Remote Supervisory Control.

THE importance of the service provided by utility undertakings of all kinds demands that the most efficient methods of control be employed throughout. In electricity supply networks, water undertakings and sewage disposal plants, to mention typical instances, generally consisting of a number of stations, unified control is essential if the highest degree of co-ordination is to be maintained between all points. When, in new or existing undertakings, personnel stationed at outlying points is responsible, either on its own initiative or under instructions from the central station, for the operation of local plant, considerable administrative advantages result from employing a system which automatically maintains the central station fully and instantaneously informed of conditions and changes throughout the undertaking. Such a system incorporates means for telephone communication and provides assurance by suitable displayed signals that instructions have been correctly interpreted and carried out, giving also immediate indication of fault conditions in the plant.

Whilst the supervision thus afforded may suffice for the efficient control of undertakings in which outlying stations are staffed, considerable economy and operating advantages may be obtained by extending the scope of the system to include actual control of the apparatus at the remote points. Particularly is this so in the case of unattended stations, which otherwise require that visits be made by control personnel, with consequent delay in effecting the desired change in plant conditions. By installing a system which combines supervision with remote control of plant, *i.e.*, a system of remote supervisory control, maximum operating efficiency is obtained since the control engineer is always fully informed and may himself effect changes in circuit breakers, transformer tappings, field regulators, sluice valves, in fact, all the variable apparatus included in the undertaking.

Perhaps the most notable example of a large undertaking employing modern administrative methods is the Grid of the British Central Electricity Board. The numerous generating stations feeding the Grid are supervised from control centres by automatic means, whilst a number of stations in the various areas are controlled and supervised with complete success without any personnel on the premises. The General Electric Company, pioneers of the modern form of remote supervisory control, contributed largely to the equipment employed on the Grid and have supplied also many other installations expressly designed for smaller local undertakings.

The outline of the operation of the G.E.C. remote supervisory control system given in the following pages will enable future references to newly-completed installations

to be readily understood. The description given relates to the control of an electric power distribution network, since this is the more common application.

Substation plant to be remotely controlled and supervised is of the electrically operated type and is fitted with auxiliary contacts to enable indications to be sent to the control point. Lamps and electromagnetic indicators at this point display the state of all switchgear, whilst associated keys are operated as required to cause the appropriate equipment to function at the substation. For the purposes of remote supervisory control the substation is linked to the control station by pilot wires. Control could be effected by employing a pilot wire for each operation and indication but such a practice would almost always result in a total of pilots that would be completely uneconomic. A minimum number of pilots is made common to the various operations and indications by installing equipment capable of selecting the apparatus to be operated at the substation and the corresponding indicating device to be operated at the control point.

Selective apparatus must be completely reliable, rapid in action, require a minimum of maintenance and be inexpensive to a degree that maintains the economic advantage of the reduction in pilot wires. These requirements were fully met for the first time when the apparatus employed in automatic telephone practice was applied to remote supervisory control. By employing selective equipment of this type the number of pilot wires in the G.E.C. remote supervisory control system is a minimum of two, two, three or four being used depending upon the number available in any given instance. Over these wires are obtained control of switchgear, indication of the state of such gear, meter readings and telephone communication.

The system may also be operated over pilot wires in use for other purposes, whilst a notable example of its application is on a power distribution network where it is operated over carrier current channels superimposed on the power lines, thus dispensing entirely with pilot wires.

An unlimited number of stations can be controlled from one point, the stations being linked by the pilot wires either in tandem or radially as geographical layout dictates. The fundamental principle is unaffected and also remains largely the same whether operation is effected over two, three or four pilots since pilot wire termination apparatus is installed to suit.

The process of selection of apparatus will be clear from the following and it will readily be understood that by a similar process any substation may be selected. In Fig. 1, therefore, is illustrated in simplified form the normal circuit conditions at control and substation, the assumption being made that the latter has been selected. The maximum of remote control apparatus is required when operation is performed over the minimum number of pilots, a two-wire system requiring more terminal apparatus than is shown in the three-wire system of Fig. 1. This description, however, gains in clarity by being applied to a three-wire system since terminal apparatus is simplified.

