be used subsequently, however, in connection with cable records.

Returning to the consideration of distribution centres: These we will suppose connected directly to the power station by feeders, usually medium potential, when the centre, if located in an area of fairly dense distribution, becomes a transforming point, supplying radial low-tension mains, spread over an area, say, two blocks square. Otherwise, as in residence districts, where these distributing mains become of too great length to be considered or in central business districts, where heavy currents entail, in even short secondary mains of 250 to 300 feet, a wasteful amount of copper, then these distribution centres simply remain points, supplying a series of comparatively small transformers, each delivering its current to several, or even, as in many instances, to but one consumer.

These distributing centres are either connected with the station by pressure wires incorporated in the feeder cables, or the feeder panel is equipped with a compensating voltmeter. By either of these devices the potential difference at a centre is constantly known, and may be kept at a certain point by automatic field regulation, or by manually operated devices of the auto-transformer or induction type. Where the expense of such apparatus is not justified, and when, upon extending the mains, their voltage falls below a certain limiting value, the original potential difference may be restored by the use of multiple taps in the transformer primaries, or by interposing kick-up transformers of small capacity in the mains.

Close regulation in lighting is important, as with the ordinary incandescent lamp 1 per cent. variation in the voltage applied to its terminals produces a 5 per cent. variation in candle-power, and a 10 per cent. variation in the latter brings complaints.

Because of the wide and rapid fluctuations produced in circuits delivering current to motors, all such apparatus consuming over 4 or 5 kilowatts is best supplied from a separate network, either polyphase or multiple wire D.C.

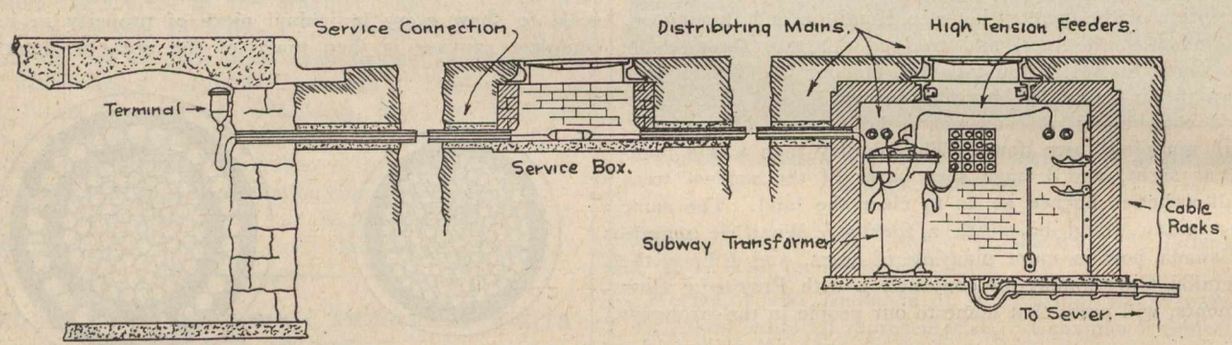
In business districts, conduit runs are located outside the curb. Throughout residence districts, however, that area between the curb and building line is often available, and the expense of tearing up, temporarily and permanently repairing the street is thus avoided, an item that may easily amount to 30 per cent. of the total cost of a particular run. Probably the type of duct most used in America is the well-known cam-single type. The objections to the multiple duct are found in the inflexibility of a conduit run constructed with them, difficulty of handling and of making joints. Fibre duct is coming into extensive use. It is extremely light; hence, cheaply transported and quickly laid. Furthermore, such material does not abraid cables drawn through it. In regard to encasement: Standard practice encloses all runs in three inches Portland concrete. At times, however, for suburban work, the sides of a conduit are left unprotected and the top covered with boards. The average cover over completed conduit may be taken as 2½ feet.

Manholes are built of brick or concrete. Where the soil is such that outside forms are unnecessary, and where a large number of similar manholes are to be built, concrete may show a saving over brick holes. Otherwise, brick construction is from 5 to 5 per cent. cheaper than concrete. The delay to the whole work occasioned by the many distinct operations and waits incident to all concrete construction is considerable in this class of work.

Service connections are made radially from shallow service boxes placed in intervals between manholes, intercepting the top row of ducts only. These services are run direct to consumer's basement. Armored cables laid in the ground without other encasement are used for this; also lead cable in single duct runs. Where distributing mains are on one side of a street only the expense of individual services may become excessive when it is usual to run a lateral to one property only, and hence through basement walls to several others.

Where the underground system connects with overhead leads, or for street lighting, the conduit is run to a point three feet from the pole, and iron or fibre bends connected to it through conduit castings. These bends, encased in concrete, rise to the surface in an easy curve of three feet radius, and either attached to lengths of exterior vertical pipe, or enter the interior of a built-up pole.

Turning to the consideration of underground cables: American practice is tending towards the universal use of paper-insulated lead-covered cables for all voltages. Not only is paper much cheaper, but for many purposes makes a better insulation than the 30 per cent. fine Para compound. The paper is wound spirally upon the conductor in layers of successively reversed lay. This core, after baking, is saturated with an oil of high insulating qualities, and finally enveloped in a lead sheath. Ordinarily, both legs of a single phase and all legs of a polyphase circuit, unless it be for arc lighting, are incorporated in one cable, with "split" insulation; i.e., suppose an insulating wall 10-32 in. thick be required between two conductors or between conductor and ground. Each conductor is covered to a thickness of 5-32 in. These cores are then assembled and wrapped with a belt 5-32 in. thick, the interstices so formed being filled with impregnated jute.



Sectional Elevation Showing Details of Distribution.

Armored cables to be laid in direct contact with the earth on the "solid system" have their lead sheaths served with a layer of prepared jute. This is followed by an armoring of iron or steel, strap or wire, a layer of jute saturated with a chemical and animal proof compound being added over all.

Joints on low potential cables may be of the patent or clamped connector type. The splice now most used, however, employs split tube connectors sweated to the bared ends of the wires. These joints are then taped, boiled out, and encased with a lead sleeve joined to the sheath by wiped solder joints. The intervening space is filled with hot insulating compound.

High potential underground cables we find in the form of substation feeders, which may run through conduit for their entire length or connect with an overhead transmission. To protect such cables from surges, caused either by lightning or by switching operations, it is customary to bridge the conductors at each terminus through a very high resistance, composed of air gaps and carbon rods in series, when an abnormal potential difference between any two conductors results in a discharge across this bridge rather than in a puncture to the cable insulation. Cumulative charges on the sheaths are prevented by thoroughly grounding the lead at several points.