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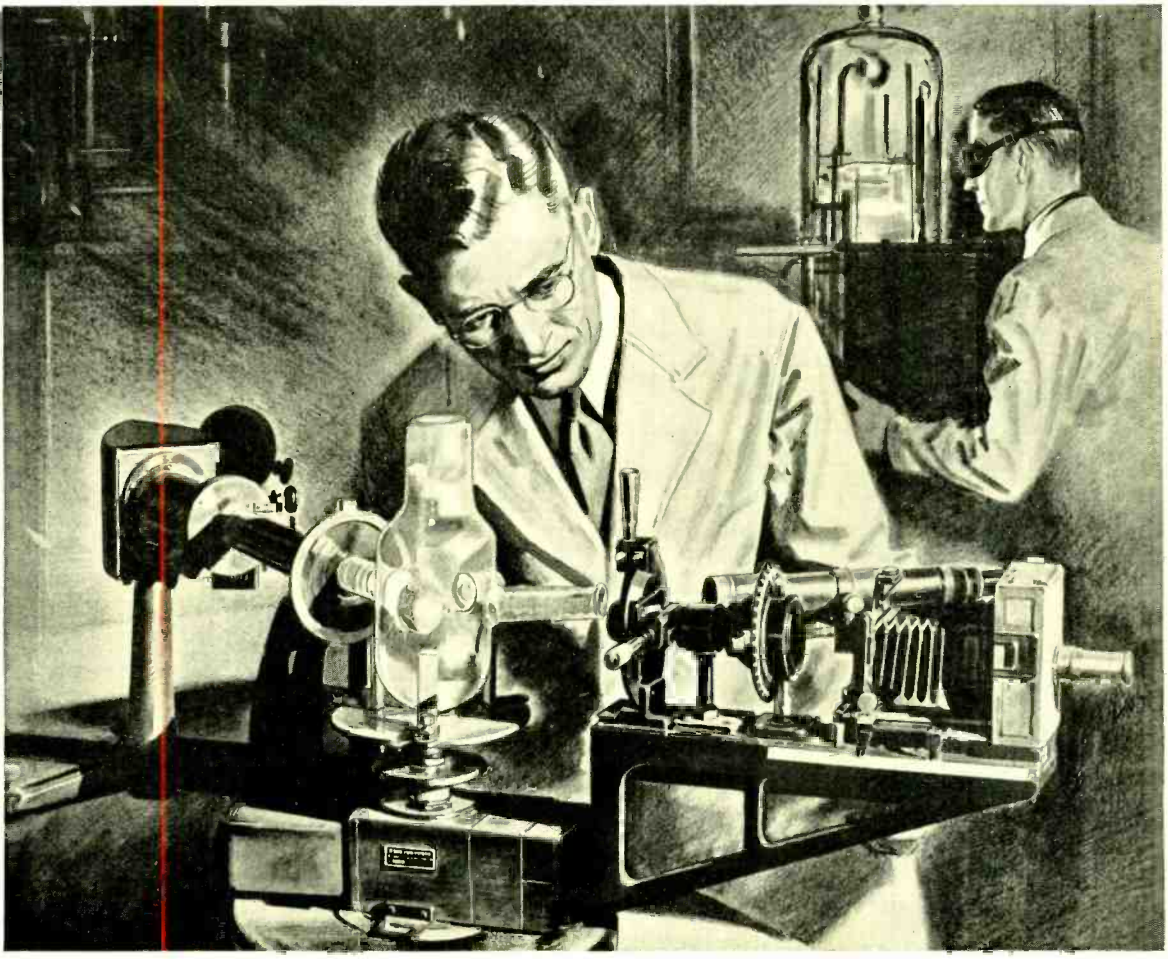


An artist's representation of one of our photoelectric laboratories

JULY 1941 VOLUME XIX NUMBER XI

A Test Set for Pulse Repeaters

By A. S. MARTINS
Switching Development Department

IN STEP-BY-STEP multi-office areas, pulse repeaters are generally employed on interoffice trunks. They receive the pulses from the subscriber's dial and transmit corresponding pulses over the trunk conductors to the called office. Each pulse repeater is usually associated with a particular trunk and is adjusted for the normal impedance of the trunk. The character of the pulse delivered to the incoming selector at the distant office, however, depends not only on the trunk impedance but on the adjustment of the subscriber's dial, the impedance of the subscriber's loop and the central-office voltage. Tests must be made on the repeater from time to time, therefore, to make sure that it is delivering proper pulses to the distant selector under all conditions encountered in service.

The method, which has been employed for checking the pulsing performance of interoffice repeaters, was to observe the action of the associated incoming selector in the distant office as pulsing test conditions were applied to the subscriber side of the repeater. This is subject to certain inaccuracies because of the variability of the pulsing ability of the incoming selectors; a particular incoming selector may operate satisfactorily whereas the succeeding switches in the train may fail with the same pulses. In addition, the method makes no provision for departures of central-office voltage from normal level.

With improvements in the transmission performance of the station set, which have permitted the use of trunks and loops of higher resistance, a need has been felt for more accurate means of maintaining pulse-repeating circuits. As a result a pulse-repeater test set has been developed. It is shown in use in the photograph at the head of this article. With this set, a maintenance man at an outgoing office can adjust repeaters with very little assistance from the distant office, and get the best possible adjustment for operating the switches at the distant office.

The pulses sent over a trunk operate the A relay of the incoming selector associated with the trunk at the distant end. The new test set includes the equivalent of one of these A relays, and also in series with it resistances which can be adjusted to equal the resistance of the trunk associated with the repeater to be tested. By sending pulses of known characteristics into the repeater to be tested, and connecting the output of this repeater to the test set, the A relay in the set will respond just as would the A relay at the end of the trunk, since it has in series with it an impedance equal to that of the trunk circuit.

The characteristic of the pulse that is of particular importance is the relative duration of its closed and open portions and the test circuit determines this by using a per cent-break meter to indicate the per cent of time that the A relay is released while pulsing. The moving element of this meter has sufficient mass so that the pointer remains essentially steady when the direct current applied to it is interrupted at rates corresponding to the extreme range of dialing conditions. The pointer thus remains steady under test pulsing, but its deflection will be determined by the time integral of the current received, and will thus be proportional to the percentage of time that the pulsing contact is closed. The scale has fifty divisions numbered from 0 on the left to 100 on the right. With no current flowing through the meter, the pointer rests at the 100 per cent mark, and thus

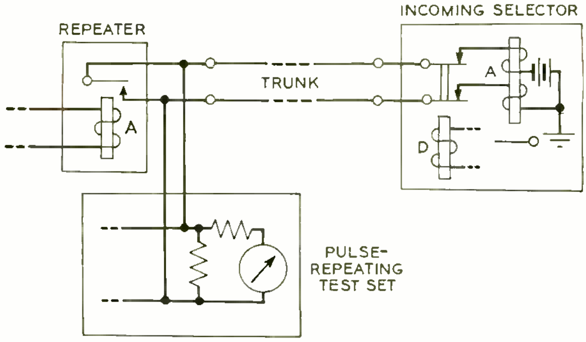


Fig. 2—Circuit connections while trunk resistance is being measured

the reading gives the per cent open period of the dialing contacts.

In making a test, the set is connected to the trunk at the output of the repeater. A key in the set permits the circuit to be arranged so that the resistance of the trunk may be measured, and then so that the resistance in the set may be made equal to it. The incoming selector at the distant office is then disconnected, and a pulsing test set is connected to the input of the repeater to supply the test pulses. By restoring the key to normal, the connections of the repeater test set are changed to allow the pulses from the repeater to operate the pulsing relay in the set over an impedance equal to that of the trunk. A contact on the set's A relay

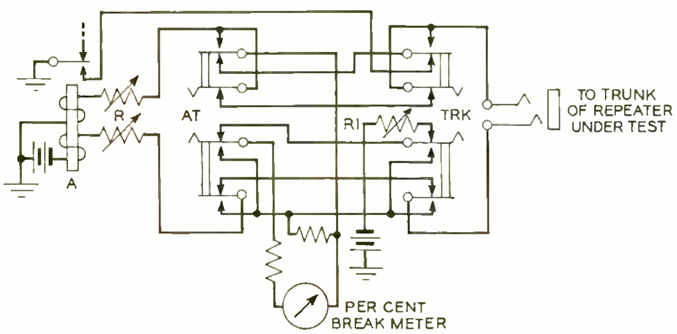


Fig. 1—Simplified schematic of pulse-repeater test set

makes and breaks a circuit to the per cent-break meter, which indicates the nature of the received pulses. The repeater is then adjusted as the results indicate desirable.

