DESCRIPTION • INSTALLATION • OPERATION

INSTRUCTIONS

PARALLEL OPERATION OF LOAD TAP CHANGERS

Using Out-of Step Switches and Latching Relays

WHEN TWO or more transformers are connected in parallel, any difference in their voltage ratios will cause a current to circulate through the loop formed by the paralleled units. It is, therefore, necessary that paralleled transformers have the same voltage ratio to prevent thermal overloading due to the circulating current. This requirement, as well as requirements for impedance, phase angle, and polarity are explained in Instruction Leaflet 47-600-4.

With load tap changing transformers, it is not enough that they be designed for the same voltage ratio. In addition, it is necessary that the tap changers, at any given time, connect to the same voltage tap; that is, the tap changers must operate together, or in step. Out-of-step switch control for parallel operation of load tap-changers operates the tap changers to meet this condition.

Out-of-step switch control also provides a safety feature. If, because of some failure in the equipment one tap changer does not operate with the others, a lock-out is provided at the first step of separation. This limits the circulating current to that caused by the voltage ratio difference of one step of the tap changer and thus protects against burn-out of the transformer.

DESCRIPTION

The out-of-step switch control works in cooperation with the standard tap changer controls, which are described in other instruction leaflets supplied with the tap changer equipment. The out-of-step switch circuits connect between the initiating circuits (that is, the manual control switch for manual control; and the voltage regulating relay, line drop compensator, and time delay relays for automatic control) and the operating circuits (that is, the motor control relays on UR and URS tap changers; and the motor starters on URN, URT, and UT tap changers). The standard controls have all their normal functions, except as limited by the out-of-step switches.

The out-of-step switch is mechanically operated through suitable gears and shafts from the tap changer operating mechanism in which it is mounted. Two contact sequences are used as indicated by the following table:

Tap Changer Position		16-L	15-L	14-L	13-L	12-L	11-L	—
Out-of-Step Switch Closed	Type 1	OS1	OS2	OS1	OS2	OS1	OS2	—
	Type 2	OS1	OS2	OS3	OS4	OS1	OS2	—

Type 1 out-of-step switch is used on tap changers designed for operation in a fixed number of steps. Type 2 out-of-step switch is used on tap changers designed to operate either bridging or non-bridging as selected by the operator.

Type 2 switch can be used in place of a Type 1 by wiring contacts OS1 and OS3 and contacts OS2 and OS4 in parallel, and this is sometimes necessary either as a manufacturing expedient or to permit paralleling a new tap changer with an old tap changer designed on a different basis. In all such cases, the connections are shown in detail on the wiring diagram supplied with the equipment.

Mechanically, design details of the out-of-step switch depend upon the tap changer. On most tap changers, the out-of-step switch is constructed of cam operated control switches. On some UNR tap changers, the out-of-step switch consists of stationary fingers to which connections are made by a rotating knobbed drum.

In addition to the out-of-step switch, the following items are also used:

One paralleling switch.

Two auxiliary relays, Type NL.

One cam operated pilot switch (127) and two cam operated limit switches (LRA or CLR) and (LLA or CLL).

The paralleling switch has three positions—Parallel Master, Parallel Follower, and Independent. This enables the selection of the master unit, operation of all units independently or operating any two or more units in parallel with one or more units by-passed for independent or stand by operation.

The Type NL relays are latching type. Momentary energizing of the operate coil operates the contacts which then remain in the operated position until the reset coil is energized.

The cam operated switches relate the electrical circuits to the mechanical position of the tap changer as will be explained below.

INSTALLATIONS

The paralleling equipment is usually mounted at the factory and shipped in place on the transformer. The connections required between units are shown on the wiring diagram supplied with the transformer.

In those cases where paralleling equipment is being added in the field or where the paralleling equipment is to be mounted by the customer, outline drawings, drilling plans, and installation instruction drawings are supplied. The installation instruction drawing gives detail information regarding the location, alignment and installation procedure for the out-of-step switch and other cam operated switches. See the "Adjustment" section of this instruction leaflet for adjustment instructions. The paralleling switch and the auxiliary relays should be mounted on a switchboard conveniently located with respect to the other control equipment for the tap changers. The auxiliary relays are open type construction and are intended for back-of-the-board mounting.

