R.F. and TELEVISION CABLES

Advantages of Polythene as an Insulating Material

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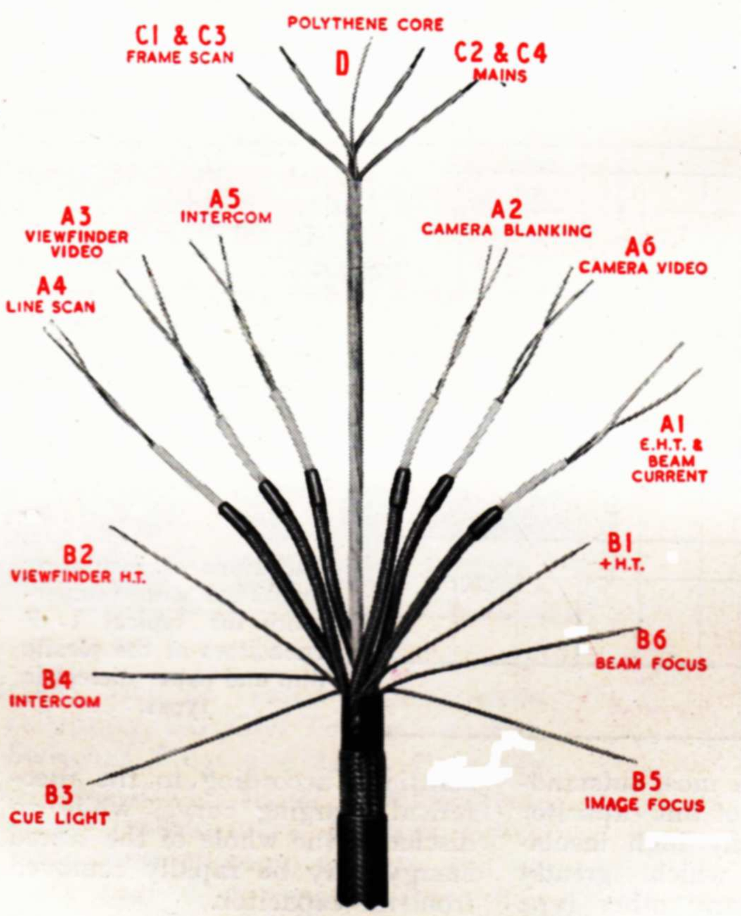
IT is only natural that the attention of radio engineers should have been concentrated mainly on the excellent electrical properties of the new synthetic plastic material known as polythene. It is often forgotten that good electrical properties are not enough by themselves, and there are many materials which, though excellent electrically, cannot be applied economically to the environment in which they are required to work. The cablemaker finds in polythene, however, a material which has allied to a low dielectric constant and low dielectric loss many other advantageous properties. It is mechanically tough, light in weight, possesses excellent properties from the point of view of waterproofing, and above all is convenient to work in manufacture. Although the grades used in cable manufacture are in a suitable plastic state at about 170°C, a cable employing polythene can operate in safety at temperatures between −40°C and 70°C. The material can be extruded on to wires with a high degree of dimensional precision which, together with the high dielectric strength, enables thin insulating coatings to be used with safety. Indeed, it is the accuracy with which cables can be made with it that constitutes one of the most important features of polythene.

Applications.—An attempt to exemplify all the ways in which polythene may be used in the making of radio-frequency cables is beyond the scope of this article, as also are its applications to the technique of moulding couplers and terminations to those same cables. It is interesting to realize, however, that polythene makes it possible to manufacture cables so small that they could hardly be used in practice because the conductors emerging from the ends would be too fragile to handle, but it also makes it possible to mould on permanent couplers in the factory, and thus render cables of this kind a practical proposition.

Apart from the well-known application of polythene to r.f. cables as a solid dielectric in which the properties already mentioned have a direct effect on the quality of the cable, there are possibilities of the exploitation of the material to develop particular features. For instance, it can be extruded as a string which, wrapped around the conductor in a helix, provides a dielectric of lower dielectric constant than of a solid extruded insulant. In practice a single string of this kind enables a dielectric constant of about 1.4 to be achieved, while a more elaborate form, using a sort of "coiled-coil" of polythene string, enables the figure to be brought close to unity.

