TELEVISION REMOTE OPERATIONS

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Television Remote Operations*

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Summary—Remote operation implies the pickup of program matter outside the studio and station. Equipment and personnel in the field, in the station, and interconnecting are always involved in a "remote". Field operations usually require two cameras, preferably employing image-orthicon tubes. Studio or film images and sound can be dubbed in between field sequences, a procedure useful for commercial announcements. A relay receiver, a picture switching or mixing device, monitors, oscillograph, and audio-control equipment are required at the station for such operation. These combined facilities provide unsurpassed program possibilities.

Remote operation is the term used by television broadcasters for the procedure of picking up program matter from points outside of their studios, transmitting, or relaying the image signals and sound into the station, and broadcasting them. It usually applies to intracity operation as distinguished from intercity or interstation relaying. The relay transmitting facilities are usually portable in this type of operation, while the receiver location is fixed.

By use of suitable remote facilities a station can broadcast a great variety of public-interest subjects at the instant of occurrence. In this way it fulfills a desire of the average individual that cannot be fulfilled by any other medium. Hence this type of broadcast has strong appeal and is extremely popular. The subject matter is usually of a nature that has been developed for visual as well as auditory appeal, the best example being sports, which can be broadcast without costly special staging for television. In view of these factors remote operations may well become the backbone of television programming and are, therefore, worthy of thorough development.

Another point not to be overlooked in the development of remote-operation techniques is their possible future application to theater reproduction. Any remote operation involves three main divisions: the field, the interconnecting facilities, and the station.

Field Operations

Typical field operations require at least two cameras. Types employing the well-known image-orthicon tube are best adapted to the tasks, chiefly because of their remarkable light sensitivity. The

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broadcaster seldom has control over illumination of his subjects outside of his own premises, especially when working out of doors, where the incident illumination varies by a factor of 1 to 1000 from a cloudy winter day to summer sunshine. The level may sink to 2 or 3 foot-candles or less before a game is called on account of darkness. Indoor events such as boxing, water polo, and many others are frequently illuminated in a hit-or-miss manner that varies from as low as 15 foot-candles up to 500. These wide variations can be taken care of in image-orthicon equipment by lens diaphragms variable from $f/1.9$ to $f/22$. Filters are sometimes added on sunny days out of doors, giving an added benefit in improved color response.

While image signals can be obtained with incident light as low as one foot-candle, the average image-orthicon tube requires about 50 to produce a signal sufficiently free of shot and thermal noise to be satisfactory for relaying and broadcasting. Noise is added in the relaying process and, while small in a good link, it cannot be neglected. Hence it is wise to have conditions as favorable as circumstances will permit at the source. Where light levels of less than 50 foot-candles are encountered indoors, and it is possible to supplement existing illuminants for the television pickup, it is desirable to do so. Artistic lighting is uncalled for in sports and many other events and simple overhead illumination is adequate. Lenses ranging in focal lengths from 2 to 24 inches are used on the cameras providing horizontal angles of view of 30 to about 2 degrees. This gives a great deal of latitude in placing cameras. For football they can be placed in press booths or even above the press booths. For boxing or wrestling the cameras can be placed anywhere from 20 feet away from the ring to 150 feet. Other events can be handled in proportion to their scope. Fig. 1 shows a typical setup.

Any television cameras, including the image-orthicon type, must have control equipment associated with them. This control equipment includes the synchronizing impulse and scanning source, usually referred to as the synchronizing generator. It also includes video and scanning amplifiers, monitors, oscilloscopes, and numerous controls on the camera action. All of these facilities are packaged in suitcase-sized units for convenient handling. However, some of them weigh 65 pounds or more. When combined with audio equipment, cables, spare-parts kits, and tool boxes, they add up to a dozen packages. It has been the practice of some operators to carry this equipment to a vantage point within a building, stadium, or arena

In some instances this is necessary, but in the majority of cases it is not. Very satisfactory operation has been achieved in most cases at WBKB by maintaining this gear in the light truck by which it is taken to the site. The equipment is located in a semifixed state on an operating bench as may be seen in Fig. 2. Up to 350 feet of cable are used on each of two cameras to reach advantageous locations. In this way, only the camera cables, microphone wires, and cameras have to be carried into buildings; up and down ramps,

Fig. 1—Typical remote camera setup.

elevators, and stairs. This saves labor in setting up and avoids having extra help attached to a remote crew who would not have duties during operation.