OPERATION

Fig. 1 shows a schematic diagram of the paralleling circuits for three tap changers equipped with out-of-step switches and latching relays. To illustrate the modes of operation, the contacts of the PS switch having sequence shown in Fig. 2, are shown assuming that unit 1 has been set to be the master unit, unit 2 has been set to be the follower unit, and unit 3 has to be set to operate by itself and independent of the bank. It will become evident as the discussion continues that, while three units are illustrated, the circuit will work equally well for two units or for more than three units by simply subtracting or adding identical units.

Assume that the voltage regulating relay of the master unit calls for an operation in the raise direction so that its time delay relay closes contact TR. Since AMA is closed for automatic operation, this completes the circuit directly to coil BRO of unit 1 and through the PS2 contacts to BRO of unit 2. The circuit then continues from BRO through PS4 and either OS1 or OS2 of both units to the common lead. Therefore, the BR latching relays of units 1 and 2 each operate and latch in the operated position. Since unit 3 is set for independent operation, its PS2 and PS4 contacts are open and its BR relay is not operated.

Also, on unit 3, PS9 and PS10 are closed so that the position of unit 3 has no effect on the series circuits through the OS switches.

Consider unit 1. The BR relay has latched in the operate position. Therefore, contacts BR are closed. This energizes the raise motor control relay, R, which starts the tap changer operation as explained in the instruction book for the tap changer. Soon after the tap changer starts, cam switch 120 closes, sealing R.

At the same time this action takes place in unit 1, exactly the same action takes place independently in unit 2. Therefore, both units have started operation.

As the units operate, either one may be the first to open its OS cam switch. This de-energizes both BRO coils, but does not affect the BR contacts because BR is a latching relay.

Returning to unit 1 operation, as the tap change continues the 127 switch of unit 1 closes. This operates reset coil BRR which returns the BR contact to the open position. R is still sealed through 120.

Unit 2, operating independently also resets its BR relay.

Continued operation of each unit opens its own 127 switch. At a later point in the operation, the next OS switch closes. Both units must independently reach this point before any BRO coil can be re-energized for making a second tap change.

Finally, each unit opens its 120 switch which de-energizes its own R coil and stops the tap changer on position as explained in the instruction book for the tap changer.

If any unit fails to complete its operation, the circuit through the OS switches remains open, so no paralleled unit can operate a second step until all units have completed the first step.

In unit 3 which is set for independent operation, the closing of time delay relay TR operates motor control relay R directly through contacts PS8 in exactly the same manner as for standard control without paralleling provisions.

The contacts PS5 connect back contact R to provide the usual feature of running the tap changer to the next lower position immediately upon restoration of voltage after a power supply interruption during a tap change. For those units operating in parallel, PS5, is opened to prevent closing both R and L in case BR might be latched in the operate position at the time of power failure.

The limit switches CLR and CLL open at the maximum raise and maximum lower positions, respectively, to prevent attempted operation beyond the range of the tap changer.