As a typical example a circuit-breaker is shown as the object to be controlled and supervised. On a panel at the control station, on which appears a mimic diagram of

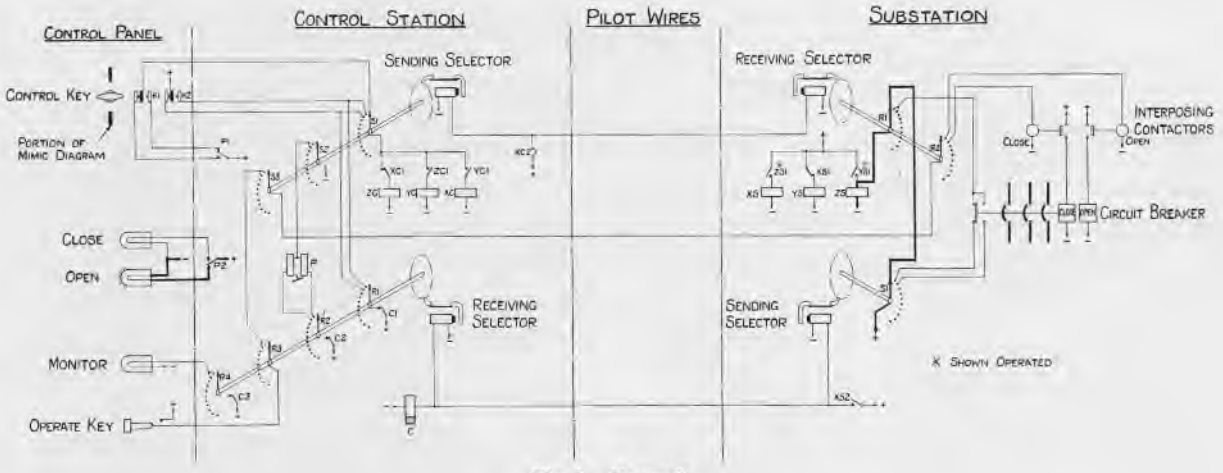

Fig. 1.—Normal.

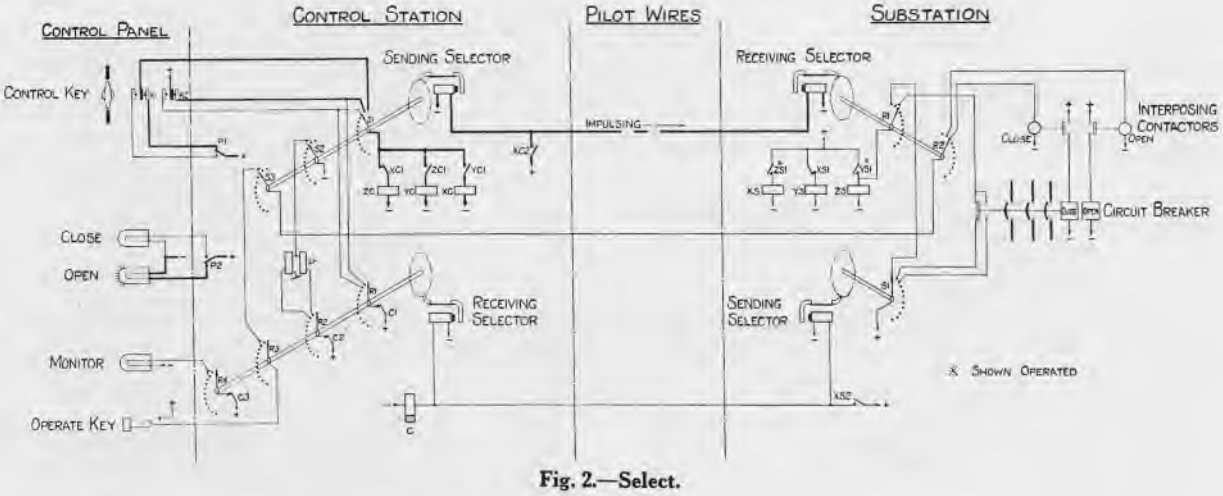

Fig. 2.—Select.