The design of simple radio-frequency cable is, however, less strikingly illustrative of the manifold qualities of polythene than are certain multicore flexible cables which have recently been developed, and one in particular, a camera cable developed for use with the latest television outside broadcast equipment has been chosen to illustrate not only the advantages of polythene, but also the factors governing the design of such a cable.



Multiple television camera cable (B. I. Callender's), showing the functions of the various conductors. Outside diameter is only 0·85in (2·1 cm).

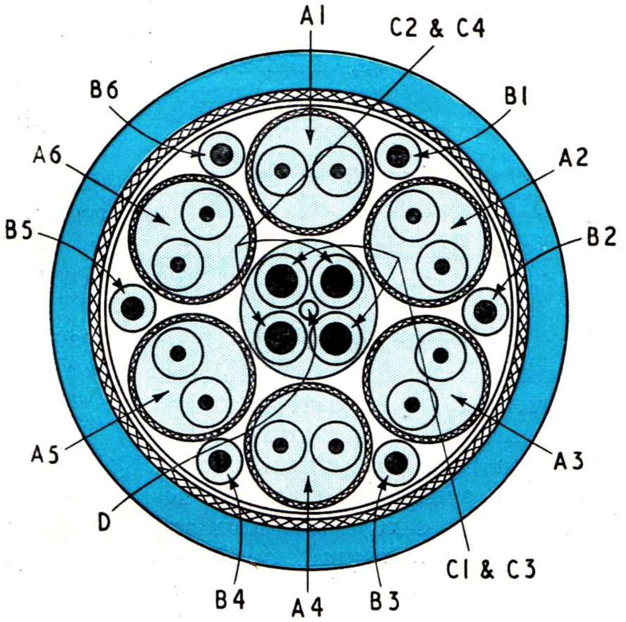
New Camera Cable.—In a modern television outside broadcast unit, a complete camera unit and link transmitter are housed in a single small vehicle, whereas at one time several large lorries were needed. Furthermore, there has been increased application of methods of remote control and supply, with the result that much equipment has been transferred from the camera to the van. The use of an electronic viewfinder fed with a video signal from the van is also now usual.

An important part of such equipment is the camera cable, since the usual practice is for cameras to operate at a considerable distance from the van. The requirements are unique, in so far as the cable must contain a variety of conductors to handle video signal with low attenuation, scan voltages, speech intercommunication, cue light circuits and so on. Mechanically it must have the smallest possible diameter, a high degree of flexibility, light weight and great robustness. Its design therefore presents the designer and the cablemaker with a problem of considerable interest, more especially since the advent of "miniaturization."

Design.—The design must be considered electrically (from the point of view of each individual circuit) and geometrically (the cable as a whole), the latter involving a degree of interdependence of the electrical requirements which leads, as in all design work, to a compromise solution. For instance, a "unit," (i.e., a self-contained group of insulated conductors) designed to handle video signal must meet certain requirements as to attenuation and this in turn is a function of its diameter. On the other hand, the diameter is bound up geometrically with that of all the other units, and we have to face the possibility that the attenuation attainable in one unit may be decided by the working voltage (and thickness of insulation) in another. It is also desirable for the sake of manufacturing economy to keep the variety of the units to a minimum, which means designing certain of the cores to satisfy two or more sets of requirements.

In the cable with which we are now concerned, the fourteen different functions shown in the accompanying illustration were finally accommodated, and it was found possible to do this within an overall diameter of 0.85in. (2.2 cm.).

Screened Twins.—It was first considered how the main pulse circuits could best be grouped, and balanced screened twin units were chosen because of their advantages over coaxials from the point of view of mutual interference. The units initially designed were those for the two video circuits, the prime requirements being for low attenuation and for a characteristic impedance of 130 ohms.



Cross section, with corresponding reference lettering, of the television camera cable shown on the preceding pago.

At the same time it was found that the twin units for the line scan and blanking signals could be similar to the video units, though somewhat larger since they must be designed to a definite minimum value of d.c. resistance. It was, therefore, decided to make these four units of the same size, design them to the required characteristic impedance and d.c. resistance, and be grateful for a slightly lower attenuation than the minimum required. There now remained two further twin circuits, one a telephone circuit and the other a pair of leads carrying 1,000V d.c. It was not essential technically for these two units to be screened, but it was desirable for safety; as a matter of manufacturing economy, therefore, all six cores were made the same.

