KELLOGG TELEPHONE REPEATER

BULLETIN 208

KELLOGG SWITCHBOARD & SUPPLY COMPANY
CHICAGO

CONTENTS

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1066 WEST ADAMS ST. • CHICAGO, ILL.

KELLOGG TELEPHONE REPEATERS

EVERY telephone man knows the value of good transmission, but there may be many who do not realize what a repeater can do for them. Some may feel that a repeater is too complicated or too delicate for their use. Others may not know that a thoroughly reliable repeater can now be bought at a very reasonable price and that it will easily pay for itself in a few months. So this bulletin is addressed to telephone men operating both public and private systems who want to increase the usefulness of their long lines.

The Kellogg repeater is designed and built to fill the needs of independent telephony, railroads, pipe lines, power companies, and other users of long line communication. It is a practical piece of equipment for operation day in and day out without tinkering or adjustment and regardless of time or weather. It is designed simply, so that the novice can understand it. It is built ruggedly, so that it will stand up. It is assembled compactly, so that any telephone man can install and maintain it.

The Kellogg repeater has power. It will overcome the loss in 157 miles of .104 copper, 15.5 miles of No. 19 B&S gauge cable, or 8.3 miles of No. 22 B&S gauge cable. This means that a repeater makes a call from Chicago, Illinois to Indianapolis, Indiana just like local service. These figures are altered somewhat by various conditions, but are close enough for an illustration of how the repeater can span distance. And, of course, other repeaters can be added along the route to extend the circuit farther and farther.

But the Kellogg repeater does more than produce volume and power. It actually improves the tone of the voice by eliminating noise and distortion arising from other sources. The Kellogg repeater is built with particular attention to tone and articulation. The average telephone equipment, especially cable, offers greater loss to high frequencies and higher tones. For that reason this repeater is made to amplify the higher tones more, which makes the voice much more life-like and more easily understood. At the same time all frequencies below 160 cycles have been suppressed so as to eliminate power line induction which is such a common source of disturbance.

The Kellogg repeater is remarkably stable. The operator has no control of the repeater gain; hence errors from that source are eliminated. The Kellogg system of gain control has a notable stabilizing effect which is a big help on circuits of a variable nature. For this reason the Kellogg repeater can be operated satisfactorily on dispatching wires and other circuits having branches and intermediate stations, where other types of repeaters are not recommended.

Circuit utility is the primary interest whether the service is sold commercially or maintained only for the transaction of company business; and poor transmission can be very expensive. Relayed messages waste time of circuits and employees. Misunderstandings cause errors and wasted effort. If the service is unsatisfactory, use of the circuit will be avoided by both the public and employees; and the investment is, at best, a partial loss. In such cases, the cost of a repeater is more than justified since it encourages full use of the facilities and assures maximum return on the money spent. The first cost of the Kellogg repeater is very reasonable for apparatus of its type and quality, and there are no rental charges.

The Kellogg repeater and power unit contain no moving parts other than a single relay of standard design. All tubes are standard radio types and can be tested in the usual way and replaced from standard stocks. Coils are wound with wire of substantial size and thoroughly impregnated to exclude atmospheric moisture. The power transformer is designed for 100% overload and consequently will not heat in continuous service. These features insure long life (low depreciation), minimum maintenance, and utmost dependability. The power required to operate an A.C. repeater is little more than that consumed by one twenty-five watt lamp.

Repeaters can often save substantial sums in the first cost of circuits by permitting the use of cables of greater length and conductors of smaller gauge where this type of line construction is otherwise desirable. The repeater is by no means a substitute for a good line, but it will compensate for some lack of conductivity and thus permit savings in both wire and supports, and will reduce future maintenance by permitting the use of conductors of higher tensile strength and less weight.

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induction pick-up resulting from joint construction or close parallel with A.C. power lines and signal circuits. In fact the repeater injects a very appreciable loss to such frequencies, reducing the noise level while raising the voice level. If the repeater is not bridged, as by simplex or composite legs, it acts as an insulating transformer barring the passage of 60-cycle hum. Telephone, telegraph and signal engineers will be interested in this characteristic and the response curve shown on the chart at the bottom of the next page.

GAINS

As every engineer knows, it is impossible to discuss in specific terms the gain possible in any repeater except as it may be used in a specific manner under a given set of conditions. In short, the gain of a repeater may be large or small, depending on the circuit and other conditions surrounding its use. Consequently, a better idea of the possibilities of the Kellogg repeater may be had by (1) a discussion of the bare repeater, (2) a discussion of the conditions affecting the possible gain, and (3) a brief consideration of a few of the more common problems.

FREQUENCY RESPONSE

Curve "A" in Fig. 1, shows the response of the Kellogg repeater at all frequencies from 100 cycles to 3000 cycles. Exhaustive tests have shown that frequencies below 200 cycles are responsible for less than 2% of articulation, but create the greatest source of noise, that is, 60-cycle induction and its second and third harmonics, 120 cycles and 180 cycles. Consequently the repeater is designed to produce little gain below 200 cycles. Similarly there is only 15% of all articulation above 3000 cycles, and the repeater gain is permitted to fall rapidly beyond that point. It will be seen that the greatest amplification, 20 db, occurs at 2200 cycles, while the average is approximately 15 db, or the 1000-cycle value. The purpose of this greater amplification at higher frequencies is to compensate in the repeater for the lower efficiency and greater losses in other equipment and in cables at these higher frequencies.

A second curve "B" shows the transmission loss of a line having the characteristics stated. A repeater on this line improves the transmission as shown by curve "C" resulting in better quality as well as volume. The repeater improves the voice quality by bringing up the higher tones, normally suppressed by other apparatus, so that the gain throughout the voice range is much more apparent to the ear than that measured at 1000 cycles. Any improvement in tone or articulation naturally makes the speech more understandable, even without increased volume. The reduction in noise-level and distortion from sources below 200 cycles is responsible for a further improvement in transmission which is most important to the ear of the listener, although not apparent in charts and figures.

The results depicted in Curve "A" are for the repeater taken by itself and are consequently independent of outside conditions. In actual service, however, other factors must be considered, the first of which is the line. In any two-way amplifier, the voice currents flowing in opposite directions must be guided in the proper channels, which function is performed by the artificial line or "network." The efficiency with which the network performs this duty depends on how exactly it matches the characteristics of the corresponding section of the line, and for this reason it is required that the line be reasonably constant so as to remain in balance with the network.

INTERMEDIATE REPEATER OPERATION

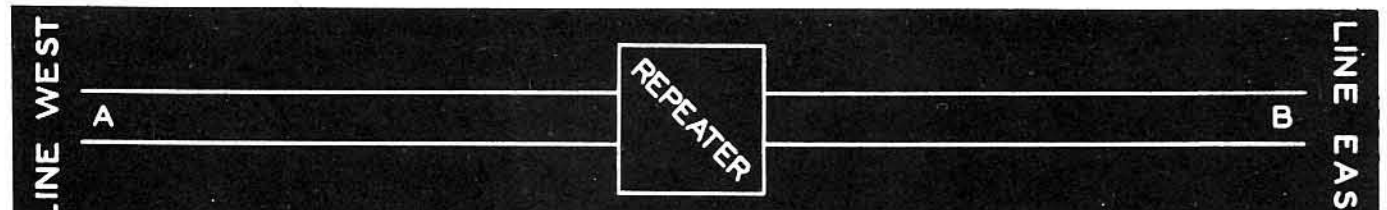
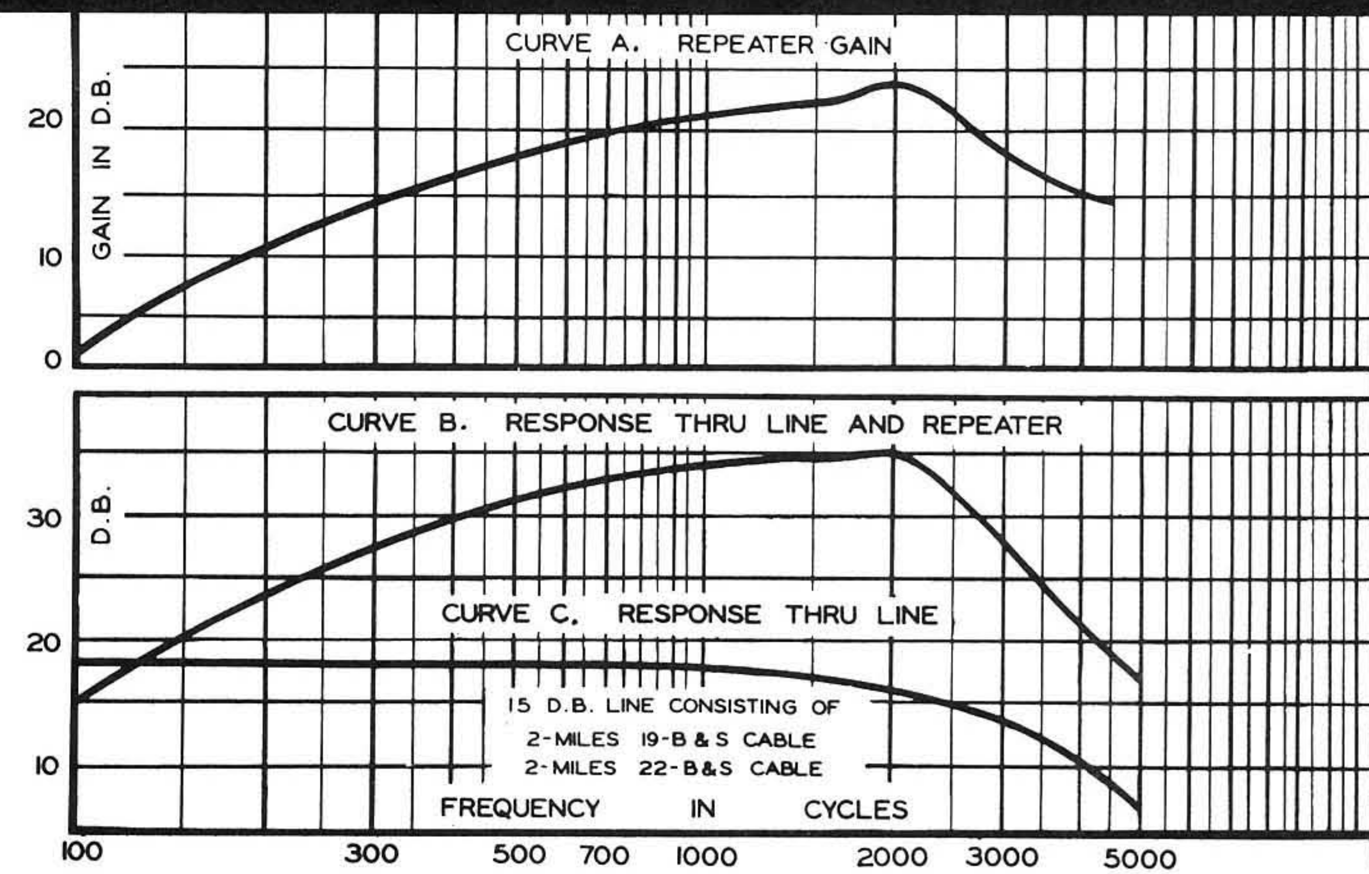


