ENGINEERING

Pictures Through a Pipe

Coaxial Cable Will Carry 2880 Telegrams Simultaneously; Economical in Operation Though Costly to Construct

By RONALD L. IVES

LIVING pictures, poured through a pipe for hundreds of miles and then sprayed on a screen, are the latest achievement of the designers of the coaxial cable, a message pipe that carries a television image, or 240 telephone messages, or 2880 telegrams simultaneously from one city to another with less loss of quality than any other cable yet designed.

Literally a pipe, the coaxial cable consists of a tube surrounding a wire, from which it is insulated with hard rubber spacers. This carefully suspended and insulated wire does not do all the work, by any means. The things that go on inside the hollow of the coaxial cable are very complex, and they are performed partly by the central wire, partly by the hollow space surrounding it, and partly by the inner surface of the tubular cable itself. There are several transmission jobs to do, and each part of the entire set-up carries its share of the load.

Multiple Carrying Job

For one thing, the coaxial cable has more to carry than its great complex of television, telephone, and telegraph circuits. The waves carrying these messages need to have new power put behind them every so often, to give them a boost and pep them up when they begin to grow weak and run down. The engineers therefore devised means for sending power over the cable along with the messages, so that repeaters at isolated points could be operated without the use of expensive local generating plants. Compressed non-inflammable gas within the tube keeps the inner wire and the insulating spacers dry, and a decrease in the gas pressure warns of trouble long before an actual breakdown occurs.

Recently, engineers of the Bell Telephone Laboratories sent newsreel pictures and sound from New York to Philadelphia via this cable. Using a screen eight inches square, images of a tennis game were received with such great clarity that the ball could be followed without difficulty. Motion picture film was fed into the New York transmitter, where a 4½ foot scanning disc, made from a circular saw, cuts the individual pictures up into 240 elements, each of which was transmitted on a separate frequency band to Philadelphia over the coaxial cable, received there, and projected onto a fluorescent screen by means of a stream of electrons.

Although it does not distort the signals to any extent, the coaxial cable conducts the different frequencies with slightly different speeds, and special equipment, to compensate for these delays, had to be invented and manufactured to compensate for this. Now, with these compensating devices, signals starting from New York at the same time arrive in Philadelphia within one quarter of a millionth of a second of each other.

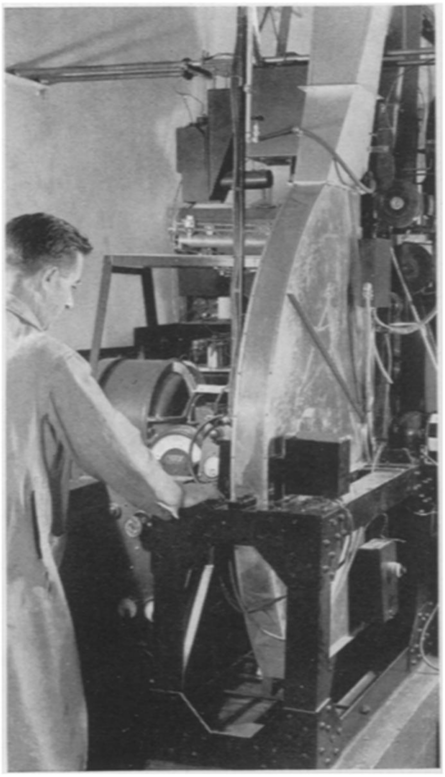
Many Relays Needed

Signals traveling over the cable become weak rather rapidly. In the old days, a telephone call to San Francisco from New York was impossible unless an operator listened at Chicago and repeated the message received there into the San Francisco line. Today, vacuum tubes do the repeating in the same manner that the amplifying tubes in your radio make the weak signals picked up by the aerial audible all over the neighborhood. With the old multi-wire cables, a separate system was necessary for each pair of wires at each repeater station. Now, one repeater at each station does all the amplifying, saving cost, space, and trouble due to the complexity and number of the old style repeaters.

Repeaters on the coaxial lines are necessary at intervals of not more than ten miles. This means that between New York and Philadelphia there are ten repeater stations, each containing one repeater for each direction of transmission. Special repeaters had to be developed for use with this cable, and developing the special new style vacuum tubes caused designers and glass-blowers many a sleepless night.

