CURRENT BALANCE METHOD OF PARALLELING CONTROL

The most widely used method for operating tap changing equipment in parallel is the "parallel reactor" type. This type is one in which the circulating current is separated from the load current and fed into the voltage regulating relay in a manner to cause the unit to change taps to reduce the circulating current. The same principle is used by many manufacturers, although slightly different circuits are used to separate the circulating current from the load current.

Several manufacturers use a method often referred to as the current-balance method. Circulating current is separated from the load current by means of the three auxiliary current transformers CP in Figure 1. Since the secondaries of these current transformers are connected in series the current in them must be equal and hence the primary currents must also be equal. Therefore, any unequal components of current are forced to flow through the paralleling reactors PX. These paralleling reactors actually have a second winding which is connected in series with the voltage regulating relay so that circulating currents affect the control circuit in such a way as to reduce themselves.

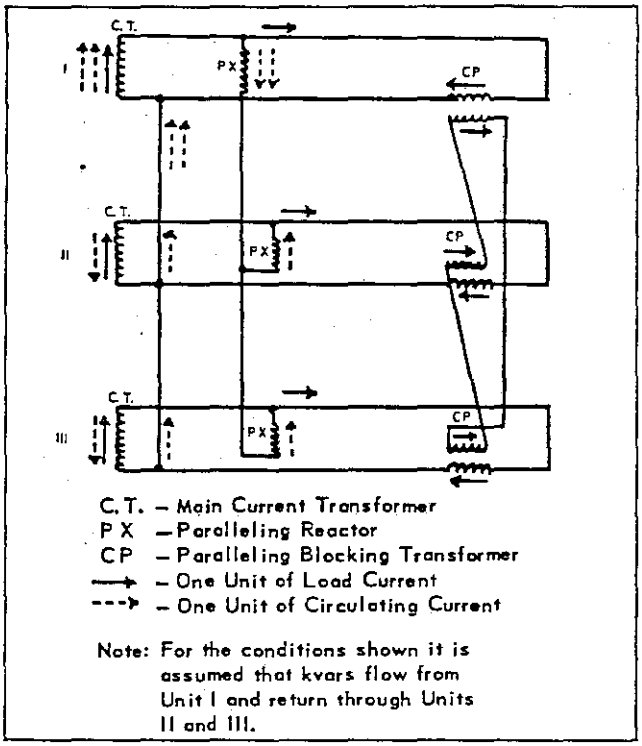

FIG. 1 Separating Circulating Current and Load Current Current Balance Method

This method uses three equalizing current transformers CB to provide correct line drop compensation, as shown in Figure 2. These current transformers are interconnected. In case one machine is disconnected and carries no load then a portion of the current in each of the other machines is forced to flow through the line drop compensator of the idle machine and each receives the same amount of compensation.

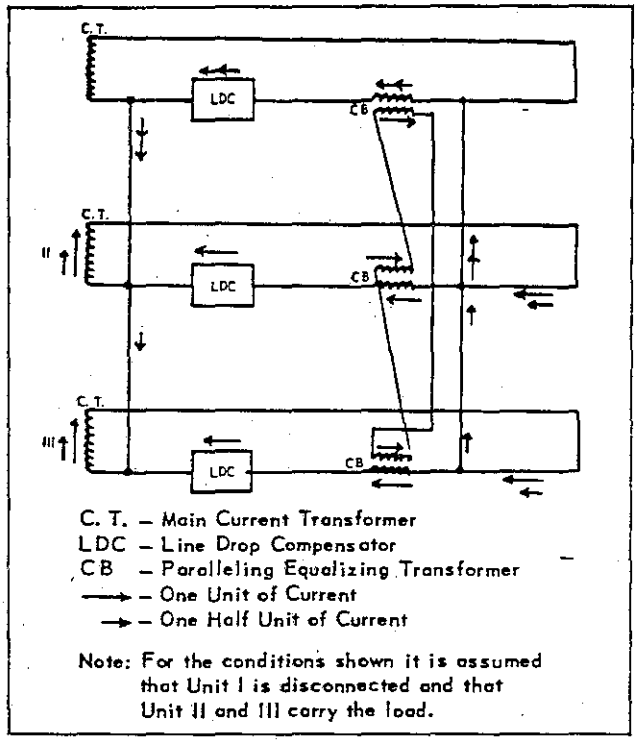

FIG. 2 Dividing Load Current for Line Drop Compensation Current Balance Method

The actual circuit used is shown in Figure 3. A total of five interconnecting wires are required between machines. In general, the paralleling reactor type of control is preferred for most paralleled circuits. The equip-