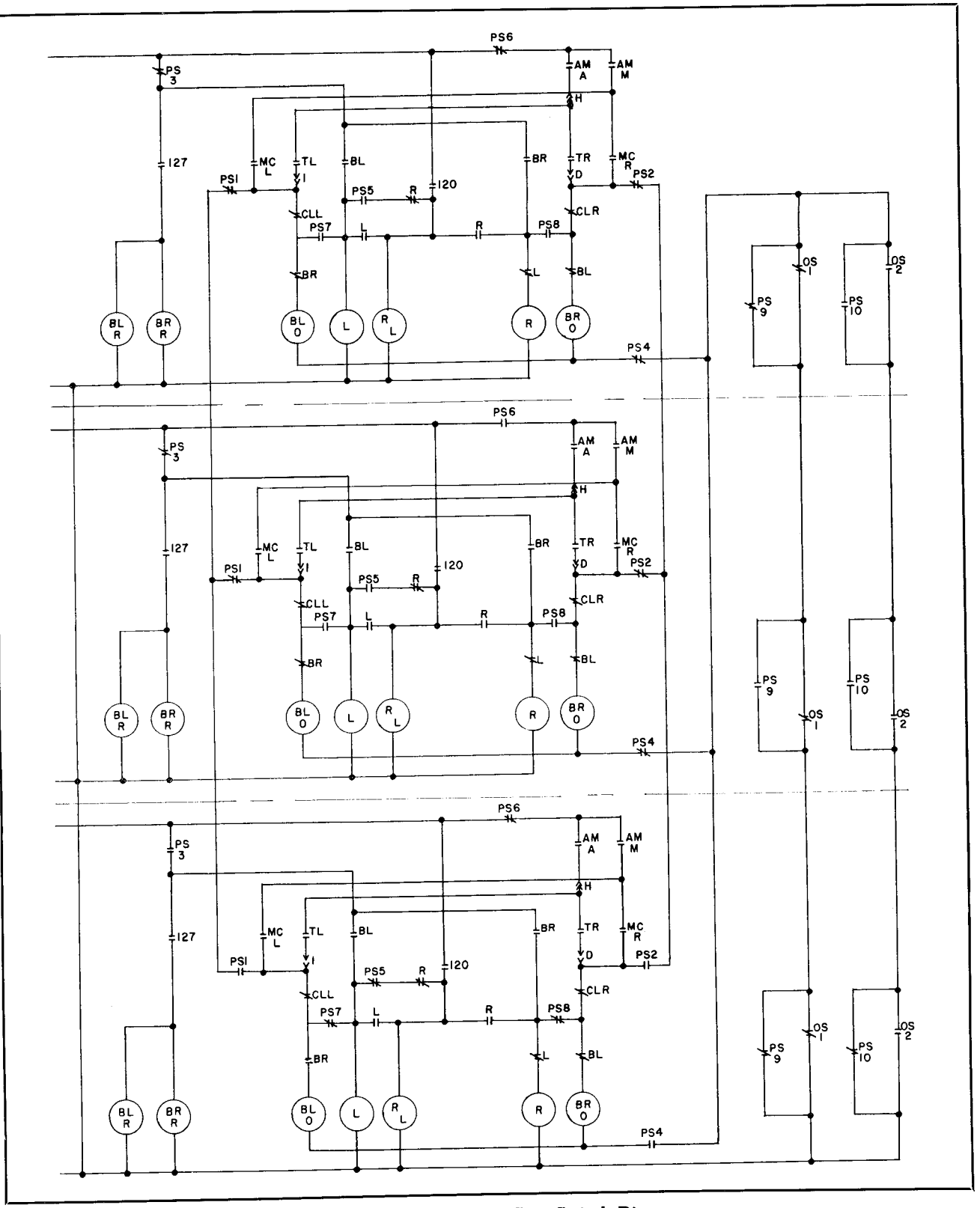

FIG. 1. Schematic Out-of-Step Switch Diagram

Note: For independent operation, all paralleling switches are set on "Independent". For parallel operation, the paralleling switch of all follower units is set on "Parallel Follower", but the master unit paralleling switch is set to "Parallel Master".

"PS" SWITCH

CONTACT	POSITION		
	IND	PAR FOLL	PAR MAST
PS1		X	X
PS2		X	X
PS3		X	X
PS4		X	X
PS5	X		
PS6	X		X
PS7	X		
PS8	X		
PS9	X		
PS10	X		

FIG. 2. Sequence Chart

The actions required by the operator may be summarized as follows:

1. To operate units separately: Set all paralleling switches on "Independent". Each tap changer will operate only from its own automatic and manual control.

2. To operate all units in parallel:

a. Operate each unit separately until all units are on the same position.

b. Select the unit which is to be "Master" and move its paralleling switch to the "Parallel Master" position.

c. On all other units, set the paralleling switch on "parallel follower".

All tap changers will operate together from the automatic and manual control of the master unit.

