

TWO WIRE DISTRIBUTING SYSTEMS AND LAMPS, 200—240 VOLTS.

BY JOHN W. HOWELL.

Distributing systems, operating at 200—240 volts with simple two-wire circuits, first attracted attention about four or five years ago. These early plants used two 110—120-volt lamps in series and were installed as a means of competing in cost of installation with three-wire plants without resorting to the alternating current system, with its disadvantages where motors are operated.

The growth of these plants was slow until the demand created by them led to the production of the 200—240-volt lamp and practical experience had shown the weaknesses of these lamps and led the makers to overcome the difficulties met in their manufacture.

What these weaknesses were, can be judged by the following extracts from previously published articles:

“The consensus of opinion at the present day of the average types of high-voltage lamps undoubtedly points to the fact that a large percentage are expected to short-circuit as soon as they are put up, and I have heard several engineers say that they expect about one in twelve to go in this way.”

“There is no doubt whatever that almost all the present day 200-volt lamps are only suitable for burning in a vertical position. As soon as any other position is adopted defects become prominent. The long thin filament soon drops onto the bulb and cracks it. Also electrostatic attractions, owing to higher voltage, cannot be resisted by the long thin filament, and this is an additional cause of the filament approaching the bulb.

The effect of electrostatic attractions on long thin filaments is even noticeable with lamps burning in a vertical position."

These are extracts from a paper read by Mr. G. Bingswanger Byng before the British *Institution of Electrical Engineers* on February 24th, 1898.

These defects have been entirely remedied, and the experience of many plants operating 200—240-volt lamps during the past year proves these lamps to be just as reliable in service as are 110-volt lamps. The development of the lamp has taken considerable time, and the growth of the 200—240-volt 2-wire system in spite of the shortcoming of the early lamp is due to compensating advantages in other elements of the system.

These advantages over the three wire system are—(1) cheapness of installation and (2)—simplicity of operation.

1.—Cheapness of installation of the 200—240-volt 2-wire system, when compared with the 110—120-volt 3-wire system, arises from the use of a single large dynamo where the three-wire system requires two, each having half the capacity; with the accompanying duplication of regulating apparatus, indicators ammeters, etc. There is also a saving of the entire cost of the neutral conductor of the 3-wire system, which conductor in street mains (as distinguished from feeders) and in house wiring, should be as large as the outside wires.

Three-wire plants in cities, whose business warrants the employment of the skill necessary to operate the system to best advantage, successfully use 110—120-volt 3.1 watts per candle lamps and get very excellent results from them. The 200—240-volt 2-wire system cannot be considered a competitor of the 3-wire system under these conditions since the best 200—240-volt lamp on the market to-day is a four watts per candle lamp. But it is my opinion that in smaller installations, whose conditions call for a 3.5 watts per candle lamp when a 110—120-volt 3-wire system is used, the advantages of the 2-wire 200—240 volt system are sufficient to offset the disadvantages of a 4 as compared with a 3.4 watts per candle lamp. Under normal conditions the performance of the present four watts per candle 200—240-volt lamp as regards life and maintenance of candle power is about 25 per cent. poorer than the present 3.5 watts per candle—110—120-volt lamp, but it is my opinion that the greater irregularities in pressure ordinarily found in the 3-wire plants we are now considering, as compared with the 2-wire plants operated under similar condi-

tions, fully counteract, by their injurious effects upon the lamps, the advantage in life and candle power which the 110—120-volt 3.5 watts per candle lamp has under normal conditions over the 200—240-volt four watts per candle lamp.

In considering the relative advantages of the two systems, in the case of moderate sized plants above referred to, we must charge against the saving effected in a 2-wire plant by its single equipment and omission of the neutral conductor, the increased capacity of machinery and conductors made necessary by a four watts per candle as compared with a 3.5 watts per candle lamp.

Considering the copper required by a 220-volt 2-wire system using four w. p. c. lamps as our unit, the copper required by the two outside conductors of a 110-volt 3-wire system using 3.5 w. p. c. lamps will be .875. The amount to be added to this for the neutral conductor will vary somewhat with location of the station with reference to the points of consumption. If we assume that one half the copper is installed for feeders and one half for the distributing mains, and that the neutral wire is one third the size of the outside wire in feeders and the same size in mains, then the total copper in the neutral conductors of feeders and mains will be 29 per cent. of the amount used in the 2-wire 220-volt system, and the total copper used in the 110-volt 3-wire system will be 16 per cent. greater than the copper used in the 220-volt 2-wire system. This comparison of the costs of copper does not consider the cost of wiring customers' premises, which is usually borne by the customer; it is, however, an advantage to the 220-volt system that this wiring will require at least 20 per cent. more copper for the 3-wire 110-volt system than for the 220-volt 2-wire system.

The 4 w. p. c., as compared with the 3.5 w. p. c. lamp, would require for the 200—240-volt 2-wire system, one seventh greater capacity of boilers, engines and dynamos than would be required for the 3-wire 110—120-volt system.

The duplication of apparatus required for the 3-wire system will only partly offset this increased cost in the 2-wire 200—240-volt system, but the cost of this duplication of apparatus, together with the increased cost of copper required, will in many cases make the cost of installation of the 3-wire system at least equal to that of the 200—240-volt 2-wire system, leaving the simplicity of operation of the 2-wire system to be balanced against the increased cost of fuel required to operate 4 w. p. c., as compared with 3.5 w. p. c. lamps.

During the time the plant is operated considerably below its rated capacity, which will probably cover even the maximum load during the first year of the plant's existence, and all but three or four hours per day at all times, I think the increased fuel consumption due to 4 w. p. c. lamps will not be appreciable because of the poor efficiency of boilers and engines with light loads, and the total increased consumption of coal during the year will, I believe, be a small consideration under most circumstances, and in my opinion not enough to balance the simplicity of operation above noted.