FIG. 2. THROUGH OR INTERMEDIATE LINE REPEATER

If "R" in Fig. 2 represents a repeater in the line "A"—"B," it is obvious that any change of condition at either terminal will change the characteristics of that end of the line. These changes are unavoidable because of the different characteristics of the drop, the cord circuit, and the connected line (either local or toll)—any one of which may be connected to the circuit. For this reason the value of the repeater network must be such as will balance the line with telephones talking, and have sufficient margin to prevent "singing" under other conditions of termination. If the balance between line and network were perfect, the repeater would operate at maximum gain without "singing" but, because of the variations at terminals, a hair line adjustment is neither practical nor advisable, and the gain of the repeater must be reduced to allow a satisfactory margin.

It is fortunate, however, that the line loss between the repeater and the terminal reduces the effect which varying terminations would otherwise have on the repeater. In Fig. 2, the line "A"-"B" is not a zero loop and, consequently, any difference between the respective characteristics of the drop and the cord circuit will be felt by the repeater only to the extent that this change affects that section of the line as a whole. If the line loss is great and the difference in termination is small, the ratio of change will be so minute that, for all practical purposes, no unbalance will result, and the repeater may be operated at maximum gain with perfect stability.



TERMINAL REPEATER OPERATION

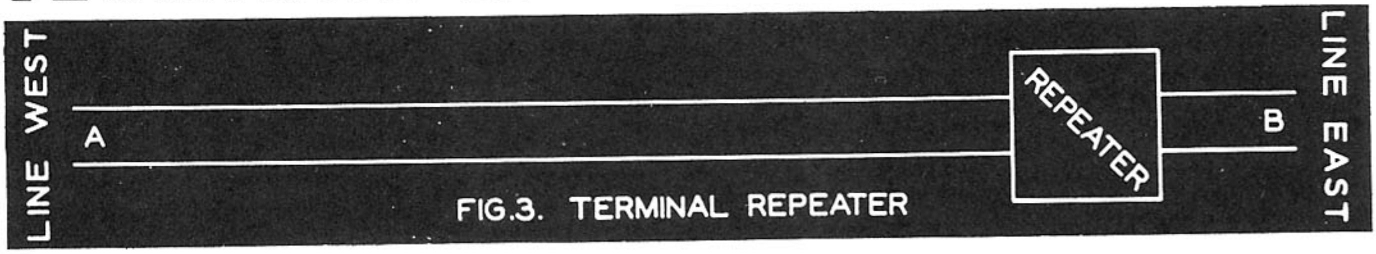


FIG.3. TERMINAL REPEATER

THIS principle is fundamental, regardless of the location of the repeater in the line, and other problems are mere variations of this theme. Fig. 3 illustrates a terminal line repeater which differs from the intermediate type only in that the repeater is located at one extremity of the line. It would now be expected that the western end of the repeater would be very easily balanced because of the length of line between the repeater and terminal "A." However, it is obvious that the eastern end is practically a zero loop and any change in termination at "B" will have undiminished effect on the repeater. If these changes at "B" represent a wide variation, it would be impossible to provide a network which would balance under all conditions. Therefore, artificial line must be inserted between the repeater and the jack to reduce the gain of that end of the repeater and to lessen the effect of changes at "B."

This "padding" or "building out" is another phase of the basic principle of reducing the ratio between the change of termination and the loss in the intervening line. In this case, loss is deliberately inserted in series to the extent that the network will balance the repeater in all of the various connections which are desired. Obviously, the range of terminal variation determines the amount of padding necessary and, consequently, the gain that is possible. It is true, however, that the repeater will not "spill" so long as one end is in perfect balance and, for that reason, the western end of the circuit will exert an appreciable stabilizing effect if the line is long or the variations at "A" are slight.

CORD REPEATER OPERATION

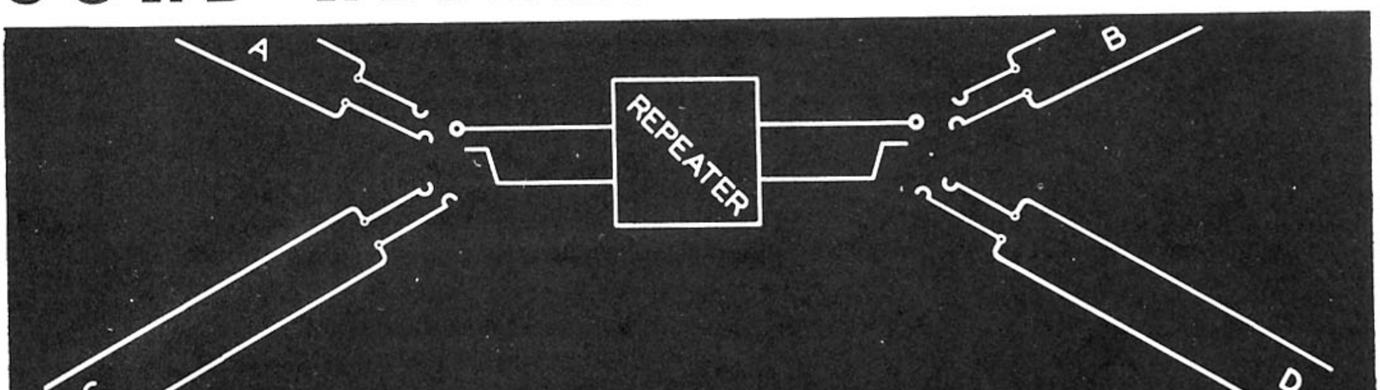


FIG.4. CORD REPEATER

FIG. 4 illustrates a cord circuit repeater, which is comparable to the line repeater, Fig. 2, in that it is located more or less in the center of the built-up circuit. In installations of this type, a balancing network is connected in each line circuit and adjusted to the value of the line and its average terminations at the distant end. Each end of the repeater will thus be in balance regardless of the line to which it is connected, and its gain is determined by the same rules as though it were to be permanently connected in each combination of circuits.

The repeater shown in Fig. 4 may be connected to long circuits extending to "D" and to "C" in which case it may be assumed that maximum gain is desired, or it may be connected to circuits "A" and "B" which are much shorter, electrically. The repeater must re- *(Continued on page 7)*

main stable despite any condition of service arising at any of the four terminals "A," "B," "C," and "D," and these changes will affect the repeater according to the ratio which each change bears to the intervening line. Obviously, a change occurring at "A" will have a greater effect than an equal change occurring at "D" because of the greater loss between terminal "D" and the repeater. Usual practice, therefore, is to pad the shorter lines to equal the value of the longest line, which results in maximum stability and a desirable uniformity of transmission over all circuits.