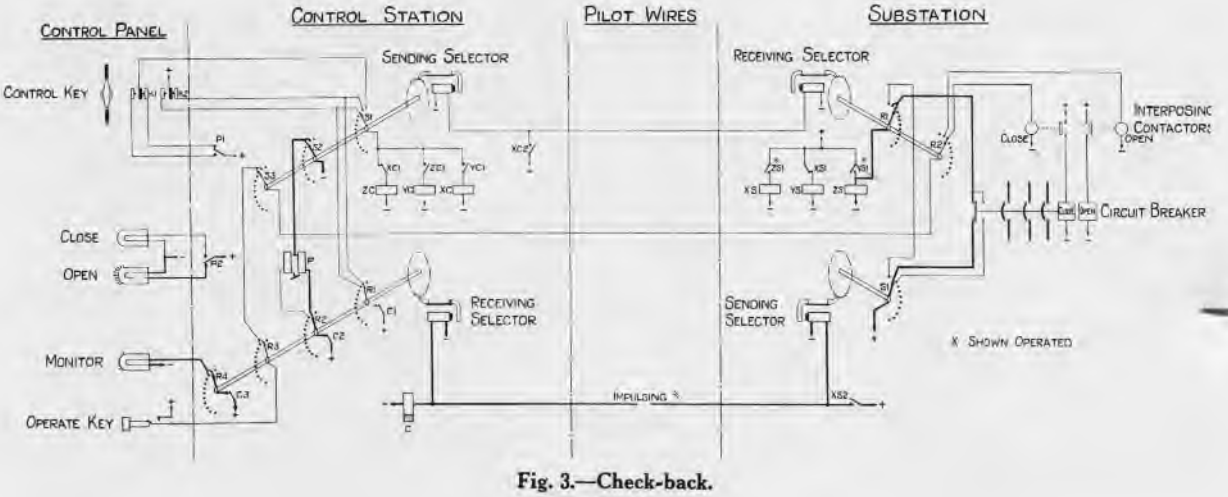

Fig. 3.—Check-back.

the whole power system, this breaker is represented by a key and three lamps. The key is so positioned on the panel that the handle appears in the line in the mimic diagram representing the appropriate power line and is thus at once identified as being associated with that particular breaker. Of the three lamps, one is coloured green and glows to denote that the breaker is open, a second, red, denotes that the breaker is closed, whilst the third is coloured white and is a monitoring lamp.

The circuits established with conditions at normal are shown in Fig. 1 by heavy lines. It will be seen that the "open" lamp glows and that, at the substation, relay ZS is held operated over a circuit via wipers R1 and S1 of receiving and sending selectors respectively. It will also be observed that the handle of the control key interrupts the line representing the power transmission line.

Selection.

When the control engineer wishes to close the breaker the control handle is turned in alignment with the mimic diagram line as shown in Fig. 2. The circuits established are again shown by heavy lines. With key contacts K1 and K2 operated, positive is extended via contact P1, contact K1, wiper S1, contact XC1 to relay ZC. This relay is one of a trio which forms an impulsing chain to step the control station sending selector and substation receiving selector as follows: contact ZC1 operates relay YC; contact YC1 operates relay XC; contact XC2 energises the driving magnets of the two selectors; contact XC1 releases relay ZC; contact ZC1 releases relay YC which in turn releases relay XC; when contact XC2 restores to normal, the selectors are de-energised and take one step. With wiper S1 standing on the second contact, a circuit is again completed for the impulsing chain, the cycle is repeated, and the two selectors step to the third contact. On this contact the sending selector no longer establishes a circuit for the relay chain and impulsing ceases. Thus the circuit conditions at the control station when this control key is turned to the "close" position cause the receiving selector at the substation to step to the third contact, to which is connected (on arc 2) the interposing contactor to close the circuit breaker. Correct selection has therefore been carried out but before actual operation is effected a check-back signal in confirmation is given on the monitoring lamp.

Check Back.

