DESCRIPTION • INSTALLATION • OPERATION

INSTRUCTIONS

PARALLEL OPERATION

OF TAP-CHANGING-UNDER-LOAD BY CURRENT BALANCE CONTROL USING REACTANCE COMPENSATOR

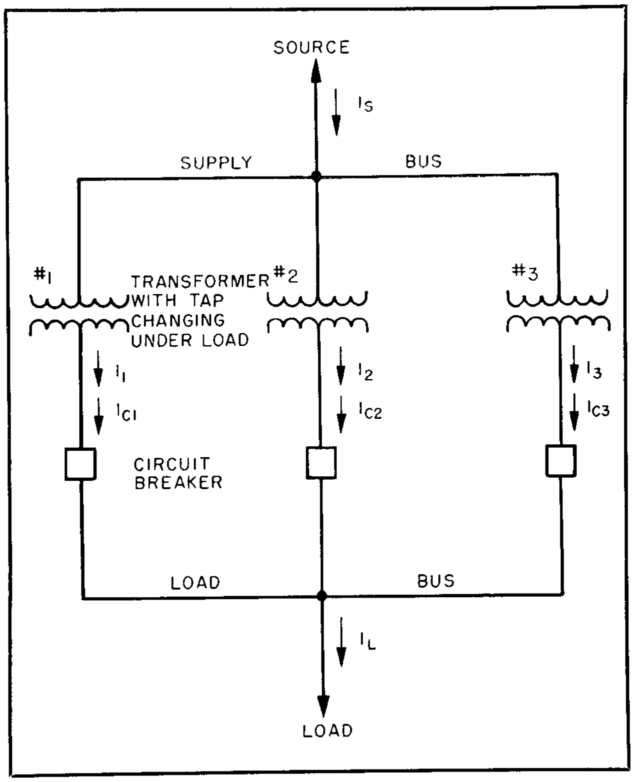

FIG. 1. Typical Circuit for Application of Current Balance Paralleling.

When two or more tap-changing-under-load transformers are connected in parallel, any differences in voltage ratios of the paralleled transformers cause a current to circulate through the paralleled units which is limited by the impedance of the loop circuit. In current balance paralleling, this circulating current is used to operate the tap changers in such a way as to reduce this circulating current to a minimum.

Sometimes when tap-changing-under-load transformers are connected in parallel, the major portion of the line drop is between the substation bus and the load center. As an optional feature in current balance paralleling, the load currents of all units can be combined so that the line drop compensation depends upon the total station load.

The paralleling requirements for the transformer, exclusive of the tap-changing-under-load, are given in Instruction Leaflet I.L. 47-600-4. This leaflet covers the equipment for parallel operation of the tap changers.

DESCRIPTION

The tap changer is operated by the standard control circuit comprising time delay and auxiliary relays and controlled by a voltage regulating relay and line drop compensator. The current balance paralleling equipment modifies this voltage regulating relay and line drop compensator circuit to introduce a voltage proportional to the circulating current, and of such polarity as to cause tap changer operation to reduce this circulating current.

For current balance paralleling, the following equipment is added to each unit:

One auxiliary current transformer, S# 1198 099.*

*If all paralleled units have equal currents in the secondaries of the line current transformers; if not, this will be special current transformer of appropriate ratio to equalize the currents in the Kl network, as described later for Fig. 3.

One paralleling current transformer, S# 1435 858.

One paralleling switch, either Minatrol 16-D-3800, group 2, or Type W 12-D-9541, group 3.

An extra terminal is added to the Flexitest case of the voltage regulating relay for the connection to Kl in Figs. 3 and 4.

For the optional feature of line drop compensation based on total load, one auxiliary current transformer, S# 1198 099.

The auxiliary current transformers are interconnected between units to form two networks. One network separates the circulating current from the load current. The other, optional, network equalizes the load current among all units.

EFFECTIVE APRIL, 1951

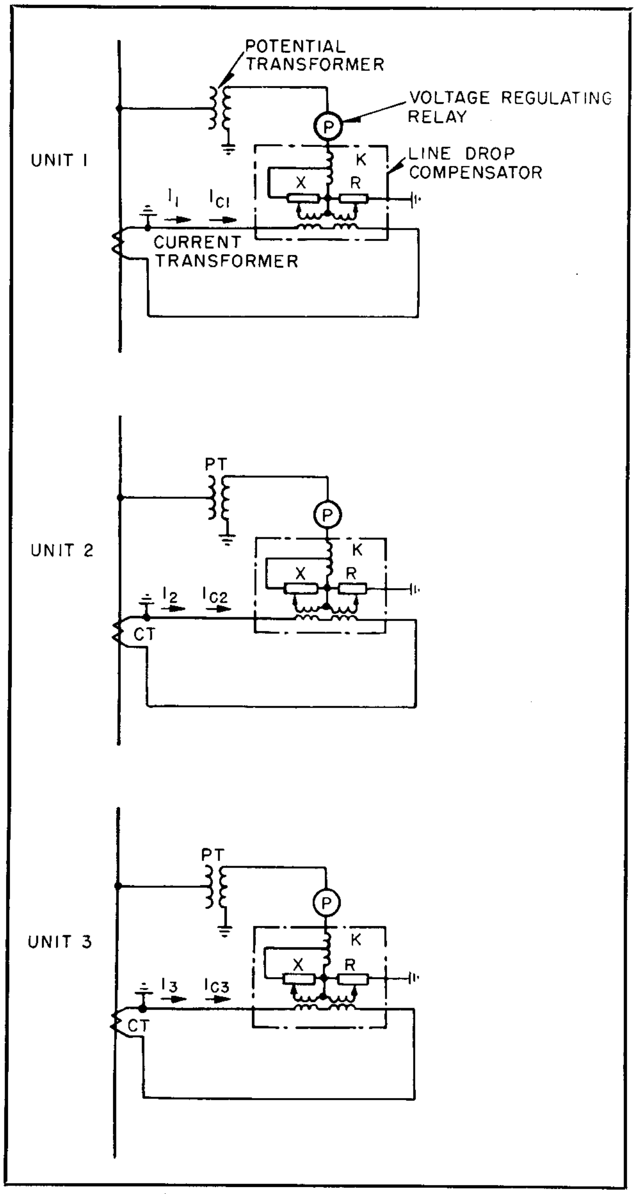

FIG. 2. Control Circuits without Paralleling Equipment.