DISPATCHING CIRCUITS

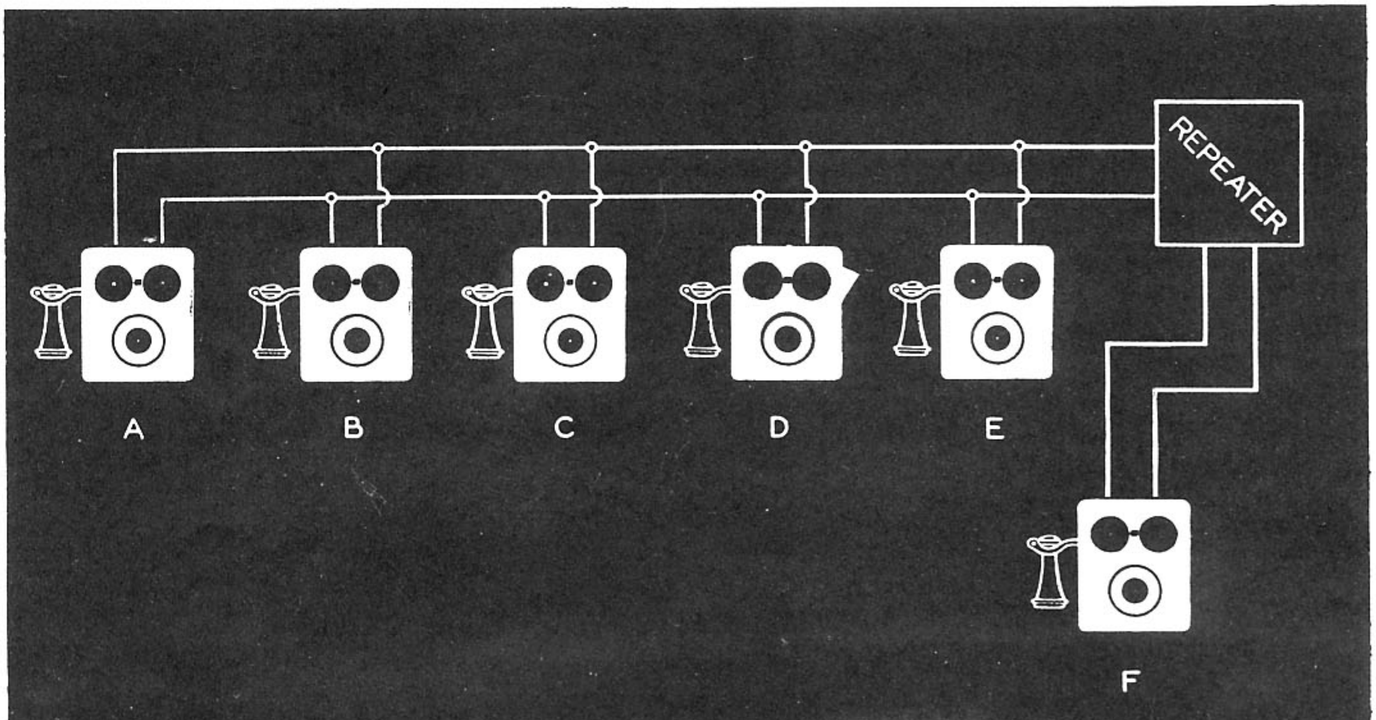


FIG. 5. LINE CIRCUIT REPEATER WITH BRIDGED STATIONS

THUS far, gain has been considered as it may be affected by length of line and variations in termination. Fig. 5 illustrates the problem of variation in line load occurring at varying distances from the repeater. This situation, most common in dispatching circuits, is governed by the same principle of "ratio of change to total loss," but is different in that the intervening loss is not always the same; and, for that reason, the problem gives play to greater judgment on the part of the engineer designing the installation.

The change taking place on this type of circuit is the change in the characteristics of the individual telephones as they may be in an idle or a talking condition. The difference in the impedance bridged across the line is a serious consideration if the station is located near the repeater, electrically, and varies, depending on the type of telephone used. The network of each end of the repeater is readily balanced against the normal line with all bridged stations idle, but the repeater must remain stable with the maximum number of receivers "off the hook." This demands a wide margin and usually requires that the gain of the repeater be reduced to make the adjustment less critical.

It is obvious that the balance of the repeater will be little affected by the removal of the receiver from the hook switch at station "A" (Fig. 5) inasmuch as there is a considerable loss, both line and bridged station, between "A" and the repeater. The change will be increasingly noticeable, however, for each station successively nearer the repeater, the maximum effect being produced by a station at the repeater location. The range between maximum and minimum may be so wide that it is impossible to obtain a balance under all conditions, in which case a resistance must be used in those stations nearest to the repeater to "build them out" and thus reduce their unbalancing effect.

TYPICAL TOLL SYSTEM

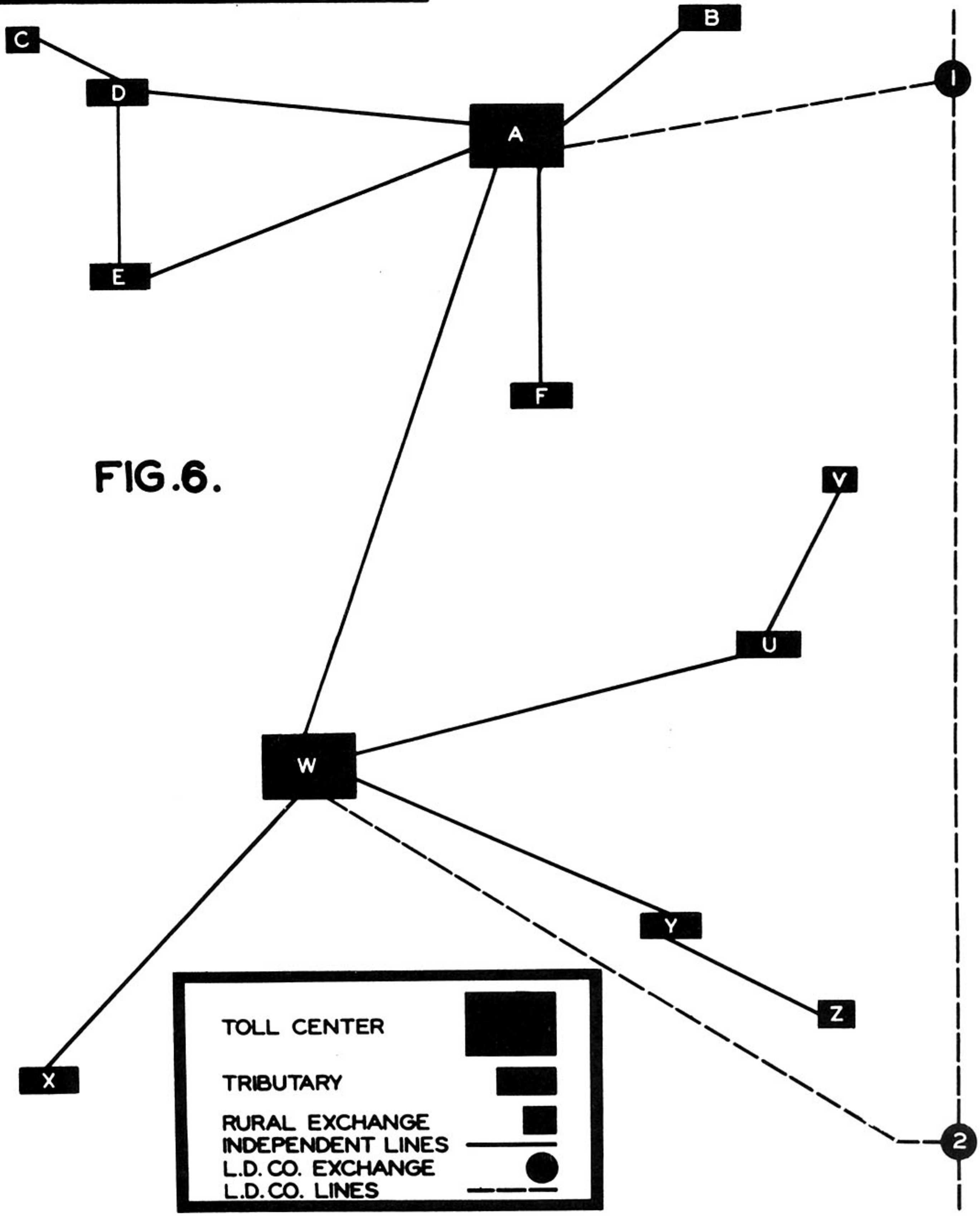


FIG. 6.

CONNECTING TOLL SYSTEMS

FIG. 6 represents a situation familiar to all commercial telephone men. It will be seen that cord circuit repeaters located at "A" and "W" would be available to all calls to and from the tributaries and would make a complete interchange of business fully commercial. For example, on a message from "C" to "Z," a repeater at "A" would compensate for all cord and line losses between "D" and "W," making switchboard "D" the electrical equivalent of a subscriber at "W."

On the assumption that transmission within each of the groups "A"-"F" and "U"-"Z" is commercial, the longest message from one group to the other would probably require only one repeater. If distances and circuits are such that two-switch connections within each group are at or near the limit of commercial transmission, it would be advisable to use repeaters at both "A" and "W" on inter-group connections involving several switches. It is also obvious that a repeater at "A" would make exchange "C" the electrical equivalent of a subscriber at connecting company exchange "I" and thus assure adequate transmission on calls handled over other lines.

This illustration is typical of how the cord-circuit and terminating losses on multi-switch connections can readily be overcome by repeaters, and shows the merging of two areas into one profitable network.

Repeaters may be operated with equal success on physical and phantom circuits. Phantom groups must be transposed to prevent cross-talk, and any intermediate equipment on one physical should be balanced by similar equipment on the other. These steps, however, should be taken even on non-repeatered circuits.

BUILDING OUT

CIRCUITS having branches and way stations are sometimes difficult to balance for the reasons given under the heading of "Dispatching Circuits" on page 7. The variable resistances used in such cases are inserted in the wiring, between the telephone and the line, and do not affect the line itself or the other stations. In effect, the telephone in question is moved electrically farther away from the repeater, and its unbalancing effect on the repeater is materially lessened. When the line is made more constant by this means, the balancing network becomes more effective; the repeater is more stable, and may be operated at a higher gain without danger of "singing."

This building out may be avoided, or reduced to a minimum, by locating the repeater at the most favorable point in the line. This location is, obviously, the spot where the greatest length of line or the greatest losses will be between the repeater and the nearest stations on either side. Consequently, a preferred location is between long runs of cable or adjacent to cable on one side and an uninterrupted stretch of open line on the other.

If neither of these opportunities is present, the repeater should be located so that the heaviest building out will be at stations of less importance or those which will be less handicapped in talking with other stations on the same side of the repeater. If the circuit shown in Fig. 5 required such treatment, stations "E" and "F" would receive the maximum resistances. Station "F," although built out, would get the benefit of the repeater on all conversations; but station "E" must talk to station "A" without the repeater's aid and transmission on this conversation might suffer seriously.