A simplified schematic of the circuit of the test set is shown in Figure 1. When the key is operated to the TRK position, the circuit becomes as shown in Figure 2. No pulses are sent into the repeater, but battery from the distant office causes current to flow through the A relay of the incoming selector, the trunk and the meter of the test set, which under this condition is employed as an ammeter. The meter deflection is noted, and then the key is operated to the AT position. This disconnects the set from the trunk, and changes the connections to those shown in Figure 4. The series resistances are adjusted until the same meter reading is obtained. The resistance of the A relay and series resistance of the test set are then the same as that of the trunk and of the A relay at the distant office, since the central-office battery is used in both cases and any voltage difference that exists is minor.

After this adjustment has been made, the key is returned to the normal position, establishing the connections shown in Figure 3. The pulsing test set can then send pulses to the repeater, which repeats them to the A relay of the test set through resistance R. The trunk, although open at the distant end, remains connected

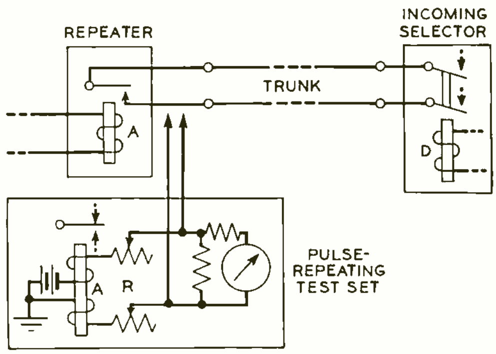


Fig. 4—Circuit connections while the resistance in the set is being adjusted to equal that of the trunk

across the repeater, and thus the effect of shunting capacitances or leakages of the trunk remain. This insures that the pulsing under test conditions is the same as under operating conditions. One side of the meter is connected to battery through an adjustable resistance R1, and the other side, to the contact of the A relay of the test set. R1 has been previously adjusted so that the meter reads 0 per cent break when the contact of the A relay is held closed. Under test conditions, therefore, it correctly records the per cent-break of the contact of the A relay. If the per cent-break falls within specified limits when the extreme subscriber line conditions are applied by the pulsing test set, the repeater is satisfactory. If not, adjustments are made and further tests are then made.

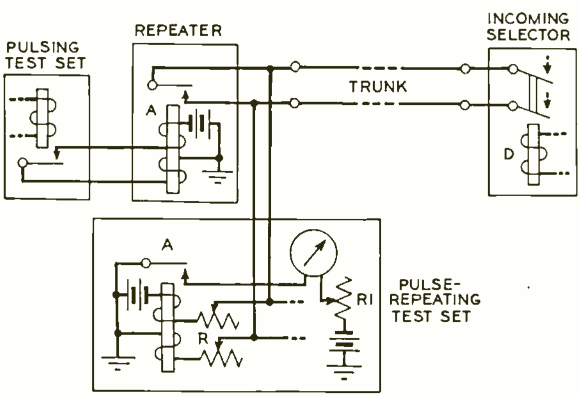


Fig. 3—Circuit connections while measuring characteristics of pulses sent out by the repeater

This method of maintaining pulse repeaters within specified per cent-break limits results in minimum pulse distortion on the particular trunk involved. It is particularly desirable to take advantage of this reduction in distortion in areas where steps are being taken to obtain increased ranges for subscriber dialing, or where the resistance of the trunk conductors approaches the maximum limit. The increased tendency towards "built-up" connections between step-by-step offices, which require several repeaters to operate in tandem, has also emphasized the necessity of applying per cent-break adjustments with the pulse-repeating test set. When pulsing difficulties are encountered on calls routed through several central offices, it is difficult for the maintenance men to localize the cause of the trouble. With the pulse-repeating test set, however, it is possible to check the pulsing performance of the various circuits in the connection, either individually or in combination to disclose the repeater circuit that is causing the trouble.

To the Congress of the United States:

One of the greatest resources in the arsenal of Democracy is our national ability and interest in Industrial Research. For the vigorous prosecution of our defense program and for the assurance of national progress after the emergency we rely heavily on the continued vitality of research by industry in both pure and applied science.

Our people can justly take pride in the record of the accomplishment by American industry contained in the report on "Research —A National Resource, Part II, Industrial Research" which I am transmitting for the information of the Congress. . . .

The report presents a clear record of how successfully we have translated our old-time Yankee ingenuity for invention into American genius for research. Our scientists have uncovered and explained the secrets of nature, applied them to industry, and thus raised our standard of living, strengthened our defense and enriched our national life. . . .

I commend a careful reading of this report to the Members of the Congress.

Franklin D. Roosevelt.

The report transmitted with the message quoted above was prepared by a committee of the National Research Council, of which F. W. Willard, President of the Nassau Smelting and Refining Company, was chairman. Among members of the committee were F. B. Jewett, O. E. Buckley, and R. R. Williams. The chapter on Mathematics in industrial research was written by T. C. Fry.

Temperature Stability of the 2B Pilot Channel

By D. B. PENICK
Carrier Telephone Development

TRANSMISSION regulation is an important factor in maintaining high standards of communication in the telephone system. This is especially true for carrier circuits. With a single pair of wires providing a number of telephone channels, the load-carrying capacity of amplifiers, modulators, and other components must be carefully related to the speech volumes, and the transmitting levels held closely to established values to meet the required standards of crosstalk, modulation and noise. In the type-C carrier system, this regulation may be accomplished automatically—during normal weather conditions—by the 2B pilot channel,* which adjusts the transmission level at the output of each amplifier in accordance with the level of a pilot frequency transmitted over the line from an oscillator at one end.

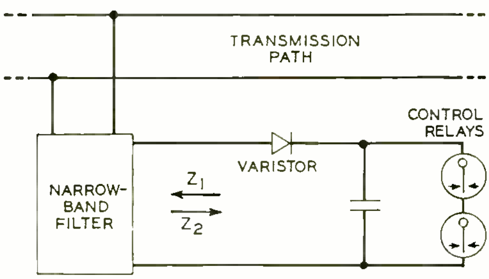


Fig. 1—Simplified schematic of control circuit to study temperature stability

The closeness with which the desired transmission can be held under normal weather conditions depends primarily on how nearly the output of the oscillator can be held to the desired value, and upon variation in the sensitivity of the control circuit that adjusts the level at each amplifier. Both oscillator and control circuit may vary in their behavior under the influence of a number of factors, chief of which is temperature. As now provided in the 2B pilot channel, the oscillator output, with all variations in temperature and battery voltages, is constant within 0.25 db.

The earliest experimental models of the pilot-control circuit were found to vary over a range of 2.5 db as the temperature varied from 60 to 110 degrees Fahrenheit. A variation of this amount was too high, and a study was made to determine its causes.

The essentials of the control circuit are shown schematically in Figure 1. A narrow-band filter* bridged across the transmission path selects the pilot frequency and sends it into a varistor-rectifier, which converts it into direct current to operate the relays controlling the regulating equipment and thereby the transmission level. These relays have a high resistance, which is nearly the whole resistance of the d-c circuit. Since they are wound with copper wire, their resistance increases with temperature at the rate of about 0.22 per cent per degree Fahrenheit, a total variation of 11 per cent within

*Record, *Feb.*, 1941, *p.* 180.

*Record, *June*, 1941, *p.* 323.

the normal range of room temperatures, which is taken as 50 degrees Fahrenheit. If the rest of the circuit is held at constant temperature, this variation alone amounts to about 0.4 db in overall sensitivity.

A typical varistor, measured at a frequency of 24.35 kc, varies in sensitivity as shown in curve A of Figure 2 when the temperature is changed. In the room-temperature range, the variation is about 0.3 db, but opposite in sign to the change due to the relays. Since these two variations oppose each other, the net rectifier variation, curve B of Figure 2, is small, in the neighborhood of 0.1 db. The condenser of Figure 1 is used to secure maximum output from the varistor, and is so large that its temperature changes have negligible effect on the sensitivity of the circuit.

An average filter measured between constant impedance terminations varies in loss at the pilot frequency about 1.3 db over the temperature range, increasing in loss with increasing temperature. This is shown in curve C of Figure 2. The sum of these individual variations still accounts for only about half of the observed 2.5-db variations mentioned above. The remainder, therefore, must be due to an interaction effect between the filter and the rectifier.

