cycles) had been used in a show to transmit emotions, and a generally superaudible 18,000 cycles to produce irritability. The body responds to a wider frequency range than the ear. The problem is that of control, not of facsimile. Listener preference testing should determine the listener response without the use of questioning—which distorts the response. Intelligent installation is often as important as the apparatus used.

Morgan stated that perhaps a good binaural effect could be secured even though the second channel transmitted only frequencies below 1500 cycles.

Hugh Knowles felt that some people prefer infidelity in reproduction. He protested the general lack of psychologists in listener preference testing work. H. F. Olson noted that his own test procedures had been checked by two psychologists.

The meeting then adjourned. Observers considered the meeting the most fruitful so far held on this controversial subject.

RADIO SYSTEMS

[*from page* 25]

they are used apart from each other. This construction provides an effective stiffener for the large chassis dimensions, as well as some shielding between the two sections.

The transformers in the main amplifier are all Western Electric types—a 247J for the input, a 264C for the push-pull input, and a 166B for the output. The latter is designed for push-pull 300A tubes, and has an impedance ratio of 4130 to 500 and 6 ohms. It is normally used with a 16-ohm load circuit, and reflects a somewhat higher load upon the output tubes than its nominal value. However, since the load desired for the 6AS7G is of the order of 4,000 ohms, the 6-ohm winding feeds a 16-ohm speaker and the 500-ohm winding feeds a remote speaker load of 1,300 ohms, thus reflecting approximately 4,000 ohms to the tubes. The interstage transformer has an impedance ratio of 18,000:100,000, and is designed for shunt feed. Suitable jobber types of transformers are listed in *Table I*.

The power transformer has seven secondary windings: 400-0-400 at 250 ma; three of 5 volts, 3 amps; and three of 6.3 volts at 5, 3, and 1 amps respectively. The two chokes are 10 henry, 200 ma units, and the d-c filament supply choke has an inductance of 22 mh at 1 amp. The total d-c filament drain for the control amplifier is 0.9 amps. The a-c drain for the main amplifier is 3.1 amps, and this is supplied by the 5-amp winding, which also feeds the 6SL7 in the power supply and the 6SJ7 in the control amplifier, making a total of 3.7 amps. The 3-amp winding is used for the heater of the 6Y6G in the regulator circuit. Although all the transformers and chokes in the power supply are surplus items, they may be replaced by standard items, using a multiple-filament transformer in addition to a combined plate and filament transformer.

Operating Characteristics

The quality of reproduction from this entire equipment is considered somewhat above average. Hum level is approximately −41 dbm—note that this is not 41 db below the maximum output as most commercial amplifiers are rated, but actually 79 db below the 6-watt maximum at one per cent distortion, about 20 db quieter than the average. This includes the control amplifier in the measurement, and was made with the input attenuator on the main amplifier set at 40 db and the volume control at maximum.

The most outstanding single feature of the equipment is the completely compensated volume control, which provides the correct aural balance to suit the output level. Most of the quality of reproduction is credited to the use of high grade components in a simple straightforward design without any shortcuts or tricks. The results appear to prove the advantages of this form of construction, and while considerably more expensive initially, the continued performance of equipment built in the professional manner will ensure lasting satisfaction.

RING RECORDING HEAD

[*from page* 13]

not correspond any more to the thickness of the magnetic coating[6].

From the graphical analysis, it can also be concluded that overbiasing is not as harmful as underbiasing. One must, however, see to it that the biasing forces which produce the proper recording conditions for the nearby layers do not fall into "tail region" of the field distribution pattern where its decay becomes more gradual, since this will result in loss of output level for high frequency signals.

Much additional work has still to be done in order to learn more about all factors which control the recording process. Because of the complexity of the problem, certain assumptions have been made which may not prove to be completely justified. For example, in the above discussion no allowance was made for the fact that the permeability of the recording medium drops when saturated. A change of permeability will lead to a modification of the field distribution (*Fig.* 1).

The conclusions advanced here are not intended to provide a complete picture of the field strength phenomenon in the recording process, but thinking and experimental work along are intended to encourage additional similar lines.

TELEPHONE RECORDING

[*from page* 15]

ringer box (9¾" x 7¼"). The weight is approximately 7 pounds.