If this circuit were of uniform wire throughout its length, a better location for the repeater would be between "C" and "D," where building out of adjacent stations would result in no handicap ("C" could talk to "A," and "D" could talk to "F" despite the local resistances) and where the repeater would be used on a greater proportion of the possible connections. But, if it is assumed that a considerable length of cable exists between the repeater and "F," and especially if "F" represents a switchboard or a dispatcher, then the location is unquestionably correct as shown, because the repeater is adjacent to the greatest source of loss and is in the path of the maximum amount of traffic. This factor of flow of traffic is also an important point to be kept in mind.

The stability of the repeater is further improved by the fact that each side of the line is terminated in a repeating coil which reduces the effect of line disturbances on the repeater. Also, the insertion of a repeating coil in the distant end of the line will improve stability by reducing the effect of varying terminations, such as the connection of lines of different lengths or different characteristics. Although the repeating coil is not an absolute termination to the extent that changes beyond the repeating coil are not reflected back, it does reduce the effect of such changes to a great extent.

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GAIN CONTROL

FIG. 7 shows the repeater and its connections to both the line and the balancing networks and illustrates the extreme simplicity of the Kellogg gain control. Each end of the repeater is connected to a transmission pad, and a repeating coil is inserted between the pad and the line. Similarly, each balancing network is made up of a pad, a repeating coil, and an adjustable capacity and resistance. Since the repeater itself is not adjustable, its effect in the line is entirely dependent upon the value of the pads "A" and "B." These pads have the effect of reducing both the input from the line to the repeater and the output from the repeater to the line, thus controlling both the grid and plate circuits. Also, the pads "build out" the circuit away from the repeater, stabilizing the repeater by reducing the unbal-

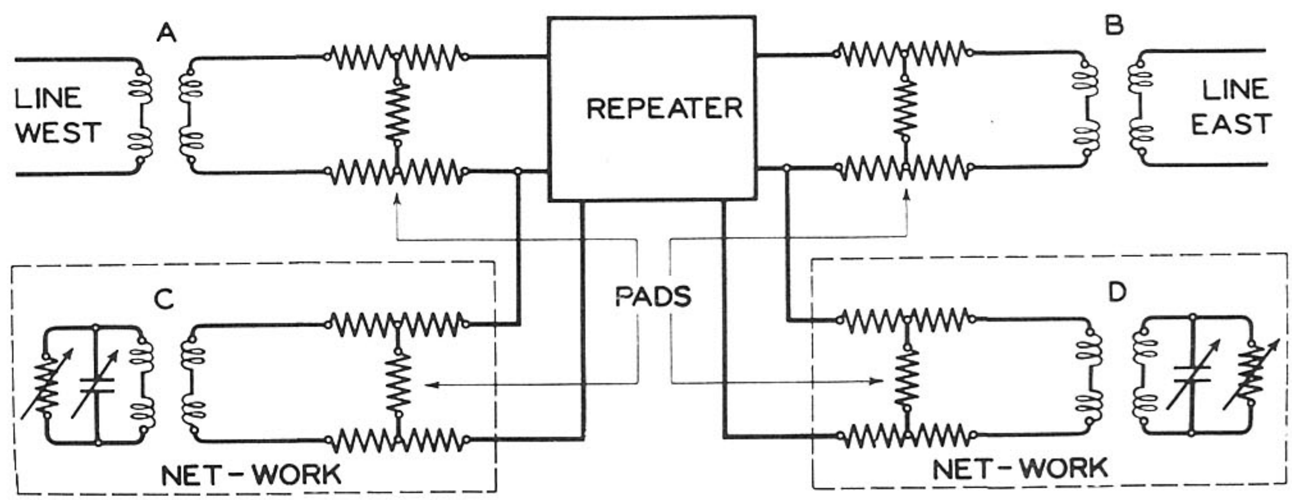


FIG.7. GAIN CONTROL CIRCUIT

ancing effect of any change of characteristics on the line. This threefold action of the pads makes this repeater amazingly stable even under unfavorable line conditions.

Although an artificial line may be adjusted to similar equivalents of an actual line in both resistance and capacity, it is a well-known fact that exact balance as to phase is usually not obtained. However, it will be noticed in Fig. 4 that the Kellogg hook-up matches the pads and repeating coils in the line with similar pads and repeating coils in the network. Thus, any variation of line characteristic or phase of current has less unbalancing effect on the repeater by reason of the intervening equipment which is identical in both pad and network.

The pads used for these balancing purposes are of the fixed type and require no adjustment after the original installation. This insures against tampering by unauthorized parties or inexperienced maintainers, and also removes that frequent cause of service delays which arises from operators attempting to increase the gain of repeaters beyond the point of stability. The pads are carefully balanced and adjusted to atated values during manufacture, after which they are sealed in metal containers with impregnation to insure against deterioration from atmospheric moisture.

APPARATUS

THE Kellogg repeater as a unit is adaptable to any type of service and may be combined with auxiliary equipment of the proper type for use as a line or cord repeater, either intermediate or terminal. This auxiliary equipment consists of repeating coils, condensers, pads, and relays as required, depending on the use to which the repeater is to be put and the local conditions surrounding the installation.

The intermediate line-circuit, as diagrammed in Fig. 2, requires, in addition to the repeater, one intermediate line circuit-unit which includes the line network and provisions for signaling as required. The ter- *(Continued on page 11)*

minal line-circuit is much the same, except that greater padding would normally be required on the drop side of the repeater than on the line side. In the intermediate repeater line-circuit the gain control pads are usually of more equal value on each side of the repeater because the repeater is located more nearly in the electrical center of the circuit. The insertion of an intermediate or terminal repeater in a line does not necessitate any changes in the switchboard equipment at the line terminal.

The cord circuit repeater, as shown in Fig. 4, consists of a repeater with cords and plugs and keys for listening and monitoring. Inasmuch as it is not feasible to equip a repeater cord-circuit with the usual type of supervision, it is necessary to modify each line-circuit to which the repeater is to be connected so that the line signal also takes care of supervision. Each of these line-circuits must also carry the balancing network for that line so that the repeater will be in balance regardless of the line to which it is connected. Also, the gain control for the repeater is included in the line-circuit, thus making it possible to have just the right amount of gain for each connection that is set up.

This equipment is added between the regular line jack and a special repeater jack which is installed for use only on connections set up with the repeater cord. Other connections are established by means of the regular cords in the regular line jack. When the regular line jack is used in connection with a non-repeater cord, ringing, listening, and supervision are the same as on any other line and cord, but with the repeater cord in the repeater jack, the operator rings with a ringing key associated with the repeater jack, and the supervisory signal is transferred to the line lamp as mentioned above.

The utility of the cord-circuit repeater is increased by the use of a terminating trunk which consists of a pad connected between two switchboard jacks. This circuit permits the use of a cord-circuit repeater for connecting local stations to a toll line. The pad is of such a value as to "build out" the average local subscriber's station to approximately the equivalent of a toll line. Thus the repeater cord may be used to connect the subscriber to the toll line with considerable gain in transmission. In practice, one plug of the repeater cord-circuit is inserted in the toll line, and the other plug in one jack of the terminating trunk. The call is then completed from the other jack of the terminating trunk to the subscriber's station with a standard non-repeater cord. Supervision on such a connection is by means of the non-repeater cord on the subscriber's end and the combined line and disconnect lamp of the toll line.

SIGNALING

THROUGH RINGING CIRCUIT

THE intermediate and terminal line-circuit equipment referred to above can be designed for any desired type of signaling. On normal circuits the 20-cycle signaling current is passed around the repeater by means of relays which operate to disconnect the repeater from the circuit and close a through, metallic path for signals. Such an arrangement is shown in Fig. 8, in which it *(Continued on page 12)*

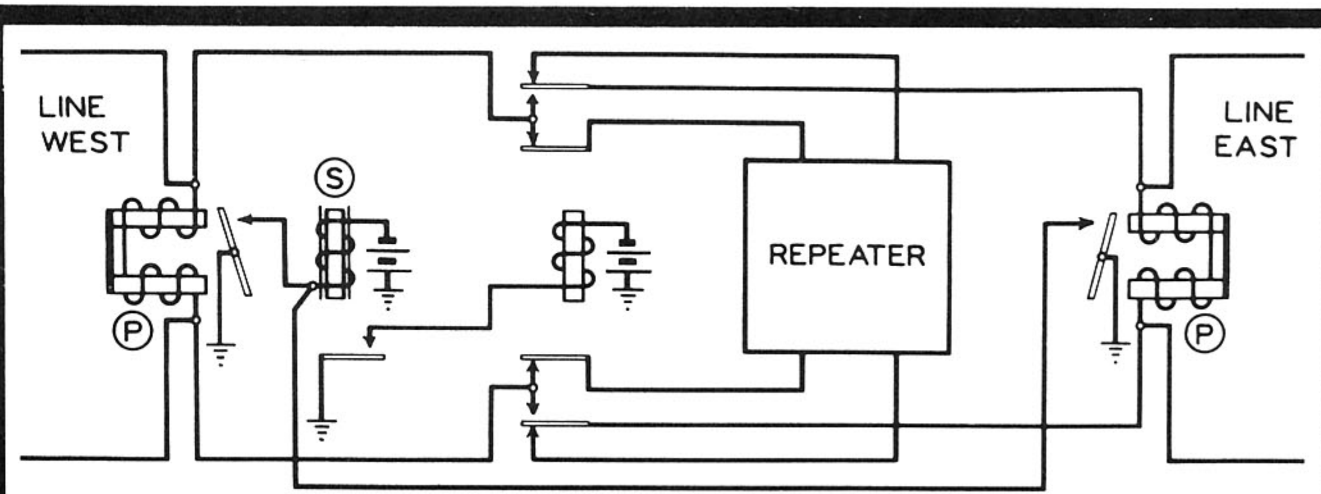


FIG.8. THROUGH RINGING CIRCUIT

will be noted that the sensitive polarized relays "P" are operated by the ringing current originated at the distant end of the line, and the secondary relay "S" is pulled up over the contacts of either polarized relay. This secondary relay removes the repeater from the line and closes the circuit for ringing purposes.