The minimum crew for an operation in a location where preliminary work has been done consists of two cameramen, one field director, two operating technicians, and an electrician, in addition to an announcer and a spotter, if required. The field director and technicians usually operate in the truck. Under favorable circumstances they can set up and commence operations in less than one hour.

During operation one technician operates the controls on the camera apparatus; the other "rides gain" on the sound and looks after the relay transmitter. The electrician assists with setup and serves as relief operator and emergency repairman. The field director co-ordinates the cameramen's work, switches pictures, and acts as liaison with the main station director in case of switches back to the studio for commercial announcements.

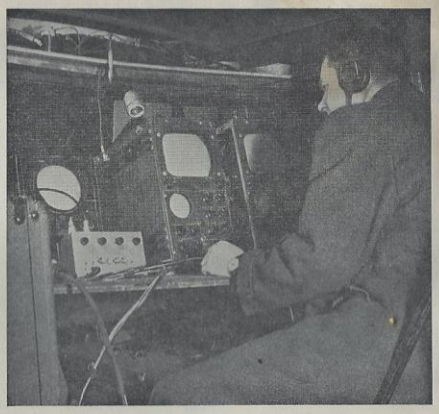

Fig. 2—Technical operator's position in remote truck.

In cases of frequent broadcasts from the same location, such as baseball games during the season, it is worth while to locate equipment semipermanently in a broadcast booth convenient to camera locations and the announcer's position.

It is helpful, particularly in sports, to provide the announcer with a picture monitor. This should be connected to the output of the control equipment and can be fed by a small coaxial cable up to 1000 feet in length, perhaps more if needed. An ordinary table-model home receiver equipped with carrying handles and a cable connection into its video amplifier is convenient for this.

A useful piece of additional equipment maintained on tap for remote operations is a gas-engine generator. The complete two-camera television chain with relay transmitter and audio equipment requires a little over five kilowatts. A 10-kilowatt 60-cycle-per-second, 115-volt, single-phase alternator driven by a four-cylinder gas engine is mounted in a two-wheel trailer which can be towed behind the equipment truck to any location where public-utility services are not available. Its excess capacity over and above apparatus requirements is sometimes used for lights. Relays have been made from the apparatus truck while in motion by using this source of power.

Audio equipment in the field consists of a Western Electric Type 22D portable speech-input equipment with from one to three microphones. Dynamic microphones are used in may instances because of their sturdiness and insensitivity to wind or drafts. This is an important consideration out of doors. Low-impedance microphone circuits are favored for their freedom from pickup of electrical disturbances in cables which are frequently 200 or 300 feet long.

Considering the foregoing it will be apparent that rather extensive intercommunicating facilites are required in the field and between there and the parent station. Basically these consist of two circuits, a technical-order circuit and a program-cuing circuit. The first interconnects the cameramen with the technical operator and ties him in with the relay operator and the parent-station technical personnel. The other circuit interconnects the announcer and cameramen with the field director and through him with the parent-station program director. The field director can also monitor the program sound.

INTERCONNECTING OR RELAY FACILITIES

Two basic functions and two auxiliary functions are required of the interconnecting communications between the field and the parent station. To dispose of the simpler ones first, the technical-order circuit and the program-cue circuit are most conveniently connected back to the station by ordinary telephone lines run to a site convenient to the location of control equipment. When operation is from the truck the lines are terminated in a building at any point nearest to where it is to be parked. They are extended by temporary flexible leads to the truck when operating. For program sound the output of the speech amplifier is fed to a telephone program cricuit

which is also terminated in a convenient spot with the order wires. The program sound is fed to this line at zero level, and it is usually equalized at the station end only. Telephone lines for these three functions are rented by the month for locations where remote broadcasts are done weekly or oftener.

The remaining interconnecting or relay function, perhaps the most important and the one posing the most problems, is that of getting the picture signal to the parent station. This must be accomplished for a frequency range of 60 cycles per second to 4 megacycles or more with good response to transient-wave shapes composed of frequencies in this range and with the least possible injection of noise or extraneous interfering signals.

