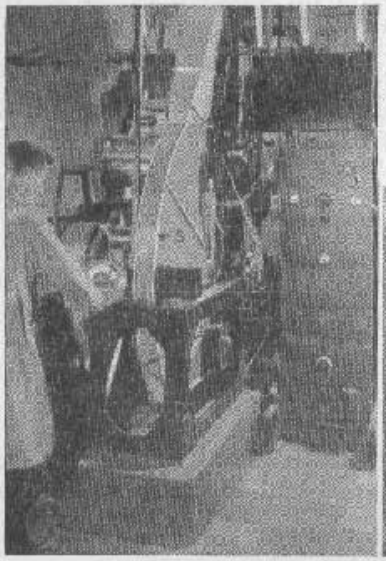
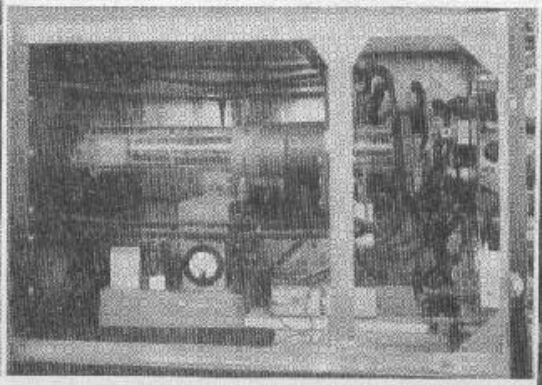
Television "Piped" from New York to Philadelphia



Enclosed lens scanning disc at transmitter is indicated at S.



A close-up of the large cathode ray tube which reconstructs the images.

Photos courtesy of Bell Telephone Lab.

Another view of the television transmitter at New York.

● IN the Bell Telephone Laboratories in New York recently a sound-picture film was run through a transmitter and its two records—sound and scene—were converted into electric currents and transmitted to Philadelphia, 90 miles distant. There the picture was reproduced on a glass screen large enough for a group of ten people to see easily, while the accompanying sound came from a loud-speaker. The sound picture described, by voice and animated diagrams, the coaxial cable system and explained briefly the operation of the picture transmitter and receiver. Some films typical of the news-reel theatre were also transmitted. The film itself told the story of the experiment.

Between the Long Lines offices in New York and Philadelphia there extends a cable which contains two coaxial-conductor units. Each unit is formed by a flexible copper tube and a single wire enclosed by the tube and held at its center by thin disks of hard rubber. Along the route are unattended installations of special amplifying equipment which receive their power over the inner wires of the two coaxials. The cable with its amplifiers and with its terminal equipment is an experimental installation for the development of broad-band transmission.

Motion pictures were recently transmitted a distance of 90 miles between New York and Philadelphia by the Bell Telephone Labs., over their new coaxial cable system. 240 line definition was used and the images were surprisingly steady and clear.

Each coaxial conductor unit with its associated one-way amplifiers is capable of transmitting simultaneously the currents of two hundred and forty different telephone transmitters. Using separate units for transmission in opposite directions, the system provides for two hundred and forty simultaneous conversations. The million-cycle range of each unit is utilized by carrier-current methods. In the present arrangement the transmitters are formed into twenty groups of twelve each. Each transmitter is limited to a frequency band of four kilocycles; and the bands from the twelve transmitters of each group are raised to successive positions between sixty and one hundred and eight kilocycles. Twenty complicated currents are thus obtained. These currents, by another modulation, are spaced in the range from sixty to one thousand and twenty kilocycles. This system of multi-channel telephony was recently tested over a looped back circuit equivalent to thirty-eight hundred miles; and transmission was satisfactory.

Another question remained: Can the system transmit satisfactorily a single message the frequency components of which occupy its entire range, that is, a current of the kind required in *television* programs. To study that possibility there were constructed in the Bell Telephone Laboratories a transmitter to originate a signal of that wide range of frequencies and a suitable receiver, both of which utilize some of the present techniques of television.