In the event that the circuit is too long for satisfactory ringing from end to end, a fresh source of ringing current may be supplied at the location of the repeater as shown in Fig. 9. In this instance relays "P" are energized by the original ringing source and in turn energize slow-release relays "S" which close the ringing relays "R" to apply the ringing source on the other end of the circuit. The operation is identical on east to west or west to east operation, a different set of relays being used in each direction.

REPEAT RINGING CIRCUIT

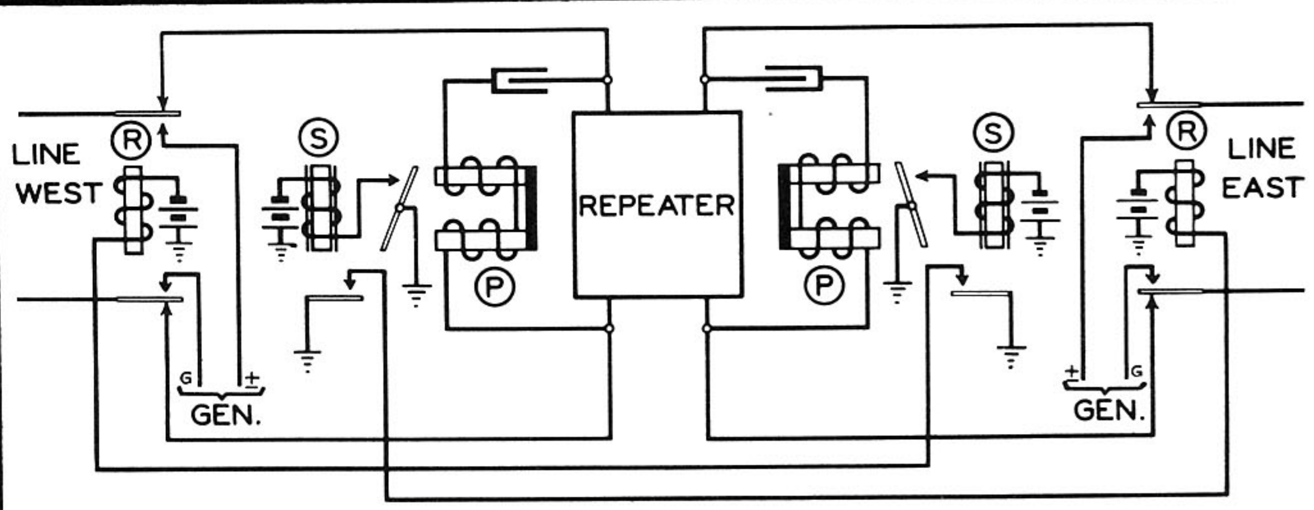


FIG.9. REPEAT RINGING CIRCUIT

For low-frequency signaling, the repeater is equipped with a low-frequency by-pass which offers very little impedance to currents of from 0 to 19 cycles. This arrangement, shown in Fig. 10, is especially recommended for 3½-cycle selector ringing such as is used on railway circuits. On composite circuits or others using high-frequency signaling, such as 135 cycles, a re-ring arrangement is recommended similar to that shown in Fig. 9 in which case relays "P" would be of a type most readily actuated by the ringing current used, and auxiliary equipment would be added as required.

LOW FREQUENCY BY-PASS CIRCUIT

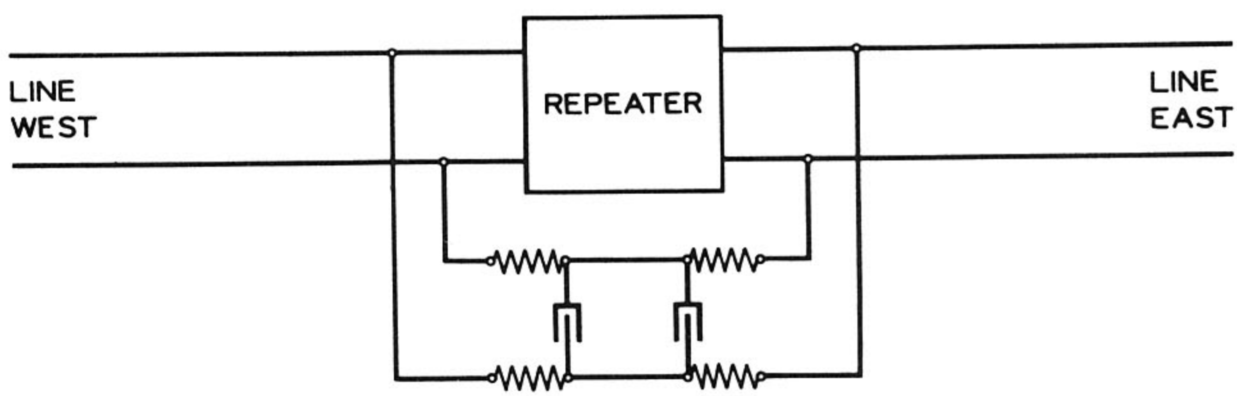


FIG.10. LOW FREQUENCY BY-PASS CIRCUIT

TELEGRAPH

THE Kellogg repeater can be used with any form of super-imposed telegraph and will not increase the telegraph lag in the circuit, nor will there be any tendency on the part of the repeater to amplify telegraph thumps which may leak into the telephone circuit. From Fig. 11 it will be noticed how readily a simplex circuit may be bridged around an intermediate repeater, this being nothing more than the usual practice for either simplex or phantom circuits. Fig. 12 illustrates the relative position of apparatus on a repeater-equipped composite circuit. The line first enters the composite equipment on each side, and the composite legs are taken off for termination or bridging through as may be desired. From the composite equipment the line goes to the repeater line unit which, in the instance shown, is of the in-

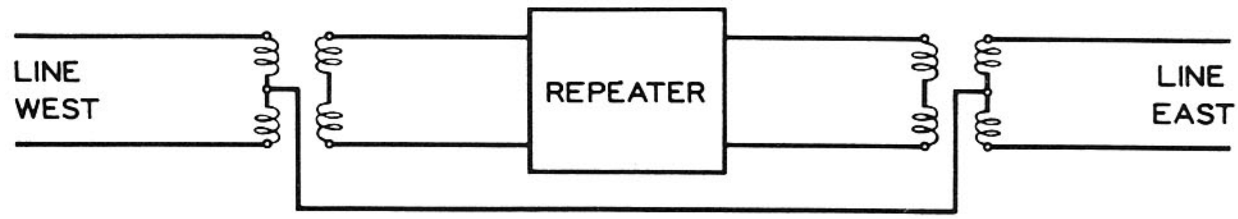


FIG.11. SIMPLEX BY-PASS CIRCUIT

termediate type with 135-cycle, repeated ringing. The repeater itself is, of course, located between the two halves of the line circuit unit and is fed from the power supply unit. A composite ringing interrupter is shown as the source of 135-cycle ringing current. It is obvious that any form of telegraphy which may be used on either simplex or composite circuits may be used on repeater circuits of the types shown in Figs. 11 and 12. Kellogg repeater-equipped circuits may be duplexed and will successfully handle both multiplex and standard printer operation.

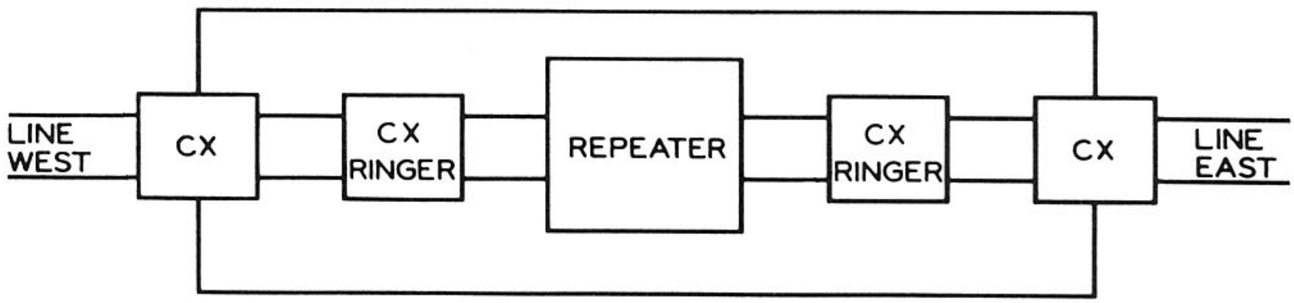
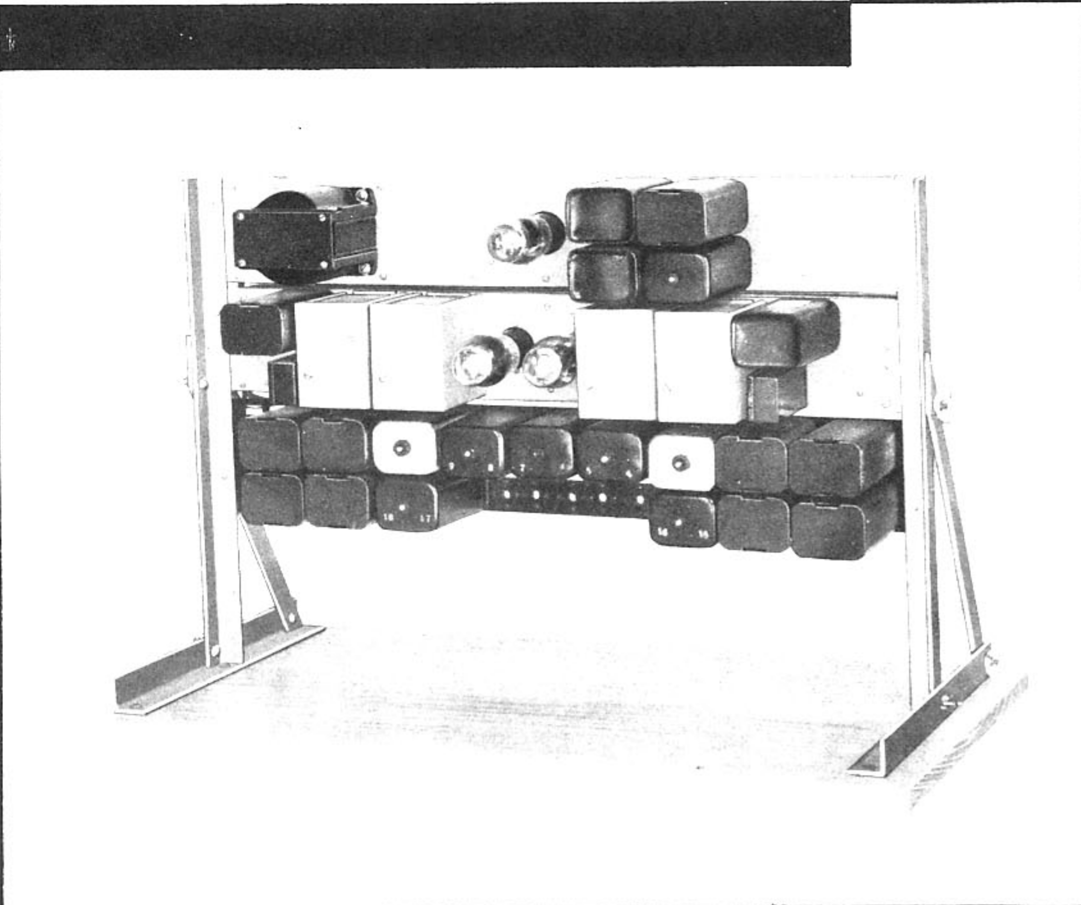