The circulating current passes through the paralleling current transformer, K1 in Figs. 3 and 4, to the reactance element of the line drop compensator, so that positive reactive circulating current produces voltage in the line drop compensator to cause the voltage regulating relay to operate the tap changer in the lower direction.

The load current flows through both the resistance and the reactance elements of the line drop compensators so that each compensator responds to its proportionate share of the load current. This permits adjusting the compensators according to the individual loads and lines. However, if the settings are different on different units, some circulating current may result.

For line drop compensation based on total load, another auxiliary current transformer, K3 in Fig. 4, forces equal division of load current so each compensator responds to a proportionate share of the total load current. This permits adjusting the compensators for substation bus to load center line drop.

The paralleling switch is a two-position manually-operated control switch which disconnects and bypasses the paralleling circuits to permit removing a unit from service.

INSTALLATION

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 and drilling plans are supplied. The paralleling switch should be mounted on a switchboard conveniently located with respect to the other control equipment for the tap changers. The current transformers may be mounted on the switchboard, or in a cubicle or accessory panel, wherever convenient for mounting and wiring. All should be located in an area free from dirt, moisture, excessive vibration and heat.

OPERATION

The operation of the current balance system of paralleling control can best be understood by reference to the schematic sketches. Three units are illustrated, but all units are identical and any number, two or more, may be used in a similar manner.

Fig. 1 shows a typical circuit on which current balance paralleling might be applied.

Fig. 2 shows the standard, or conventional, voltage regulating relay and line drop compensator circuits for the three transformers of Fig. 1.

Fig. 3 shows the relays and compensators of Fig. 2 with the circulating current segregation network added for current balance paralleling.

Fig. 4 shows the circuits of Fig. 3 with the addition of the optional load balance network.

In these figures, the currents are indicated by arrows identified as follows:

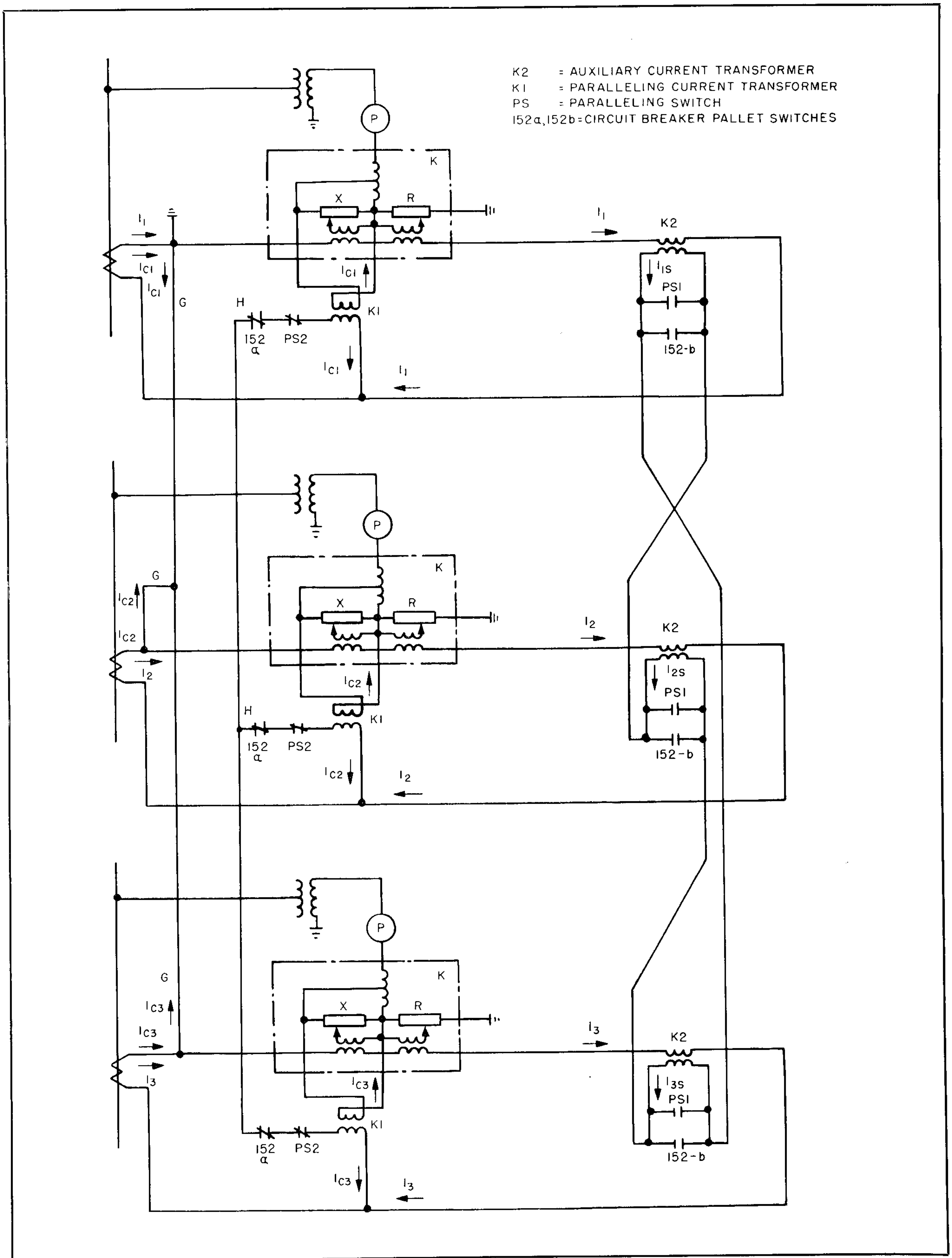

FIG. 3. Control Circuits for Current Balance Paralleling.

I_1, I_2, I_3 = load current in transformer units 1, 2, and 3 respectively, as determined by the circuit constants.

I_{C1}, I_{C2}, I_{C3} = circulating current in transformer units 1, 2, and 3 respectively, as caused by any voltage ratio unbalance.

$I_L = I_1 + I_2 + I_3$ = total load of the bank

$I_{C1} + I_{C2} + I_{C3} = 0$, since no circulating current appears beyond the source and load buses.

In Fig. 1, the current in each unit is shown in terms of the main power circuit. The total current in each unit is the vector summation of the load and circulating currents, or $I_{unit\ 1} = I_1 + I_{C1}$, $I_{unit\ 2} = I_2 + I_{C2}$, $I_{unit\ 3} = I_3 + I_{C3}$.