The key to this effect is found in the behavior of the rectifier impedance with changes in temperature, and in the relation of this impedance to that of the output of the filter. A fundamental transmission principle is that the maximum transfer of energy from a generator of impedance $Z_1 = R_1 + jX_1$ to a load of impedance $Z_2 = R_2 + jX_2$ occurs when $R_1 = R_2$, and $X_1 = -X_2$. In other words, the resistance components of the two impedances should be equal, and the reactance components should be equal but of opposite sign. When these conditions do not exist,

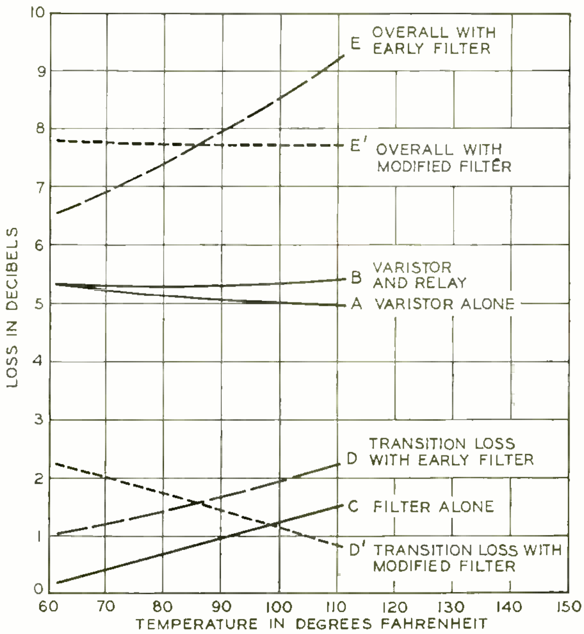


Fig. 2—Variations in loss over the range of room temperatures of various elements and combinations of elements of the regulating control circuit

there is a transition loss.* So far as stability with temperature is concerned, this transition loss need not be zero; it is essential only that it remain constant with changes in temperature. If, however, either $R_1 + R_2$ or $X_1 + X_2$ varies with temperature there will be a variation in transition loss, and thus a change in the sensitivity of the circuit.

The resistances of both filter and varistor, although not equal, are essentially constant with tempera-

*In db equal to 10 log $\frac{(R_1+R_2)^2 + (X_1+X_2)^2}{4R_1R_2}$.

ture, and thus do not contribute to any variation in transition loss. The reactance component of the original filter was also constant, and equal to about +2800 ohms. The reactance component of the rectifier, however, was negative and varied with temperature as shown in Figure 4. Since these two reactances are of opposite sign, their algebraic sum, which enters the equation for transition loss above, is equal to their numerical difference, and to make the value of this difference more obvious, the negative of the filter reactance is also plotted in Figure 4. Since this difference increases with temperature, the transition loss also increases with temperature, and is shown as curve D in Figure 2 as calculated from the formula. The sum of the ordinates of curves B, C, and D of Figure 2 thus gives the overall loss of the complete rectifier in combination with the filter, and this loss is shown by curve E.

The change in transition loss, it will be noticed, is about half the total loss, and thus accounts for that part of the total loss that was not accounted for by the filter and varistor losses above. If the slope of this curve of transition loss could be reversed, that is, if the loss could be made to decrease with temperature rather than increase, the total of all the losses would then remain about constant with temperature. Had the filter reactance been numerically less than the rectifier reactance—in other words, had the curve of the negative of the filter reactance lain above the curve of rectifier reactance that is shown in Figure 4—this condition would have been met.

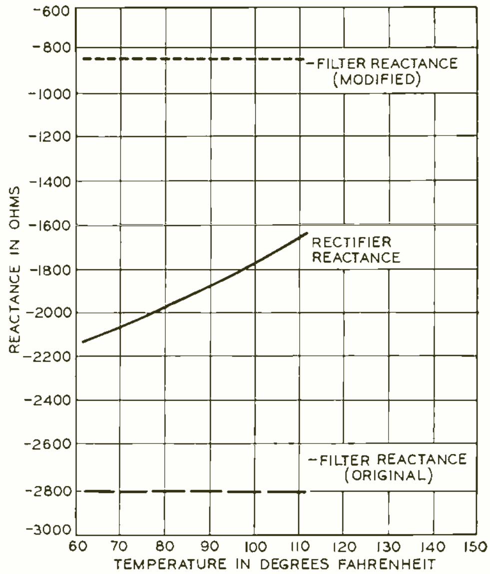


Fig. 4—Variation in reactance with temperature of rectifier reactance and the original and modified filter reactances

It was thus obvious that a high degree of stability could be secured by decreasing the filter reactance sufficiently to make it less numerically than the rectifier reactance. The output impedance of the selective circuit of the filter is actually very much lower than that of the rectifier, and in the original circuit an auto-transformer had been used to step the output impedance up to the 2800 ohms. To make this impedance lower, as now seemed desirable, a different auto-transformer could have

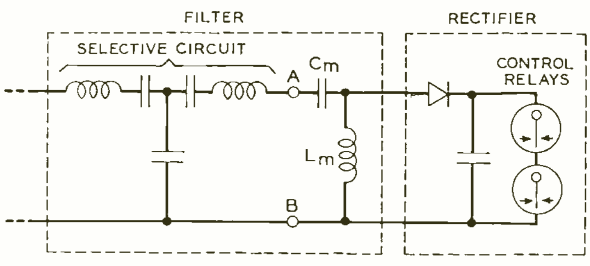


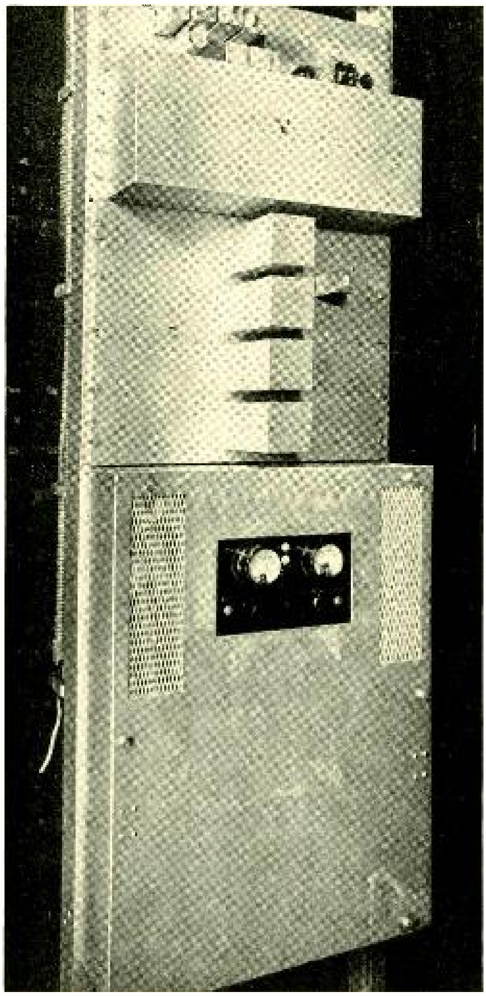
Fig. 3—Schematic of filter and rectifier showing C_m *and* L_m *used for impedance transformation*

been designed. It seemed simpler and more economical, however, to add the reactance elements C_m and L_m to the filter, as shown in Figure 3. These do not affect its selective action but modify the reactance of the filter as seen from the rectifier. They provide the proper impedance transformation because a capacitance and inductance, tuned to resonance, present a low impedance when they are in series and a high impedance when they are in parallel. It will be noticed from Figure 3 that C_m and L_m are in series with respect to the selective circuit, and thus present a low impedance to match the low impedance of the selective circuit. They are in parallel with respect to the rectifier, however, because the very low impedance of the selective circuit has the effect of connecting the A terminal of the capacitance to the B terminal of the inductance through a low impedance. The choice of values for L_m and C_m must be guided by the fact that the rectifier is in parallel with L_m, that the selective circuit is in series with C_m, and that the desired output impedance of the filter must be inductive. A more detailed consideration of these factors gave suitable values for these circuit elements. The modified transition loss secured is shown by curve D′ of Figure 2, and the overall net loss—the sum of B, C and D′—is shown by the curve E′. With the modified filter the total change in loss with temperature is only 0.1 db.

At the pilot frequency, the effectiveness of the stabilization under service conditions is indicated by continuous recorded measurements which have been made of transmission level on a typical, short, type-C system regulated by a 2B pilot channel. The maximum observed deviation was about ±1 db. Half of this deviation is inherent in the method of regulation, since no regulation takes place until the level is 0.5 db higher or lower than normal. The remaining deviation of ±0.5 db, then, includes the variations of both pilot supply and control circuits as well as other small variations.

