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Wire and Cable

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The first significant thing to be said about wire and cable in the decade to come is that greater amounts of it will be used. Population increase, higher living standard, and ever-widening application of electronics provide a firm foundation for forecasting continued expansion of production in this field. Projected statistics indicate doubling of the dollar-value of the electronic market. In our speculations about "What's Ahead in the Significant Sixties" we shall survey the function uses of wire products in (1) consumer products, (2) industrial applications, and (3) military applications, including in the latter the area of space research.

Most of It

An obvious and less glamorous fact is that the major portion of wire and cable produced in the next 10 years will be made of materials now known and in use, and by processes now commonplace in the industry. Consumer products (home, business houses, and schools: see table I) for the most part do not have requirements in the extreme ranges of operating conditions (temperature et al); therefore, the exotic, ultra-new insulating materials are not likely to find extensive service in this highly competitive field. To a lesser degree, this applies to the industrial market as well and, as will be seen, is true in part of the military field.

This is not to preclude improvements in degree which will be made, some of them relatively soon. There will be available during the period elastomers with greatly improved resistance to ozone. Thermoplastics more resistant to thermal effects are in the offing, while improvements in the process of applying insulation will avoid certain internal stresses which are now set up by processing. Changes in manufacturing equipment come slowly due to the investment involved. It is likely that some developments that have been in process will come to fruition, bringing higher rates of production, closer controls on dimensions, and improved quality of product.

Factory sales of consumer products increased approximately 16% during the past eight years. The rate of increase will be greater in the sixties, but with the bulk of sales moving from the top of the list in table I toward the lower half.

The Growth of It

Factory sales of electronic equipment for industrial applications quadrupled from 1950 to 1958. Industrial and commercial electronic sales are currently approximately one-half the dollar volume of consumer sales and servicing. During 1960 to 1969, industrial use of electronics will overtake and surpass the consumer field. This carries the implication that the quality standards which the wire and cable industry must meet will grow increasingly stringent. This, in addition to environmental requirements, will demand materials to meet higher temperatures, lower temperatures, and other physically and electrically rigorous conditions. Reliability here has priority over the competitive market position that pertains in the consumer area.

The need for reliability and the high cost of manpower for installations may indicate a greater use of factory assembled cables and harnesses with connectors attached. This is simplified with the emphasis on unit or modular construction of equipment.

The Types of It

The types of wire and cable enumerated below are expected to change in the decade ahead as indicated.

1. *Hook-up wire* — thinner walls, higher voltage breakdown, higher temperature stability, improved stress crack resistance.

2. *Lead wire* — higher temperatures (150-200°C at much lower cost than "Teflon" or silicone), greater flexibility and flexing life, ease of processing.

3. *Power cords*—for small appliances, improved plastics will largely replace rubber. Power tools and much flexible service will find elastomers with high

ozone resistance. Three conductor cords will become standard everywhere as they now are in some states.

4. *High voltage leads*—higher breakdown, longer life due to improvement in corona resistance (better materials and changed construction).

5. *TV antenna lead-in*—little change in currently available constructions without changes in input impedance of receivers.

6. *RF cables* — impedance can be modified on specific applications and Teflon or ceramics used for higher temperatures but little improvement is in sight on the general temperature and frequency stability of polyethylene.

7. *Audio cables*—slightly smaller in size to give better space factor, improved shielding methods.

8. *Control circuit wire*—same points apply as on No. 1 and No. 2 with special applications in nuclear fields requiring materials with higher radiation resistance.

9. *Microphone cables*—flexibility and flex life, low capacitance (though this will be less important due to the low input impedance of semi-conductor circuits), improved shielding and low noise generation in cable.

10. *Camera cables*—smaller diameters with special applications using materials to give high radiation resistance.

11. *Multi-conductor cables — paired* cables: thinner walls, smaller diameters, shielded pairs having good shield isolation. Unpaired cables: Dimension factors same as paired cables, and with other points of No. 1, No. 2, and No. 8. Flat parallel conductor cables will be used in many applications, both as pre-cut harness and as interconnecting cable.

12. *Strain gauge cables**—Smaller diameters, low noise generation, radiation resistance.

**Applies to many instrumentation cables.*

Meeting the above requirements is obviously going to mean modification of present materials and the development of new ones.

Alloyed, plated and composite conductors will increasingly be used to provide longer flexing life, greater tensile strength and, in some cases, operation capability at higher temperature extremes. Increased resistivity of some of the alloys will introduce problems of heating and voltage drop which will have to be considered by equipment designers.

The past five years have seen the cracking of the lid on a virtual Pandora's Box in the field of chemical synthesis. The work of Karl Ziegler in Germany, Giulio Natta in Italy, and a series of researchers in this country reached a climax of 20 years labor with the development of methods of "tailor-making" the molecules of substances to produce characteristics which had been Nature's secrets before. Variously termed "stereo-specific polymerizations" and "graft and block polymerization," the processes can produce results such as the new synthetic rubber with most of the desired characteristics of natural rubber.

