source is quite important, as the other colors in the heated filament may be noticeable. Some railroads are now using the improved types of purple glass and are obtaining an improved indication.

Aerial Cable Versus Open Line

"What are the advantages or disadvantages of aerial cable as compared with open line wires for line circuits on automatic signal territory or coded C.T.C. territory?"

Would Consider Cable for C.T.C. Code Wires

C. A. Taylor
Superintendent of Telegraph and Signals
Chesapeake & Ohio, Richmond, Va.

The general practice on the Chesapeake & Ohio has been to use open line wires in automatic-signal territory, especially where the number of wires required could be carried on one crossarm. In the majority of cases where more than one crossarm has been required, we have used aerial cable rather than installing a second arm. However, we have had but few cases where the pole line was in such condition that a second arm could be added without rebuilding the line.

There is no question in my mind but that the use of aerial cable in place of open line wire, especially in territories where the wires are subjected to heavy sleet storms, provides more dependable service. However, there is a question as to whether the additional expense of the aerial cable would be justified in most instances.

It is our practice to use copper-covered steel weather-proof line wire for signal circuits, and, with our pole lines being maintained in good condition, little trouble resulting from breakages of the wire has been experienced during bad weather in winter months.

We have never installed any long stretches of C.T.C., but if we should ever have occasion to make an installation of this kind in territories where there are usually severe sleet storms, we would probably consider very seriously the use of aerial cable for the code wires. We feel, however, that before definitely deciding which type of construction should be used, a check would have to be made as to the number of sleet storms that had occurred in that particular territory in recent years. From this study we could then determine whether we would be justified in spending the additional money that would be required to place the code wires in cable, as against installing open line wires.

Advantages More Important with C.T.C.

J. H. Schubert
Signal and Telephone Engineer
Nashville, Chattanooga & St. Louis
Nashville, Tenn.

The advantages of aerial cable are as follows: Fewer interruptions from breaks due to wind and sleet, and less liability of trouble from crosses, grounds and lightning. These advantages are considerably more important in C.T.C. territory than in automatic signaling.

The disadvantages of aerial cable are the comparatively high first cost and possible trouble from being damaged by shots or bullets.

Open Line for Coded C.T.C.

B. J. Schwendt
Assistant Signal Engineer,
New York Central
Cleveland, Ohio

The advantages and disadvantages of open line or cable in connection with C.T.C. are quite fully discussed in my article on page 31 of the January, 1930, *Railway Signaling*. At that time unit-wire controlled C.T.C. was in mind, involving a greater number of conductors, and cable was recommended. In the meantime, coded C.T.C. has come into use, and the total number of line conductors as a result has been materially reduced. This changes the problem in favor of open line wire, as many of the conditions justifying cable instead of open line wire, pass out of the picture.

In addition to this, I believe it would require a special design of cable or a "loading" of cable circuits in order to overcome the capacity effect on impulses transmitted over long distances. For short distances (10 or 15 miles) this would probably not be difficult or cause any extra expense.

Disadvantages Are Few

W. F. Zane
Signal Engineer, C. B. & Q., Chicago

The advantages of aerial cable, as compared with open line wire, considerably outnumber the disadvantages. Aerial cable suspended in rings on messenger, with the messenger grounded at frequent intervals, practically eliminates lightning trouble from the line. This results in a saving in avoiding damage to the apparatus and in reducing train delays.

The installation of aerial cable also greatly strengthens a pole line, which reduces the chances of the signal conductors being out of service and helps to keep the telegraph and telephone conductors in service during storms. During storm trouble, even if the pole line goes down, an aerial cable can be kept in service by hanging it on a fence or laying it on the ground.

The construction of aerial cable is such that the C. T. C. control circuits are protected from crosses with telegraph or other current-carrying wires. In numerous cases sleet will break and tangle the wires above the cable and wind them about it, but no shorts or grounds develop.

Another source of trouble, prevalent in territory with which I am familiar, is that of persons along the right-of-way throwing pieces of baling wire into the line. If the conductors are non-insulated, or if the insulation is old and off, the baling wire causes a cross in the signal circuits; an aerial cable installation eliminates this trouble.

The disadvantages in the use of aerial cable may be classified under one heading, namely, some one shooting into it. Such cases are not frequent enough to be considered prevalent. The painting of the cable may be thought of as a disadvantage, but my experience has been that the cost of painting, about once every six or seven years, is the only necessary maintenance, and is less than the maintenance of open line. Aerial cable, I believe, is preferable for C. T. C. use, as it completes an installation in a permanent way.

Cost Considerations Decide

J. P. Muller
Signal Engineer, Boston & Maine
Boston, Mass.

It seems to me that there are very few facts that can be definitely stated concerning the use of open line wire or cable. However, the following is my opinion of the uses of both.