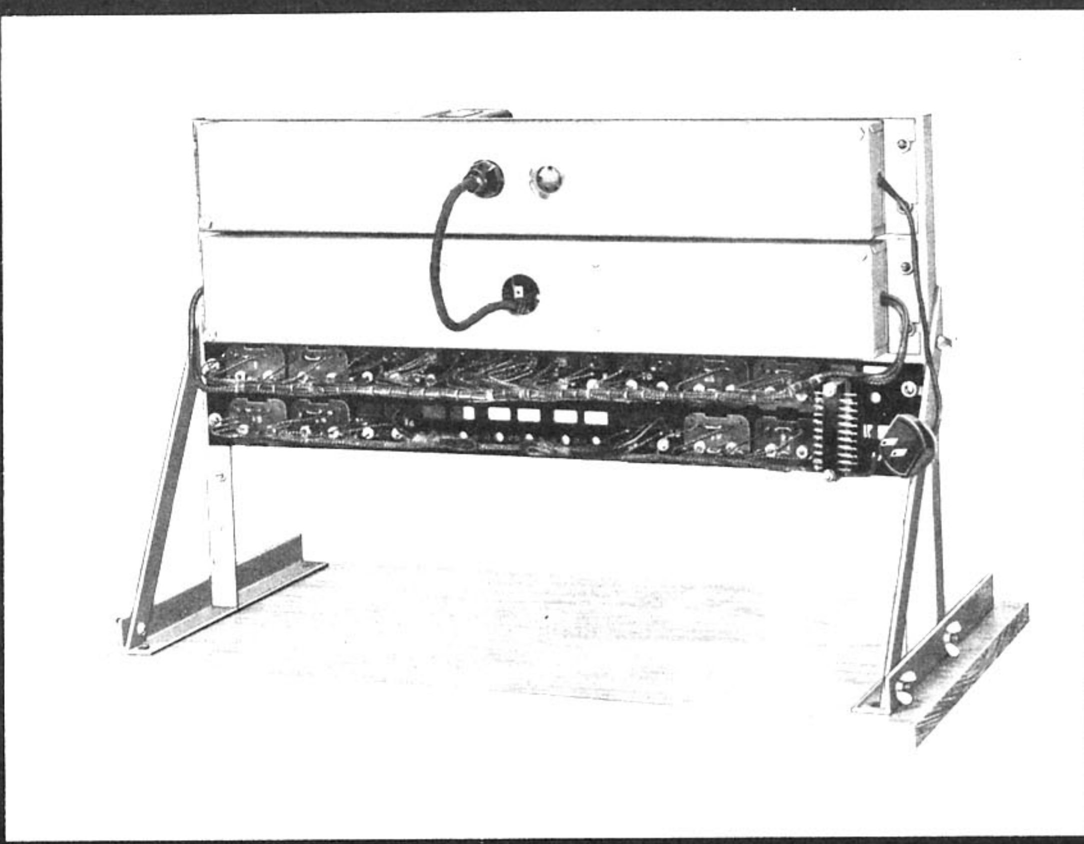
FIG.12. COMPOSITE BY-PASS CIRCUIT

ASSEMBLY

FIGURE 13A shows the general style of Kellogg repeater equipment, assembled in standard form on plates for relay rack mounting. The upper mounting plate contains the repeater, while the lower mounting plate carries the power unit. On the front view will be seen the input transformer and output transformer for the east and west end of the circuit, also the terminating repeating coils and the condensers. The tubes are located in the center. The power unit carries on its face the power transformer, rectifying tube, filter equipment, and the automatic emergency-battery switching relay. Fuses, connecting *(Continued on page 15)*



FRONT
VIEW
Fig. 13A



BACK
VIEW
Fig. 13B

blocks, and other miscellaneous units are carried on the rear of the mounting plates under the overall can cover which is shown in Fig. 13B.

The method of connecting the power unit to the repeater is shown in this illustration, also the attachment plug for making connection to 110-volt 60-cycle alternating current. Below the repeater and power unit a testing and patching panel can be added which is described under the heading of "Accessories" on page 18. The line-circuit units of various types are made up on mounting plates similar to those shown in Fig. 13A and B, the mounting plates varying in width depending on the amount of equipment required in the circuit. Dimensions are given in a later paragraph under the heading of "Racks," pages 16, 17 and 18, and connections from one unit to the other are described under the heading of "Installation," page 19.

POWER

THE No. 101 power unit used with the No. 1 repeater is designed to operate from 110-115-volt, 60-cycle, single-phase, alternating current. It produces all the voltages necessary for the correct operation of the repeater, which voltages are controlled by semi-fixed resistors and transformer taps which are set for normal commercial voltage before shipment of the repeater from the factory. Unless the commercial current at point of installation differs greatly from the accepted standards and the rating of the power unit, no change in these adjustments is ever required. A No. 280 or similar rectifying tube is used, which has a long life and a constant output in this service. Replacement need not be expected oftener than once every 12 months on continuous 24-hour operation. The power unit can be supplied for operation on other frequencies and other voltages, but each unit must be used on current of the voltage and frequency for which it is designed and adjusted.

As insurance against interruption to service by reason of failure of the commercial current, a throw-over relay is provided as a part of the power unit to switch automatically the repeater from the power unit to emergency batteries. It has been found that tube filaments are not the source of worry that they once were. In repeater service tubes are discarded because of loss of sensitivity rather than for filament failure, and it is therefore much to the advantage of the user to have the repeater switched from A.C. to D.C. operation rather than to have the repeater dropped out of the line and the line cut through metallically in the event of A.C. failure. In this way transmission on the circuit is maintained at an even level, and service is continuous even though the change-over should take place in the middle of a conversation. In the Kellogg repeater, long filament life is further assured because the repeater tubes are operated at an average voltage well under the manufacturer's normal rating.

Commercial current has become so dependable that emergency battery is required only in cases where continuous operation of the repeater is of extreme importance. Blown fuses, defective house wiring, and interruption by storm damage are the sources of A.C. failure which must be guarded against in most instances; and the frequency or duration of such interruptions is largely a matter to be determined locally by the purchaser. However, the current consumption of the Kellogg repeater is so low that an emergency battery source is not a matter of any great moment. The usual installation requires only six No. 6 telephone dry cells for "A" supply and 180 volts of radio "B" batteries for plate current. Under normal conditions of average commercial current, the life of these dry cells is determined by the shelf life of the battery rather than by the current consumed, and one set of emergency batteries will insure uninterrupted service for many months. The A.C. power consumption of the Kellogg repeater, including power unit losses, is 32 watts. The D.C. consumption when the repeater is operating on the emergency dry cells is 0.5 amperes at 5 volts and 15 milliamperes at 180 volts.

The relays used in the various types of circuits may be designed to operate on any D.C. voltage that is available. If no direct current is used at the repeater location, a six-volt rectifier will be furnished to supply current for relay operation, and emergency battery and an automatic throw-over relay can be had if desired. The power consumption of this equipment depends on the number of relays to be operated.

