First decision, properly made in the early planning stage, is whether primary distribution lines will be overhead or underground. Trend is toward overhead. It offers a lower cost system that's easier to expand. But don't make decision on trends alone. An underground system, although it costs more, is unaffected by lightning, plant fires, cranes, etc. And where appearance is a prime factor (if your plant is in or near a residential area) you have another vote for underground. Soil contamination, corrosive fumes, building layouts, distances between buildings, all influence final decision.

Utility tunnels, carrying power services between powerhouse and outlying buildings, are used in some plants. All the power services—steam, water, air, electrical cables — are included. *Prefabricated tunnels are available, offer installation savings.*

Type of conductors, insulation, covering, come next. Conductor size for load carrying alone can be found from standard tables and voltage-drop charts. But size for short-circuit-current carrying is another matter. With wider use of breakers on feeders and selective tripping with its necessary time delay (p. 106), your cables must be able to stand short-circuit heating during the delay period. Sizing for this factor is based on allowable temperature rise of insulation and on time delay period.

Aluminum or copper is another decision to make early. It won't do to design the system for copper, then swing to aluminum later. Size of conductors, pullboxes, etc., must be larger for aluminum.

More power engineers see long-term advantages of standardizing on cable sizes. Even where it means oversizing, resulting simplification pays off both dur- installation and after the plant is in operation.

many plants the torch is bowing out to bolted compression fittings for cable joining.

For underground ductwork, fiber conduit in concrete is a good bet. Under light traffic, little concrete required and top of conduit need not be more than in. below surface (somewhat lower in cold climates). For stretches exposed to heavy traffic, lay conduit deeper, consider reinforcing..

Cable reliability boils down to selecting correct cable, connectors, insulation, covering. Lead-coverings are giving way to newer synthetic insulations. This avoids need for costly lead wiping.

Many are adopting new liquid-tight flexible metallic conduit. Liquid-tight covering over flexible conduit permits use outdoors, in wet spots indoors. Typical use: leads from rigid conduit to motor box.

High points in cable selection

What are on-the-job conditions? Will cable be in conduit, underground ducts, buried in earth, suspended overhead? Consider load, voltage, location, ambient conditions, hot spots, mechanical interference. Is electrolysis a potential problem?

What is best insulation and covering? Get to know the newer insulation materials and conditions for which each is best suited.

What are limitations? Determine maximum current-carrying capacity under the cable's operating conditions. Study effect of your cable selection on installation. Simple example: Two, or more, single cables, in parallel, often prove more economical and easier to install than one large cable.

With new cable types on tap, the trend is toward overhead high-voltage primary distribution: low installed cost, easy expansion

Current-carrying capacity, line losses, voltage drop, provision for future needs, all face the power engineer planning primary and secondary distribution. Handbooks and manufacturers' catalogs generally give enough information on this score. Assuming this data is at hand, let's look here at the types of cables finding use today, more specifically, several now receiving major consideration.

Primary Feeders. Today's plants, made up of many smaller buildings, spread over large areas. Electrically, that spells scattered load units and long primary feeders from either the primary substation or the plant powerhouse. This scattering of load over large areas has been a significant factor in the trend to overhead primaries.

Preassembled aerial cable is a low-cost method getting much attention, especially in modernization programs. An existing pole line, tower line or structural-steel framework for conveyors, pipes, etc, can serve as cable support. For a 3-phase circuit, this cable is made up of three insulated, shielded and jacketed conductors bound to a messenger. Cable needn't be kept clear of towers or buildings, except where chafing is probable. Close spacing with other cables and materials, plus minimum allowable ground clearances, lead to great freedom in choice of supports. Where neutral is grounded, messenger may serve as neutral to carry phase-unbalance currents. Terminating and splicing is simplified, since the cable is made up of separate conductors that are individually insulated and jacketed.

Interlocked-armor cable gets the nod from many power engineers for 3-phase primary distribution above ground level. This grown-up version of long-familiar low-voltage armored cable may be used indoors or out. Outer metal armor, either galvanized steel, bronze or aluminum, covers a chemical and moisture-resistant sheath. Combination forms flexible conduit and conductors in one easy-to-install cable. Bronze armor is a frequent choice in chemical plants. Standard hardware and supporting racks are available. Terminating and splicing methods have been worked out to cut field labor to the bone.

Users of interlocked-armor cable report sharply reduced installation cost once methods are mastered. Where this isn't the case, trouble can be traced to lack of advance planning to take full advantage of this cable's economy. Since conduit isn't needed, there's no confined air space around conductors: this translates into 20% greater current capacity than for same cable in conduit.