Discovered two generations ago, the coaxial principle was useless to communication engineers until the development of the modern vacuum tube. Now, the number of signals which can be simultaneously carried over the cable is limited only by the repeater and terminal equipment. The coaxial cable will carry anything that is fed to it. Engineers are now at work developing better feeding equipment.

Theoretically, the cable is very simple. Just put a wire inside a tube, with the center line of the wire on the center line of the tube, and you have a coaxial cable. Long ago it was discovered that a coaxial cable, in practice, worked almost exactly as called for by theory. The problem lay, not in making the cable work, but in making sections of cable more than a few feet long. Obviously, building two ninety-five mile lengths of cable in ten-foot sections, all



THE IMAGES START HERE

A rebuilt circular saw is used as a scanning disk at the Bell Laboratories in New York City, where images originate. So fast does this disk rotate that special equipment had to be designed to keep air friction from heating it dangerously. The metal casing by the man's hand is the ventilating housing around the scanning mechanism.

by hand, would make the cost prohibitive.

Telephone engineers had to lay aside their voltmeters and slide rules for a time and invent machinery that would make this cable in lengths of at least 500 feet. When this was done, a test section of cable, two miles long, was installed, and all possible difficulties solved before the dimensions of the long cables were decided upon. The finished New York - Philadelphia cable is only seven-eighths of an inch in diameter, and this includes two coaxial lines, eight ordinary wire lines, insulation, and a lead sheath. This is only one-ninth the size of a standard size toll cable.

Current Travels in "Skin"

Currents in the coaxial cable don't travel in the same manner as those in a lamp cord. High frequency currents, like those used in modern long-distance telephone transmissions, travel on the outer portions of the wires. The higher the frequency, the more they tend to travel in the surface of the wire, or "skin." Because of this, the outer tube of the cable carries the signals on its inner surface, while interfering currents, like "static," ride its outer layers, and cannot mix with the signals. As the signal frequencies increase, more and more of the current tends to travel as a radio signal, guided by the cable structure, and imprisoned by the outer tube.

Manufacturing of the final cable was done by machine, and lengths of more than five hundred feet were produced. Hard rubber insulating discs were stamped out of stock sheets, then cooled off until they were springy, and snapped onto the central wire at regular intervals.

Locked in Copper Jacket

Then the outer tube was spun on by special machines which assembled it from strips of rolled copper so shaped that they would interlock. This completed the electrical portion of the coaxial unit, but a double steel armor was necessary over the outer tube to protect it from crushing during installation. Two coaxial units and eight wires are bound together with paper wrapping and sheathed in lead to make the completed cable.

Before installation, each 500 foot length of coaxial cable was tested for each of several possible troubles, then sections were pulled into underground conduit, and the ends spliced, specially-designed tools being used in the work. Gas under pressure is contained in the cable to keep the humidity constant. Any change in gas pressure indicates trouble in the cable, and by locating the pressure change, the defective section of cable can be cut out and replaced before an actual breakdown occurs.

Repeaters were placed in manholes along the route, each repeater being designed to operate for weeks or months without attention, and a special control current for the repeaters travels over the cable, one voice channel being devoted to it. Changes in temperature change the operation of the cable. Burying the cable reduces these changes, but special automatic compensators have been designed to eliminate their effects entirely.

Each repeater is as large as two good radio sets, and is schielded in a metal container similar to a radio shield. All repeater equipment, from the long-life filaments in the repeater tubes to the specially-insulated transformers and condensers, is designed to have an enormous margin of safety, for engineers have learned that breakdowns are expensive.