SINCE 1897 KELLOGG

FLOOR TYPE MOUNTING RACK

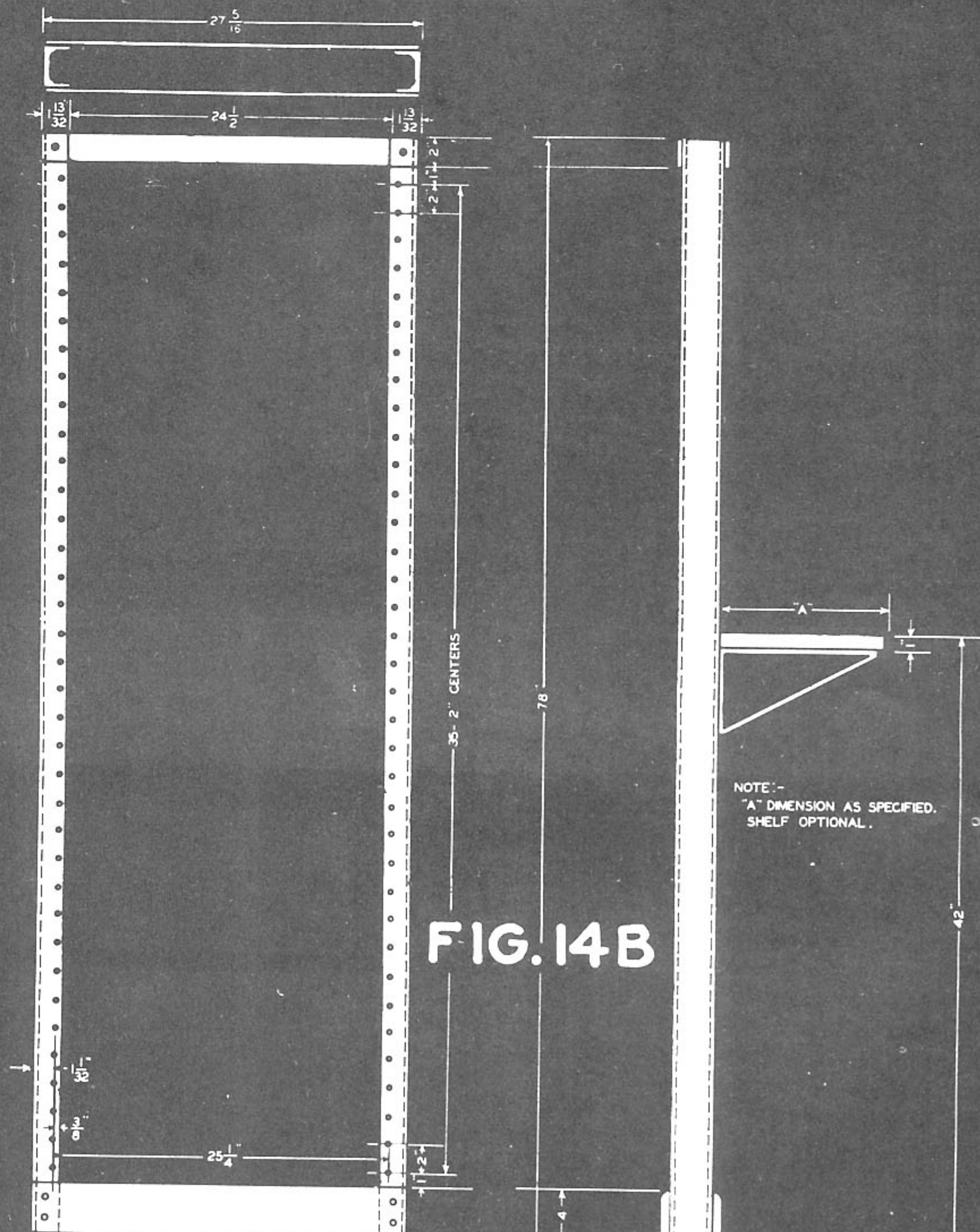


FIG. 14B

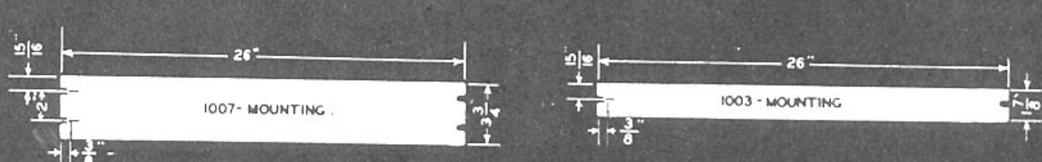


FIG. 14A

TABLE TYPE ENCLOSURE

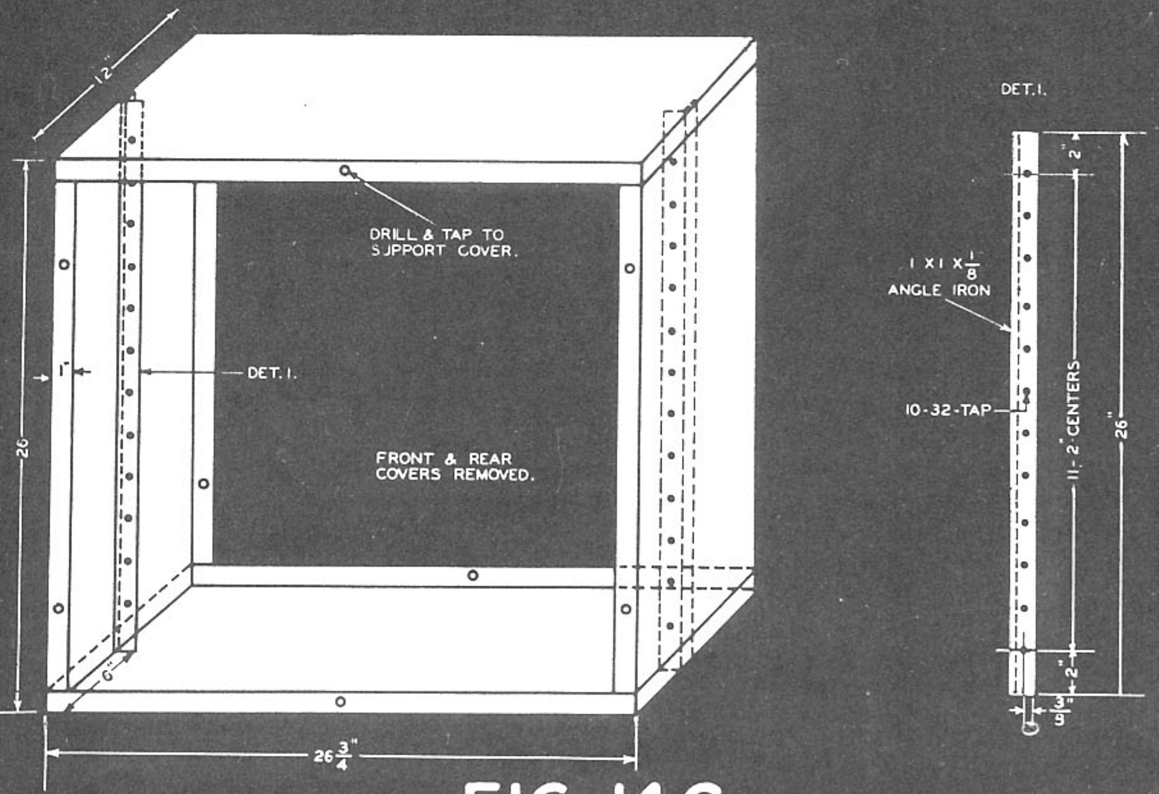


FIG. 14 C

WALL TYPE MOUNTING RACK

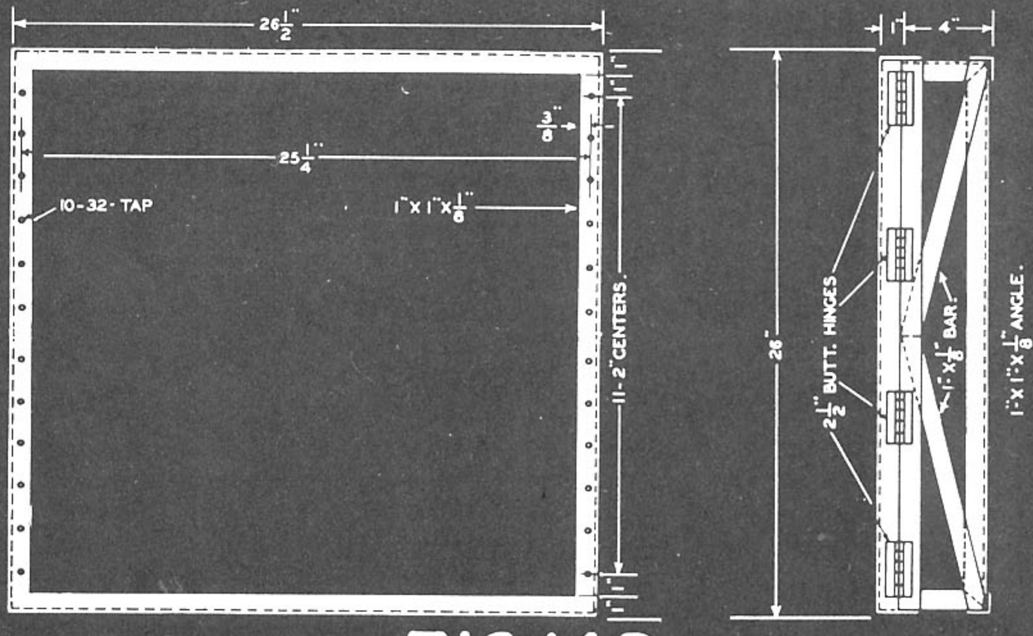


FIG. 14 D

RACKS

As stated before, Kellogg repeater equipment is assembled on mounting plates which, in the standard form, are 26″ long for mounting with No. 10/32 machine screws on standard Kellogg relay racks having 25¼″ horizontal mounting centers. The vertical space depends on the type and the amount of equipment to be supported. The repeater unit, the power unit and the intermediate line-circuit unit, and the terminal line-circuit unit each occupies a 4″ mounting. The equipment for terminating each line used in connection with a cord-circuit repeater, the cord-circuit unit, and the terminal trunk unit, each requires a 2″ mounting. Detail dimensions of these mounting plates are as shown in Fig. 14A.

Fig. 14B gives the dimensions of the standard floor-type mounting rack which is recommended for installations having an ultimate of four repeaters or more. If additional space is required, a second rack may be installed alongside of the first; or the shelf may be dispensed with, permitting equipment to be mounted the full height from top to bottom. This type of rack is finished in aluminum lacquer.