Commercial Service Over Coaxial Cable

On June 9 the coaxial cable between Stevens Point and Minneapolis became part of the nation's communication system. This cable is two hundred miles long, and cost $2,500,000. It contains four coaxial tubes, set up to form two complete paths of which one is in use, the other in reserve to be switched in automatically in case of trouble. Terminal facilities have been installed for 48 circuits which will be put in service as the load requires. Between terminals there are 37 repeaters, most of them unattended. Total gain under average conditions is about 2400 decibels



Electronic Inverter for Interim Power Supply

By D. E. TRUCKSESS
Power Apparatus Development

POWER for the repeaters of the coaxial, or L, carrier system is transmitted as alternating current over the coaxial cable itself. At terminals and main repeater stations this power is supplied from commercial power lines; and gasoline engine alternators are provided to carry the load should the commercial power supply fail. If this were the only precaution taken, however, there would be an interruption of communication for the few minutes required to get the emergency generator started. To bridge this gap between the failure of power and the starting of the emergency generator, and to carry the load over short-time failures of power, the Laboratories has developed an electronic inverter, which will take over the alternating-current supply within a few cycles after the failure occurs. On restoration of the a-c source, the inverter will transfer the load back to it within a slightly shorter interval. It is not proposed to have the inverter carry the load except for short periods; its primary purpose is to prevent an interruption of communication while an emergency generator is being started or over a short outage.

The essential elements of an inverter are shown in Figure 1. The a-c mains are connected to the plates of two thyratron tubes through a transformer, and the positive of the station battery is connected to the mid-point of the secondary winding. A condenser is connected across the two plates, in parallel with the secondary winding of the transformer, and the grids are supplied through another transformer with the negative of a grid battery connected to the mid-point of the secondary to give a fixed grid bias. The primary of the grid transformer is connected to a mechanical frequency generator, such as has been developed for operating radio receivers from a 6-volt battery. The generator is connected to the 24-volt filament battery, and supplies about one watt of 60-cycle power. This a-c driving voltage is used to change the bias on the two grids alternately, so that first one tube will become conducting and then the other. As each tube in turn becomes conducting, a spurt of current flows through it from the plate battery, and this current flowing through the secondary of the plate transformer induces a voltage in the primary winding. Since these spurts of current to the two tubes flow in opposite directions through the secondary windings, an alternating voltage is induced in the primary, and the frequency of this voltage, which is controlled by the exciter voltage, is 60 cycles per second.

Thyratrons are gas tubes with a critical negative grid voltage at which they become conducting. Once current flow between plate and filament has begun, the grid loses control, and the tubes will remain conducting until the plate current is interrupted. The grid battery furnishes sufficient negative bias to make the tubes become conducting only at some point on the positive half-cycle of the exciting wave. The bridging condenser C serves to interrupt the current through one tube as the other becomes conducting. Assume, for example, that V1 is conducting. The end of condenser C connected to V1 will be essentially at the negative potential of the battery because there is only the small drop through the tube between it and the filament. The end of C connected to V2, however, will be at approximately the positive potential of the battery because no current is flowing through the half of the secondary winding of the transformer between V2 and the battery. As a result, C will be charged to practically the battery voltage with the positive end connected to V2. When V2 becomes conducting at the next half-cycle of the exciting source, the two terminals of the condenser will be connected together through the low impedance of the two tubes in series. As a result the condenser will discharge, and drive the plate of V1 negative with respect to its cathode. The conduction of V1 will thus stop, and the load current will pass through V2, giving the other half-cycle in the primary winding. The condenser will then be charged in the opposite direction, and will be ready to stop the conduction of V2 at the end of this half-cycle.

The condenser also serves as a means of adjusting the output a-c voltage in the primary of the plate transformer. This voltage is propor-

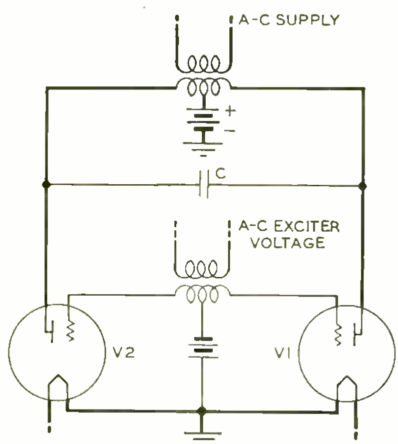


Fig. 1—Essential elements of an inverter circuit for interim power supply

tional to the rate of change of current in the primary winding and this rate depends on the rush of current through the tube and also on the charging current to the condenser. By varying the size of the condenser, the output voltage can be changed.

Commercial power lines now-a-days are very dependable. Outages are comparatively rare. The use of the inverter will thus be small, and its cost should be kept low or the expense of the protection provided would be higher than could be economically justified. It was felt desirable, therefore, to make the inverter equipment serve a double purpose. The battery used as a source of power for the inverter will also serve various other purposes in the central office, and it must be kept charged.

It will be noticed that the circuit shown in Figure 1 is essentially like that of a full-wave rectifier; the differences being that for a rectifier, the negative terminal of the battery would be connected to the midpoint of the transformer, there would be no a-c excitation, and provision would have to be made for adjusting the grid bias in accordance with the battery voltage. It seemed entirely feasible, therefore, to use the inverter as a rectifier for charging the battery under normal conditions, and to provide a transfer relay that would change the connections to those required for inverter action on failure of the a-c power.

An inverter-rectifier of this type developed for the L carrier system is shown in simplified schematic form in Figure 2. A trial installation of one of these inverter-rectifiers at the Long Lines building in New York City is shown in the lower part of the photograph at the head of this article. T1 in Figure 2 is the plate transformer and T3, the grid-exciting transformer. The master control circuit changes the circuit from rectifier to inverter action when the a-c voltage drops to 90 per cent of its normal value. Besides the circuits that control the transfer on low voltage, the master control also includes a number of interlocking circuits to insure the proper sequence of actions under all conditions. The change of connections is made by operating relays TR and GR, the former disconnecting the a-c supply leads and reversing the connections of the plate battery and the latter connecting the a-c grid excitation with its fixed-negative battery. The bridging condenser C of Figure 1 is supplemented by an

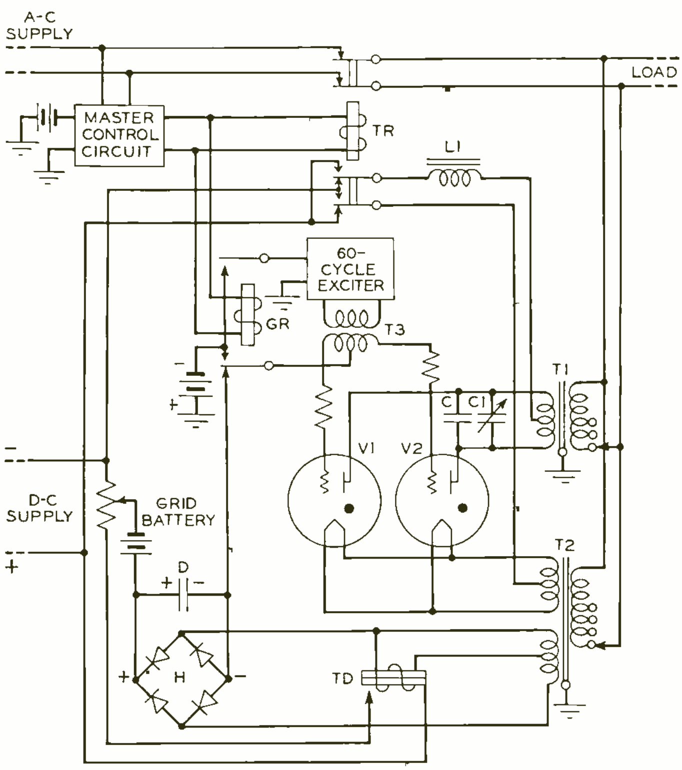


Fig. 2—Simplified schematic of the inverter-rectifier developed for the L carrier system

adjustable condenser C1 in parallel with it to provide control of the a-c output voltage. The varistor rectifier H, with the condenser D, is used to control the grid bias when the circuit is used as a rectifier. The control of the output of the circuit under rectifier operation is by the magnitude method as already described in the September, 1938, issue of the RECORD.

Transformer T2 supplies the voltages for the regulating circuit and the filament current under both rectifier and inverter operation. Relay TD, effective only after the circuit has been shut down, prevents application of high voltage to the tubes until the filaments have had time to reach approximately their normal heated temperatures. The coil L1 acts as a filter in the battery circuit under both conditions of operation. A view of the inverter with cover removed to show the arrangement of the apparatus is given in Figure 3.