In Fig. 2, the same currents are transferred to the conventional control circuits. If it were attempted to operate with just this control, the operation would be unstable. For example, assume that unit 1 has a slightly shorter time delay relay setting than units 2 and 3, so that it operates first to raise its voltage. Then, unit 1 having higher voltage output, the circulating current is positive in unit 1 and negative in units 2 and 3. Therefore, the moment unit 1 operates, the currents become: $I_{unit\ 1} = I_1 + I_{C1}$, $I_{unit\ 2} = I_2 + (-I_{C2})$, $I_{unit\ 3} = I_3 + (-I_{C3})$. Increased current in unit 1 causes its line drop compensator to operate the voltage regulating relay to cause additional "raise" operations of the tap changer. Decreased current in units 2 and 3 cause their line drop compensators to operate the voltage regulating relays to cause "lower" operations of the tap changers. Thus, with only the conventional control, the first unbalance which creeps into the system becomes cumulative until the tap changers reach their limit positions.

Fig. 3 shows the circuits which are added in current balance paralleling to cancel, and in fact reverse, this cumulative tendency. In each unit, the current in the main current transformer is the same as before: $I_{unit\ 1} = I_1 + I_{C1}$, $I_{unit\ 2} = I_2 + I_{C2}$, $I_{unit\ 3} = I_3 + I_{C3}$. An auxiliary current transformer, K2, has its primary connected in series with each line drop compensator, and its secondary connected in series with the secondaries of all the other K2 transformers. The K2 ratios are selected so that the normal values of I_1, I_2, and I_3, as determined by the circuit capacities and impedances, make $I_{1S} = I_{2S} = I_{3S}$. (For example, if all units are the same kva rating, K2 has the same ratio on all units. If unit 1 is twice the kva rating of units 2 and 3, K2 will make the overall ratio of CT plus K2 in unit 1 twice the corresponding ratio for units 2 and 3). Since $I_{1S} = I_{2S} = I_{3S}$, the series circuit of the K2 secondaries is a very low impedance circuit to I_1, I_2, and I_3 and allows I_1, I_2, and I_3 to flow through the line drop compensators, K.

However, I_{C1}, I_{C2}, and I_{C3} cannot be similarly balanced since $I_{C1} + I_{C2} + I_{C3} = 0$. Therefore, the series connection of K2 secondaries presents a high impedance to the circulating current, forcing it to flow into the common connection, G, and keeping it out of the line drop compensator. At G, $I_{C1} + I_{C2} + I_{C3} = 0$, which means that a positive I_{C1}, at this point, becomes a negative component of I_{C2} and/or I_{C3} and, as such, flows through the current transformers and K1, PS2, and 152a, of units 2 and/or 3 in the negative direction to H. At H, it recombines and again becomes positive I_{C1}, flowing through 152a, PS2, and K1 of unit 1 back to the unit 1 current transformer. (Note: If all units do not have the same CT ratio, auxiliary transformers must be used in leads G and H in order that the overall ratio will be the same to make I_{C1}, I_{C2}, and $I_{C3} = 0$ at G and H).

The currents I_{C1}, I_{C2}, and I_{C3} flow from the secondaries of K1 to the reactance elements of the line drop compensators, K. The reactive elements, only, are used since the loop impedance to circulating current (Fig. 1) is largely reactive. The K1 connections are directly to the total reactive element so that the X adjustment for line drop compensation does not affect the sensitivity to circulating current. (Exception: When other requirements make it necessary to use the type RC, RD, or RE line drop compensator, the X adjustment does affect the circulating current sensitivity proportionately, requiring corresponding adjustment of the taps on K1). The polarity of the connections from K1 to X is reversed, relative to the line drop compensator connections, so that increased positive circulating current causes the voltage regulating relay to operate the tap changer in the "lower" direction. Operation in the "lower" direction reduces the positive circulating current. Thus, the paralleling circuits operate the tap changers toward minimum circulating current, and this control is in addition to and independent of the line drop compensation due to I_1, I_2, and I_3.

The circuit breaker pallet switches, 152-a and 152-b are shown in Fig. 3 with the circuit breakers all closed. Suppose that the circuit breaker of unit 3 opens, then contacts 152-b close and contacts 152-a open. The closing of 152-b provides a by-pass around K2 of unit 3 for the series circuit so that $I_{1S} = I_{2S}$ satisfies the equality requirements of K2

