some extent as the frequency increases, for $\omega = 2\pi \times$ frequency. The quantity ωL is known as the "reactance," and the quantity $\sqrt{(R^2 + \omega^2 L^2)}$ is known as the "impedance." The relation between these quantities is clearly shown in Fig. 55.

A REVIEW OF MODERN SIGNALING PRACTICE ON AMERICAN RAILWAYS.

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A review of the conditions existing in the United States at the present time, with reference to the operation of switches and signals, develops the following:—

Centralized installations for operating switches and signals are limited to (1) those in which the required movements of the functions are made by manual force through mechanical connections brought to a central point, and (2) those in which some form of stored power is controlled from a central point for such operations.

The first is represented by the mechanical interlocking mechanism which is in such general use throughout the world as to require no particular description. There has been, in America, very little, if any, change in the details of the apparatus or of its installation for a number of years. The use of 1-in. pipe connections is universal for the operation of switches, movable point frogs, draw-bridge couplers, and their respective locks, compensated for the effects of temperature changes by an equalizing system of cranks and levers. It is also very generally used for the operation of home signals. Wire connections (one wire for the front connection and one for the back) are still used for the operation of distant signals which can be located not over 1,300 to 2,000 ft. from the tower. But when the signal has to be located at a greater distance, liquid carbonic acid gas (stored in steel bottles) or electricity (derived from a battery) is used as the source of operating power, located at the signal and controlled electrically from the tower.

The second comprises those in which hydraulic, pneumatic, or electric power is stored and used for the operation of the various functions. Owing to the severe climatic conditions which continue in winter for from two to four months throughout the northern portion of America the use of hydraulic switch and signal apparatus is subject to such derangement and such interruptions in operation as to be very unsatisfactory. A small number of plants of this type have been installed but have been discontinued and replaced by other kinds which are free from the troubles which are inseparable from the use of liquids as a means of power transmission under such climatic conditions.

The use of compressed air has been quite extensive and has given a very fair degree of satisfaction as the means for operating switch and signal installations in this country. This kind of power application is represented by two types: (1) low pressure, in which the air is used at a pressure of from 15 to 25 lbs. per sq. in., and (2) high pressure, 80 to 100 lbs. per sq. in.

The low-pressure type has many points of excellence, but for some reason has not become very popular, probably on account of the great number of pipes leading to the switches and signals. Inquiry develops the fact that no plants of this type have been installed since 1905 anl also that, as the existing plants require extensive reconstruction or renewal, this type is giving place to some form of all-electric apparatus.

The high-pressure type is represented only by the Westinghouse electro-pneumatic system. A very large number of plants at large and complicated junction points and terminals have been installed and are in very satisfactory operation throughout the entire country. It is a recognized fact, however, that compressed air under high pressure is subject to a number of characteristic losses in efficiency, which will limit its use. The loss on account of the heat generated, due to the work of compression, is unavoidable and amounts to from 50 to 60 per cent. of the energy expended in storing this kind of power. The losses due to leaks in the distributing pipes are variable but increase as the system grows older, and often become an element of serious expense, necessitating extensive repairs and renewals.

The application of all-electric interlocking plants has made rapid strides in the last eight or ten years and, as this type offers very superior advantages, it bids fair to take the lead. The reasons for this are: (1) greater flexibility in application and use; (2) in the storage of the power and its distribution the losses can be reduced to a very small figure; (3) the distribution and application of the power is free from any inherent troubles due to variations or extremes of temperature.

This type of interlocking development is represented by the product of four principal companies. The common feature in all of the designs is the use of motors for the movement of switches by means of gears, a screw, a worm or by a cam motion plate, any one of these mechanical devices being susceptible of development to meet the requirements. Signals are operated generally by motor-driven gears, dwarf signals sometimes being operated by solenoids.

All power interlocking is arranged so that the completion of the movement of the switch or signal gives a return indication at the machine in the tower, releasing the mechanical locking and insuring that the position of the switch or signal, as the case may be, corresponds with that of the operating lever.

The locking between the levers of the machine is mechanical, being generally of the same type as that for mechanical interlocking plants, though not made nearly so heavy, not being called on to withstand such applications of force as is usual in the manipulation of mechanical levers.

Electric locking of the levers in the interlocking machine may be arranged to effect the following in either mechanical or power operated plants:—

(1) Advance Locking.—This is generally used at points where trains pass at high speeds to prevent the taking away of the route which has been cleared for an approaching train, the switch levers remaining locked until the train has passed or until the signalman has operated a releasing device which is arranged to take time, thus requiring deliberation and giving an interval during which the train can be stopped. The signal levers are never included in this advance locking but can, in their proper rotation, be restored to their normal positions at any time.

(2) Detector Bar Locking.—Electric locking is used for this purpose in connection with track circuits in yards where such circuits are used in place of mechanical detector bars.

(3) Route Locking.—This form of electric locking is used to lock all switches in a route so that they cannot be moved in advance of a train after the train has accepted the route, even though the mechanical locking on the machine has been released by the leverman in placing his signal lever in the normal position.

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