A further development of this method is the addition of desired properties to a substance by combining hitherto inorganic elements into the complex molecules of organic type compounds, which means that materials can be compounded with properties "to order." The silicones are a beginning point. The addition of phenyls or other cyclic structures provide greater radiation resistance. The mechanical toughness, abrasion resistance, and oil resistance of silicone can all be improved by this method and will eliminate the braids and other protective coatings now used over wire insulations of silicone types.

We have yet to see the properties of substances using tin where silicon is now the radical. The phosphinoboranes likewise promise valuable properties. Thus a basic change in meeting higher temperature requirements will be to move from strictly organic compounds to semi-organic or inorganic polymer chains.

Low temperature range and many general purpose insulations will be high molecular weight materials that do not require vulcanization or plasticization in the processor's plant. Polyurethanes or polyisobutylenes are examples of very high molecular weight materials.

Table I—Consumer Products

Home and Business
- Radios and TV (entertainment broadcast)
- Recording equipment
- Hi Fi—mono and stereo
- Electronic appliances
  - Air filters
  - Temperature controls
  - RF ovens
- Intercom
- Annunciator
- Music systems
- Alarm systems
- Closed circuit TV (theft protection)
- Bookkeeping computer systems

Schools
- Language systems
- TV classrooms
- Paging systems

Automotive
- Ignition, lighting, accessories

Table II—Industrial Applications

Control systems
- Automation
  - Temperature (environment)
  - Processes
  - Punched cards or tapes
  - Magnetic tapes

Two-way radio

Instrumentation

Data processing

Computers

Telephone systems

Aircraft controls (commercial), navigation, landing

Nuclear systems
- Power
- Medicine
- Tracing

Corrosive surface treatments si[illegible] lar to anodizing of aluminum w[illegible] will produce some excellent insu[illegible] tions with little or no diameter ad[illegible] tion.

With regret, we must say that [illegible] commercial availability of flexib[illegible] ceramics will be deferred to the [illegible] of the Sixties or into the "Sp[illegible] Age Seventies."

Whether used with civilian or m[illegible] tary equipment, applications of [illegible] trical wire can be reduced to either transmission of power or transmission of a signal. The consumer and industrial uses listed above can all be found in military service. However, let us consider the special requirements which military applications will impose upon wire and cable.

In the next 10 years, the principal changes in Armed Forces equipment in which wire is used will involve more rigorous environmental requirements for vehicles (undersea, surface, air, and space) and their associated apparatus, and more complexity and sophistication of electronic equipment.

Table III shows only a few of the military applications of electronics.

Environmental requirements will include even wider extremes of both high and low temperatures and exposure to cosmic and nuclear radiation. Capability of operation at 2500° F for a few minutes and 4000°F for a few seconds will be needed during the sixties. Vibration, acceleration, shock, and vacuum are equipment problems which will be magnified as space vehicles become more ambitious and will be shared by the wire in the equipment in areas not protected for the sake of the human cargo.

Most of the progress in environmental resistance must come from the development of new materials and ways of applying them. The pressures of the military requirements will hasten the development of materials mentioned above but which might not be commercially feasible nearly as soon.

As more and more functions are pressed into a given amount of space, miniaturization will increase in importance. Entirely new methods of current transfer will probably be developed. Printed circuits have been with us for some time, and already work is being done in the field of moletronics, in which complete circuits are grown into a crystal.

Obviously, there is not much room inside a crystal for hook-up wire as we know it today. However, the most miniaturized circuit imaginable is of no value mounted on the head of a pin unless there is a way to get information into it and out of it. Miniaturized wires and cables will be used in most such applications.

Table III—Military Applications

Communications
- Telephone
- Radio
- Teletypewriter
- Infrared beam
- Television
- Electronic megaphones
- Public address systems

Navigation
- Radar altimeters
- Radio direction finders
- Automatic pilots
- Radio beacons
- Landing aids

Fire control and missile guidance
- Radar
- Infrared
- Acoustic

Target detection and countermeasures
- Radar
- Sonar
- Scatter
- Infrared
- Hydrophone
- Mine detectors
- Radioactivity monitors
- Jammers

In land-based equipment, environmental problems will not be as severe as in vehicles. However, long-term reliability will be stressed and in increasingly complex data handling equipment miniaturization will be important.

Actually, as in the case of consumer and industrial products, any added cost of micro-miniaturization must be justified by some benefit. Therefore, as now, much military wire and cable will be standard types but manufactured to meet stringent MIL specifications.

The wire and cable industry will experience the significant sixties as both prosperous and demanding. Greater volume but with higher standards of quality to be met consistently will provide a continuing challenge. New materials and methods will become available as the demands bring them forth.