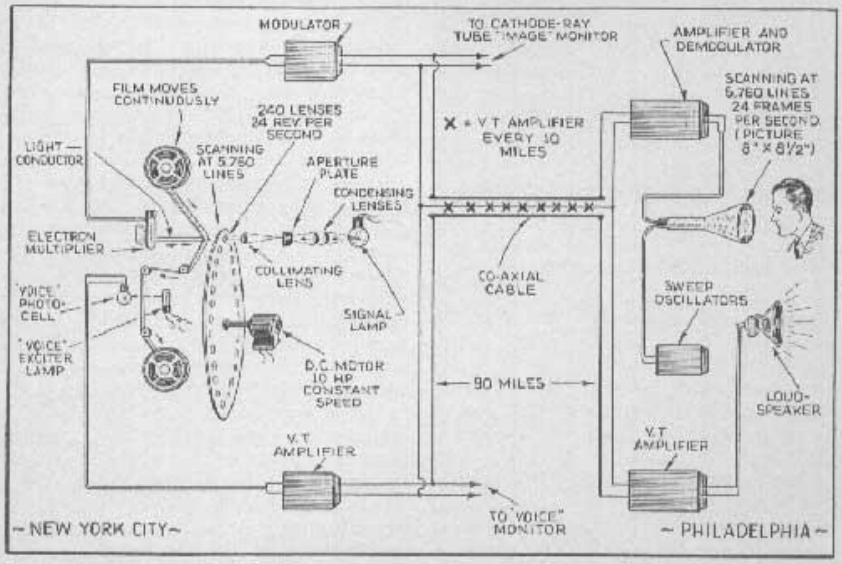


Diagram shows in simplified fashion the set-up for transmitting television over the coaxial cable between New York and Philadelphia.

Lens Disc Scans Film Images

For a signal which can be repeated over and over a motion picture is used; it moves uniformly past a picture gate where lenses in a large rotating disc sweep across it a light beam three-thousandths of an inch square! The light passing through the film enters an electron multiplier. The resulting current contains frequencies between zero and about eight hundred kilocycles. Before transmission it is raised by modulation about one hundred kilocycles higher.

High Frequencies—*Sharpness of detail in a picture implies a rapid change from light to*

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Television "Piped" from New York to Phila.

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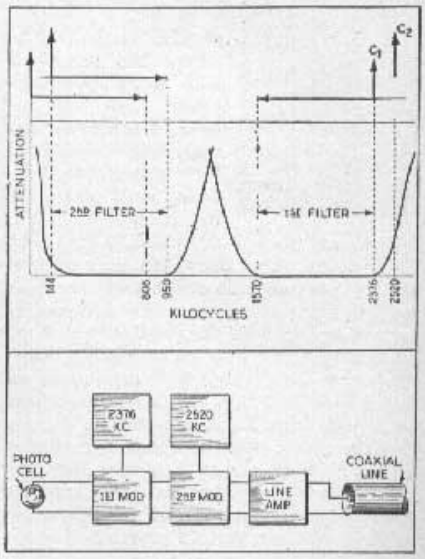
dark and vice versa. That in turn means a current from the photoelectric device that changes rapidly from strong to weak. A changing current can be shown to be a group of alternating currents whose frequencies reach higher values as the change becomes more rapid. Conversely, if the circuit suppresses some of these high frequencies, the current will seem to change more slowly. That in turn means blurred television details. Hence a high quality system is designed to handle high frequencies.

At the receiving terminal, in a cathode-ray tube, the current is supplied to a set of plates so arranged that the current corresponding to the brightest spot on the film centers the electron stream on an aperture one two-hundredth of an inch square. For less bright points the beam does not center on the aperture and fewer electrons pass. The stream then passes two more pairs of plates; one of which sweeps it back and forth fifty-seven hundred and sixty times a second; and the other up and down twenty-four times a second.

Scanning Frequencies—To permit the use of standard sound-film in the transmitter, the system is designed to scan 24 "frames" a second. The scanning disc contains 240 lenses and runs at 24 revolutions per second, scanning 5760 lines a second. Similarly the screen at the end of the receiving tube is scanned horizontally by the electron stream at the rate of 5760 lines a second, that is 240 lines for each of the 24 frames which are transmitted each second.

In transmission over the cable the lowest frequencies fall behind the highest, taking about twenty millionths of a second longer in travel. In that time the cathode beam can move forty times its width. The effect is the same as if the finer the picture details the more out of synchronism were scanning disc and cathode beam. For the new coaxial transmission, however, delay equalizers were developed to keep together all the components of the current to a precision corresponding to the motion of the beam for half its width, that is, *a dead-heat finish between all the frequencies to within a quarter of a millionth of a second!*

Amplifiers designed for a still wider band are under development, which will permit more telephone channels and more detail in a transmitted scene.



In the recent demonstration of television transmission over the coaxial cable between New York and Philadelphia a frequency band width of 806 kc. was employed. Since the coaxial cable is not designed to transmit frequencies below 60 kc., however, the original frequency band from 0 to 806 kc., had to be raised by modulations to a higher position in the frequency spectrum.