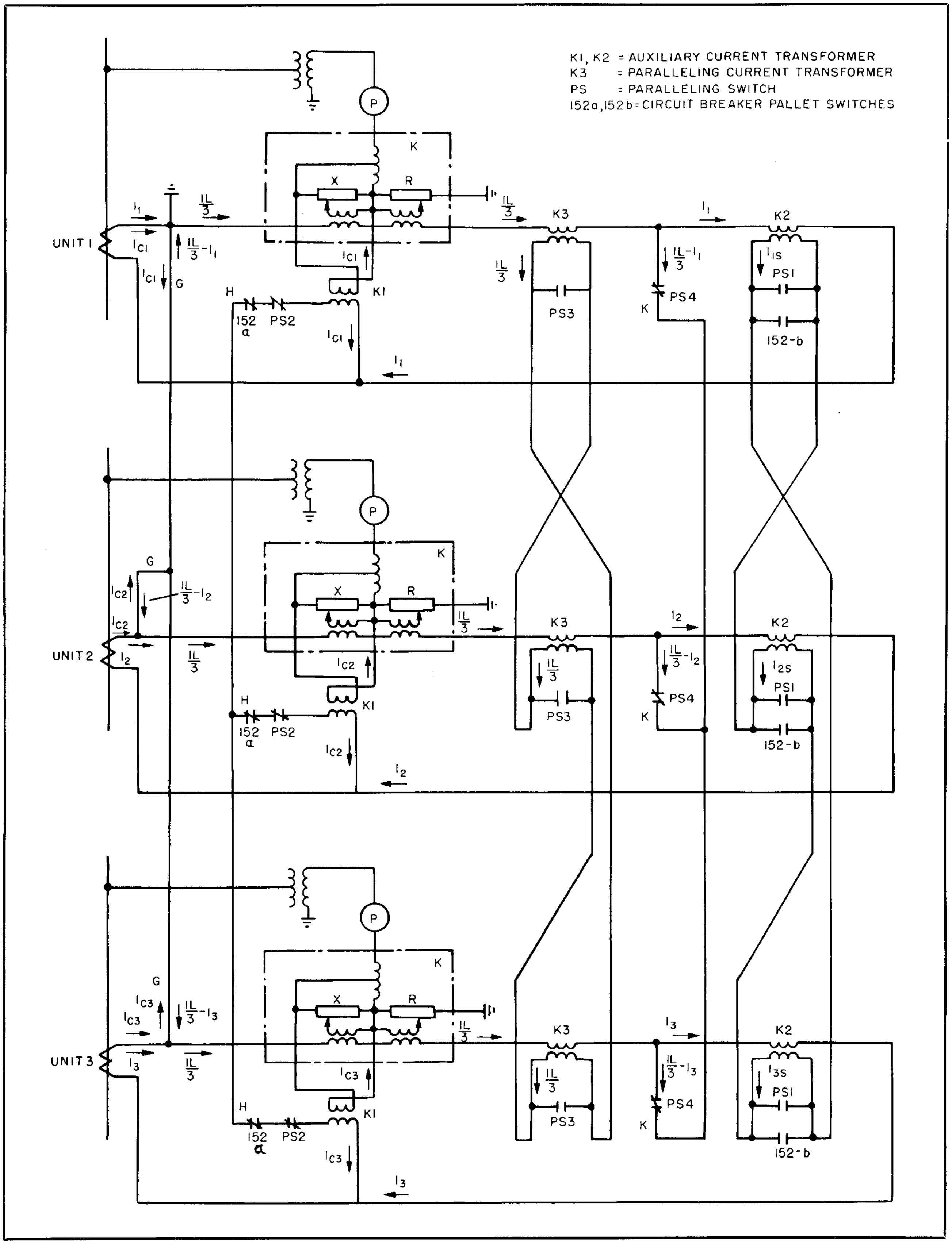

FIG. 4. Control Circuits for Current Balance Paralleling with Line Drop Compensation Based on Total Bank Load.

and permits I_1 and I_2 to flow through their respective line drop compensators even though I_3 is now zero. The opening of 152-a opens the circuit through Kl to prevent any portion of the circulating current taking the path from G through K, K2, and Kl of unit 3 to H. Thus, when the circuit breaker of unit 3 opens, units 1 and 2 continue to operate in parallel as a bank of two units.

The paralleling switch contacts PSl are in parallel with 152-b and contacts PS2 are in series with 152-a, so that the paralleling switch provides a means of manually removing a unit from parallel operation. With K2 by-passed by PSl and with the circulating current path opened by PS2, the control of that unit is effectively the same as Fig. 2. Thus, if by bus switching, unit 3, for example, is connected to a different load than units 1 and 2, the paralleling switch of unit 3 can be set on "independent" and unit 3 will operate and regulate its load without either affecting the parallel operation of units 1 and 2 or being affected by units 1 and 2.

In Fig. 4, the K3 network is added for making the line drop compensators respond to total load current instead of to the currents in the respective units. The K3 network is exactly the same as the K2 network except that contacts 152-b are omitted, the K3 current transformers are all the same ratio regardless of the unit Kva's, and the interconnection through PS4 is a direct connection with no elements corresponding to Kl. Currents I_1, I_2, and I_3 flow through K2 as described for Fig. 3. However, because K3 ratios are all the same, equal currents must flow through the line drop compensators and K3 primary; this current is IL/3 (or IL/2 for two units, IL/4 for four units, etc.). Any difference between I_1, for example, and IL/3 flows through connection G to unit 2 or 3 where it adds to I_2 or I_3 to make IL/3 through K of those units. This is possible since $I_1+I_2+I_3=I_L$ and $3(I_L)/3=I_L$. Leaving K3, the corresponding currents flow through PS4 so that I_1, I_2, and I_3 flow through K2, as in Fig. 3. Since the current in each compensator is IL/3 and since there are no 152-b contacts, each unit will have its share of the total load current regardless of how the load divides between units or how many circuit breakers open.

The paralleling switch contacts PS3 by-pass K3 as PSl by-passes K2 and PS4 opens K as PS2 opens H, so that setting the paralleling switch of one unit on "independent" removes that unit from the bank, permits it to operate independently, and lets the remaining units operate as a bank of two units.

The operation of current balance paralleling circuits will automatically respond to changing load conditions, and will operate to keep circulating current to a minimum. However, there are a few limitations which should be noted and recognized.

1. The circulating current response is through the standard control which includes time delay relays. During this time delay, the circulating current is limited by the loop impedance only.

2. In case any part of the tap changer or its control should fail to operate correctly, it is possible for the tap changers to become separated by the full tap range. Unless the loop impedance is sufficiently large, the resultant circulating currents may cause dangerous overloading of one or more of the transformers. Where such a possibility exists, suitable overload alarm device should be provided.

3. For proper operation, the K2 current transformer ratios must be selected to give equal secondary currents at normal load division between units. At the same time, the ratios for the circulating current must all be the same since the circulating current summation must equal zero.

4. To keep all units together without hunting, all voltage regulating relays and line drop compensators must have the same settings.

5. If for any reason, it is impossible for the tap changers to reduce the circulating current to a low value (examples: unusually low sensitivity settings on Kl, transformers having different tap voltages, tap changer power supply failure), the circulating current adding vectorially to the load current in X may overload this element of the line drop compensator.

ADJUSTMENT, MAINTENANCE, INSPECTION

The only adjustment is the tap connection on the paralleling current transformer. This adjustment is probably best made by trial. For increased sensitivity, the taps should be connected for higher secondary current.

Note: The secondary of the paralleling current transformer is connected directly to the reactance element of the line drop compensator. Any current greater than that required to produce a voltage sufficient to operate the voltage regulating relay serves no useful purpose, but only overloads the compensator. Therefore, the paralleling current transformer taps should be connected for the lowest secondary current which will give the required sensitivity to circulating currents.

The sensitivity which can be used depends upon the loop circuit impedance, the fineness of the tap changer steps, and the number of units being paralleled. Minor differences in the paralleled circuits make it probable that the circulating current will not reduce completely to zero. The sensitivity must be reduced sufficiently that this minimum circulating current will not cause hunting. On the other hand, increased sensitivity will cause smaller circulating currents to operate the tap changers and thus keep transformer heating to a minimum. A practical operating point will usually keep the tap changers within one or two steps of each other.