3. To operate some units in parallel with the other units running independently:

a. Select the master unit and set its paralleling switch on "Parallel Master" position.

b. Select the follower units and set their paralleling switches on "Parallel Follower" positions.

c. Set paralleling switches of remaining units on "Independent" position.

The Master and Follower unit tap changers will operate together from the automatic and manual control of the master unit. The remaining units will operate independently from their own automatic and manual control.

MODIFICATIONS

The above description applies to the basic paralleling circuits. In order to meet specific problems, modifications are sometimes required. The more common special features are described as follows.

1. Paralleling a new unit with an old unit.

Many older units were equipped with out-of-step switches for paralleling, but used conventional relays instead of latching relays. Such units may be paralleled with new units, as shown for a typical case in Fig. 3. Note that where the original installation did not provide all the features of the latest design, the original limitations will still remain. In Fig. 3, for example, the old unit per IL-46-702-7 retains the original limitation that it can not be operated independently of the bank unless the OS switches are jumpered. To make this unit the master unit, leave the PS switch on parallel and jumper PS5. In general, the operation of the new unit is as described above in this leaflet, while the operation of the old unit remains as in the original installation.

2. Circuit breaker interlock.

For coordination of circuit relaying, particularly network relaying, it is sometimes necessary to interlock the tap changer controls with the circuit breaker position to prevent tap changer operation when the circuit breaker is open. This can be easily accomplished by connecting circuit breaker pallit switches to open the time delay relay circuit whenever all circuit breakers are open; A circuit for this, as commonly used on unit substations, is shown in Fig. 4. Contact PS21 of the paralleling switch is closed on the master unit only.

3. Line Drop Compensator Interconnections.

For some applications, more or less units may be paralleled at different times to supply the same load In such cases, it is sometimes desired that the line drop compensation depend upon total bank load rather than on the load through the master unit only.

In Fig. 5, the currents of all units are added, but the total is then forced by auxiliary current transformers to divide equally among all line drop compensators regardless of how many units are actually carrying load. Note that manually or automatically operated switches can be added as shown by the arrows. When this switch is operated to make a unit independent, the remaining units then divide the total current of the units remaining in parallel equally among themselves, and the independent unit's line drop compensator operates on the current in that unit only.

4. Out-of-Step Alarm.

[Some operating conditions require an alarm in case the paralleled units become out-of-step. This feature can be added by using a time delay drop-out relay plus an auxiliary connected to the out-of-step bus as shown in Fig. 6. The paralleling switch may have a contact PS21 which is closed on the master unit only so that all units may be identical.