The use of aerial cable, or of open line wire would depend primarily on the number of conductors, the location of the pole line and the density of traffic. If more than 10 conductors were required, aerial cable would appear to be the choice, while for a smaller number of conductors it may be advisable to use open line wires. The initial cost of the two

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types of construction as compared to the total cost of the signal system, together with the character and location of the existing pole line, cost of maintenance and future changes in circuits would be the deciding factor.

In dense traffic zones where the circuits require a large number of wires which may be subjected to heavy storms, I believe aerial cable in the long run will be more satisfactory and more economical, especially where telegraph and telephone circuits are of the open-line type construction. Communications may be cut off, in which case the signals must operate to keep trains moving.

Booster Transformers on Signal Lines

"Under what circumstances is it advisable to use a booster transformer in a signal power distribution line? In general, what are the limitations of this method of voltage adjustment?"

Applicable in Some Cases Involving Intermediate Loads

C. E. Stryker

Chief Engineer, Fansteel Metallurgical Corporation, North Chicago, Ill.

The use of booster transformers should be avoided except where line conditions make their use imperative. Booster transformers are usually located some distance from the point of power supply and are used to raise the voltage at the point of utilization to the desired value. The need for raising voltage usually results from excessive line drop.

Wherever possible, the line drop should be reduced. If it is caused by low power-factor loads the line current can be reduced by improving the power-factor by the use of condensers. If the line drop is due to excessive load the transmission voltage can be increased, as from 230 to 460, thus decreasing the line current and hence the voltage drop.

Even where the difficulty is not due to low power-factor and the transmission voltage cannot be increased it is better to supply a higher voltage at the feed than to use a booster at the load end. An arbitrary example will make this clear. Power is supplied at 230 volts over a line of No. 6 copper to a load of 1,000 volt-amperes three miles away. If a booster transformer is used at the load end the voltage at the line terminal will be approximately 135 and the line current about 7.5 amp. If, instead of using a booster, the supply voltage is increased to compensate for the line drop, the line current will be about 4.5 amp. It is apparent that the power loss in transmission is nearly three times as great when using the booster as it is using higher supply voltage.

One condition, which is unfortunately of common occurrence, in which the use of a booster is the most practical solution arises where there are loads intermediate between the power source and the location at which low voltage prevails. Here it is not feasible to increase the supply voltage because that would result in excessive voltage at the intermediate locations. In such cases, the booster is located at the point at which the voltage has dropped as low as can be utilized satisfactorily. The ratio of the booster should be such that it will step up the voltage obtained at the point to approximately the voltage at the source of supply.

In calculating line drop so as to determine the proper booster ratio, it should not be forgotten that since the booster is a step-up transformer (usually an auto transformer) it will draw a higher current from the supply line in proportion to its ratio.

Usually Not Advisable

Wilmer Welsh

Circuit Engineer, C.C.C. & St. L. Cincinnati, Ohio

The use of a booster transformer on a signal power-distribution line is not advisable except as a temporary expedient where the line voltage is too low to supply adequately existing loads or where additional loads or a line extension are required. The load must be fairly constant, else at times of light load the line voltage may become excessive. If a fuse is burned out on the primary side of the booster while the secondary is carrying current, there is some danger that a voltage may be induced in the booster primary sufficiently high to cause an arc across the opened fuse and break down the insulation.

The limitation of this method of voltage adjustment lies chiefly in the allowable current-carrying capacity, for satisfactory voltage regulation, of the wires leading from the source of power to the booster. In this section of the line, the current is the sum of the load current and booster losses.

Because of the objectionable features of the booster arrangement, other measures to improve line-voltage regulation are usually preferred. Where leakages or other line defects occur they should be corrected. Efficient transformers and other apparatus should be used, and these should be limited in capacity and number to meet, but not greatly exceed, existing requirements.

Where the power-factor of the line is low, capacitors may be used to balance the reactive component of line current and reduce the resultant line loss. As a last resort, it may be necessary to string larger wires, raise the voltage of transmission, change from single to three-phase operation, or take power from another source.

Try Capacitors First

Harry M. Jacobs

Commercial Engineer, General Electric Co. Schenectady, N.Y.

It is assumed that the questions have reference to a method of compensating for an excessive voltage drop in a medium-voltage signal power-distribution line. Excessive voltage drop is due to excessive line current. If, after a thorough diagnosis, it is found that the high current is the result of low power-factor, capacitors properly installed will reduce the line current and hence reduce the line voltage drop.

If the application of capacitors will not produce a sufficient improvement, or if the power-factor is not low, booster transformers might be used advantageously. Capacitors add no appreciable load to the line, but a booster transformer imposes about the same additional load as a line transformer of corresponding wattage capacity. In some instances the addition of the booster transformer load may increase the voltage drop to such an extent that no voltage increase will result and therefore great care should be taken to select and properly locate booster transformers.

With these conditions in mind, our answers to these questions are as follows:

1. Booster transformers should be considered only after it has been determined that the application of capacitors will not sufficiently reduce the line voltage drop.

2. The load of the booster transformer will reduce the anticipated voltage increase and the ultimate limit is reached where the two are equal in which case the transformer is ineffective.