The only maintenance required by the current balance paralleling equipment is occasionally blowing out any accumulated dust and dirt and inspecting the contacts of the paralleling switch.

RENEWAL PARTS

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

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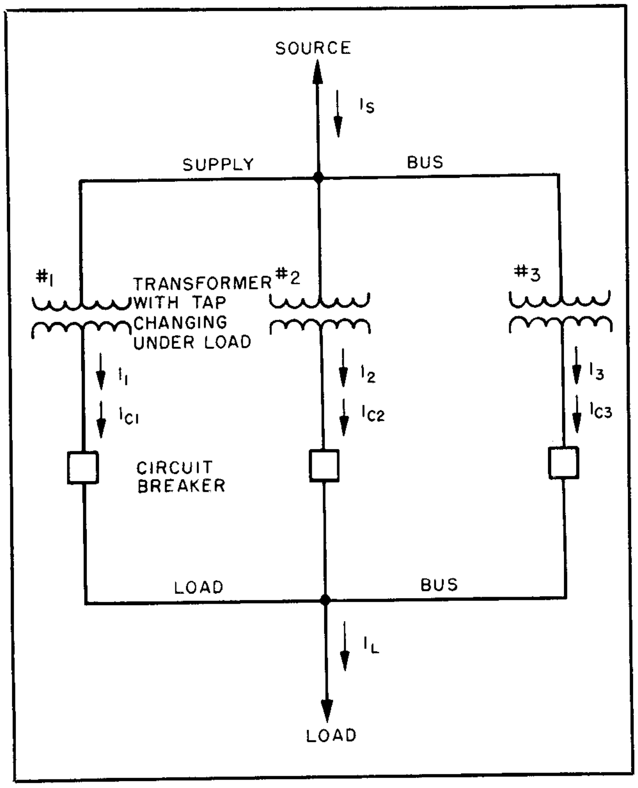

FIG. 1. Typical Circuit for Application of Current Balance Paralleling.

When two or more tap-changing-under-load transformers are connected in parallel, any differences in voltage ratios of the paralleled transformers cause a current to circulate through the paralleled units which is limited by the impedance of the loop circuit. In current balance paralleling, this circulating current is used to operate the tap changers in such a way as to reduce this circulating current to a minimum.

Sometimes when tap-changing-under-load transformers are connected in parallel, the major portion of the line drop is between the substation bus and the load center. As an optional feature in current balance paralleling, the load currents of all units can be combined so that the line drop compensation depends upon the total station load.

The paralleling requirements for the transformer, exclusive of the tap-changing-under-load, are given in Instruction Leaflet I.L. 47-600-4. This leaflet covers the equipment for parallel operation of the tap changers.

DESCRIPTION

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For current balance paralleling, the following equipment is added to each unit:

One auxiliary current transformer, K2 in figures 3 and 4.

One paralleling current transformer, K1 in figures 3 and 4.

One paralleling switch, PS in figures 3 and 4.

An extra terminal is added to the Flexitest case of the voltage regulating relay for the connection to K1 in Figs. 3 and 4.

For the optional feature of line drop compensation based on total load, an additional auxiliary current transformer, K3 in figure 4, is needed.

The auxiliary current transformers are interconnected between units to form two networks. One network separates the circulating current from the load current. The other, optional, network equalizes the load current among all units.

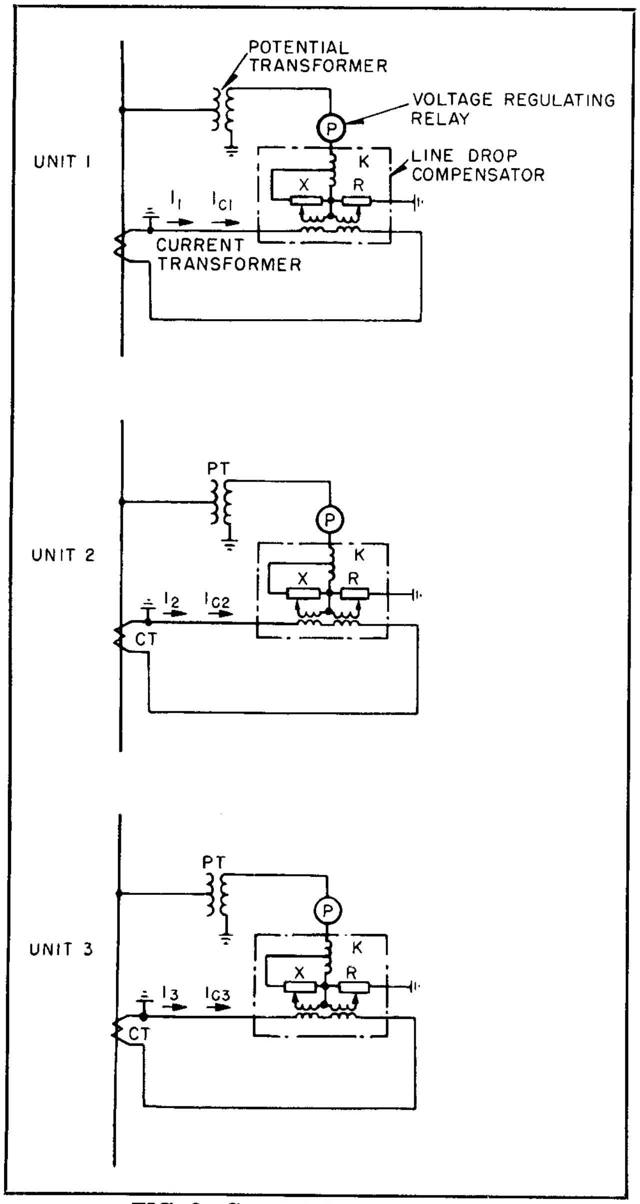

FIG. 2. Control Circuits without Paralleling Equipment.

The circulating current passes through the paralleling current transformer, K1 in Figs. 3 and 4, to the reactance element of the line drop compensator, so that positive reactive circulating current produces voltage in the line drop compensator to cause the voltage regulating relay to operate the tap changer in the lower direction.