The intracity relaying of video signals can be accomplished by telephone lines, coaxial cable, and very-high-frequency radio. Telephone lines of the ordinary type must be highly equalized at intervals of only one to one and one-half miles.[1] Apparatus for this service as well as coaxial lines or other special conductors have not been readily available in Chicago up to the date of this paper and the cost of such service is quoted at a high figure. Experience at Station WBKB, upon which this paper is based, has been confined to radio relaying. Line transmission undoubtedly has merits in freedom from noise and interference but for mobility and economy of operation, very-high-frequency radio-beam equipment cannot be surpassed. Even in the matter of first cost, based on present quotations, the radio-relay equipment offers a decided economy. Modern microwave apparatus employing frequency modulation can offer a bandwidth scarcely equaled by line equipment available and, for distances of a few miles, can probably equal line facilities in the matter of noise or interference.[2]

Station WBKB so far has not been able to enjoy the advantages of this up-to-the-minute type of equipment, yet it has established an enviable record of achievement in remote operations with less-elaborate equipment which is worthy of special mention.

Radio relaying in a large city like Chicago is somewhat akin to a short person viewing a motion picture in a crowded theater. Everywhere he sits someone's head is in the way. Very-high-frequency waves do not penetrate through buildings very well and the higher the frequency the more severe this limitation becomes. In Chicago the highest points for receiving relayed signals giving unobstructed paths from the greatest number of points do not happen to be at or even adjacent to the location of the station, so relay operation

by WBKB has been done best in two steps, requiring two sets of equipment. An important part of this equipment is installed as a repeater station atop one of the tallest buildings in the Chicago loop. The relationship of the remote operation to the parent-station facilities and the function of the repeater station are illustrated in Fig. 3.

The basic unit of relay equipment at WBKB is a 210-megacycle transmitter of 20 watts output, amplitude-modulated. Double-sideband transmission is used with a frequency response out to $4^1/_2$ megacycles. This unit is carried with the mobile camera equipment and at most locations is operated in the truck. Its output is fed to antenna arrays of varying numbers of elements depending upon the distance over which the relay is to work. These antenna arrays are usually set up in advance of a broadcast and if repeated broadcasts are to be made from any location, one of them is left there. On a succeeding broadcast it is only necessary to drive the truck to the location and connect the antenna lead. Arrays of 20 half-wave dipoles having gains of about 14 decibels are used in most locations. With this transmitting and antenna equipment satisfactory relays have been conducted from points up to 15 miles distant from the station.

Reception on top of a tall building in the Chicago Loop is accomplished with an eight-element antenna, four of the elements being parasitic reflectors. The receiver is a superheterodyne with one radio-frequency stage, five intermediate-frequency stages, and one cathode output video stage. The output of this receiver is monitored with an oscilloscope and a television receiver before being coupled into the succeeding relay equipment. This is a 1300-megacycle, amplitude-modulated apparatus of about one watt output. Its antenna is a dipole with parabolic reflector. The beam is directed from the building, as shown in Fig. 4, to the building where the studios and transmitter are located. The distance is only about one-half mile. The circuit is very reliable, unaffected by weather conditions, and contributes a negligible amount of noise to the system.

Reception of this 1300-megacycle beam is accomplished with a half-wave dipole antenna and 60-degree corner reflector. The receiver employs a cavity-tuned oscillator, crystal mixer, and three stages of intermediate frequency. It has been found that the noise level at the output of the receiver, for a given signal input, depends very much upon the forward-to-inverse conductivity ratio of the crystal mixer. This ratio ranges from 3 to 1 up to 100 to 1 in various crystals as measured with low direct voltage. A high forward

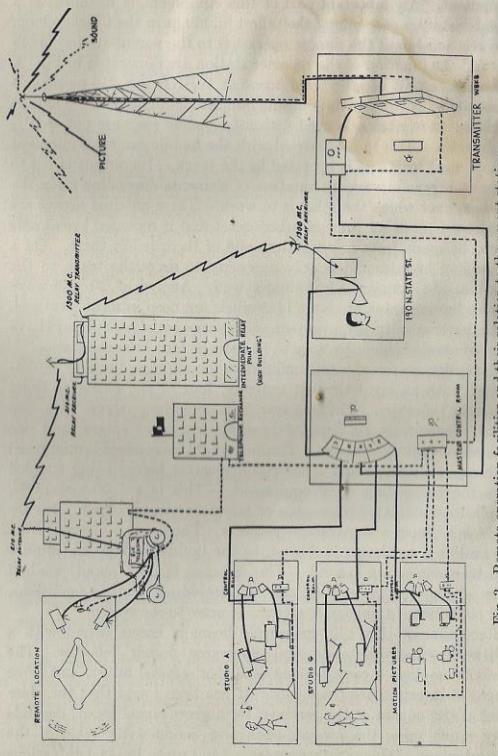

Fig. 3—Remote-operation facilities and their relation to the parent station.