Increasing Number of Signals

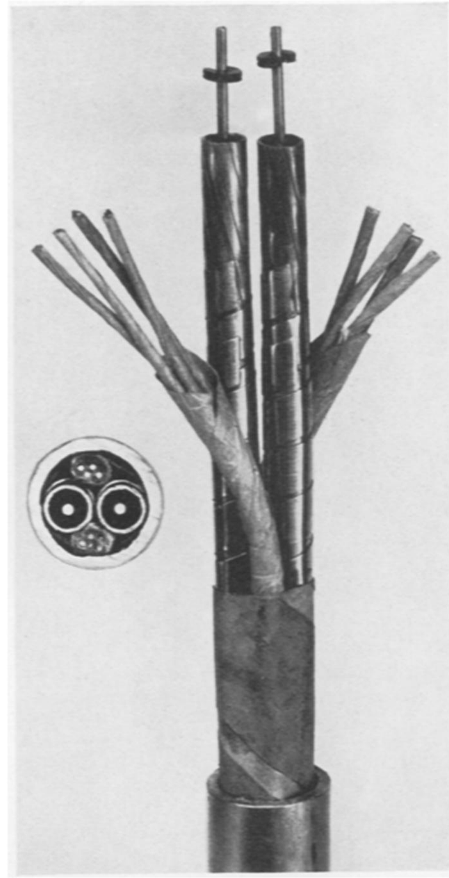
Engineers have for years been harassed by the problem of where to put more wires, and how to increase the number of signals that can be sent over a single pair of wires. Long ago, methods of sending more than one signal at a time over a single pair of wires were developed, but the limitations of standard cable made application of these methods difficult, and impossible at higher frequencies. Television transmission, for example, must have channels that will carry very high frequency signals without distortion if a detailed image is wanted.

With the coaxial cable, now capable of carrying a million-cycle wave band, and using one set of repeaters at each station, much of the congestion trouble is solved. Once, 240 voice channels necessitated 240 repeaters. Now only one repeater, with correspondingly less power need and fewer chances of getting out of order, is needed. Nine coaxial cables can be installed in the conduits that now carry a single standard toll cable.

The problem of where to put more wires is by no means solved. In a few years, engineers will worry about where to put more coaxial cables. But the cable does make possible advances in the communication industry which will save it, for some years at least, from becoming bogged down by its own conplexity.

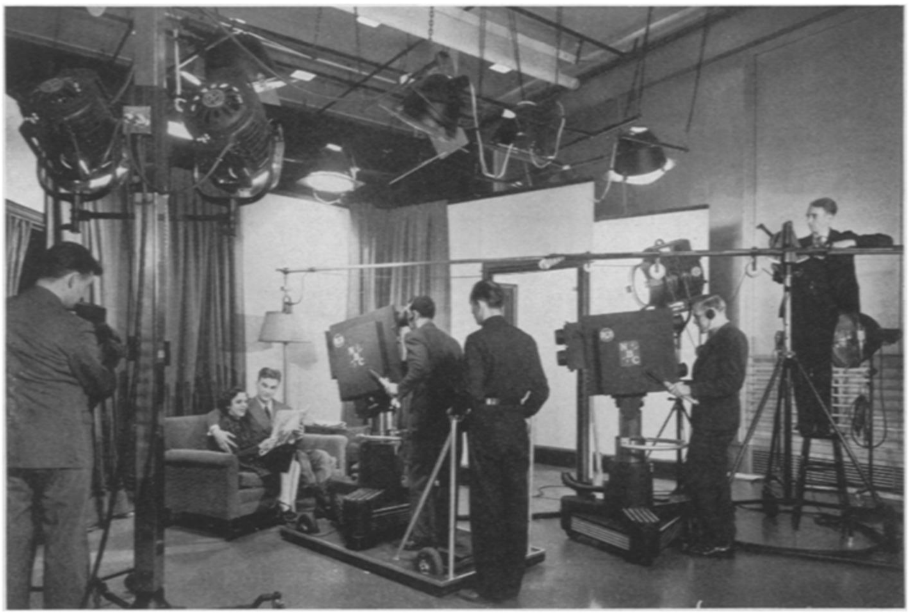
Today, in the thickly-settled industrial areas, there is no such thing as a telephone wire, or a telegraph wire. Wire lines carry all sorts of communications. Only the very local lines have a single use. Trunk lines may be carrying at any time such widely diverse things as radio programs, telephone calls, telegrams, wirephotos, and even police alarms. As our civilization becomes more complex, the number of uses of a wire channel increases greatly.