The load current flows through both the resistance and the reactance elements of the line drop compensators so that each compensator responds to its proportionate share of the load current. This permits adjusting the compensators according to the individual loads and lines. If a unit is removed from service but the same total load is supplied by the bank, the line drop compensation will increase.

For line drop compensation based on total load, another auxiliary current transformer, K3 in Fig. 4, forces equal division of load current so each compensator responds to a proportionate share of the total load current. This permits adjusting the compensators for substation bus to load center line drop. If a unit is removed from service but the same total load is supplied by the bank, the line drop compensation will remain unchanged.

The paralleling switch is a two-position manually-operated control switch which disconnects and bypasses the paralleling circuits to permit removing a unit from service.

INSTALLATION

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.

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Fig. 1 shows a typical circuit on which current balance paralleling might be applied.

Fig. 2 shows the standard, or conventional, voltage regulating relay and line drop compensator circuits for the three transformers of Fig. 1.

Fig. 3 shows the relays and compensators of Fig. 2 with the circulating current segregation network added for current balance paralleling.

Fig. 4 shows the circuits of Fig. 3 with the addition of the optional load balance network.

In these figures, the currents are indicated by arrows identified as follows:

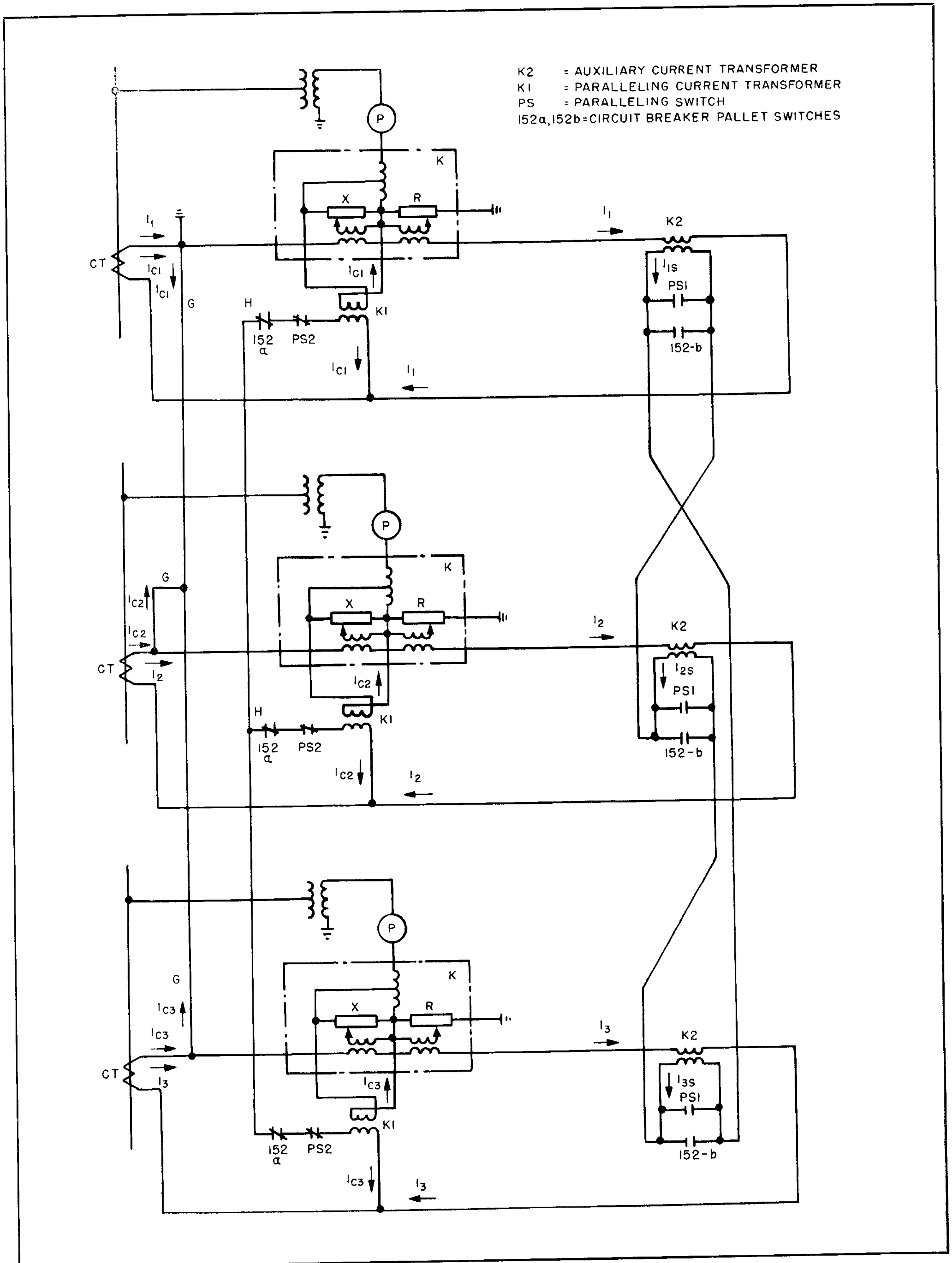

FIG. 3. Control Circuits for Current Balance Paralleling.

I_1, I_2, I_3 = load current in transformer units 1, 2, and 3 respectively, as determined by the circuit constants.

I_{C1}, I_{C2}, I_{C3} = circulating current in transformer units 1, 2, and 3 respectively, as caused by any voltage ratio unbalance.

$I_L = I_1 + I_2 + I_3$ = total load of the bank

$I_{C1} + I_{C2} + I_{C3} = 0$, since no circulating current appears beyond the source and load buses.

In Fig. 1, the current in each unit is shown in terms of the main power circuit. The total current in each unit is the vector summation of the load and circulating currents, or $I_{unit\ 1} = I_1 + I_{C1}$, $I_{unit\ 2} = I_2 + I_{C2}$, $I_{unit\ 3} = I_3 + I_{C3}$.

In Fig. 2, the same currents are transferred to the conventional control circuits. If it were attempted to operate with just this control, the operation would be unstable. For example, assume that unit 1 has a slightly shorter time delay relay setting than units 2 and 3, so that it operates first to raise its voltage. Then, unit 1 having higher voltage output, the circulating current is positive in unit 1 and negative in units 2 and 3. Therefore, the moment unit 1 operates, the currents become: $I_{unit\ 1} = I_1 + I_{C1}$, $I_{unit\ 2} = I_2 + (-I_{C2})$, $I_{unit\ 3} = I_3 + (-I_{C3})$. Increased current in unit 1 causes its line drop compensator to operate the voltage regulating relay to cause additional "raise" operations of the tap changer. Decreased current in units 2 and 3 cause their line drop compensators to operate the voltage regulating relays to cause "lower" operations of the tap changers. Thus, with only the conventional control, the first unbalance which creeps into the system becomes cumulative until the tap changers reach their limit positions.