conductivity and low inverse conductivity provides the highest signal-to-noise ratio. The cutput of the second detector of this receiver is a cathode output video stage feeding a 73-ohm coaxial line extending to the control room.

THE STATION OPERATION

Entering the station control room from a remote location are the three telephone lines and the one coaxial line from the relay receiver. The technical-order wire has taps leading to the repeater station and the relay receiver at the station building. It terminates on the desk of a technical operator in the control room. From there he is in touch

Fig. 4—1300-megacycle relay transmitting equipment at repeater station.

with other station personnel. Fig. 5 shows the master-control room at the station through which all the relay and communication circuits pass and are co-ordinated with station operations. The program-cue line terminates at the director's console in the control room. The director is in communication with other program personnel at the station and with the technical operator. The program line passes through an equalizer, an amplifier that makes up a loss of some 50 decibels in the lines and equalizer, and thence into a nemo circuit on the audio console. From this point it is supervised by an audio operator who is on hand to dub in commercial announcements or station breaks.

The coaxial line from the relay receiver terminates in a video console where it is under control of the video operator who also is on duty to dub in shots from the studio or film for commercials or station

breaks or to switch over to a succeeding program. On a remote program without too much studio or film pickup the technical operation can be handled by four technicians: the technical supervisor, the audio operator, the video operator, and the transmitter operator.

With the facilities described, WBKB has handled, by remote pickups, a range of subject matter which is fairly representative of the great possibilities open to television through this type of operation. Some of the subjects covered to date have been: baseball,

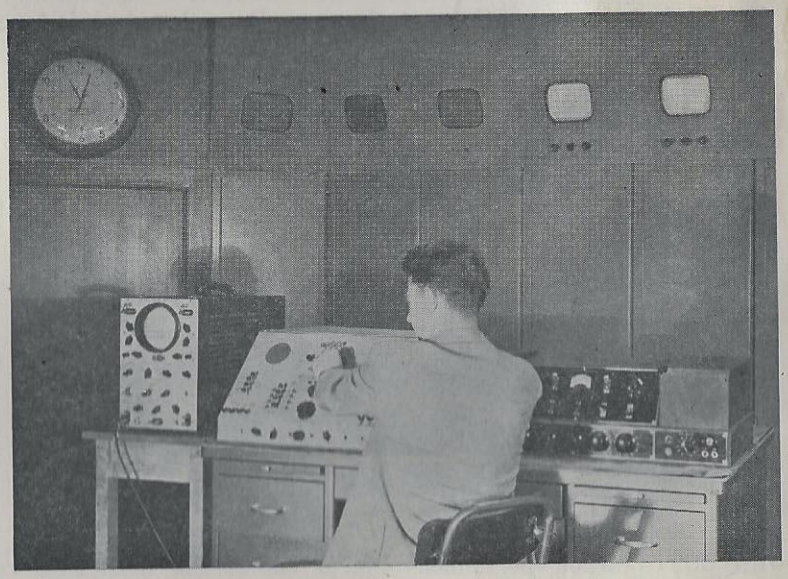

Fig. 5—Station master-control room, co-ordination point for remote and studio productions.

basketball, hockey, ice follies, boxing, wrestling, billiards, water polo, Museum of Science and Industry events, stock exhibitions, golf tournaments, football, a circus, and automobile racing. This list probably will be expanded manyfold in the months and years to come. It offers an engaging example of the horizons opened to the television receiver viewer through this remarkable medium, television remote operation.

REFERENCES

(1) Abraham, L. G., and Romnes, H. I., "Television network facilities," *Elec. Eng.*, p. 477; May, 1947.

(2) W. J. Poch and J. P. Taylor, "Microwave equipment for television relay service," *Broadcast News*, p. 20; October, 1946.