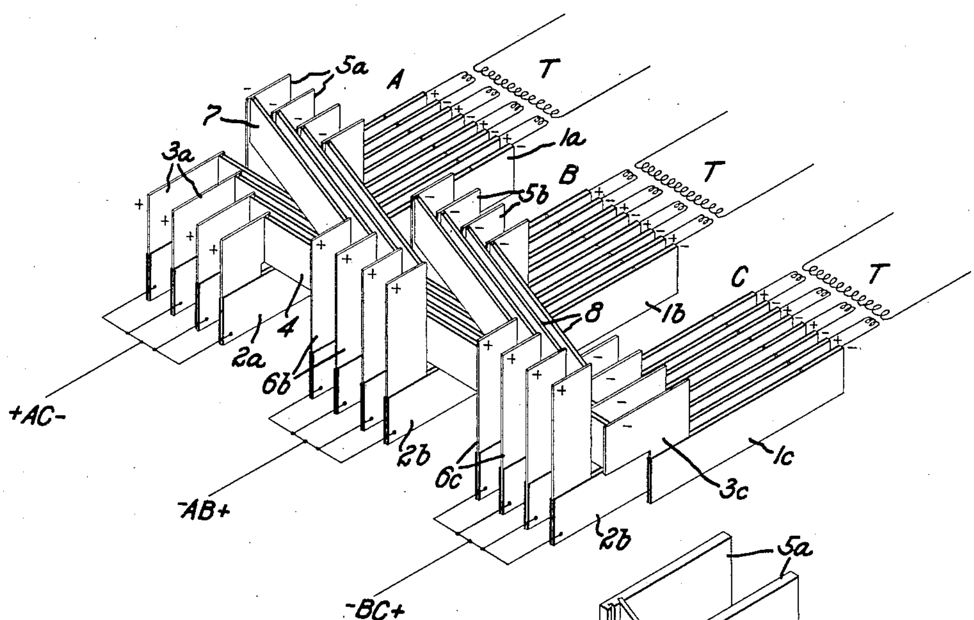
Sept. 29, 1942. H. H. RUDD 2,297,170

HEAVY DUTY DELTA CONNECTION

Filed June 12, 1941 2 Sheets-Sheet 1

Fig. 1.



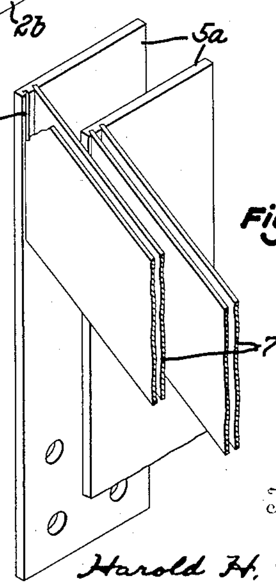


Fig. 8.

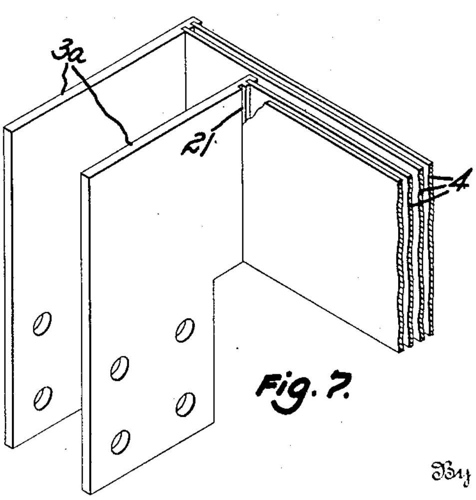


Fig. 7.

