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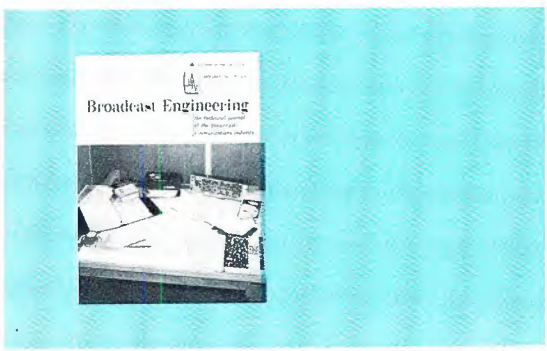

A TELEPHONE SYSTEM FOR ON-THE-AIR USE

By Wayne Jones*—A large amount of telephone on-the-air programming requires an elaborate installation.

Since its opening in December, 1959, Montreal radio station CKGM has featured daily "open line" programs, inviting listeners' opinions, via their home telephones, on various topics. CKGM engineers, therefore, have spent considerable time developing the most functional and flexible system for airing the calls, keeping in mind the necessity for the best possible on-air sound, and for previewing the program (and when warranted, deleting objectionable material) during an actual broadcast.

Numerous installations have been tested during the past five years, but until now, all have been only partially satisfactory, while some left much to be desired. Most systems consisted of a key-set telephone, with the announcer using a handset, an operator's headset, and most recently, a simple speakerphone arrangement.

The telephone equipment was connected to the broadcast console through a standard recorder connector supplied by the telephone company. This system, however, had several disadvantages. The announcer, at times, had to contend with both his regular on-air headset and the cumbersome telephone headset. His voice would often feed through the telephone, via the recorder connector, into the console, causing an objectionable filter effect. The effect could be reduced if the announcer positioned his mouthpiece away from his mouth and if the operator "rode levels" on the telephone mixer at the console. The operator also had to close this mixer completely whenever the announcer selected lines, in order to prevent the loud click from sounding on the air.

During programs, an operator answers and screens all calls before the announcer takes them on the air. Although visual indication was provided to the announcer in the form of steady or flashing lamps on his key set, it was often difficult for him to discern which line to take next. Occasionally, he would take a call on the air while it was being screened by the operator. Also, as the lines used for this program appeared on other sets throughout the station, a call on the air could be interrupted by an unsuspecting party elsewhere in the station.

To solve these and other problems, the following system was developed and installed in cooperation with the Bell Telephone Company of Canada.

The new system had to satisfy several conditions:

1. The announcer should not have to wear any headsets other than his normal broadcast headset.
2. There should be no objectionable filter effect in the announcer's voice while using the telephone; that is, the output provided by the telephone company should contain only the distant party's voice and not the announcer's.
3. Some means must be provided whereby a call already on the air could not be interrupted, and conversely, the announcer should not be able to put on the air a line in use off-air, for example, a call being screened by the operator.
4. The equipment must be silent in operation, both mechanically and electrically; *i.e.*, switches should not click, and it should be possible to leave the console mixer position for the telephone open while the announcer is selecting lines.
5. The equipment must be easy to operate and not allow "on-air" errors.
6. The equipment must be flexible. It should allow restricted conferencing and other special effects as the need arises.
7. The operator should retain overall control of the system and, from his position in the control room, be able to supervise its operation.
8. The equipment must be provided with a backup system in case the main system fails.
9. The aesthetic appearance of the studio must be maintained. Preferably, the equipment should be "built-in."

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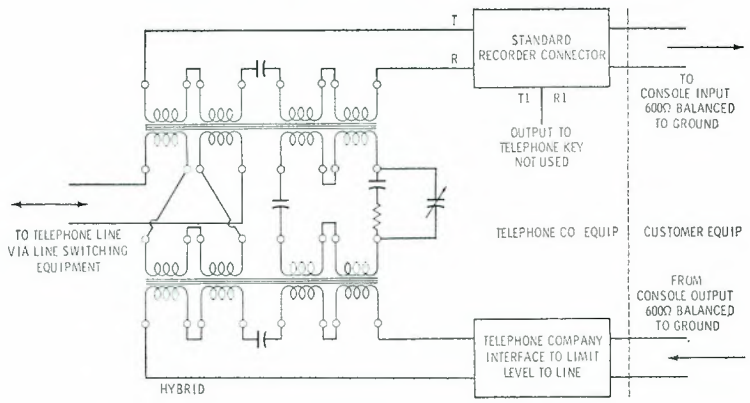

Fig. 1. A simplifield schematic of the hybrid circuit used at Montreal's CKGM.