Mounted therein are two multiple-purpose vacuum tubes (Type 12AU7s), two standard relays, a dry disc type rectifier, and the associated transformers, condensers, resistors, etc. Three "Line" terminals and three "Telephone" terminals are provided in the box, the third terminal in each case being for use with divided ringing. A power "on-off" toggle switch is mounted on the cover for easy access. Connections for the (a) "Start-Recording" Control Switch; (b) Commercial Power (115-V, 60 Cycles, AC) and (c) Recorder, are provided through a "Cannon" type multiple-conductor receptacle attached to the base. Simplicity of connecting and disconnecting the power and recorder are thus assured.

The equipment is arranged to provide a 1400-cycle-per-second oscillator, a single stage amplifier, an electronic timer and a simple selenium cell-type rectifier for plate potential power supply. The tube filaments are energized from the commercial power through a variable resistor which compensates for differences in line potentials, thus lengthening tube life.

The 1400-cycle oscillator, being an electronic device, is stable and extremely reliable, and its output is amplified to raise it to normal voice levels as required by the FCC. The electronic timer controls the 15-second tone interval and the 1/5 second tone duration as also required by the FCC order. This timing is accomplished through the operation of one of the associated relays.

During the time that the tone is connected to the line, it is also fed into the recorder but at a considerably reduced level so as to prevent recording "blast" effect. While normally designed for operation with recorders having a-v-c, there is included a feature in the coupling transformer network between the recorder and the line which permits one of two levels to be used, thus adapting the unit to both a-v-c and non-a-v-c recorders. Interlocking circuits are also included so that when the recording control switch is in the "non-recording" position, the tone is removed from the line, a shunt is placed across the input to the recorder, and plate battery is removed from the tubes. In this position, the equipment consumes approximately 35 watts as compared to a current consumption of 40 watts when in the operating position.

CRYSTAL AMPLIFIER

[*from page* 21]

layers in daily use, such as selenium and copper-oxide rectifiers. These usually deteriorate about ten per cent the first month or two of use, with little further change for ten years or more. There is one significant difference that must be considered—we are working the triode at current densities fantastically above that of the copper oxide barrier. A plate current of 3 ma is 3,000 amperes to the square inch if the contact area is a thousandth of an inch square, while copper oxide works at roughly one ampere per square inch. Of course, the triode is localized heating, while the copper oxide passes current over a large area.

There seems to be no particular effect with cold down to at least 100°F. below zero except differential shrinking in the amount causing the contacts to break loose. Perhaps it carries its own oven in the local heating adjacent to the contacts. But above 80°C. we are in trouble, and at present it seems a final sort of limitation.

Contact Material

The difference between beryllium copper and tungsten is very great. The tungsten is much harder, and its initial penetration of the barrier is much greater. It maintains its point dimensions almost unchanged with severe shots. Our impression is that the G_m is less, as a rule.

Beryllium copper penetrates the barrier little if at all by initial pressure, it seems to weld more easily, but it suffers the disadvantage that it flattens markedly under shots. Therefore, the spacing changes, and it must be resharpened after each series of shots. Stainless steel seems to be somewhat intermediate, but we have insufficient data to judge yet. We have not had time to form a thin film of metal for contacts, as the dimensions are very small and require a special set up for plating or cathode sputtering. We are still hunting for some one-thousandth with diameter balls of high conductivity. Carbonyl iron or Fe_3O_4 balls in this size range are readily available, but they seem too high in resistance. We have not yet tried a soft catwhisker plated with hard material, such as hard chrome.

Spacing is a compromise between G_m and leakage. Too close a spacing, such as one-half thousandths, gives excessive grid curent rise with changes in plate voltage and current, but gives a large G_m. A distance of four thousandths cuts down interaction, both d-c and dynamic, but the G_m suffers. A good compromise is 1.5 thousandths, but this is an open question.

Nature of Etched Crystal Surface

With some mild etches, little perceptible change is noted, except a slight dulling of the polished surface. Some etches form rounded nodules on the surface, starting as barely perceptible under maximum magnification and, if continued, growing to nearly a half-thousandth in diameter.

Others erode the surface in a manner similar to hot water eroding ice, giving rounded masses of great dimensions that interfere with the placing of catwhiskers. This type gives a thyratron action.

So far the writer has stopped with double etching, but is considering triple or more etches for specific purposes.

The nodule structure has the advantage that the catwhisker will not slip, which is a serious difficulty on a fully polished surface, with a cœfficient of friction of only .005 or so. In the mount shown last month, this problem is solved.