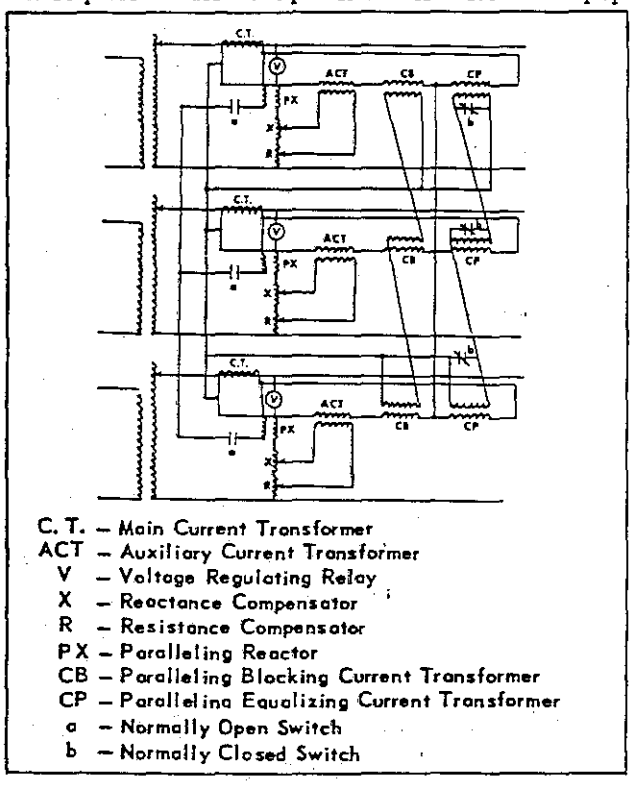

FIG.3. Current Balance Control Diagram

ment required can be added to any standard regulator and the modification is no problem. The control is simple and reliable and can be adapted to circuits paralleling any number of machines with no increase in complexity. This type of control is by far the most popular of all the various types.

SELECTING THE SENSITIVITY OF THE PARALLELING REACTOR

In order to achieve proper parallel operation of regulators or transformers with tap changing under load it is necessary to insure the following:

1. The individual units shall not hunt under any conditions.
2. Following any conceivable system disturbance, the units, if given an opportunity, shall pull back together to such positions as will reduce the circulating current to a tolerable limit.
3. During normal operation the circulating current shall be reduced to a minimum consistent with individual stability.

This can be accomplished by selecting the proper tap connection on the paralleling reactor PX. The tap connections available are shown in Figure 4.

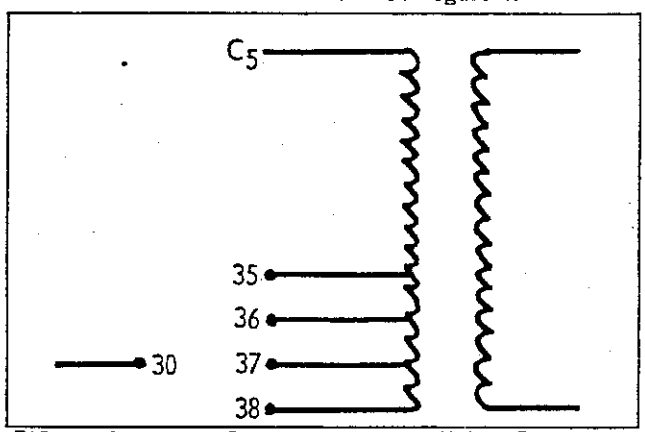

FIG. 4 Sensitivity Connections on Paralleling Reactor

A. FOR ONLY TWO UNITS IN PARALLEL

To achieve these aims for two units operating in parallel adjust the various components of the control circuit as follows:

FIRST: If more than one current transformer ratio is available select line drop compensator current transformer ratios as nearly as possible in proportion to the kva capacities of the units. Load current will divide essentially in proportion to the C.T. ratios and not in proportion to the kva capacities of the units if the ratios of the C.T.'s are not in exact proportion to the kva's.