10. A 1400-Hz beep to the caller every 15 seconds, as required by law, must be supplied to inform the caller that his conversation is being recorded and/or broadcast.

The telephone systems that evolved may be divided into two sections: the equipment used to connect the telephone line to the broadcast equipment, and the line-selecting, or switching, system.

Telephone Equipment

The initial work evolved around a basic speakerphone system. This unit is the familiar "hands-free" telephone supplied by the telephone company for commercial and private use.

Basically the speakerphone system is composed of four items: a control unit containing plug-in amplifier cards; a microphone, or transmitter, with a built-in preamp; a speaker; and a power transformer. The telephone line is connected to the control unit, where it is split by a hybrid coil into a transmit and a receive circuit. The transmit circuit consists of a series of amplifiers fed by a microphone, and the receive section is a series of amplifiers feeding a speaker. Because the hybrid is not 100% efficient, feedback would result if it were not for a unique feature of the speakerphone, its voice switching circuitry. Whenever sound above threshold level is presented to the microphone, the receive path is switched off and the transmit path is switched on, almost instantaneously. Because of this feature, information presented to the microphone appears on the telephone line and not at the speaker. The speakerphone is incorporated into the console by using the control-unit receive channel to feed the console. Thus the filter-effect problem is solved; that is, the announcer's voice feeds the console only by means of the broadcast microphone and not by way of the telephone microphone.

The use of this voice switching circuitry is the key to the new system. An additional modification to the standard system was the inclusion of two transmitters, rather than the conventional single transmitter. This was found necessary to maintain an adequate transmit level to the caller when more than one person was present in the studio.

To provide a greater control of the transmit level and to make up for the loss which occurs when two microphones are used in parallel, a variable-gain amplifier was inserted in the transmit path.

The voice switching circuitry causes another effect: The announcer's voice always takes precedence over the telephone caller. If both are speaking, the caller will not be heard. This may or may not be desirable in all applications, but it is helpful if the line is noisy.

Normally, speaker gain on the speakerphone is adjusted by means of a volume control on the transmitter chassis. This control was removed and relocated in the control unit. Adjustment of this control, and variable-gain amplifiers in the transmit path, permits the voice switching threshold to be varied over a limited range. In the "on-air" studio, it was found desirable to add a relay which operates simultaneously with the studio microphone on/off relay. This mutes the speakerphone speaker in the studio. At the same time, the relay transfers the speaker output to the telephone input on the console. Thus, the telephone output appears at the console only when the announcer's microphone is on. There is a slight leak from the transmitter to the control unit output and, if this switch were not made, the announcer's voice, via this telephone link, could appear on the air in spite of the fact that his announce microphone is off. The action of the muting relay permits the announcer to converse with callers prior to going on the air without fear of the call going on the air—even if the operator has neglected to close the telephone pot.

In an early trial, the speaker was not muted with the announcer's microphone so that the announcer could hear the caller without using his headset. It was found that this was not desirable, because the operator could not cut an unwanted caller off the air by simply closing the telephone "pot." The caller would come through the announcer's microphone. The speaker in the recording room is not muted, however, because immediate cutoff is not necessary.

An alternate to the speakerphone method is the use of a 4-wire terminating set. This device, basically a hybrid circuit, is used by telephone companies in toll circuits to change 2-wire lines to 4-wire lines.