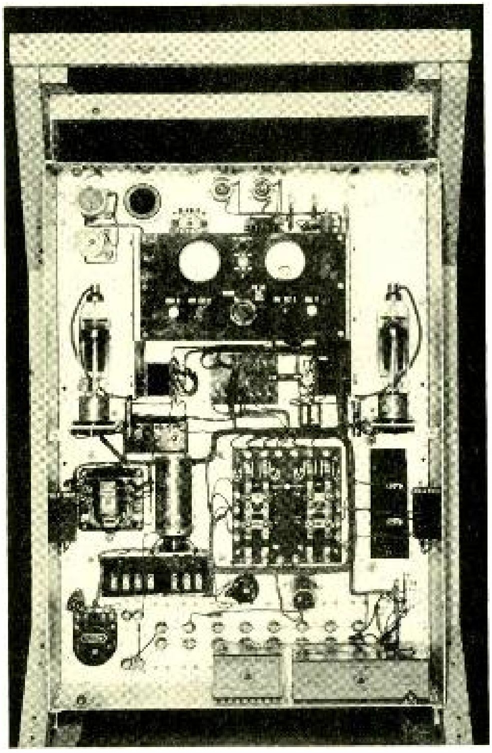
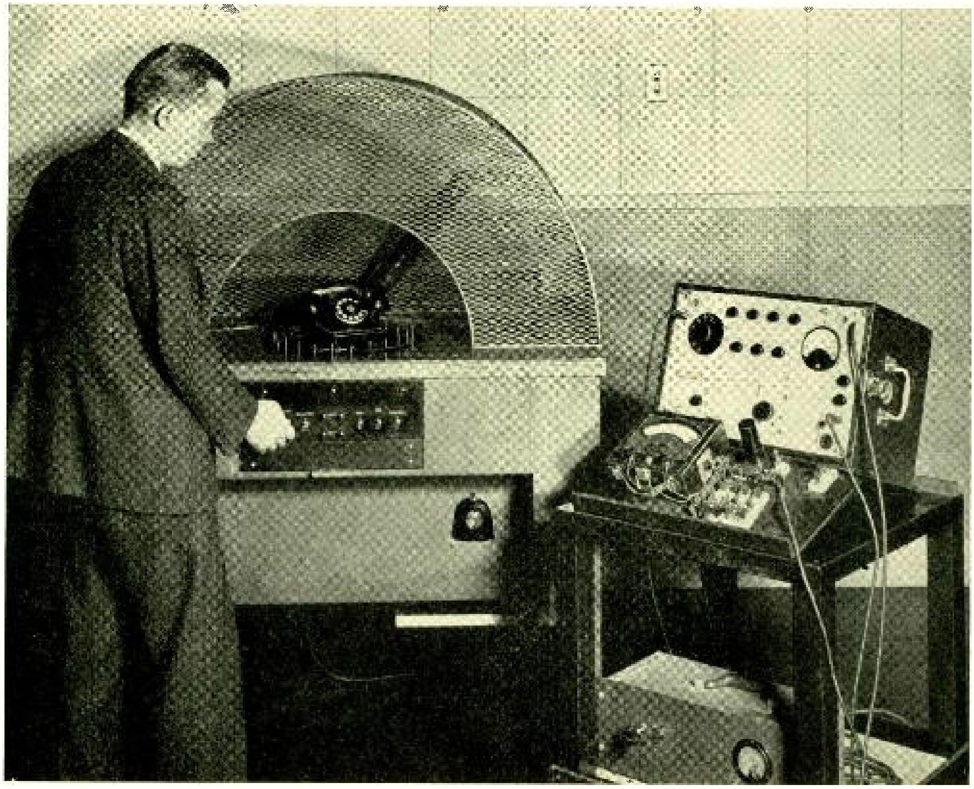


Fig. 3—An inverter-rectifier with its cover removed and mounted in its shipping crate

The primary of the plate transformer is provided with taps, and the ratio of the transformer is made such that by use of these taps the rectifier will charge either a 132 or 142-volt battery at any a-c line potential from 210 to 250 volts. Connections to the taps are made to give a proper transformer ratio for charging.



Sound-Integrating Machine

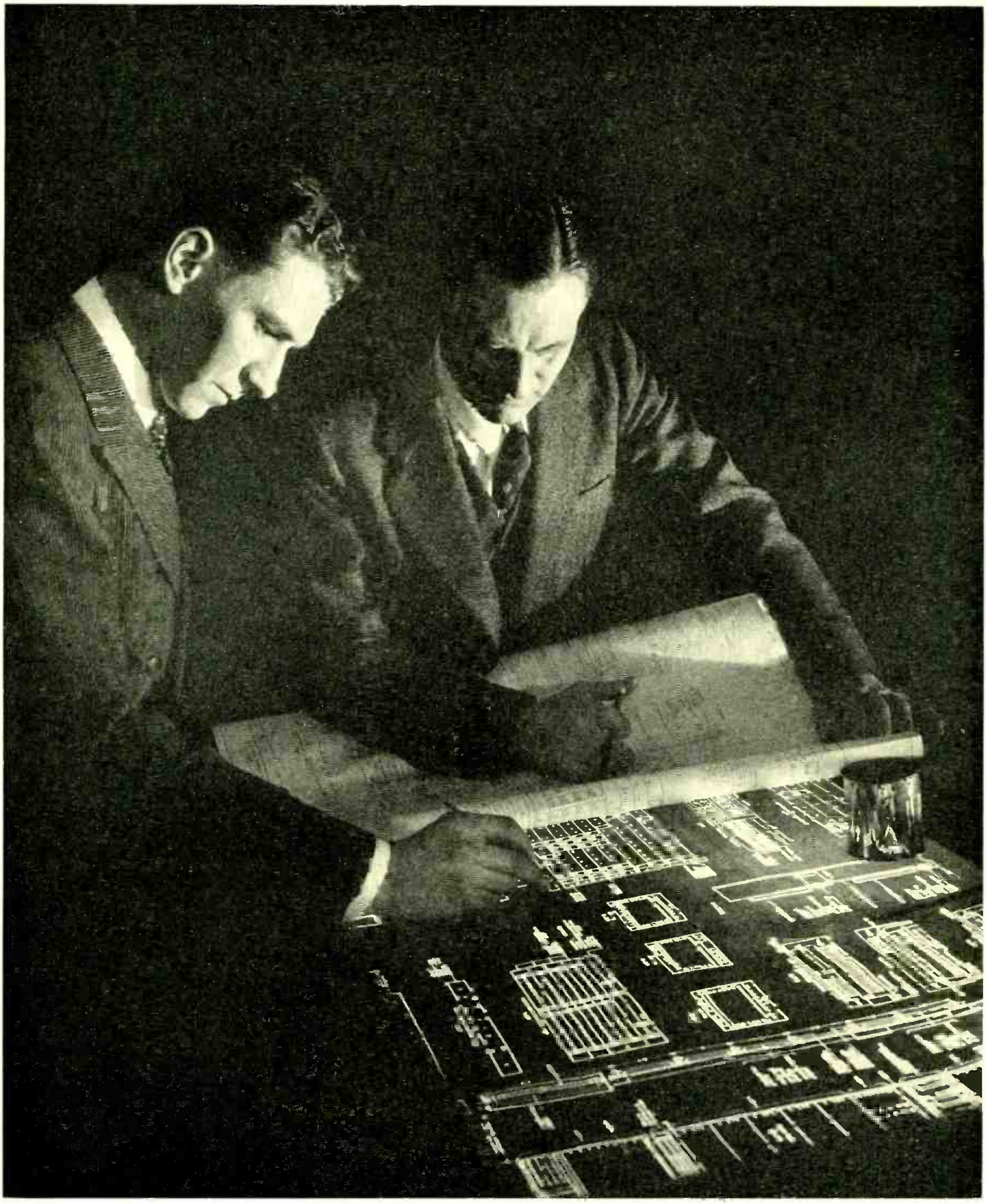
EXPLORING the sound field around a small source such as a ringer or loud speaker is usually a laborious and time-consuming task because it involves making many measurements in all directions around the radiating source. This effort is now avoided by doing the work automatically with a sound-integrating machine. The apparatus to be tested is rotated on a turntable while a small condenser microphone, which is mounted on the end of an arm, is swept back and forth over it. This arm is oscillated in a vertical plane through an angle of 180 degrees by a cam which moves it progressively more slowly as it approaches the ends of its excursion so that equal radiating areas are traversed in equal times. The output of the microphone is amplified and applied to an analyzer to determine the sound intensity in different frequency bands. A meter reading gives the average intensity of the sound in a selected band; and multiplication by a factor, involving the area of a hemisphere whose radius is the length of the microphone arm, gives the total power radiated in that particular band.

This integrator measures sound outputs in about one-fiftieth of the time previously required to make separate observations at many points about the source. It has been used extensively in developing ringers and telephone-set housings.