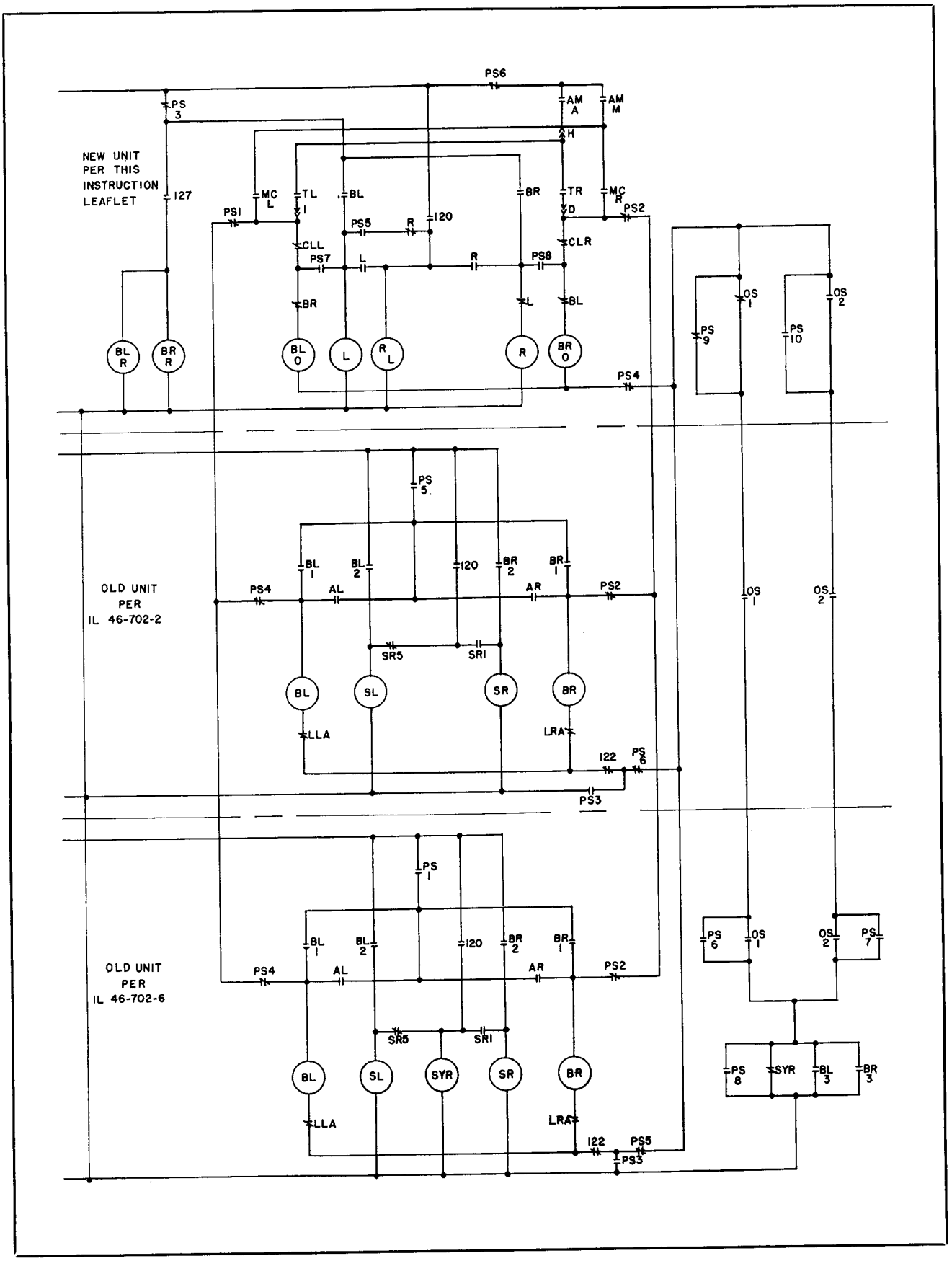

FIG. 3. Parallel Diagram for New and Old Units

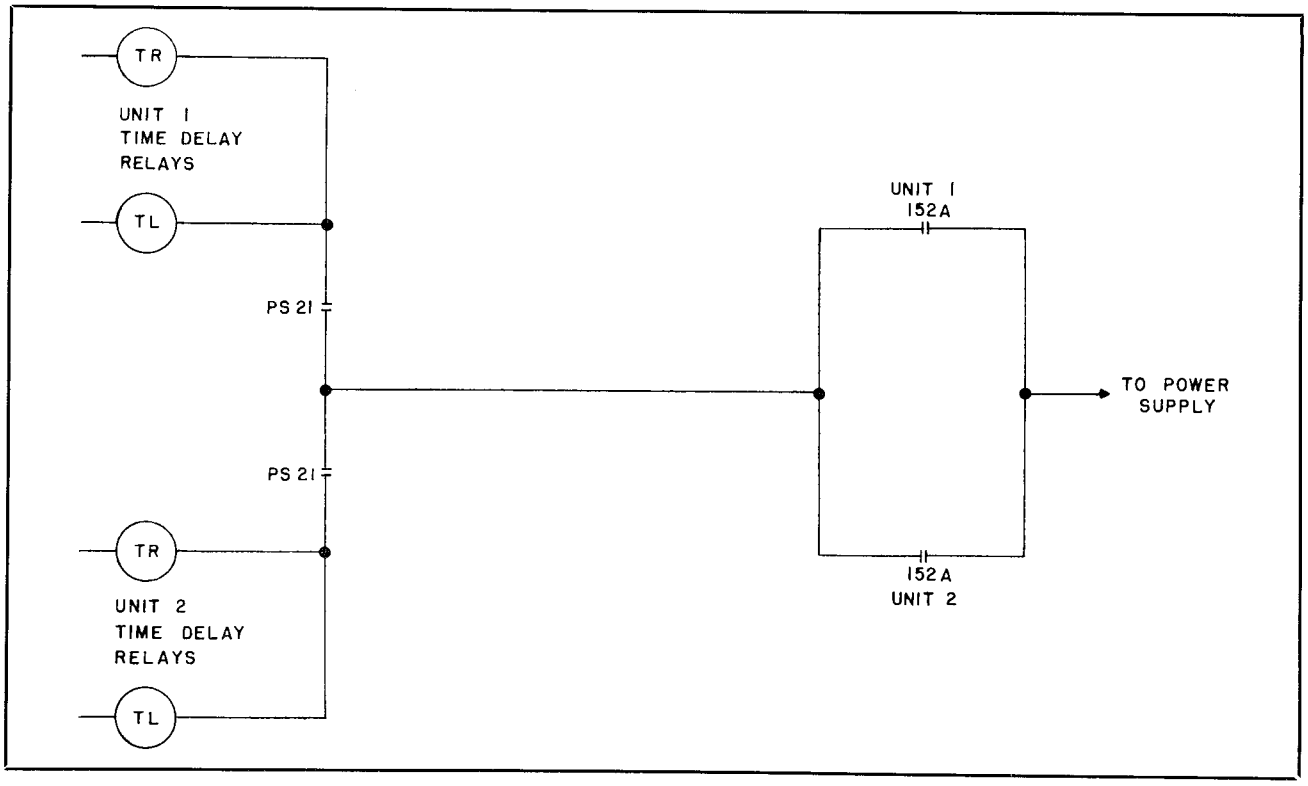

FIG. 4. Circuit Breaker Interlocks

The alarm relay is normally energized through the out-of-step switches. During each tap change, this circuit is momentarily opened. The time delay should be set to be greater than the time for one tap change so that the normal operation will not give an alarm. The out-of-step switches repeat on each second position. Therefore, the time delay should be less than the time for two tap changers. The contacts of the alarm relay may be connected to any conventional annunciator alarm mounted at the control center.

ADJUSTMENT, MAINTENANCE, AND INSPECTION

When out-of-step switch control is installed at the factory, all initial adjustments are made before shipment. The following cam sequence adjustments are required only if the paralleling equipment is installed in the field.

In all cam adjustments, the 120 cam is taken as the basic gauge for the other adjustments, since the 120 cam is factory adjusted to make the tap changer stop centrally on position.

Adjustment of 127 Cam. Starting with the tap changer centrally located on position, the 127 switch should close after the OS switch opens.

Adjustment of OS Cam. Starting from position, the OS switch should remain closed until after 120 opens.

Adjustment of LRA or CLR Cam. As the tap changer approaches the maximum raise position from the next lower position, the LRA or CLR switch should open before 127 opens.

Adjustment of LLA or CLL Cam. As the tap changer approaches the maximum lower position from the next higher position, the LLA or CLL switch should open before 127 opens.

All cams are purposely made oversize to permit filing the edges of the cams to make the above adjustments.

In addition to the above adjustments of the paralleling equipment, the entire tap changer control should be carefully checked and adjusted, according to the instructions furnished with the tap changer. It is especially important that the brake be properly adjusted to center the tap changer on position and that the motor control relays or starters be free of any sticking or sluggishness.