Several generations ago, before the underground cable was developed, the tangle of overhead wires threatened to become unmanageable. Today, the underground cable sometimes becomes a problem, for it has to share the space under the paving and over the subway with power wires, gas, water and sewer pipes, often with steam pipes and pneumatic lines. Intercity lines have right-of-



IT ISN'T VERY BIG

The coaxial cable is only seven-eighths of an inch in diameter, and within its lead sheath are two coaxial channels, each capable of carrying a million-cycle band, and eight wires for controls or any other desired use. So complex and difficult is the construction of this cable that special stranding machines had to be developed before construction was started, and special tools were invented for its installation.



SOON TO COME?

Television broadcasts to the general public have been predicted for many years, but the corner around which commercial television was reputed to be has not yet been found. Lack of transmission channels, one of the great obstacles, can be partly rectified by the use of coaxial cables for intercity transmission. High cost seems to be the chief remaining obstacle.

way problems which are becoming more acute each year.

Coaxial cables will not be a cureall, but they will allow service to be increased to nine times the present volume with the existing cable ducts. After that —but the engineers have enough trouble already!

Television broadcasting has long been cursed with a problem even worse than that of the telephone engineer. Television needs a very wide band of frequencies for a single image. These wide channels are available only on the very short waves, whose effective range is limited to "sight distance" from the transmitter. Rebroadcasting of the same program from many stations, which is standard practice today in sound broadcasting, has heretofore been impossible in the case of television because there were no wire channels between broadcasting stations over which the television signals could be sent for rebroadcasting. The coaxial cable, although designed as a communication channel, and not specifically as a "television pipe" may speed the coming of television broadcasts and rebroadcasts because it *can* carry the frequencies necessary for television transmission.

Television's future is very uncertain. Undoubtedly, more and better television transmissions will be available in the future, but whether that will be in a few years, or a few decades, or a few centuries, the engineers will not predict. Ten years have already elapsed since television images were wired from Washington, D. C., to New York City. Great improvements have been made in the quality of the received image in that decade, but each improvement has necessitated a wider channel. Today, with modern technique, each line in the image requires as wide a channel as one telephone conversation. Hence, while a telephone conversation from New York to Philadelphia costs 65 cents in the daytime, a television conversation would cost $156.65, if the rates were based on the channel width used.

Cost, rather than anything else, will be the major factor retarding television development. Few people, for example, could afford to make a television call from New York to San Francisco at rates based on channel use. If, as, and when people want to see their friends while telephoning to them, the channels will be in readiness. It seems, however, that a visit would be very much cheaper than a television interview.

Telephone engineers are not satisfied with their million-cycle cable. Why not use the cable to its full capacity? Why not install new terminal equipment and repeaters capable of handling two million cycles—why not five million? In the various communication laboratories scientists are already making, testing, and improving repeater and terminal equipment to care for a band of two million cycles, which carry 480-line television images, 480 telephone or wirephoto signals, or 5760 telegrams.

If a 2½-million cycle band is made usable, television images eight inches high will have 65 lines to the inch, which will look better than the average newspaper illustration. Perhaps television will then become a pleasure, rather than a strain, to watch, and those who have the price can sit at home and observe activities anywhere in the world.

Science News Letter, March 12, 1938

ARCHAEOLOGY

Hill Feared by Natives Yields African Secrets

A HILL with a tongue-twister name has been yielding graves and other clues to South Africa's past.

This hill named Mapungubwe is on the bank of Kipling's "great, greasy, grey-green Limpopo River."

Awe-struck natives always said climbing Mapungubwe meant death. Their ancestors had buried treasures up there, and no one dared even to point to the sacred hill, in the wild region where it lay.

But five years ago, a group of white men located the hill and found what they hoped for—buried treasure. It was, in fact, a skeleton with numerous ornaments of gold plate.

Fortunately, the treasure hunters were educated men, and one reported the find to the University of Pretoria. From then on, Mapungubwe has been probed by eager scientists, seeking a long-lost chapter of prehistory.

In a big archaeological volume called "Mapungubwe," Prof. Leo Fouche of the University of Pretoria and other scientists give a progress report.

Excavations have dispelled native mysteries, showing that the hill was occupied by two separate peoples. After several centuries, they left. There was no fighting, no hasty departure, judging by lack of confusion in the ruins.

But before the people went down the hill for the last time, they apparently buried their sacred objects with their chief. One grave, nicknamed the Scepter Burial, contained a skeleton buried with a gold scepter in one hand.

This episode in African prehistory