A few months ago I made a trip through some of our central states, visiting a number of 200—240-volt plants to get a knowledge of the practical workings of the systems from the persons actually operating them, hoping to get from their experience, information concerning existing conditions which would be of value in the lamp factory.

Naturally, my first questions to the man who operated the plant concerned the lamps; were they generally satisfactory? were they long lived? did they ever explode? I was greatly pleased with the answers I received. The lamps were reported to be almost universally satisfactory. They were very long lived, in fact too long lived, for better service would be rendered if the lamps were renewed when they began to get dull, and not allowed to remain in service after they ceased to give a first class light.

These 4 w. p. c. 200—240-volt lamps may be used for 600 hours and still give a good light, but I think this is about the limit of their useful life. If not taken in they will keep on burning for a long time and will give an average life of over double that figure before breaking.

The reports concerning exploding were equally satisfactory. For the past year or more, exploding lamps had been practically unknown; previous to that time, however, this had been one of the most serious objections to the system.

All these plants have been installed with switches, cut-outs, and other appliances made for 110—120-volt installations, and it is remarkable how little trouble has been caused by them.

Sockets.—Ordinary key sockets have been freely used and experience has shown the Edison screw socket and lamp base to be preferable to other types. Some engineers recommend keyless sockets and good snap switches, to avoid possible failure of the key socket to break the circuit.

In order to get the desired factor of safety, the General Electric Company has recently developed a special key socket for this work, having a break-gap twice as great as the sockets designed for 110—120-volt systems, and having a fibre insulating lining between the outside shell of the socket and the screw shell which is connected with the circuit. This fibre lining projects sufficiently beyond the screw shell to prevent contact with the circuit when the lamp is in the socket. The lamps are provided with short bases designed to be completely covered by this fibre lining, so it is impossible to get a shock by touching the lamp when it is burning.

Flexible Cord.—Flexible cord has been freely used, and is all right if the best quality is used. For this purpose the conductors should be covered with rubber $\frac{1}{32}$ " thick and the outside covering should be silk, or if cotton it should be slicked with a compound which makes it non-inflammable.

Rosettes.—Rosettes designed for 110—120-volt circuits having fuses, have given a good deal of trouble, so it has become good practice to leave out the fuse wire and put copper wire in its place thus having no fuse between the lamp and the fuse block close to the switch controlling the circuit.

The General Electric Company has produced a new porcelain rosette with fuse wires over one inch long, which have been severely tested with very satisfactory results. Their use with fuses will give protection to individual lamps, which is very desirable, as it increases the safety of the wiring.

Cut-outs.—Fusible cut-outs designed for 110—120-volts, have failed in many instances, and have often proved much more fusible than their makers expected them to be.

A complete line of fuse blocks carrying special 200—240-volt fuses has been developed recently by the General Electric Company. These are fitted with the cartridge type of fuse, the fuse being contained in a tube which is provided with brass terminals which fit in spring clips on the fuse block. The fuse wire is inside the tube and is soldered to the brass terminals. The tube is then filled with a plaster compound which smothers the arc formed when the fuse blows. These fuses have been severely tested with 500 volts, and currents many times their rated capacities, and have always opened the circuits without a flash.

Switches.—Standard knife switches or quick-acting snap-switches having large break distances, should be used. Such switches specially designed for 200—240-volt installations are now being developed.

Wiring.—Standard methods of wiring for 110—120-volts are approved for 220—240-volts. Good rubber covered wire run on porcelain knobs or cleats is specified by the fire underwriters.

Arc Lamps.—Good arc lamps burning two in series on 220-volt circuits are on the market. Each lamp is provided with an automatic cut-out which throws an equivalent resistance into the circuit when one lamp is extinguished, thus permitting the use of one lamp if desired.

Future.—The future of the 200—240-volt system depends largely upon the development of a more economical lamp. All other elements of the system can be made entirely satisfactory with the means and knowledge now at our command, but the production of a more economical lamp calls for an advance in the art of lamp manufacture. That this advance will be made and a more economical lamp will be produced, I have no doubt, and hope to see such a lamp placed upon the market at an early date.

DISCUSSION.

PROF. GEO. D. SHEPARDSON said that high-voltage systems should be planned with an ample reserve of generating machinery for the following reasons: First, that high-voltage lamps are of low economy, generally 4 watts per candle-power initial, and, on account of the difficulty of getting a sufficiently high resistance, are generally of large candle-power, starting at 18 or 20 and running up to perhaps 22 c. p., making a double increment of the load. The dynamos must, therefore, not only be 25 per cent. larger because of the inefficiency of the lamp, but about 20 per cent. more on account of the increased candle-power of the lamps. He thought that the disparity between the 110 and 220-volt lamps was likely to remain, since any improvement in the one would effect a similar improvement in the other. One reason for the comparative perfection of the 220-volt was the very difficulty in manufacturing, since only the best manufacturers could solve the problem at all, while anyone could make a 110-volt lamp. The illumination of 220-volt lamps is, as a rule, steadier than that from 110-volt lamps, since, with the same voltage regulation, the candle-power varies much less in lamps of the lower economy.

MR. H. H. HUMPHREY stated that the rate of improvement of the 220-volt lamp was much faster than that of the lower voltages, and that the difference between the two would, in his estimation, soon vanish. While one year ago it was difficult to get any guaranty or even promises from the lamp manufacturers, his company has lately ordered 10,000 lamps with guaranties nearly as good as can be obtained for 3.5 watt 110-volt lamps. The guaranteed life was just as high, but the drop in candle-power was allowed to be a little greater.