After the initial adjustment has been made, the only maintenance required is occasionally blowing accumulated dust from the relays and paralleling switch, also occasionally inspecting the relays, paralleling switch, and cam operated switch contacts. (The cam operated switch contacts on UR

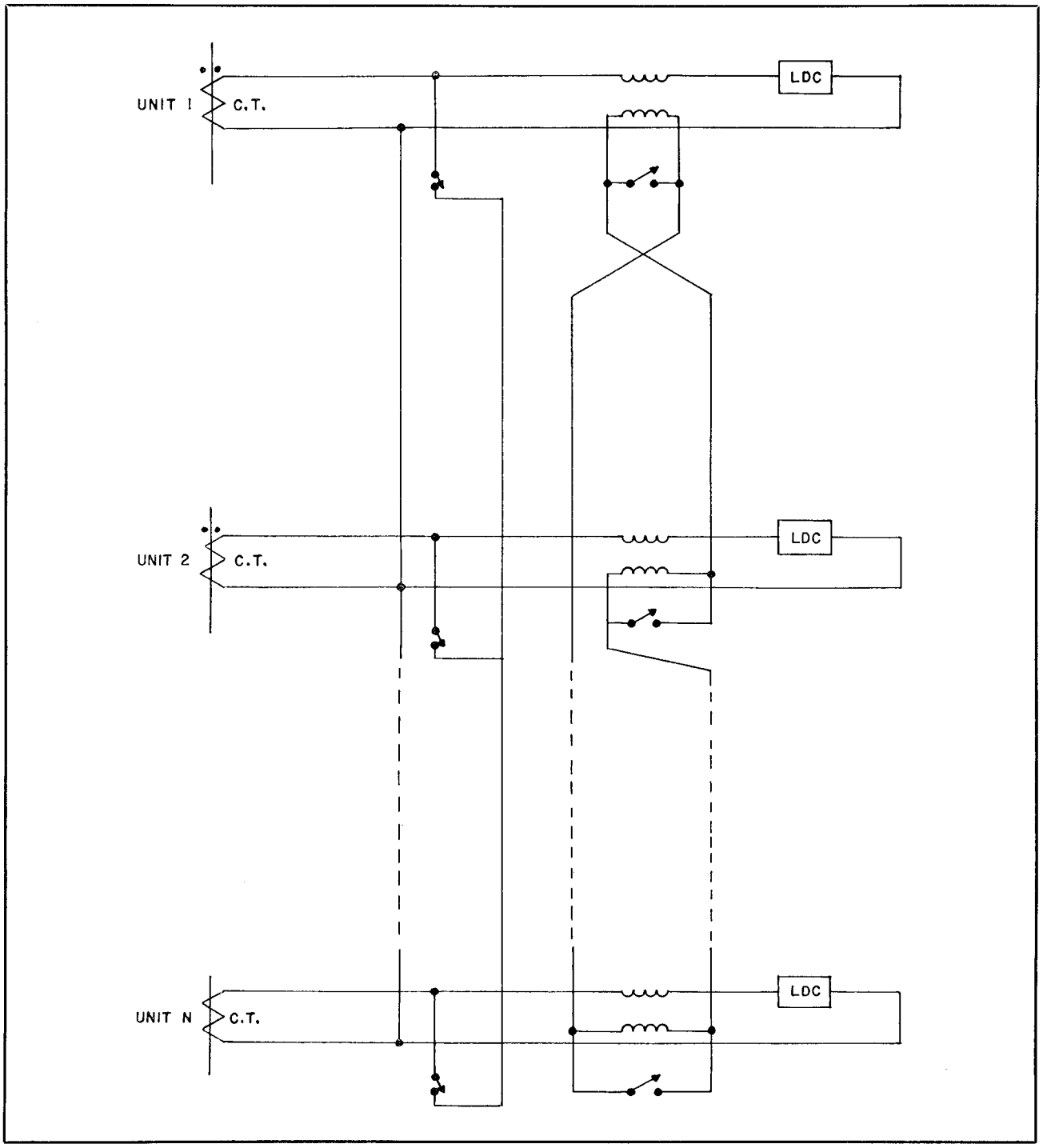

FIG. 5. Line Drop Compensator Interconnections

tap changers should be inspected each time the tap changer house is opened for inspection of the main contacts. On all other tap changers, the cam operated switches are accessible through hinged doors and can be inspected whenever convenient). An occasional drop of light machine oil on the roller shaft of each cam follower is recommended, but excessive oiling should be avoided to prevent collecting dirt and grit.

During maintenance operations, the unit being worked on must be removed from service. For the case of three units in parallel, set the unit to be removed for independent operation and leave the remaining two units in parallel.