This is accomplished through double modulation. The first modulation employs a carrier of 2376 kc., and results in a lower side-band from 1570 to 2376 kc., and an upper side-band from 2376 to 3182. A filter then removes all of the upper side-band except a small section of its lower frequencies, which is passed by the sloping corner of the filter characteristic. A second modulation with a carrier of 2520 kc. results in an upper side-band from 4090 to 4896 kc., and a lower side-band from 950 to 144 kc., with the addition of a group of somewhat lower frequencies corresponding to the vestigial upper side-band passed by the first filter. A second filter easily removes the upper side-band, and is accurately designed to cut off the vestigial frequencies below 144 kc., so that the frequencies transmitted run from 144 to 950 kc.

Images Transmitted on New Single Side-band System

Dr. Frank B. Jewett, President of the Bell Telephone Laboratories, made the following statement on coaxial cable developments:

"In order properly to appraise the demonstration of television pictures transmitted over the coaxial cable from New York to Philadelphia and the semi-technical explanation of it, it is necessary to understand just what the demonstration was designed to show; what it was and was *not;* and what was new and an advance over the preceding art.

"The demonstration was *not* the first transmission of television image currents for long distances over wires. The first such demonstration was made by the Bell System in 1927 when television image currents were transmitted from Washington to the Bell Telephone Laboratories in New York and there reproduced. In that demonstration transmission was over specially conditioned telephone circuits of ordinary construction. The characteristics of such circuits were sufficiently good for the poor grade of television picture then attainable by the equipment for scanning and reproducing (50 lines, corresponding to a frequency band width of approximately 22,500 cycles).

"The latest demonstration was *not* designed to show an improved television per se. In fact the images (240 lines) were inferior in grain to those produced by the most modern television equipment (441 lines or better). This was not due to any limitation imposed by the scanning or reproducing apparatus, but to the limitations imposed by the experimental terminal and repeater equipment now on the New York-Philadelphia cable. This equipment limits the top frequency of the transmitted current to approximately 1,000,000 cycles so that a 240-line picture is about the finest grain image that can be transmitted.

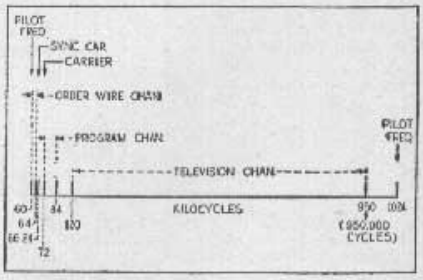


Diagram above shows television transmission band of nearly one million cycles used in the transmission of images.

"What the demonstration did show for the first time is the unique and economical utilization for television currents of the frequency band of a long coaxial cable. Instead of transmitting the television currents by the *double* side-band method common to radio broadcasting, a method for *single* side-band transmission was developed, thus utilizing to the fullest the frequency range for which the cable system was equipped. The double side-band method has been used in Europe for transmission of 180 line images over coaxial cable. In that *transmission* each side-band occupied only about 1/3 of the transmission range of the cable system, amounting to the television use of the available frequency range at only 33 percent efficiency. In the method which has just been demonstrated at Philadelphia a single side-band is obtained by double modulation and precise filtering; and this side-band is placed to avoid the first 100 kilocycles of the frequency range of the cable system where transmission is unsatisfactory and the various components cannot easily be amplified. There was also introduced compensation for the different velocities of transmission of different frequency components. The result is the delivery of an essentially perfect replica of the almost infinitely complex current produced at the sending end by the scanning equipment.

The image control desk and the screen behind which a large cathode ray tube was mounted.

2,000,000 Cycle Repeaters To Be Tried Next

"These are results never before obtained. As soon as the present experiments are completed the experimental 1,000,000 cycle repeaters on a portion of the cable are to be replaced by experimental 2,000,000 cycle repeaters, as the next orderly step in the development of equipment which will give a coaxial cable system capable of accommodating the maximum number of telephone channels which it is economical to handle on such a cable or the widest band of frequencies which the best television scanning and reproducing apparatus may require.

"As stated above, a 1,000,000 cycle band will accommodate television currents corresponding to about 240-line pictures. It will also afford channels for about 240 simultaneous high grade telephone channels. A 2,000,000 cycle system will provide about 480 telephone channels or accommodate television currents corresponding to about 350-line pictures."