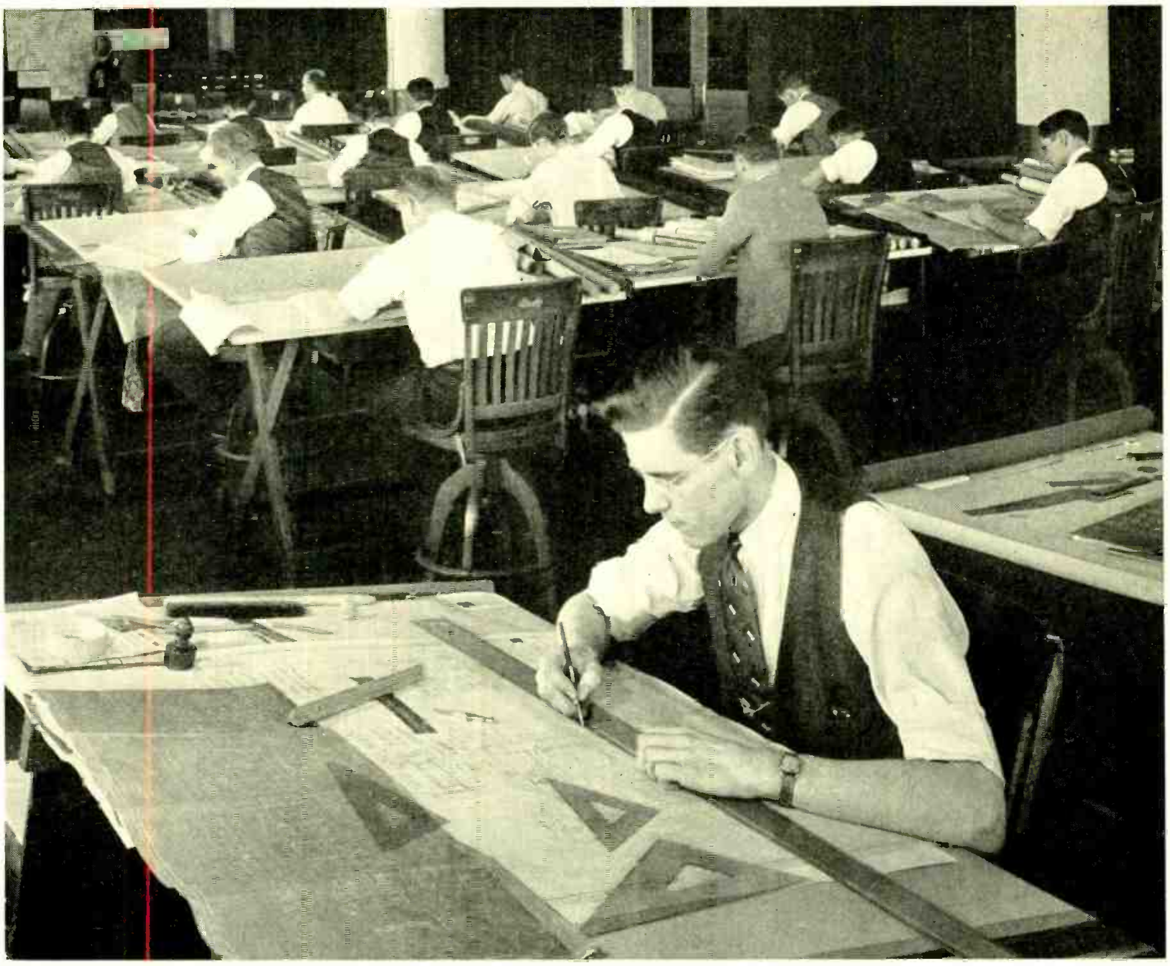
TELEPHONE SYSTEMS DRAWINGS

LAST year 8600 new drawings were completed by the Systems Development drafting group, and added to the 230,000 already held in the department's vaults. The production and handling of this great store of engineering data is a major problem. Suggested improvements in method have been carefully studied and frequently adopted; some of them have been described in earlier issues of the Record. The accompanying photographs review the current method of handling Systems drawings.

The inception of a new drawing is shown above: an engineer is explaining to a draftsman the features of a new piece of equipment which he wants laid out



Many "new" drawings are actually old drawings with changes, additions or deletions. If the changes are not too considerable, it is economical to make a "Van Dyke negative," opaque the parts to be redrawn, and then draw in the new material on a photographically reproduced tracing



Inking in the lines on an assembly drawing which shows the elements of a telephone equipment design. The drawing is first laid out in pencil to get an orderly arrangement; then the lines may or may not be inked in, according to the use to which the drawing is to be put

Lettering is a specialized job in itself; it is usually done with the help of celluloid templates that assure uniformity in the size and shape of lettering. Uniformity of line weight is obtained by using pens of specified size

To visualize equipment that has been designed but not yet built, a three-dimensional effect can be given to an engineering sketch. Shading is painted in by hand or blown in with an airbrush

Typing is faster than hand lettering; when there is need on a drawing for a long list of apparatus, standards or the like, the material is typed on white paper and then transferred to tracing cloth by a photographic method

A section of one of the vaults where almost a quarter-million tracings are stored. The vaults are protected from fire by an overhead sprinkler system; and each tracing drawer is protected from sprinkler water by an individual waterproof curtain

Bell Laboratories Lecture Equipment

CIVIC organizations and other groups of thoughtful purpose always have need of program material. They have learned to look to their Telephone Company as a source; the company on its part is glad to accept invitations, since each is an opportunity to meet its subscribers and make new friends.

Although these groups assemble primarily for what they hear, they are intrigued by demonstrations which they can see. With this in mind C. D. Hanscom of the Laboratories' Bureau of Publication, coöperating with J. O. Perrine, Assistant Vice President of the A. T. & T. Co., recently assembled a variety of equipment for use in Bell System lectures. Only simple demonstrations were chosen, for simplicity has been found to be no detriment to interest and entertainment value.

One of the most unusual demonstrations is a Rochelle salt crystal which flashes a neon lamp when hit with a gavel. This illustrates how a change in mechanical dimensions, caused by a blow from the gavel, generates momentary voltages of considerable magnitude by the piezoelectric effect.

A bar of steel (a permanent magnet) floating in mid-air demonstrates the power of modern magnets. A permanent magnet concealed in the base of the apparatus repels the bar, and holds it up against the force of gravity; a full package of cigarettes can even be supported in addition to the bar. There are also permalloy rods in the collection which are so permeable that they are magnetized by the earth's field when held pointing north at or near the angle of declination. This is demonstrated by their ability to attract and hold short pieces of permalloy tape. For convenience in carrying, these rods are made in two parts which are screwed together for a demonstration. Two similar short rods, one of steel, which is magnetized, and the other of soft iron can be used to test the ingenuity of the audience by asking them to determine from the action of the rods on each other which is magnetized.

Decreased size of loading coils, made possible by Bell Laboratories researches on magnetic alloys, is illustrated by a display board on which are mounted a coil with an iron dust core, a much smaller coil of equal efficiency with a permalloy core and a still smaller one with the same electrical characteristic whose core is molybdenum permalloy. Samples of the 2121-pair cable for exchange areas are included; also a piece of the Minneapolis-Stevens Point coaxial cable which transmits frequencies of several million vibrations per second.

How coal becomes transmitter carbon is illustrated by samples of granulated coal and carbon in bottles or tubes which show several stages in the series of crushings, screenings and roastings involved in its manufacture.

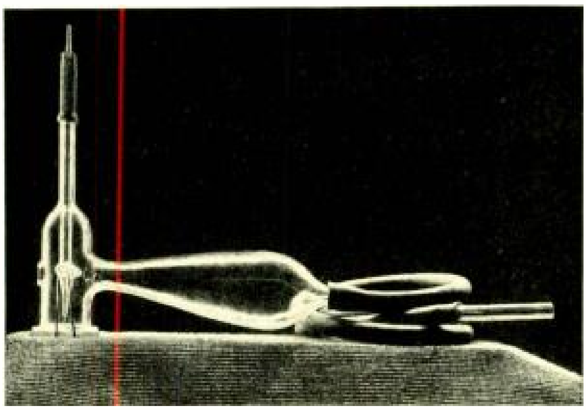


Fig. 1—Minute samples of dust are collected for micro-analysis by sucking them onto a microscope slide with the "impinger"

Microchemical methods of detecting minute impurities and thin films of corrosion are required in analyzing some telephone materials. The ex-

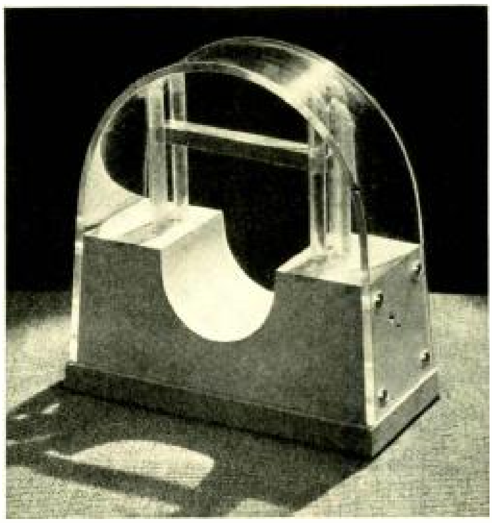


Fig. 2—The repulsion of a strong permanent magnet concealed in the base of this apparatus supports the magnetized "wobbly bar" against the force of gravity

treme sensitivity of these tests is illustrated by pressing a moistened paper of cadmium diethyl-dithiocarbamate paper against the fingers of a person who has held a penny. Discoloration of the paper shows where traces of copper have remained on the fingers.