Underground Distribution. For this, many engineers are shifting to butyl-base synthetic cable insulation. This serves in conduit, underground ducts, tunnels, also directly in the earth. Cable can stand rough treatment, survive nearly any atmospheric condition, operate in the 80-85 C range with proper jacket.

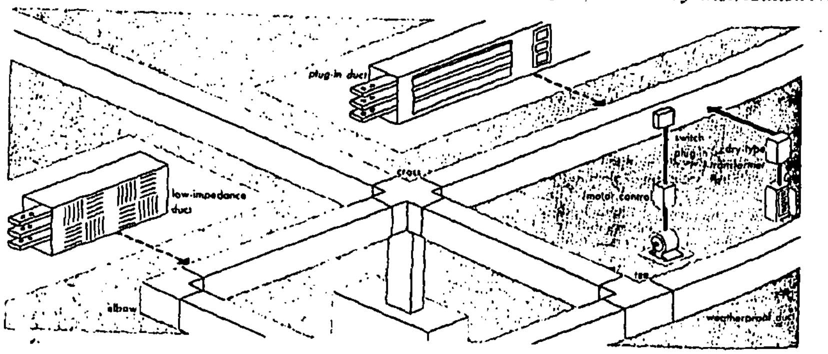
Varnished-cambric lead cable is an old standby and still first choice of many for underground distribution. Labor costs for handling and terminating are high. Lead sheath offers virtually positive assurance that moisture will not enter cable. Also, sheath's low resistance offers good grounding protection; its thermal capacity helps absorb heat from short-time overloads. In spite of these time-proved advantages, high installed cost of lead-covered cable causes industry to look to newer and less costly cable types.

Secondary Feeders. Selecting cable for hot or damp locations has always been a headache. But a relative newcomer in this country promises to be the best solution in some cases. This self-contained wiring system comprises copper jacketing enclosing conductors spaced and insulated by noncombustible mineral insulation. It is completely moistureproof, can stand continuous operation in ambient temperatures up to 250C. There is no need for conduit; copper sheath usually offers sufficient mechanical protection. Aluminum may be used for sheathing in the future.

This wiring system is rigid yet flexible, so hand-pressure bending is usually enough to shape to any needed contour. Once formed, wiring stays put when fastened with straps. Fittings seal both ends of run at terminal boxes. Because of all-mineral insulation, system is claimed to be immune to age-deterioration. Insulation is stable up to 2800 C. Power engineers are looking into this wiring for jobs where moisture, heat or restricted space are problems.

Interlocked-armor cable also sees use for low-voltage feeders, with same advantages as for high voltages. Unique virtues of bus duct are cited below.

Bus-duct has proven itself as the modern key to compact secondary distribution . . . since power loads are plugged-in, changing machine location becomes simple, fast



You'd be out of tune with modern secondary distribution methods if you didn't consider bus duct where shifting of production machines is common. Bus duct is a metal-enclosed system of bus bars (generally copper, but aluminum is coming in) available in prefabricated sections, for simple installation. Prefab fittings — tees, elbows, crosses — make running duct in any direction and around obstructions a field assembly job rather than a major construction problem.

Plug-in feature permits fast connection and disconnection of machines on production floor. Plants can be retooled, buildings revamped, without major wiring changes since bus duct, unlike conduit and cable, can be taken down and reassembled with minimum labor, using same parts again.

Users of bus duct cite three major advantages that tie in nicely with any modernization program: (1) Maximum flexibility meets changing future demands. (2) Simple installation chalks up labor savings. (3) There's minimum disruption of service during changes and it's easy to tie in with other secondary distribution methods.

There are four distinct types of bus duct available today that generally meet all distribution needs. Plug-in duct, most used for branch runs, provides outlets for plugging-in switching equipment about every foot. Where machines are to be swapped around, you need only unplug switch and push it into another outlet at new machine location.

Low-impedance duct is logical choice for long feeders where voltage drop must be held down and currents are heavy. Even for short runs where impedance is important, as with welder loads, low-impedance duct is a good bet.

Weatherproof feeder duct, for outdoor runs, has gasketed steel enclosure and weather-resistant hardware. Where voltage drop must be kept to a minimum on outdoor runs, use weatherproof low-impedance bus duct.

Aluminum is here for bus duct. Aluminum-oxide problem (see next page) is being challenged with zinc-copper-silver plating. Maker knows this will remove aluminum oxide and predicts it will prevent oxide reforming when duct is in operation. At joints, pressure-compensating spring washers give pressure, claimed permanent, of over 1000 psi. Early figures point to 41% weight advantage over copper.