When the receiving selector stepped from the first contact the circuit holding relay ZS was broken. Relays ZS, YS and XS form the substation impulsing group; with the removal of the hold on ZS the group operates in a manner similar to that of the group at the control station. Contact XS2 steps the substation sending and control station receiving selectors (Fig. 3). With the sending selector on the second bank contact a holding circuit is again established for relay ZS and impulsing ceases. Relay C at the control station is slow to release and held during impulsing, releasing when impulsing is complete. Contact C2 holds relay P in a position which maintains a circuit for the "open" lamp via contact P2. Contact C3 lights the monitor lamp associated with the breaker to provide confirmation that the correct breaker has been selected for operation.

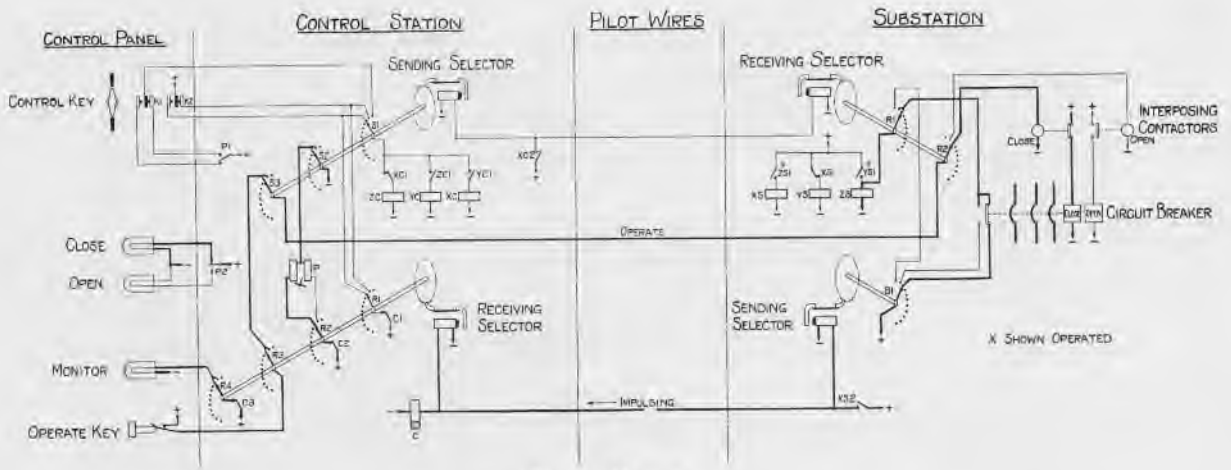

Fig. 4.—Operate.

Operation.

The selectors are now positioned on contacts which prepare a circuit for the "close" interposing contactor. Having received the check-back signal the control engineer depresses the common "operate" key to operate the interposing contactor and close the breaker (Fig. 4).

When the breaker closes, the auxiliary contacts change over and break the circuit which, in Fig. 3, held relay ZS. The impulsing group thus operates again and at contact XS2 steps the sending selector at the substation and receiving selector at the control station. After taking one step, however, wiper S1 re-establishes the hold circuit for relay ZS and impulsing ceases. The one step taken by the control station receiving selector in sympathy positions wiper R2 on the contact connected to the second coil of relay P. This relay operates and at contact P2 extinguishes the "open" lamp and lights the "close" lamp. Operation and indication are thus complete.

Summary.

The foregoing may be summarised and amplified as follows: whilst only one is shown there are other breakers and similar apparatus to be operated and these are connected, via interposing contactors, to other contacts on the second arc of the substation receiving selector. Similarly their control keys are connected to corresponding contacts on the sending selector at the control station. When a control key is thrown the sending selector steps to the contact marked by the key, and the substation receiving selector steps in sympathy to a contact connected to the appropriate apparatus. Whilst this latter selector steps, the substation sending and control station receiving selectors also step, the position taken up depending entirely on the position taken by the substation receiving selector. If the correct apparatus were not selected, that is, if this receiving selector were incorrectly stepped, then the position occupied by the control station receiving selector would not be such as to permit a circuit to be established to light the monitor lamp adjacent to the control key operated. The absence of the check-back signal on the monitor lamp would denote incorrect selection, and even if the warning were ignored, depression of the "operate" key would be ineffective. Correct