Fig. 3 shows the circuits which are added in current balance paralleling to cancel, and in fact reverse, this cumulative tendency. In each unit, the current in the main current transformer is the same as before: $I_{unit\ 1} = I_1 + I_{C1}$, $I_{unit\ 2} = I_2 + I_{C2}$, $I_{unit\ 3} = I_3 + I_{C3}$. An auxiliary current transformer, K2, has its primary connected in series with each line drop compensator, and its secondary connected in series with the secondaries of all the other K2 transformers. The K2 ratios are selected so that the normal values of I_1, I_2, and I_3, as determined by the circuit capacities and impedances, make $I_{1S} = I_{2S} = I_{3S}$. (For example, if all units are the same kva rating, K2 has the same ratio on all units. If unit 1 is twice the kva rating of units 2 and 3, K2 will make the overall ratio of CT plus K2 in unit 1 twice the corresponding ratio for units 2 and 3). Since $I_{1S} = I_{2S} = I_{3S}$, the series circuit of the K2 secondaries is a very low impedance circuit to I_1, I_2, and I_3 and allows I_1, I_2, and I_3 to flow through the line drop compensators, K.

However, I_{C1}, I_{C2}, and I_{C3} cannot be similarly balanced since $I_{C1} + I_{C2} + I_{C3} = 0$. Therefore, the series connection of K2 secondaries presents a high impedance to the circulating current, forcing it to flow into the common connection, G, and keeping it out of the line drop compensator. At G, $I_{C1} + I_{C2} + I_{C3} = 0$, which means that a positive I_{C1}, at this point, becomes a negative component of I_{C2} and/or I_{C3} and, as such, flows through the current transformers and K1, PS2, and 152a, of units 2 and/or 3 in the negative direction to H. At H, it recombines and again becomes positive I_{C1}, flowing through 152a, PS2, and K1 of unit 1 back to the unit 1 current transformer. (Note: All units must have the same CT ratio, since $I_{C1} + I_{C2} + I_{C3} = 0$ must be true for both Fig. 1 and Fig. 3 or 4).

The currents I_{C1}, I_{C2}, and I_{C3} flow from the secondaries of K1 to the reactance elements of the line drop compensators, K. The reactive elements, only, are used since the loop impedance to circulating current (Fig. 1) is largely reactive. The K1 connections are directly to the total reactive element so that the X adjustment for line drop compensation does not affect the sensitivity to circulating current. (Exception: When other requirements make it necessary to use the type RC, RD, or RE line drop compensator, the X adjustment does affect the circulating current sensitivity proportionately, requiring corresponding adjustment of the taps on K1). The polarity of the connections from K1 to X is reversed, relative to the line drop compensator connections, so that increased positive circulating current causes the voltage regulating relay to operate the tap changer in the "lower" direction. Operation in the "lower" direction reduces the positive circulating current. Thus, the paralleling circuits operate the tap changers toward minimum circulating current, and this control is in addition to and independent of the line drop compensation due to I_1, I_2, and I_3.

The circuit breaker pallet switches, 152-a and 152-b are shown in Fig. 3 with the circuit breakers all closed. Suppose that the circuit breaker of unit 3 opens, then contacts 152-b close and contacts 152-a open. The closing of 152-b provides a by-pass around K2 of unit 3 for the series circuit so that $I_{1S} = I_{2S}$ satisfies the equality requirements of K2