A simplified schematic of the hybrid is shown in Fig. 1. By connecting the repeating coils as shown, it is possible to separate the two-direction (transmit and receive) pair into two single-direction pairs. This means that a signal presented to the transmit input will appear only on the telephone line and not at the receive output. Conversely, the receive output will contain only signals coming from the telephone line. This is accomplished by setting up a carefully balanced bridge circuit and nulling out the transmit signal from the receive section. The balancing network containing the vari-

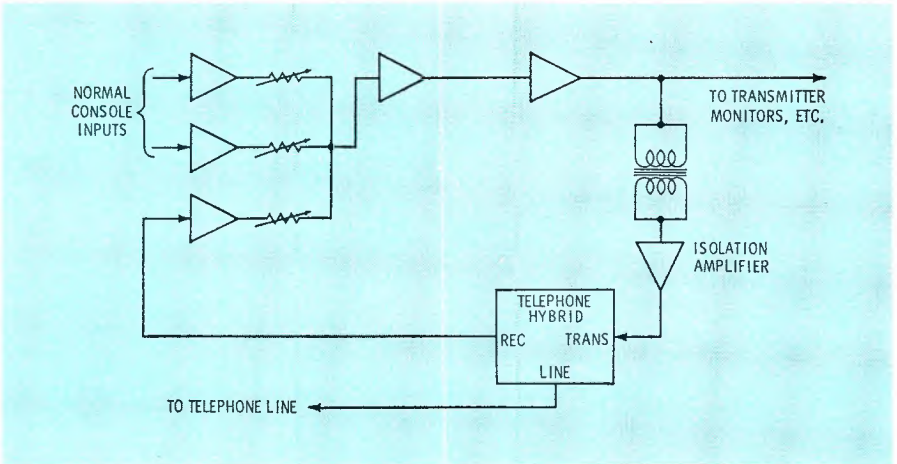

Fig. 2. Input from console to the hybrid is fed through isolation transformer.

able capacitor is used to balance the bridge against the telephone line. An optimum value is selected because each line has different capacitive, resistive, and inductive characteristics. These parameters are a function of line length, cable type, intermediate equipment in the line, and the equipment at each end of the the line.

As might be expected, the isolation between transmit and receive sections is not perfect. The leakage is, however, low enough to make the hybrid very useful in our application. No discussion of actual values in decibels will be given here because so many variables are involved.

In order to connect the radio-station equipment to the telephone-company equipment, an interface is required. On the receive portion of the hybrid, this interface takes the form of the standard recorder connector. This provides the isolation necessary and supplies a 1400-Hz beep at 15-second intervals to the caller as well. This is possible because the hybrid is not 100% efficient, and the beep presented to the receive leg is fed back to the caller.

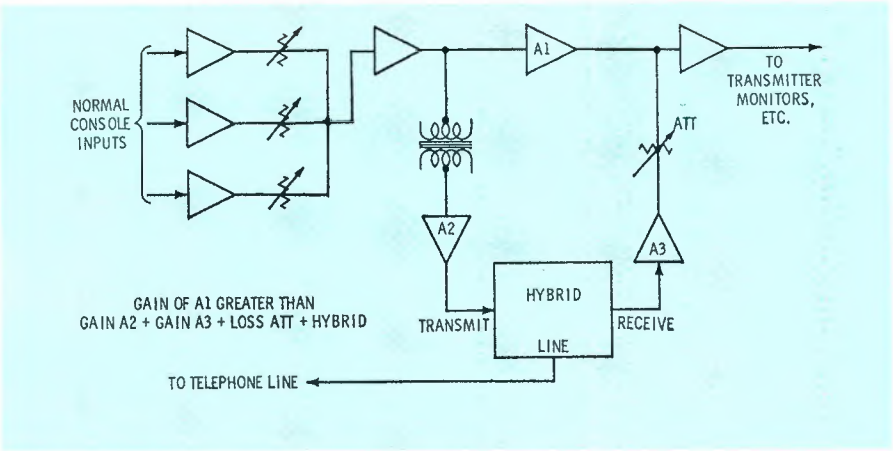

Fig. 3. Better method for connecting hybrid involves opening console circuit.

The interface inserted in the transmit leg is used to insure that the customer will not feed the telephone line with too much level, which would interfere with other circuits in adjacent cable pairs. The interface also provides the correct impedance match to the customer equipment.