For the case of two units in parallel set both units for independent and the unit remaining in service can run automatically or manually.

RENEWAL PARTS

Order renewal parts from the nearest Westinghouse Office, or from the Sharon, Pa., Plant, giving serial number, type, and S.O. or style number stamped on the main transformer nameplate and a complete description of the parts required.

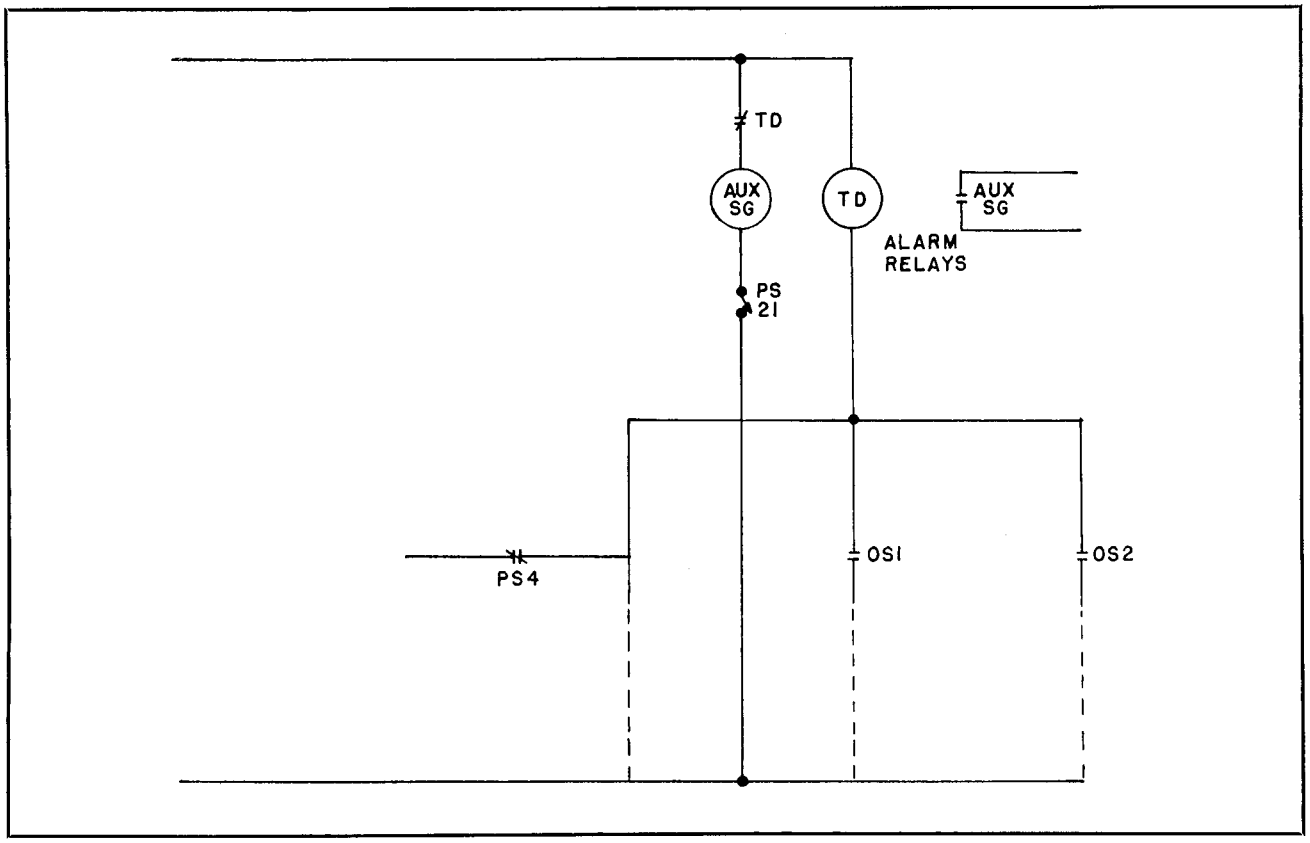

FIG. 6. Out-of-Step Alarm

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