Fig. 14C illustrates the standard cabinet mounting, which holds one repeater with power unit and accessory line-circuit equipment. This housing is particularly desirable where repeaters are located in an out-of-the-way place where they must be protected from mechanical injury and unauthorized tampering. These cabinets may be locked as shown in the illustration, and they may be stacked one on the other if two or more repeaters are used. The cabinet is substantially constructed of steel and finished in olive green lacquer.

Fig. 14D illustrates the wall-mounting type of cabinet which has a side-swinging relay gate on which the equipment is mounted, using the standard mounting plates. This type of rack is recommended for locations in which floor space is at a premium. The cabinet is finished in olive green lacquer, is substantially built, and may be locked with a standard padlock if desired.

ACCESSORIES

In exchanges having several repeaters, it is recommended that the toll lines be wired through a toll test board to facilitate testing. Such equipment would also permit a repeater to be patched from one routing to another so as to maintain the best possible toll facilities when regular routings are in trouble. If a repeater is to be patched from one circuit to another, it is advisable that it be equipped with adjustable network and gain control. For this purpose equipment has been designed similar to that shown in Fig. 15. This photograph shows a variable resistance unit suitable for use in a balancing network and designed for relay rack mounting. Companion units of capacity and attenuation are available for network and gain control respectively, all having similar appearance, and are assembled in blocks of uniform size.

These units are also useful for balancing repeaters as they are being installed and for checking existing installations. They may be connected to the repeater in place of the standard fixed units and can be quickly adjusted to the best operating values. Fixed units of these values may then be substituted with the assurance that the balance is both accurate and permanent. In portable form these instruments are assembled in imitation leather carrying cases: two resistance units and two capacity units in one case, and four attenuation units in a similar case of the same size and appearance.

The power equipment for the Kellogg repeater is all self-contained within the power unit; consequently no changes or additions are necessary on the exchange power board or in the exchange battery. Standard main frame protection and termination is satisfactory for repeater-equipped line-circuits, but it is, of course, desirable that heat coils or fuses be of a type that does not vary in resistance with climatic or other conditions, and that they be firmly held in their mountings to avoid loose connections.

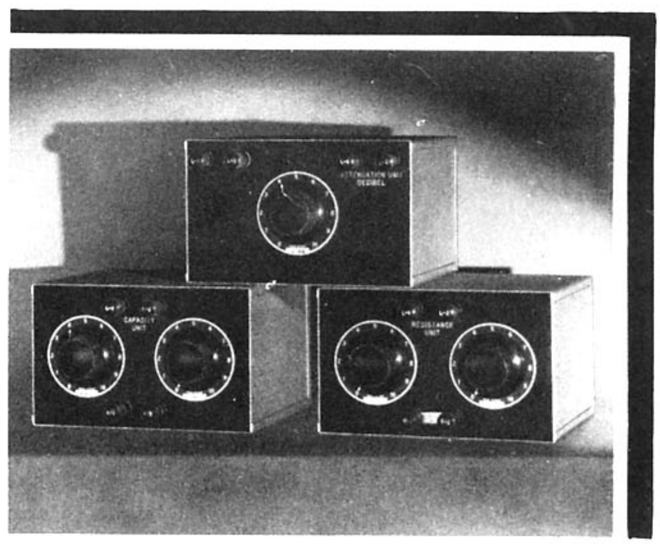


Fig. 15.

All the repeating coils for Kellogg repeaters and line-circuit units are mounted on the mounting plates with the other equipment for such circuits. However, if the purchaser desires, repeating coils can be furnished for coil rack mounting and the reader's attention is called to Kellogg bulletin No. 206 which describes and illustrates this equipment. It might be mentioned that the Kellogg No. 21 type coil is specially designed for use in connection with the Kellogg No. 1 repeater, and the best results will be obtained by using these matched units.

INSTALLATION

INASMUCH as the Kellogg repeater is shipped in completely assembled units, the installation is very simple. All apparatus pertaining to each circuit is located on one mounting plate, completely wired to terminals for the convenience of the installer. The design is such that the minimum number of wires is required for inter-connection and for connection between the various units and the main frame or switchboard as required. It is also necessary that 110-volt, 60-cycle A.C. be provided at the repeater rack for connection to the power unit, and a ground for connection to the apparatus cases which also serve as a shield to prevent stray currents and coupling between apparatus. If emergency power is used, these batteries must be wired to the power unit. Obviously the cost of such an installation is extremely low in both time and material; and it will be found that, with a little experience, the balancing of Kellogg repeaters is very easy. On account of the wide margin of stability, a balance is readily obtained under average conditions, and the careful installer may be sure that the repeater will continue to perform without interruption and without readjustment.

MAINTENANCE

STANDARD radio tubes are used in the Kellogg repeater, and they may be tested on the standard equipment found in every radio store. All tubes should be checked once a month to insure good sensitivity, and duplicate tubes are furnished with each repeater to permit such tests without removing the repeater from service. A repeater operating 24 hours a day will require approximately one new set of tubes a year. No further maintenance is required because none of the other apparatus is subject to deterioration. All coils and condensers are carefully wound, balanced, tested, and hermetically sealed to insure long life and perfect uniformity. All apparatus is repeatedly inspected throughout the manufacturing processes, and each unit is given special laboratory tests before shipment.

GUARANTEE

ALL Kellogg repeaters are guaranteed against defects of material or workmanship appearing within ninety days from date of purchase. Parts which are believed defective should be returned for inspection to the Kellogg Company in Chicago, transportation charges prepaid. If inspection shows that the parts are defective they will be replaced without charge. The liability of the Kellogg Company under this guarantee is limited to the supplying of new parts as stated above.

TRANSMISSION EQUIVALENT OF NON-LOADED, METALLIC OPEN WIRE CIRCUITS (12″ SPACING)

GAUGE	DIAMETER IN MILS.	MATERIAL	TRANSMISSION EQUIVALENT IN DECIBELS	
			PHYSICAL	PHANTOM
8-AWG	128	Bare Copper	.048	.040
10-NBS	128		.048	.040
9-AWG	114		.058	.048
12-NBS	104		.068	.057
10-AWG	102		.071	.060
14-NBS	80		.105	.088
9-AWG	114	Bare Copper Clad 47% Conductivity	.116	
10-AWG	102		.139	
12-AWG	81		.193	
14-AWG	64		.265	
6-AWG	162	Bare Copper Clad 40% Conductivity	.087	
8-AWG	128		.12	
9-AWG	114		.14	
10-AWG	102		.16	
6-AWG	162	Bare Copper Clad 30% Conductivity	.114	
8-AWG	128		.16	
9-AWG	114		.19	
10-AWG	102		.22	
6-BWG	203	Bare Iron (BB)	.16	
8-BWG	165		.20	
10-BWG	138		.23	
12-BWG	109		.30	
14-BWG	83		.38	
14-AWG (Copper)		Twisted Pair Drop Wire	.76	
18-AWG (Copper)			1.04	
17-AWG (Copper Clad)			1.61	
17-AWG (Bronze)			1.60	

TRANSMISSION EQUIVALENT OF CABLE

NON-LOADED	LINE IMPEDANCE IN OHMS		TRANSMISSION EQUIVALENT IN DECIBELS PER MILE											
			No. 22-AWG		No. 19-AWG		No. 16-AWG		No. 14-AWG		No. 13-AWG		No. 10-AWG	
	Side	Phantom	Side	Phantom	Side	Phantom	Side	Phantom	Side	Phantom	Side	Phantom	Side	Phantom
Non-Quad. Paper			1.53	1.36	1.09	0.96	0.73	0.64	0.59	0.50	0.49	0.41	0.29	0.25
Ouadded Paper			1.45	1.35	1.09	0.94	0.68	0.60	0.54	0.47	0.47	0.41	0.33	0.30
Silk and Cotton Switchboard			2.08		1.61									
Wool Switchboard					1.41		1.04							
Rubber Sub.			1.5											
Imp. Paper Sub.					1.8		1.3							
LOADING SYSTEM														
E-28-16	650	400			0.56	0.47	0.29	0.24			0.15	0.13	0.083	0.070
H-28-16	640	390			0.58	0.48	0.30	0.25			0.16	0.13	0.086	0.072
H-31-18	666	403			0.56	0.47	0.30	0.24			0.16	0.13		
H-44-25	800	450			0.48	0.40	0.25	0.21			0.13	0.12		
H-135-N	*		0.68		0.38		0.20							
H-172-63	1550	750			0.28	0.28	0.16	0.16			0.104	0.104		
H-174-63	1550	750			0.28	0.28	0.16	0.16						
K-200-130	1500	950					0.15	0.12			0.085	0.069	0.05	0.04
M-44-25	650	400			0.57	0.48	0.29	0.24			0.15	0.13	0.081	0.070
M-88-N	**		0.96		0.51		0.24							
M-174-106	1300	800			0.33	0.26	0.18	0.15			0.11	0.089	0.072	0.058
M-174-N	1240		0.66											
			LINE IMPEDANCE IN OHMS											
*(H-135-N)			1300		1280		1280							
**(M-88-N)			990		860		960							

TRANSMISSION EQUIVALENT OF TELEPHONE AND SWITCHBOARD APPARATUS

REPEATING COILS ON SIDE CIRCUIT	Loss db.	REPEATING COILS ON PHANTOM CIRCUIT	Loss db.	RINGERS	Loss db.
No. 21-A Kellogg	0.65	No. 21-A Kellogg	0.20	1000 ohms	0.15
No. 18-A Kellogg	0.60	No. 18-A Kellogg	0.20	1600 ohms	0.07
No. 76-A W.E. Co.	0.65	No. 76-A W.E. Co.	0.20	2500 ohms	0.055

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