

THE USE OF AUTOMATIC MEANS FOR DISCONNECTING DISABLED APPARATUS.

BY H. G. STOTT.

This subject may preferably be divided into three sections, as follows:

- (a) Generating apparatus.
- (b) Transmission apparatus.
- (c) Receiving apparatus.

(a) *Generating Apparatus*.—That no overload device should be used in the generating plant to disconnect disabled apparatus may be stated as a general proposition.

Experience has probably been responsible for the evolution of the art to a point where it has become not only possible, but necessary to eliminate all overload devices.

Only a brief statement of the reasons for abandoning the use of overload apparatus will be necessary.

In case of an accident to one generating unit, the other units in multiple with it will immediately begin to force current into the disabled one, and the increased load on the good units, due to their normal load plus the short-circuit current supplied to the crippled unit will, in all probability, trip all the circuit-breakers simultaneously, thus interrupting the service.

Without automatic circuit-breakers the overload on the good units would cause the potential of the system to fall so low that the service would, in all probability, be as completely interrupted as in the former case, unless the attendant succeeds in locating and disconnecting the crippled unit immediately.

Should he fail to do so, the service will inevitably be interrupted, and a great deal of damage done to the crippled unit by the current from the good machines.

It is then evidently necessary to have some means of discriminating between a current coming out of the machine and one going into it. Modern apparatus can safely carry 200 per cent. or more load for a few minutes, but if a unit has become crippled it will immediately cease to be a generator and become a receiver. All that is necessary to do then is to install on each generator a suitable circuit-breaker which will operate *only* when the direction of flow or energy through it is reversed.

This type of safety device has been developed for both D.C. and A.C. apparatus so that it operates quite satisfactorily.

As an additional precaution in large plants, a second reverse-current relay should be installed which will merely light up a letter or number in front of the operator so that in the event of the failure of the first automatic device the faulty machine may be quickly disconnected by hand. These reverse-current relays should have a time-element and current-limit attachment, which should be set for not less than three seconds, so that a slight reverse current, or one of momentary duration, such as is liable to occur at the moment of multiplying, will not operate the circuit-breaker.

(b) *Transmission*.—When transmitting power through overhead and underground cables, it is essential to successful operation to be able automatically to disconnect the feeders from (1) the generating station, and (2) if there are duplicate transmission lines, from the receiving station.

(1) At the generating station this should obviously be done by an overload circuit-breaker whose operation is delayed by a time-element which may be set at from one to ten seconds according to the local conditions.

This is all the protection necessary or desirable where only one transmission line exists.

(2) With two or more transmission lines in multiple, an entirely different set of conditions exist as in case trouble develops in one, current will be fed back from the receiver end into the fault through the good feeders; the result will be that all the feeder overload breakers at the generating station will trip, thus shutting down the entire line and, in all probability, shutting down all synchronous receivers on the system, due to the resultant fall in potential.

Reverse-current relays at the receiver end of the feeders operate satisfactorily, provided the fault is not severe enough to drop the potential.

If, however, the fault amounts to a short-circuit the potential at the receiver end will fall so low that the potential coil of the differentially-wound relay will not receive enough current to enable the relay to operate.

Reverse-current relays on the receiving end of feeders are not as yet to be depended upon, but recent improvements give promise that we may soon expect to find a satisfactory solution of this important problem.

When only two feeders are in use a method devised by Mr. L. Andrews, of England, seems to be very satisfactory. At the receiver end the two feeders are connected together through a choking-coil wound entirely in one direction. The current is drawn from a tap in the centre of this winding. Under normal conditions the feeders supply equal current through each half of the winding to the tap, but as the currents pass in reverse direction through the winding the resultant flux is *nil* and, therefore, the resultant inductance is *nil*, the only loss being that due to the ohmic resistance of the coils.

Should a short-circuit occur in one of the lines, the current from the other line will flow through both halves of the reactive coil in the same direction, thus producing a strong choking effect and limiting the current to an inconsiderable amount.

As the overload circuit-breaker on the faulty feeder at the generating station will trip immediately, it is then only necessary for the attendant at the receiving station to open-circuit the section of the reactive coil connected to the faulty cable and short-circuit the other half connected to the good cable. This device, I am informed, has given excellent results in England, but for obvious reasons would not be suitable for more than two feeders.

Where possible, the safest plan at present is, in the writer's opinion, to run the feeders entirely separate at the receiving end, only putting the D.C. end of the rotaries in multiple, or in cases where low tension alternating current (2000 volts or less) is supplied, putting the secondaries in multiple. If, under these conditions, reverse-current relays are installed at the receiving end of the feeders they will operate very satisfactorily as the reactance of the rotaries and transformers will be sufficient to limit the reverse current in the faulty cable, thus allowing the

reverse-current relays to operate as there has been no serious fall of potential.

The greater the number of feeders used between the generating station and the substation the better this method becomes, as, for instance, with two cables a fault in one will only reduce the capacity 50 per cent. until the operator can synchronize all the apparatus, which was running on the faulty cable, and as the apparatus and converters will continue to run at full speed only a few minutes will be necessary to synchronize on the good feeder, which will in the meantime carry the whole load, so that no interruption to service will occur. With three cables this would mean a loss of capacity of 33.3 per cent., and with four cables 25 per cent., etc.

(c) *Receiving Apparatus*.—This should be treated in exactly the same way as the generating apparatus, namely: use reverse-current relays *only* to operate the circuit-breakers on the rotaries, etc., and use time-element overload relays only on the low-tension feeders leaving the substation.

The above remarks apply generally to both d.c. and a.c. apparatus, with the exception of the part devoted to transmission apparatus, which, of course, only applies to a.c. transmission.
