NOTES ON THE ALTERNATING CURRENT SYSTEM OF DISTRIBUTION.

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Distributing systems are usually referred to under two headings—direct and alternating.

The direct current distributing system, starting in the early '80's and appearing generally in its three-wire form, is what may be termed a universal system, since from the same conductors, and without any modification whatever at the customer's service, current is furnished direct to any electrical apparatus, whether for supply of power, light or heat.

The alternating current distributing system, making its appearance in its single-phase form about the same time as the direct, never started as a means of universal supply, being confined in its earliest stages of development to the furnishing of energy for light and heat only. To the absence of the alternating current motor can probably be traced its restricted use and the early slow progress in this form of current supply. Had there been early developed a single-phase motor which would have met all the conditions of a direct current motor in construction, economy and cost, then there is no doubt but what the three-wire, single-phase alternating current system would have come rapidly to the front. As to whether it would take the place at the present time of large installations of direct current supply, might perhaps be doubtful, since the storage battery as a part of the general system is gaining ground and rapidly becoming indispensable.

The alternating current distributing system was first exploited as a house-to-house supply, and continued as such until within

recent years, when efforts were made to interconnect the secondaries to increase the efficiency and reliability of the system. It was soon found, however, that the paralleling of transformers in old systems already erected, through small secondary mains, was much like paralleling compound generators through a small equalizing bus, and many failures were the result. Steps were then taken to install mains of such a size as to make the drop or loss between two transformers negligible, and for a short time many plants operated successfully with transformers in multiple on fairly long secondary mains. As the demand for current on the mains increased, however, the change in the size of conductors was not followed up, and the old trouble returned. The system, to-day, therefore, has almost reverted to a house-to-house supply, although the transformers are arranged in groups, connected to secondary mains, and providing, in case of accident, for interconnection.

The only practical and successful method of paralleling transformers on secondary mains of distribution is the placing of each transformer or bank of transformers on a separate feeder and providing at the station means for regulation on such feeder, so as to make it possible to divide up the load on the different transformers and compensate for any difference in transformer regulation. Such a system is in successful operation in several large plants, and is productive of good results. When the alternating current system is permanently standardized the transformer will no doubt be considered a part of the feeder, only one transformer or bank of transformers being installed at a single distributing point of a single feeder.

As before mentioned, owing to the early absence of any commercial single-phase motor, there was no incentive to standardize and develop the alternating system, as has been done in the case of the direct, and it was not until the last few years that the alternating system, by the abandonment of the single-phase and the change to multiphase, approached anything like a universal system of supply. Up to the time of the appearance of the multiphase motor the development of motor business on alternating systems was very restricted, as the uses to which the single-phase motor could be put were more or less limited. On the other hand, the introduction of the multiphase motor necessitated a change in the entire system of distribution, and it is not until the last few years that single-phase has entirely given place to

multiphase systems; not, in fact, until it became apparent that the multiphase motor, under any stage of development, would prove superior to the single-phase. Probably the simplest multiphase alternating current distributing system which would be first thought of would be the two-phase, three-wire primary and three-wire secondary. Such a system might be satisfactory where light only is used and where the middle wire of the secondary system is always kept of proper size to maintain the balance, but there is no doubt that the better commercial form is the four-wire secondary, or in fact, the two phases taken directly from the machine to the customer's service. With the same number of conductors, a further saving of copper is secured by the use of the four-wire, three-phase. With either of these systems, where transformers are a part of the individual feeder, a complete interconnection of mains can be secured. When the supply from these secondary mains is introduced into the premises of the customer, necessity for installation of additional transforming apparatus arises. If the secondary be of a pressure of 110 volts between phases, either large motors must be installed at this pressure or step-up transformers used. In either case the mains must be very large to take care of this low pressure motor current, and especially when such multiphase motors are frequently stopped and started. If the secondary be of a pressure of 220 volts, the size of conductors can of course be reduced; but it is still necessary to install a transformer or balancing device if 110-volt arc or incandescent lamps are used.

With the object of simplifying the system, in many cases the multiple network of secondary mains has been omitted, and in their place a multiple network of primary mains substituted, the transformers being located on the premises of the customers. This reduces the system to a house-to-house supply and makes necessary the building of vaults or in other ways satisfying the insurance companies, as the full pressure is introduced into the premises of the customer. Such an arrangement necessitates an increase in the transformer capacity of the system, since the capacity of the transformers must be nearer the capacity of the connected load; whereas if grouped and the supply furnished through secondary mains, the transformer capacity can approach nearer the actual maximum load of the system.

In order to reduce the fluctuations of pressure in the lighting circuit, caused by large direct-connected alternating current mo-

tors stopping and starting, there have been devised several systems which provide separate means of supply for motors and for lights, by providing additional "power" conductors, but in nearly all cases such systems necessitate the installation of primary transformers on the premises of the customer. With a view of furnishing a single service to the customer without installing apparatus on the premises, there are one or two systems employing four or five low-tension conductors in the secondary, from which different combinations of pressure are secured for the separate operation of motors and lights, but such systems have not been put to extended central station use.

But if the alternating system has not yet attained the standard of a large distributing system for compact territory, it is nevertheless alone in its field of transmission and house-to-house supply in scattered territory, and yet even in these fields too much attention cannot be paid to the consideration of future permanent supply, there being many cases of its having been used as a very temporary means of "getting there." A generator is bought, a few miles of small-sized conductors erected, enough transformer capacity installed to supply the present wants, and the installation is complete and trouble begins. When extra transformers are required, they are purchased one by one in small sizes and connected to feeders already too small to carry the load. The idea of a change in the size of conductors never occurs, and soon the station manager does not think much of the alternating system, and by that time the public generally agrees with him. This state of conditions is due to the fact that the system has not been designed with an idea of permanency, and the future and uncalculated demand upon it completely destroys its usefulness. Such a state of affairs existed in the pioneer days of direct current engineering, the future demands seldom receiving the consideration which they warranted. Inspectors "determined" the system and visited every corner of the city, every private house, hotel, etc., and finally "determined" that the heaviest direct current mains in the business section should be 27,000 c. m. and the feeder 41,000 c. m. Three years later, in the same city, these mains were replaced by others of eight times the capacity, and were even then too small. Such was true of the simple direct current system, and it was even more true of the alternating system. The idea that the alternating high-pressure system saves copper, and that therefore it may be possible to save it all, has often brought about a final failure of a promising success.

What is required to-day, however, if the alternating current, besides retaining its field of transmission and scattered distribution where it is supreme, would enter the compact direct-current field of distribution, is :

First.—A standard type of motor, which can be used for all classes of business demand, and will meet the same commercial requirements as the present direct-current motor.

Second.—A universal system of supply which does not require transformers, etc., or anything outside of the meter itself, to be located on the premises of the customers.

Third.—Some apparatus which, in connection with alternating current, will take the place of the storage battery supply on the direct current.

With these requirements complied with, the alternating current distributing systems can expect to take the place of many of the large direct-current systems, not only for the supplying of light, heat and power but also for transportation.

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