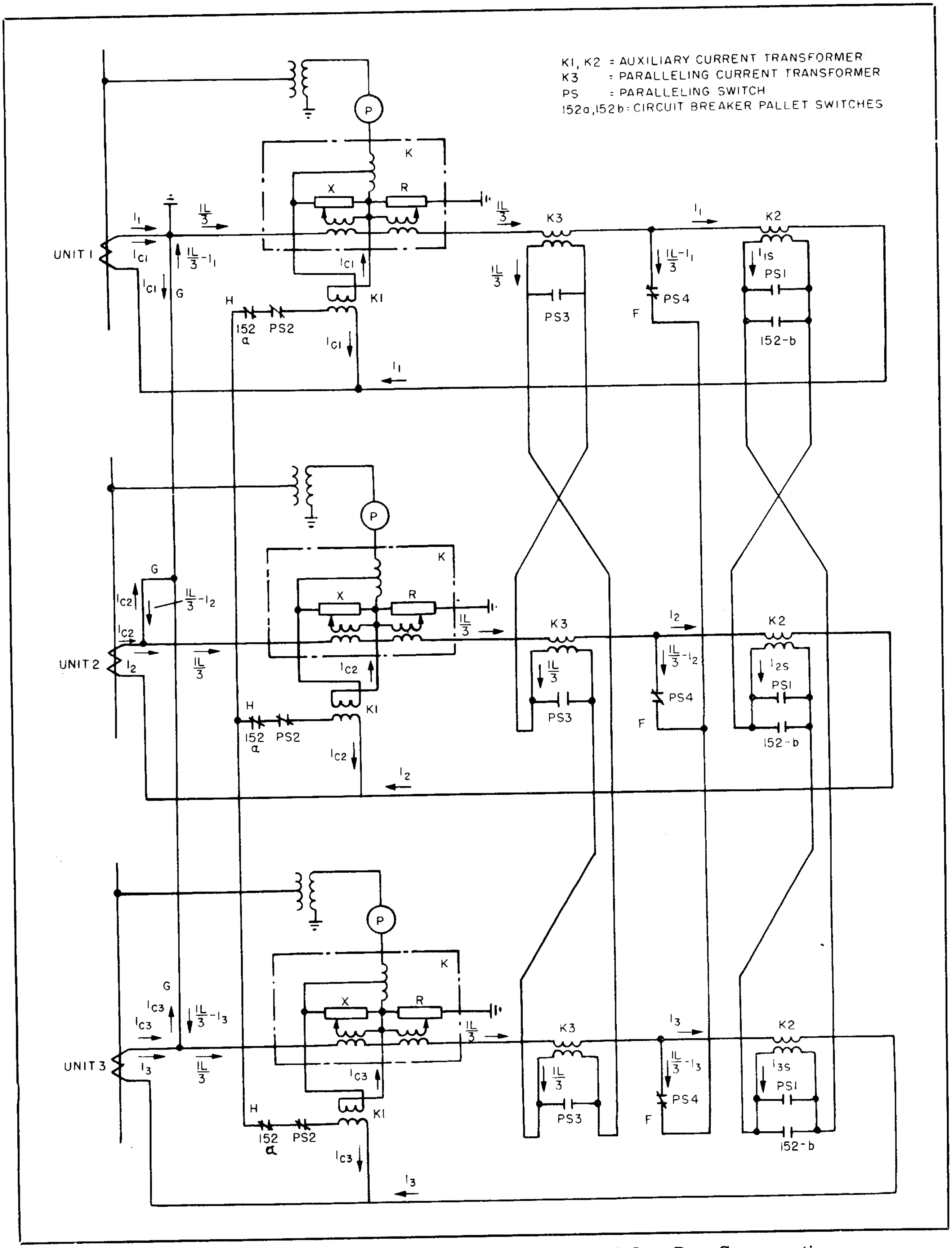

FIG. 4. Control Circuits for Current Balance Paralleling with Line Drop Compensation Based on Total Bank Load.

and permits I_1 and I_2 to flow through their respective line drop compensators even though I_3 is now zero. The opening of 152-a opens the circuit through K1 to prevent any portion of the circulating current taking the path from G through K, K2, and K1 of unit 3 to H. Thus, when the circuit breaker of unit 3 opens, units 1 and 2 continue to operate in parallel as a bank of two units.

The paralleling switch contacts PS1 are in parallel with 152-b and contacts PS2 are in series with 152-a, so that the paralleling switch provides a means of manually removing a unit from parallel operation. With K2 by-passed by PS1 and with the circulating current path opened by PS2, the control of that unit is effectively the same as Fig. 2. Thus, if by bus switching, unit 3, for example, is connected to a different load than units 1 and 2, the paralleling switch of unit 3 can be set on "independent" and unit 3 will operate and regulate its load without either affecting the parallel operation of units 1 and 2 or being affected by units 1 and 2.

In Fig. 4, the K3 network is added for making the line drop compensators respond to total load current instead of to the currents in the respective units. The K3 network is exactly the same as the K2 network except that contacts 152-b are omitted, the K3 current transformers are all the same ratio regardless of the unit Kva's, and the interconnection through PS4 is a direct connection with no elements corresponding to K1. Currents I_1, I_2, and I_3 flow through K2 as described for Fig. 3. However, because K3 ratios are all the same, equal currents must flow through the line drop compensators and K3 primary; this current is IL/3 (or IL/2 for two units, IL/4 for four units, etc.). Any difference between I_1, for example, and IL/3 flows through connection G to unit 2 or 3 where it adds to I_2 or I_3 to make IL/3 through K or those units. This is possible since $I_1+I_2+I_3=I_L$ and $3(I_L)/3=I_L$. Leaving K3, the corresponding currents flow through PS4 so that I_1, I_2, and I_3 flow through K2, as in Fig. 3. Since the current in each compensator is IL/3 and since there are no 152-b contacts, each unit will have its share of the total load current regardless of how the load divides between units or how many circuit breakers open.

The paralleling switch contacts PS3 by-pass K3 as PS1 by-passes K2 and PS4 opens F as PS2 opens H, so that setting the paralleling switch of one unit on "independent" removes that unit from the bank, permits it to operate independently, and lets the remaining units operate as a bank of two units.

The operation of current balance paralleling circuits will automatically respond to changing load conditions, and will operate to keep circulating current to a minimum. However, there are a few limitations which should be noted and recognized.

1. The circulating current response is through the standard control which includes time delay relays. During this time delay, the circulating current is limited by the loop impedance only.

2. In case any part of the tap changer or its control should fail to operate correctly, it is possible for the tap changers to become separated by the full tap range. Unless the loop impedance is sufficiently large, the resultant circulating currents may cause dangerous overloading of one or more of the transformers. Where such a possibility exists, suitable overload alarm device should be provided.

3. For proper operation, the K2 current transformer ratios must be selected to give equal secondary currents at normal load division between units. At the same time, the ratios for the circulating current must all be the same since the circulating current summation must equal zero.

4. To keep all units together without hunting or sacrifice in sensitivity to circulating current, all voltage regulating relays and line drop compensators must have the same settings.

5. If for any reason, it is impossible for the tap changers to reduce the circulating current to a low value (examples: unusually wide voltage band width settings, transformers having different tap voltages, tap changer power supply failure), the circulating current adding vectorially to the load current in X may overload this element of the line drop compensator.

ADJUSTMENT, MAINTENANCE, INSPECTION

The only adjustment is the tap connection on the paralleling current transformer. This adjustment is probably best made by trial. For increased sensitivity, the taps should be connected for higher secondary current.

Note: The secondary of the paralleling current transformer is connected directly to the reactance element of the line drop compensator. Any current greater than that required to produce a voltage sufficient to operate the voltage regulating relay serves no useful purpose, but only overloads the compensator. Therefore, the paralleling current transformer taps should be connected for the lowest secondary current which will give the required sensitivity to circulating currents.

The sensitivity which can be used depends upon the loop circuit impedance, the fineness of the tap changer steps, and the number of units being paralleled. Minor differences in the paralleled circuits make it probable that the circulating current will not reduce completely to zero. The sensitivity must be reduced sufficiently that this minimum circulating current will not cause hunting. On the other hand, increased sensitivity will cause smaller circulating currents to operate the tap changers and thus keep transformer heating to a minimum. A practical operating point will usually keep the tap changers within one or two steps of each other.

One feature of current balance paralleling is the fact that units do not have to be in step to be paralleled, as the paralleling control will act to bring the units into step. However, in order to minimize circulating currents at the time the power circuit is closed, it is recommended that the units be placed on corresponding tap positions before paralleling.

The only maintenance required by the current balance paralleling equipment is occasionally blowing out any accumulated dust and dirt and inspecting the contacts of the paralleling switch.

RENEWAL PARTS

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

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(Rep. 10-56) Printed in U.S.A

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