The hybrid is connected to the console as shown in Fig. 2. Oscillation will take place if the gain of the console, a function of the telephone-pot setting, is equal to or greater than the loss between the transmit and receive sections. In practice, the loss should be sufficient to allow a satisfactory level from the caller. A somewhat better method of connection is shown in Fig. 3. It involves breaking into the internal circuitry of the console and could present problems in consoles with high-impedance, unbalanced circuitry.

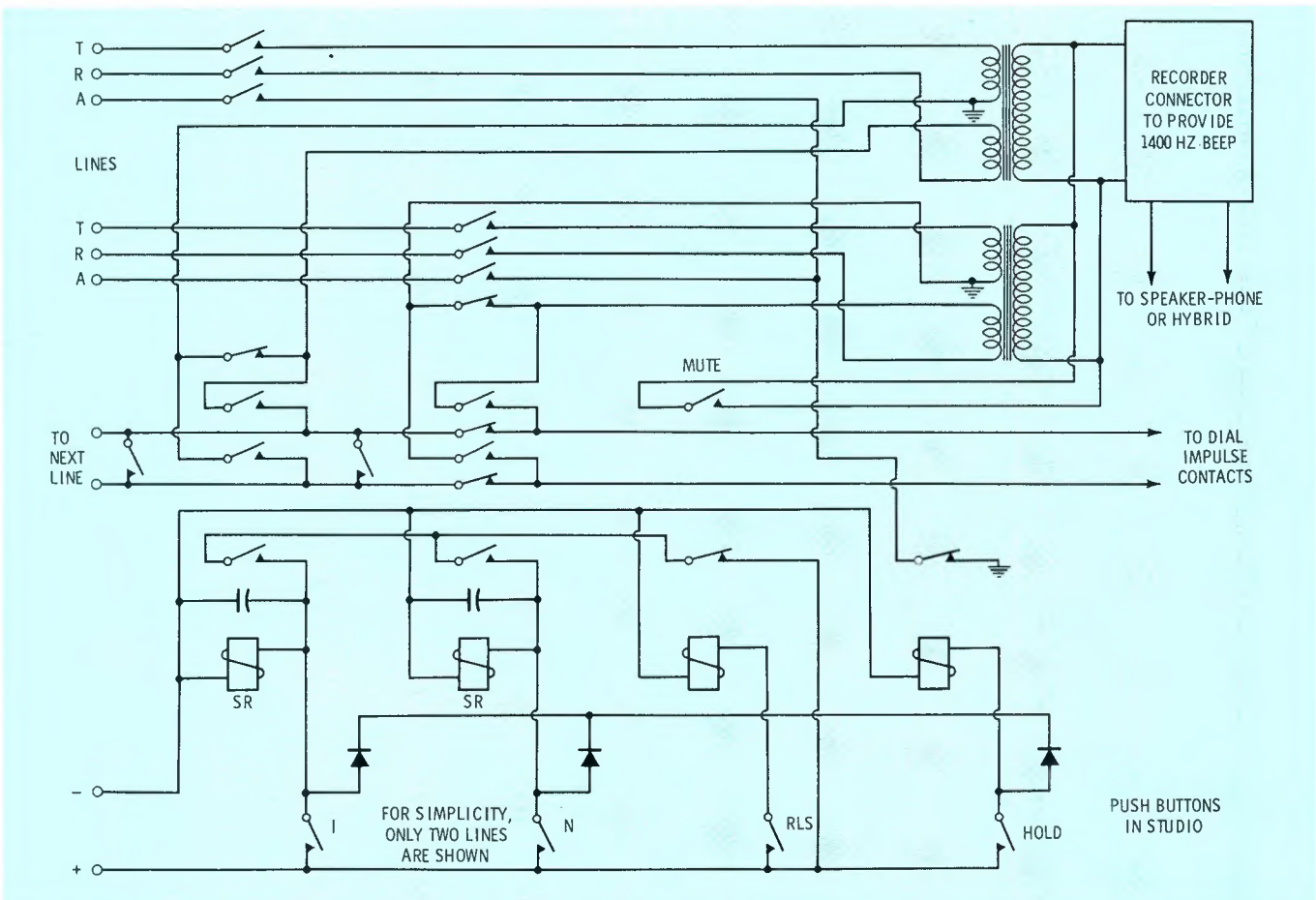

Fig. 4. Basic circuit of CKGM switching system shows only two line inputs for simplicity in explanation of operation.