Minute samples of dust are sometimes collected for micro-analysis from telephone apparatus by an impinger which sucks the dust from very small areas and collects it on a microscope slide. This instrument is included among the exhibits for lecture use.

There are also grasshopper fuses which indicate when a circuit has been blown in central offices. A colored glass bead flips out and an alarm sounds. Their acrobatic behavior is demonstrated by mounting them on a box which contains a dry battery to blow the fuses, as shown directly below.

Telephone poles are protected against decay by treating them with preservatives. A collection of borings taken from treated poles shows that the distance the preservative penetrates differs greatly with the kind of wood. The value of wood preservatives is illustrated by the difference in decay of treated and untreated blocks which were put in bottles in the laboratory and inoculated with destructive fungi.

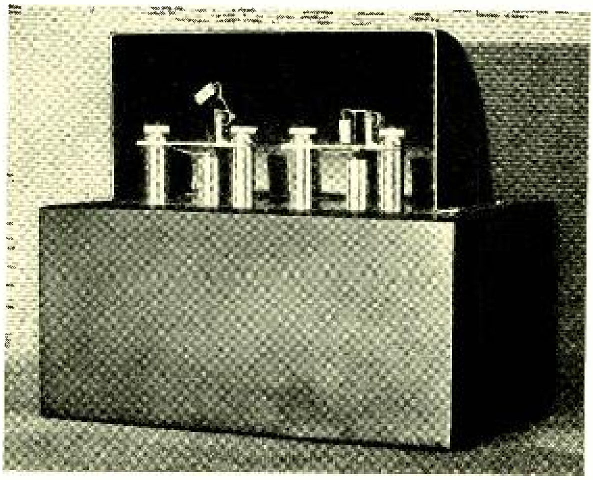


Fig. 3—Grasshopper fuses, which flip out a colored glass when a circuit blows in central offices, are demonstrated by blowing the fuses with current from a dry battery concealed in the box

To illustrate the complexity of the equipment required in crossbar dial offices, there was prepared a roll of cloth blueprints which shows the circuits and associated information for a single unit of such a system. The roll is over fifty feet long.

When linemen call a central office from the field they sometimes use a whistle that emits a 1,000-cycle tone with interruptions twenty times a second. When held near their handset transmitter this whistle sends over the line the signal required to operate a ringer in the central office. These whistles are recommended for the demonstration kit.

The care taken to obtain compactness in the design of switchboard apparatus when space is at a premium, is illustrated by a strip of switchboard lamp sockets. An example of decreased maintenance requirements and lower cost is the substitution of a gas-filled tube in the combined handset for the relay previously used to produce the ringing current.

Copper oxide rectifiers are used as modulators and demodulators in some carrier-frequency circuits instead of vacuum tubes. They cost less, require no servicing and last indefinitely. For comparison a D-98914 varistor and two 101F vacuum tubes are recommended. One of these varistors does the work of two vacuum tubes in carrier systems.

Manholes are occasionally contaminated with carbon monoxide by accidental leaks from illuminating gas mains. To protect workmen against injury from this source, there is provided a detector which consists of a glass ampule containing palladium. On breaking in absorbent cotton the liquid turns dark if the gas is present.

A replica of Bell's original telephone is usually included with the exhibits.

Instructions have been prepared. Special items and those requiring special instructions to demonstrate them are obtained from the Laboratories. Standard items can be ordered directly from Western Electric.

Transmission Talk

By M. D. BRILL
Transmission Apparatus Development

WHENEVER an American makes or does something new, he tries to invent a new expression to describe it. And as Yankee ingenuity is proverbial our language is constantly being enriched by a stream of freshly coined words. The larger part of them are soon forgotten; but others—the better ones—survive because they carry a meaning that cannot otherwise be expressed so easily or so well.

An especially good environment for growing words is any profession that involves tools or operations peculiar to itself. Expressions come into use which are particularly apt for the pursuit at hand, and yet are bewildering to the uninitiated, until at length an industry has not only its "tools of the trade" but also its "talk of the trade."

The communications art has its share of expressions almost meaningless to the layman, but entirely clear to those working in that field. Many of them have been compiled in a "Glossary for Telephone Transmission" by K. S. Johnson, but as time goes on new ones are coined and take their places in the language. In the rather restricted field of carrier-transmission networks some of the recent expressions which enjoy considerable usage are "roof" filter, "cellar" filter, "frogging" filter, "comb" filter, and "pimple" filter. The transmission networks referred to are not new types, but the new descriptive phrases indicate the function of the networks in a transmission system in a pointed manner that the older generic classifications such as "low-pass" or "high-pass" filter could not equal. Definitions of these filters in the thumbnail sketch style of the "Glossary" may prove useful to those interested in the communications art.

A *"roof" filter* is a low-pass filter used in a carrier telephone repeater to limit the upper frequency end of the transmitted band to its prescribed useful range. It eliminates high-frequency disturbances which might cause noise or crosstalk in adjacent systems.

A *"cellar" filter* is a high-pass filter used in a carrier telephone repeater to limit the lower-frequency end of the transmitted band. Except for the difference in the frequency end which it limits, its function is the same as that of a roof filter.

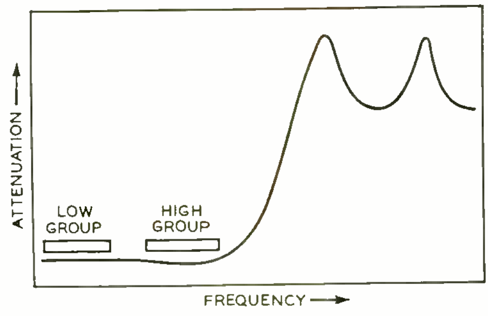


Fig. 1—"Roof" filter, typical characteristic

"Frogging" filter: The term "frogging" derives from the expression "frog" in railway engineering which refers to the mechanical device permit-

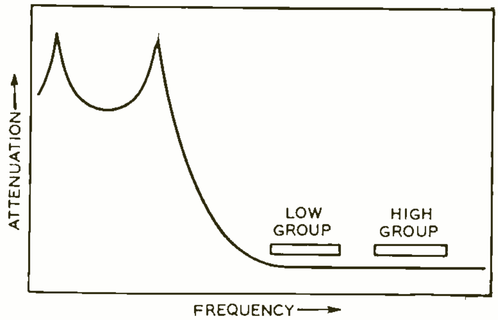


Fig. 2—"Cellar" filter

ting wheels on one rail of a track to cross an intersecting rail. In telephone transmission terminology, "frogging" means the transfer of the intelligence-bearing frequencies of an open-wire carrier system from a particular line

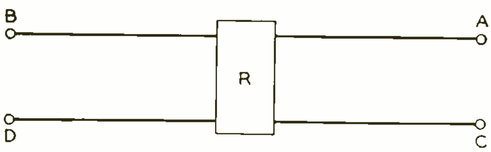


Fig. 3—"Frogging" may be required for certain arrangements of carrier lines that use common repeaters

entering a repeater to a different line leaving the repeater. The geographical arrangement of the carrier telephone facilities occasionally makes this necessary, and the basic situation is illustrated in Figure 3. Suppose that cities A and B are the terminals of a type-C carrier telephone system operating over line ARB, and R is a repeater point. Similarly, suppose C and D to be terminals of another type-C system operating over line CRD, and R to be a repeater point for this system likewise. If it is desired to add a type-J carrier telephone system between cities A and D, and a type-J system between cities C and B without constructing additional open-wire lines, then such systems must switch from one line to the other in passing through repeater point R. This would be known as a "frog" of two type-J systems. Additional transmission apparatus is, of course, necessary to effect this frog, and one such piece of apparatus is known as a "frogging" filter. This filter is of either the "low-pass" or "high-pass" type and serves to eliminate the increased crosstalk at the repeater resulting from the frogging process. Frogging filters may be, but are not necessarily, roof or cellar filters.