The Quad Unit.—The best basic arrangements of the units in a cable is the so-called "six plus one" in which six are laid around a seventh, for this gives the best utilization of available space with round units, and, especially in a flexible cable, gives a uniform appearance and pleasant feel. In the cable described, this arrangement was used, and, the twins already mentioned having been designed, only one space was left for two circuits. These two, being a 50-c/s mains pair and the frame scan supply, were, in view of a common requirement of low d.c. resistance, grouped together in the early consideration of the design and were now accommodated in a four-core unit which forms the centre "heart" of the cable. This unit is a star quad in which the diametrically opposed wires are used as balanced pairs, an arrangement which can give a low level of interference between the two circuits involved and is, when employed in an appropriate case, economical of space.

Filling Odd Spaces.—All the more important circuits were now accommodated, but there remained four still to be fitted in. The cable would already be nearly 0.7in. in diameter, without its sheath, but it was clearly possible to lay insulated wires snugly in the grooves formed between the six twins without increasing the overall diameter. The maximum permissible diameter of these would be only 0.072in. and the requirements for d.c. resistance made it necessary to use 0.032in. wires. However, a polythene coating 0.020in. thick is easily applied and is safe at 300V d.c., so six such wires were added. This actually provided two spare cores and these were in the event used, one for a further intercommunication circuit, and one as a second 300-V h.t. line.

Characteristics.—The electrical characteristics of the units are given in the accompanying table, together with some notes on the circuit requirements governing each item. All the units are solid insulated, the twin and quad units being of the usual twisted construction.

The Complete Cable.—The photograph shows that the six twins are laid around the quad, the six single cores being laid in the outer interstices between the twins without increasing the overall diameter. An overall wire braid is added, mainly as mechanical reinforcement, and is insulated from the individual screens by varnished cambric tape. The cable illustrated is sheathed with P.V.C., but a polythene sheathed version is also in service.

The manufacture of a cable such as this is only made possible by the use of polythene as an insulant

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since this material not only has the dielectric properties necessary if a relatively low attenuation and high breakdown voltage is to be achieved in a small cable, but can also be applied with a high degree of accuracy by modern extrusion technique. It is moreover a great tribute to the equipment designers that it should be possible to use a camera cable having such small conductors, especially for runs so long as 1,000 feet (300 metres).

Couplers.—The cable is fitted with couplers integrally moulded in polythene. These enable two lengths of cable to be connected together instantly with all the circuits correctly disposed and screened. Continuity of screening is maintained by brass plates which divide the inside of the coupler body into nine compartments. These extend right up to the face of the coupler so that only a slight gap remains when two are connected together, and the screening braids of the twin units are connected to them. Each screened twin, and the star quad, is brought to pins or sockets in its own compartment, while six single cores are spread between the two remaining compartments. Spare pins and sockets are used for earth continuity. The couplers are locked together by screwed rings in the usual way.

This latest type of cable is normally supplied for convenience in 200ft. lengths with couplers so that camera chains can be run out to any required length, and the latest B.B.C. television outside broadcasting equipment is thus equipped. The cable described was designed to the requirements of Pye, Ltd., for use with mobile television equipment.

Cable Type T1816		Characteristics		Governed primarily by requirements for :
Unit	Number in cable			
Screened Twin	6	Diameter	0.2 inch	General. Geometrical.
		Capacitance	11pF/ft	Video circuits
		Impedance	130Ω	Video circuits
		Attenuation (1Mc/s)	6.1db/1,000ft.	Video circuits
		D.C. loop resistance	53Ω/1,000ft	Line scan circuit.
		Max. working voltage (conductor to screen).	2kV	E.H.T. and beam current circuits.
Quad	1 (two circuits)	Diameter	0.22 inch	General. Geometrical.
		D.C. loop resistance	9.3Ω/1,000ft.	Mains. Frame timebase.
		Inductance	80μH/1,000ft.	Frame timebase.
Single Wires	6	Diameter	0.072 inch	Geometrical.
		D.C. loop resistance.	10.7Ω/1,000ft.	H.T. and cue light circuits.