Warning

If you spend sixteen dollars for a Bell or Sylvania Transistor, it is in capsule form, and can be re-adjusted only with great experience and much specialized equipment. So take great care not to give it inductive surges, or capacitor discharges which will burn it in another layer and lower the flash-over point so the unit is useless. A simple precaution is to use an a-c power supply with a slow heating rectifier tube, and switch the filament or heater of the rectifier. This is hard on some rectifiers, but they are easily purchased at a low price, and it will be a long time before transistors are as easy to obtain. Also be careful, if it does flash-over, that a high value of capacitance does not discharge through it. You can easily lose half a dozen units in merely becoming acquainted with germanium triode.

As mentioned above, a complete history of burning deeply into a too-thick barrier would require making several hundred curves. These have been compressed into *Fig.* 2 et seq. These are very general, and indicate the result of several thousand such measurements. Spacing was .0015 inch, with beryllium copper contacts at a pressure of about 3 grams, sharpened after each run (this is easy if you spend three days making a precision jig for it, and find just the lapping compound and technique to maintain the elliptical edges parallel). It will be noted the plate impedance is reduced rapidly, and plate current increases. Maximum power gain in this case corresponds to minimum plate impedance reached, which then rapidly rises above this optimum point in the curve. Voltage gain is rather constant, as is grid impedance.

D-C Gm of 4.5 Million

This particular crystal repeatedly showed the peculiar curve of *Fig.* 3. By the time we had burnt in the cat-whiskers, the flashover point was about twelve volts. Operating at eight volts on the plate, this extremely unexpected curve was noted. It was a true smooth rise in plate current from 0.5 ma to 5 ma with a change on the grid of only 1 millivolt in the region of half-volt positive potential on the grid. The return curve was half of a hysteresis loop.

At six cycles the effect was much reduced, and at 100 cycles disappeared. So this seems to be a rapid heating effect in the barrier. There are many places where this could be extremely useful, such as in AVC and guard circuits of many types where relatively slow drifts must be prevented, or in voltage regulation, and in similar circuits. This is certainly one task the single vacuum tube cannot promise, and leads us to speculate what other unexpected dividends the germanium triode may offer.

Terminology

We have used unblushingly the terms grid, plate, and cathode for these units of the triode that perform those functions. We all realize the cathode is the anode for the "plate" circuit, but the terms are unmistakable, and the writer feels they will become standard without question.

We are on delicate ground with the next suggestion—that the whole series of devices, whether amplifying or not, be known as germanium triodes. The inventing company may call it what it likes, and we would normally defer to their right without question, but they have been so prolific of somewhat similar devices as Thermistors, Varistors, and so on that they have overloaded our ability to digest new terms.

We might use the term "control action" for the useful control of plate current by the grid. We need to reserve some term such as "interaction" for the leakage and other undesirable effects that occur when our etch is faulty or the contacts are too close together. Let us leave this open.

We need some designation for the ratio of increase-in-plate-current to increase-in-grid-current as the plate voltage is raised. We often find that grid current increases several ma for each ma increase in plate current. This is "current loss." If we break even, we could have loss zero, or a gain of 1. This must also be decided in the future.

Life-Test Oscillator

The assembly shown in *Fig.* 4 is a test and demonstration unit. It is a-c—d-c from the power line, drawing about 300 mw on a.c. It is very accessible for clipping on oscilloscope leads to determine phase angles and the complicated wave shapes to be expected from germanium triodes. It is used with a Cossor double-beam oscilloscope, which has calibrated controls so that not only the whole wave can be measured in terms of voltage, and microsecond duration with better than 5% accuracy, but also each component can be so measured, without photography if it is a repetitive phenomenon, of course.

Tests lasting up to four days with this unit show no appreciable change in amplitude of oscillation of a welded triode, within limits of about two per cent.

Present Conclusion

There is a long, hard road before germanium triodes will be produced in quantity, with reasonable uniformity, and at a competitive price. As a general purpose unit for the replacement of a large percentage of vacuum tube types, the prospects are quite dim. The low input impedance is a large handicap, and a source for the heavy grid current is often hard to find. We have some hope of practically eliminating the grid current by negative bias, but the low input impedance will remain. Great work in circuitry, especially concentrated on the common cathode circuit, may raise the input to at least several thousand ohms.

We hope for infinite life, and feel we are justified in that. It is also possible to visualize a unit for a factory cost of about 5 cents, provided the germanium mass can be produced and worked in the form of a sphere produced by melting and forcing through an orifice, for instance. Or if we localize at least some useful effects in the barrier layer in such form we can, paint it in effect, in a printed circuit, then we have a price picture that would look good.

As to size and temperature, we are in a good position. Vibration is also rather easily overcome. The device is noisy at low levels of signal. We have no comment on this feature at present.