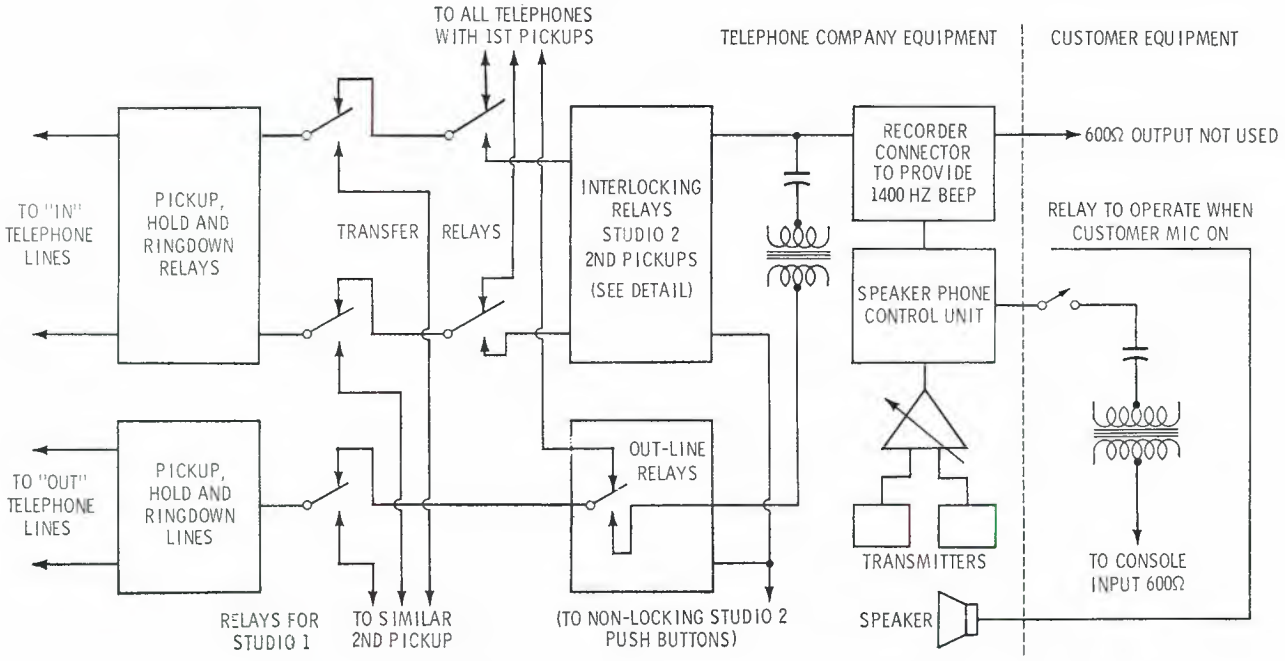

Fig. 5. Functional diagram of switching arrangement in Fig. 4. indicates relationship of various system elements.

We use the former method at CKGM. It is used in conjunction with an alternate back-up system to the speakerphone. It is also valuable in other ways; because it feeds anything going through the console to the telephone line, the announcer need not be in an adjacent studio to be heard by the telephone caller (as is true of the speakerphone system). He may be "on remote." Thus, although a particular program may be on location, all the telephone facilities of the studio are retained without the use of telephone equipment at the remote location. Since various telephone contests, etc., form an integral part of our daily format, this feature is very desirable.

It is difficult to indicate which of the two systems, the speakerphone or the hybrid, is better. The speakerphone is cheaper and easier to connect to the console, but the hybrid provides better quality to and from the caller and the other advantages enumerated.

The Switching System

Several switching arrangements are possible. Our primary system is similar in operation to the ordinary key-telephone set in that push buttons are used to select lines. (See Figs. 4 and 5.)

Figs. 6 and 7 show that the studio equipment consists of built-in, flush-mounted call directors. Six lines are associated with our system, four for receiving calls and two for placing outgoing calls. Each of the four incoming lines appears at two separate pickup buttons, a first pickup and a second pickup. The first pickup operates conventionally;

Fig. 6. ON AIR studio arrangement shows all components.