SECOND: If more than one potential transformer ratio is available, select potential transformer ratios as nearly exactly equal as possible, since the line voltage level held by the various voltage regulating relays is proportional to the ratio of their potential transformers.

THIRD: Select from Table I the minimum band width consistent with the size of the individual steps. The larger the band width the greater the circulating current. The smaller the band width the smaller the circulating current, but band widths less than those of Table I may result in hunting of one or more units.

FOURTH: Set all voltage regulating relays to the selected band width.

FIFTH: Set all voltage regulating relays to the same line voltage level. With equal potential transformer ratios this means equal voltage levels at the voltage regulating relays.

SIXTH: Set all line drop compensators to the same values of resistance and reactance compensation.

SEVENTH: Set all voltage integrators or time delay relays to the same time delay.

EIGHTH: Select from Table I the maximum sensitivity tap of the paralleling reactor consistent with the size of steps, the already selected band width and the impedance of the loop. With extremely low loop impedances, this may require a larger band width than determined in step 3 above.

B. FOR MORE THAN TWO UNITS IN PARALLEL

To achieve the afore-mentioned aims for more than two units operating in parallel adjust the various components of the control circuit as follows:

Follow the first seven steps exactly as outlined above.

EIGHTH: Select from Table II the maximum sensitivity tap of the paralleling reactor consistent with the size of the steps, the already selected band width and the equivalent impedance of the loop using for the latter a value calculated as follows:

$$\text{Equivalent } Z \text{ of loop} = \frac{N}{N-1} \times (Z \text{ individual})$$

Where N = number of parallel circuits (3,4,5, or more)

Z individual = the percent impedance of a single circuit from the common point on the source side of the tap changer to the common point on the load side of the tap changer.

SUMMARY: A study of Table I will indicate the desirability of:

1. Using the minimum band width consistent with the size of step and loop impedance.
2. Using the maximum sensitivity of the paralleling reactor consistent with the size of step, the band width and the loop impedance.

TABLE I

Size of Step	5/16%					15/32%				5/8%			15/16%	
Range of Regulation 32 Steps 16 Steps	± 5% ± 2½%					± 7½% ± 3¾%				± 10% ± 5%			± 15% ± 7½%	
Possible Band Width (Volts) More Than Less Than	¾ 1	1 1½	1½ 2	2 3	3 4	1 1½	1½ 2	2 3	3 4	1½ 2	2 3	3 4	2 3	3 4
Reactor Sensitivity Connect	Minimum Loop Impedance % With Which Band Width & Reactor Sensitivity Can Be Used													
High 30 & 38	16.7	12.5	8.4	6.3	4.2	18.8	12.5	9.2	6.3	16.7	12.5	8.4	18.8	12.5
Med. High 30 & 37	14.6	11.0	7.3	5.5	3.7	16.5	11.0	8.1	5.5	14.6	11.0	7.3	16.5	11.0
Med. Low 30 & 36	12.5	9.4	6.3	4.7	3.2	14.1	9.4	7.0	5.0	12.5	9.4	6.7	14.1	10.0
Low 30 & 35	10.5	7.9	5.3	4.0	3.0	11.8	7.9	5.8	5.0	10.5	7.9	6.7	11.8	10.0
Reactor Sensitivity	Resulting Circulating Current Will Not Exceed % *													
High	3.4	5.0	6.7	10.0	13.4	5.0	6.7	10.0	13.4	6.7	10.0	13.4	10.0	13.4
Med. High	3.8	5.8	7.7	11.5	15.3	5.8	7.9	11.5	15.3	7.7	11.5	15.3	11.5	15.3
Med. Low	4.5	6.7	8.9	13.4	17.8	6.7	8.9	13.4	17.8	8.9	13.4	17.8	13.4	17.8
Low	5.4	8.0	10.7	16.0	21.4	8.0	10.7	16.0	21.4	10.7	16.0	21.4	16.0	21.4

* The circulating current listed is a maximum and will be considerably less in most installations.