The faults of continuously curving G_m and μ could be corrected to some extent if we increase our G_m. Increase in power output seems difficult. We have tried the road of multiple pairs of contacts on the one crystal, but the body heats up. Many crystals in parallel is one answer, but not a particularly good one.

So, for the present, we are almost all thinking in terms of specialty and experimental uses, or where price is not a factor. It promises to be a good multivibrator and pulse counter up to a thousand a second. As an oscillator of good life, and good amplitude stability, but rather poor frequency stability, it could well have wide immediate application.

By plating on concentric rings we may find a pentode, and so on. By a third or fourth etch we may modify the barrier layer still further, particularly to raise the input impedance. The burning-in of the grid is a much less delicate process than for the plate, so we may arrange matters so the grid is a layer or so up from the plate level.

The present state of theory of operation is by no means satisfactory to *anyone*, I believe, and it obviously needs much more data and verification before we can explain such diverse factors as this article discusses. This leaves us free to hope that the limitations are temporary, and we may have a device of almost unlimited capabilities.

WIRING STANDARDS

[*from page* 18]

of cable and *no* farther apart than *twice* the diameter.

4. *Double-stitch* at *all* breakouts, bends and corners. *When in doubt, double-stitch it!*

The cable shown in *Fig.* 3 is a sample production cable used in equipment of *Fig.* 4. This cable contains 50 shielded wires, and 132 single conductor wires of various lengths and gauges. To make this cable in limited production and to studio specs would average from 9 to 12 hours labor by a journeyman, depending upon the quantity involved. Also note in *Fig.* 3 upper right, the three spot ties instead of ½-hitch lacing. This portion of the cable will be formed into gooseneck in the equipment. It is not good practice to lace goosenecks. The spot ties keep the harness well-formed, but allow the flexing of the wires to form their natural curve without any stress on the cable proper.

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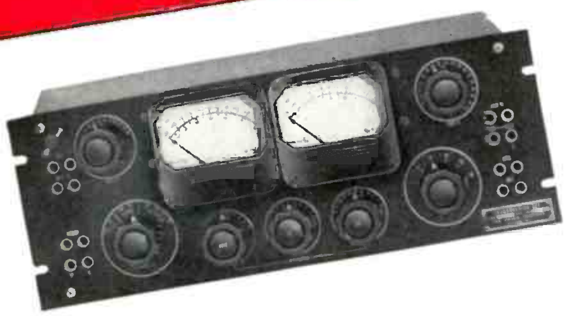
DIMENSIONS: 9⅜" high x 6½" wide x 12⅞" long.



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5. Source and load impedances within ±2% over range 50 cycles to 15 KC.

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RECEIVING SECTION: Frequency response is ±0.3 DB from 30 to 10,000 cycles. Will measure levels of —30 to +10 DBM* at zero VU meter indication when terminating a line. Impedance is 600 ohms in both the transmitting and receiving sections.

* DBM is based on a reference of 1 MW into 600 ohms.

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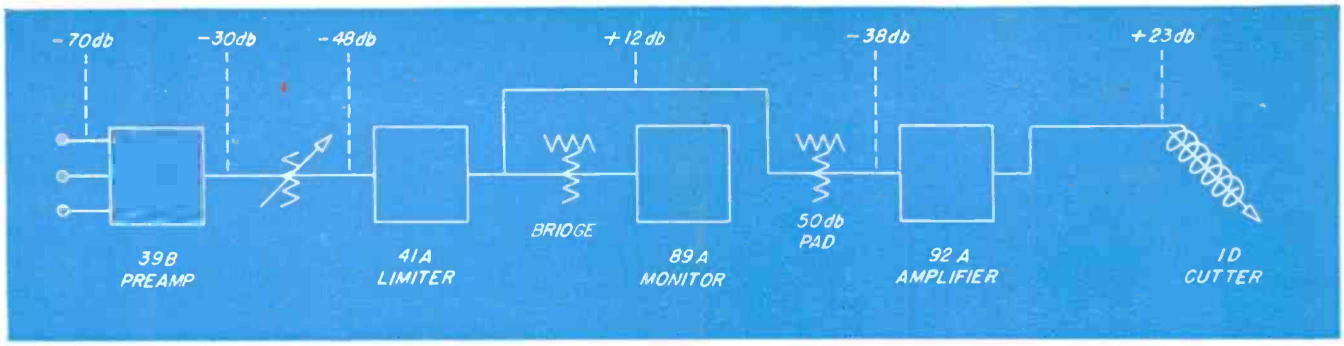

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