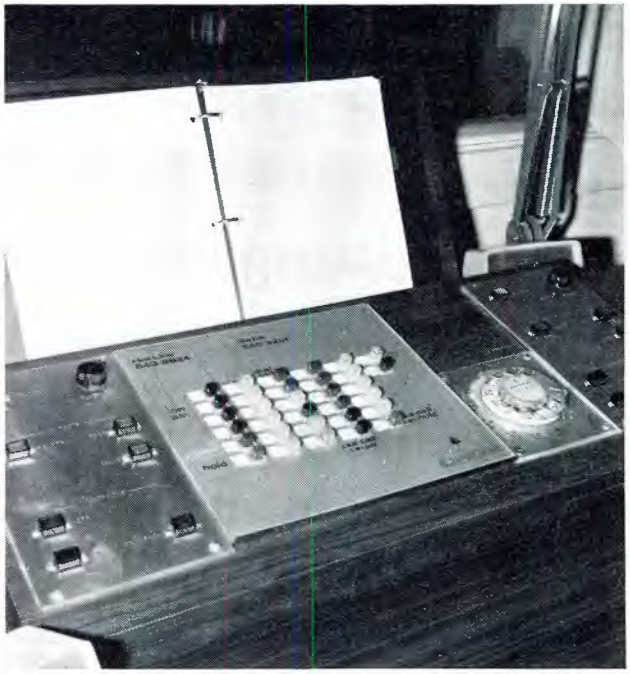

Fig. 7. Close-up of the flush-mounted call director unit.

that is, the button locks and is used in conjunction with a standard telephone handset. In practice, this pickup is used by the operator (who is equipped with an identical call director) to answer and screen the calls. If a call is to be used, the line is placed on "hold," and a transfer button is pushed. This excludes the line from all first pick-ups and transfers it to the second pickups. The second pickups appear at the studio call directors on non-locking, momentary-action push buttons. This type of button differs from a regular button in that it operates silently.

The reason for the transfer action is the prevention of interference with a line which is "on-air." In addition, the announcer cannot put a line on the air prematurely; the operator must first transfer it.

We wished to have a conferencing circuit incorporated into the system. While the regulatory tariffs of the telephone company are "sticky" on this point, they do provide it as a standard accessory to a PBX and conferencing circuit, which allows a maximum of two outside trunks and three internal stations to be bridged in a conference.

The circuit provides for capacitive coupling of the lines. Since no amplifiers are used in the circuitry, transmission is not guaranteed between the two outside trunks. If one or both of the outside parties is at a considerable distance from the circuit, transmission between these parties will suffer. We were willing to tolerate this disadvantage, however, and a circuit similar to the one provided for the PBX was incorporated.

Any two lines may be bridged by simultaneously pushing the pickup buttons associated with the particular lines. The objective is to allow the moderator to converse with two people simultaneously, and it is seldom necessary for the two callers to converse between themselves. Therefore, the nonamplified conferencing does fall within the telephone-company tariffs.

Normally the four incoming lines are jammed, and an alternate method for placing outgoing calls had to be provided. Two out lines were incorporated in the system in a manner different from the in lines. As before, they appear on first pickups, but these lines may be placed on the air by simply pushing a single, momentary-action button instead of by using a transfer button. This action excludes the line from all first pickups and connects it, via the telephone dial, to the speaker-phone. If the line is vacant (normally the case because these are unlisted lines), pushing the button will put dial tone on the speaker-phone, and a call may be dialed. By using the second out line, a sec-