A *"pimple" filter* augments the loop loss of a directional filter set over small frequency bands where deficiencies in loss exist for some unusual service conditions. Such filters possess high discrimination over small frequency ranges and derive their name from the resemblance of their attenuation characteristic to what Webster calls "a small, pointed elevation of the skin"—in short, a pimple. In their simplest form, they consist merely of one-mesh resonant circuits; in more complicated forms they may be conventional band-elimination filters.

A *"comb" filter* is used at the terminals of a carrier telephone system to prevent a leak of the unmodulated carriers to the line. These filters assist the balanced modulators in this function, and make frequent checks of modulator balance unnecessary. In

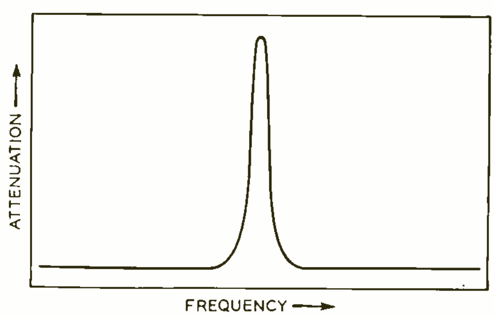


Fig. 4—"Pimple" filter

the type-K carrier telephone system they consist of a parallel connection of quartz crystals, each crystal cut for a particular carrier frequency. The crystals introduce extremely sharp attenuation peaks at their respective resonant frequencies, hence the descriptive name "comb."

The word "filter" is itself an excellent example of an expression whose meaning has been extended by new usage. Derived from the Latin *feltrum*, meaning "felt," or "fulled wool," which was used to strain liquors, it originally referred to any material or device employed to separate a liquid from particles of solid held in suspension. Chosen by transmission engineers to describe a circuit that suppresses certain frequencies and passes others, it has served its purpose with complete satisfaction to all concerned.

Many of the best "new" words, like "filter," are not new at all except in meaning. "Frog," referred to above, is another good example. The railroad device so called was given the name because it looked like a frog. This is a pure Americanism; in England a railroad frog is a "crossing." Other neologisms are newly meaningful combinations of old words, many of them extremely vivid, like "cloud-burst," "roughneck," "blowout," "stuffed-shirt" and "brass hat." Genuinely new words are comparatively rare,

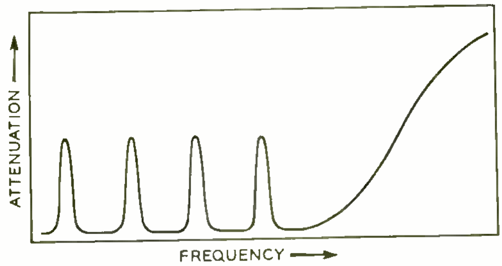


Fig. 5—"Comb" filter

and many of them are likely to remain synthetic. To take familiar examples, "vodas," "compandor" and "codan" all still seem to creak at the joints. "Musa" is better; and although it still lingers below the salt, the best of the Bell System product to date is undoubtedly the cableman's name for the 108A amplifier: "bliffy-sniffer."

Secretarial Key Equipment Using Neon Signals

TO ANSWER several telephone lines at a central point where the simplest secretarial arrangement meets the customer's needs, the 103A key equipment has been developed. It differs from other key boxes in that the signal lamps are neon tubes with cold cathodes. They require no auxiliary apparatus or power supply. The box contains all of the equipment except the telephone set and an audible signal which is common to all of the lines. Each lamp gives a visual signal when the associated line is rung and it also serves in place of a relay to sound the common audible signal. The neon lamp has three electrodes. When ringing current is applied to the two which are connected to the tip and ring of the line the gas in the tube ionizes, thereby providing a conducting path to the third electrode and thence through the audible signal to ground.

To pick up the calling line the two-way locking key, which is associated with the lighted lamp, is operated in the direction of this lamp. The turn-button key shown at the upper right-hand side of the box connects and disconnects the audible signal.

This equipment is available with capacities for ten and twenty lines and it may be multipled for operation from two locations. There are several types of ringing supply and this single secretarial pick-up can be used or adapted for use with most of them.

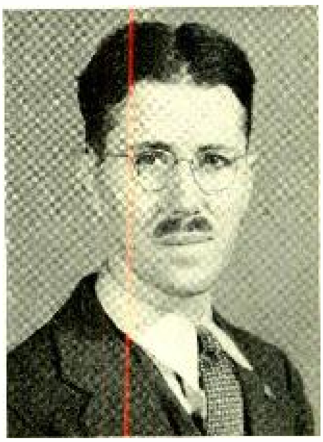
Contributors to this Issue

D. E. TRUCKSESS received a B.S. degree from Pennsylvania State College in 1926, and joined the Technical Staff of the Laboratories in the same year. With the Systems Development Department he has been chiefly engaged in the development of power apparatus. Recently he has given particular attention to the development of regulated rectifiers.

D. B. PENICK came to the Engineering Department of the Western Electric Company in 1924, where he worked on special problems in the development of vacuum tubes. In 1937 he transferred to the Systems Development Department and has since been engaged in development work on carrier telephone terminals. Mr. Penick received his B.S. degree in Electrical Engineering from the University of Texas in 1923 and a B.A. from the same institution the following year. In 1927 he received an M.A. from Columbia University.

D. E. Trucksess

M. D. BRILL was graduated from Columbia University in 1928 with the B.A. degree. After a year of graduate work in physics and engineering, he joined the Apparatus Development Department of the Laboratories in the summer of 1929, returning to Columbia in the fall to complete his work for the M.A. degree which he received in 1930. He then returned to the transmission networks group of the Laboratories. Subsequently, he transferred to the Radio Development Department where he was associated with the development of aircraft receivers. He then returned to the networks group



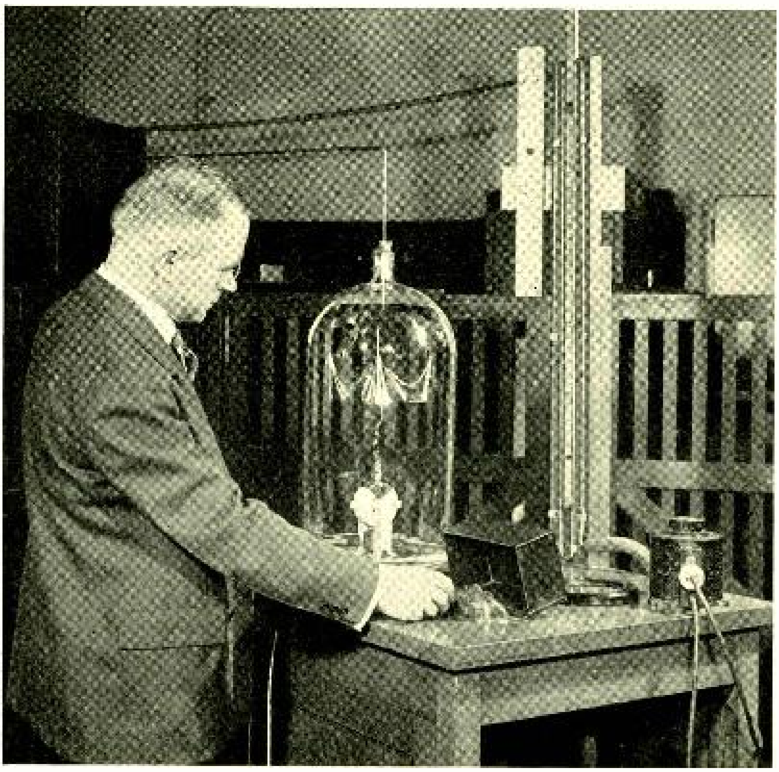
D. B. Penick

M. D. Brill

A. S. Martins

where he has engaged in the study and development of filters, equalizers and networks for telegraph, voice frequency, program, and carrier-frequency systems.

A. S. Martins entered these Laboratories in 1928 and shortly afterward became a technical assistant in the Systems Development Department. He has completed the Laboratories' student engineering course and is at present attending classes at the Polytechnic Institute of Brooklyn from which he expects to receive a degree of B.S. in Electrical Engineering next year. In 1936 he transferred to the step-by-step systems laboratory group where he has been engaged mainly with problems relating to pulsing of step-by-step systems circuits.



Testing at Reduced Air Pressures

Among the problems encountered in the development of communication equipment for aircraft has been the design of transformers of light weight to deliver high a-c potentials at high altitudes. Special precautions must be taken to avoid flashovers in insulating such transformers because the dielectric strength of air is markedly lower at high altitudes than at sea level. In studying the transformers in the laboratory the low atmospheric pressures encountered in flight have to be simulated. This is accomplished by putting them under a bell jar from which the air is exhausted by a vacuum pump. The air pressure is measured with a mercury manometer and is held at the desired value while tests are made on the dielectric strength of the insulation