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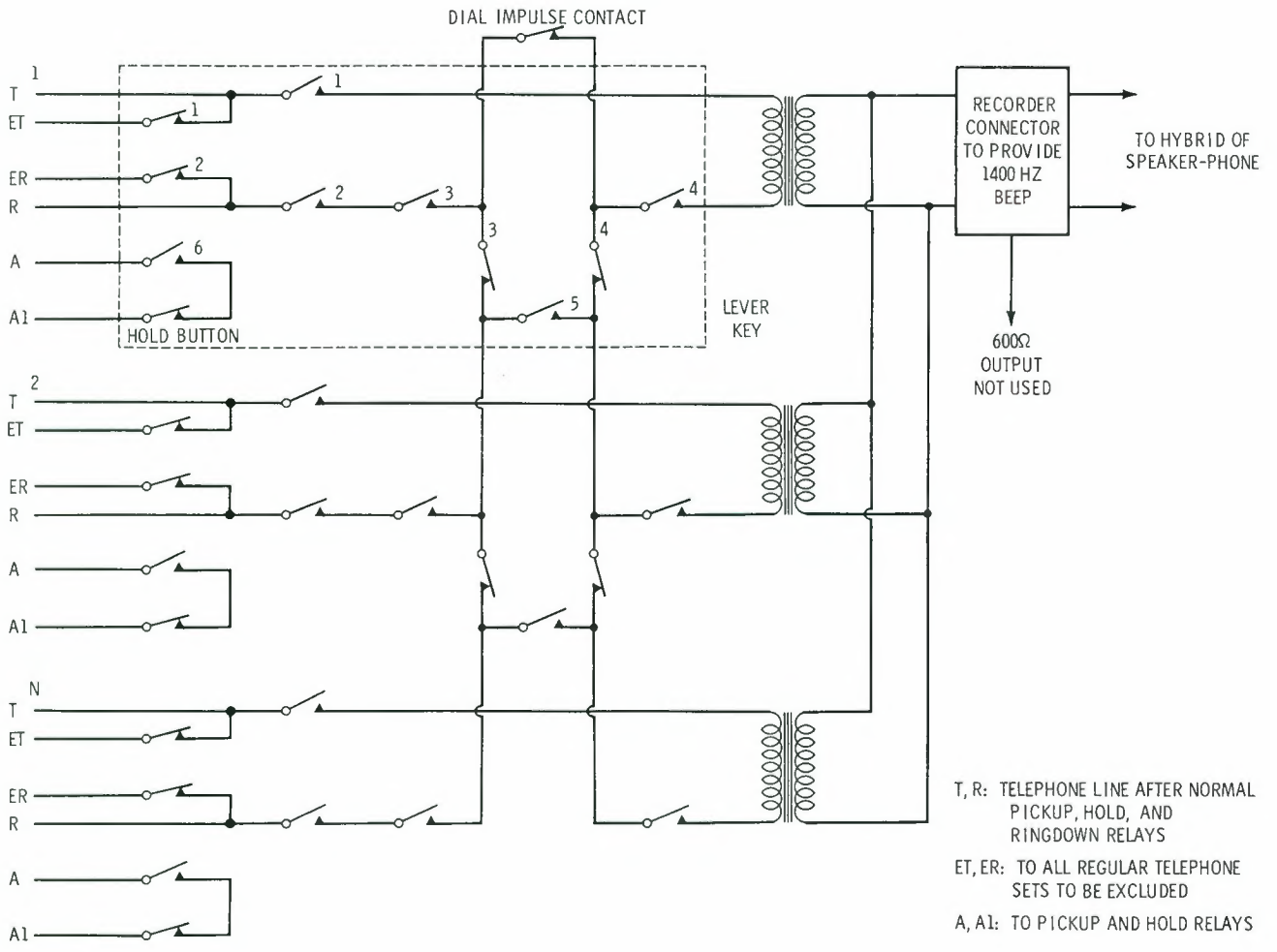

Fig. 8. Alternate switching method is simpler to construct, does not require relays, but is not as smooth in operation.

both studios are completely interchangeable, both electrically and physically, in the event of failure of either.

Conclusion

It is hoped that this article will aid the broadcaster planning an "open-line" program or one wishing to modify his facilities for this type of programming. The telephone equipment is a mutual project of the telephone company and the broadcaster. Careful analysis of needs by both should result in a flexible, functional, and reliable system. ▲

Editor's note: A new recorder connector, which supplies the filtered 1400-Hz beep in the caller direction only, has been developed especially for on-the-air applications for the Western Electric Company, and bears the part number KS-19645. It must be ordered through the local telephone company with the order number USOC-RCZ.