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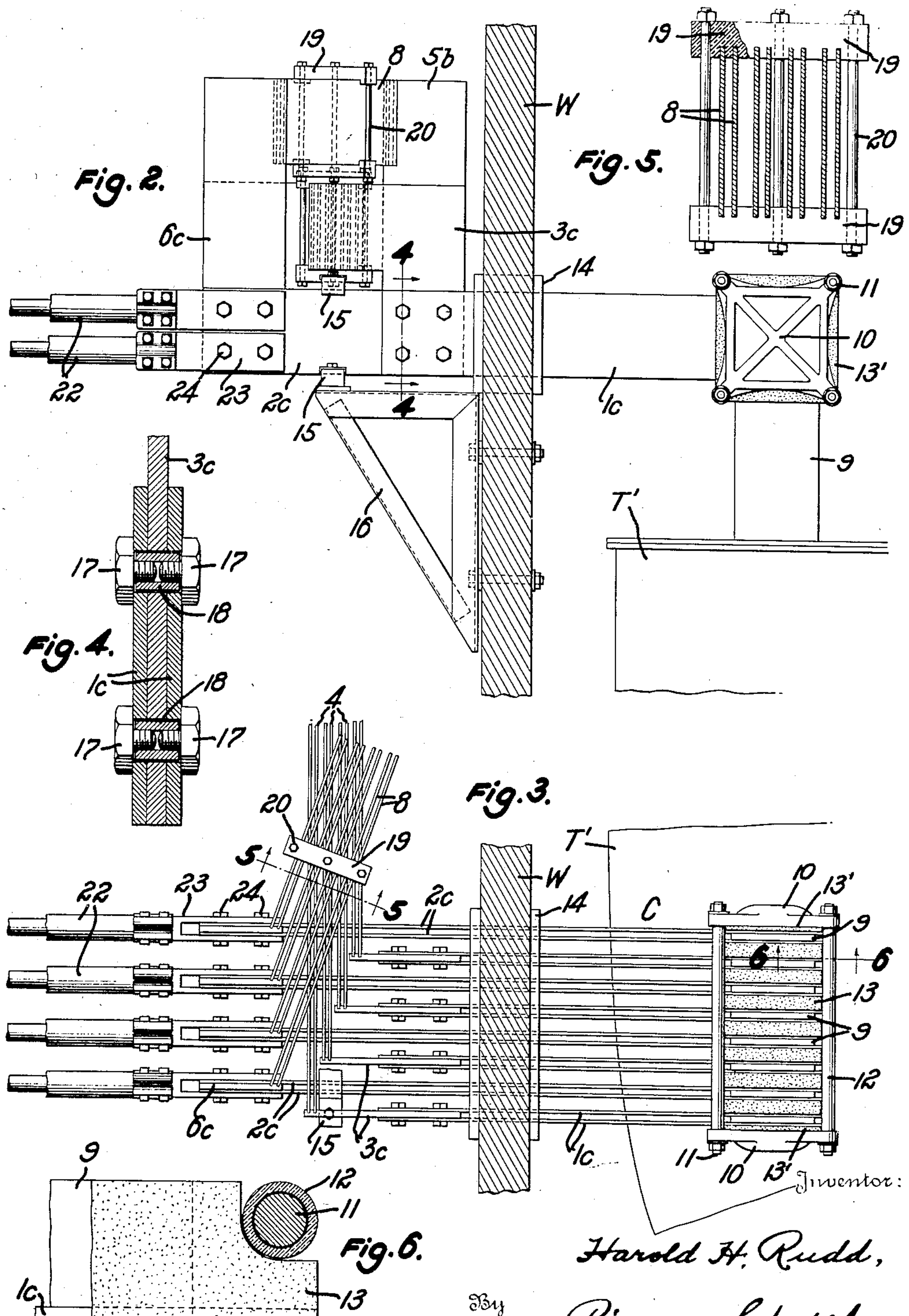

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2,297,170

HEAVY DUTY DELTA CONNECTION

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12 Claims. (Cl. 171—97)

This invention relates to heavy duty delta connections, and particularly to delta connections for use between an electric furnace and a transformer having for each phase a plurality of secondary windings with individual terminal members.

The bus or delta connections for supplying a low voltage, heavy current to a Heroult furnace comprise a plurality of copper bars of rectangular cross-section that should be vertically arranged to present a minimum surface area upon which dirt may collect. The current flow may be of the order of thousands of amperes, for example 40,000 amperes and upwards, and it is therefore desirable to reduce the inductance to a minimum by interlacing the conductors, by making the connections of all phases of approximately the same length, and by reducing the length of all conductors to a minimum. It has not been possible to satisfy these apparently contrary design requirements with the previously proposed delta connections from three phase transformers with multiple section secondary windings, and the interlacing of conductors of approximately the same length for each phase resulted in relatively long bus conductors that extended to a considerable distance above and/or below the level of the horizontally arranged bus members that were connected to the transformer terminals of the secondary windings.

Objects of the present invention are to provide delta connections or bus members of relatively short length and space requirements that are interlaced to reduce the inductance of the connections to a minimum. An object is to provide delta connections comprising vertically disposed bar conductors located at only two levels above and/or below the level of the horizontally alined bar conductors that are secured to the terminals of multiple section secondary windings of a transformer. A further object is to provide delta connections for multiple section transformer secondary windings in which the connecting members of each set are of the same length and, if desired, the connecting members of all sets may have the same length.

These and other objects and advantages of the invention will be apparent from the following specification when taken with the accompanying drawings in which:

Fig. 1 is a schematic perspective view of a bus system or heavy duty delta connection embodying the invention;

Fig. 2 is a fragmentary side elevation of the bus system;

Fig. 3 is a fragmentary plan view of the same;

Fig. 4 is an enlarged and fragmentary vertical section of the bus system as seen on the plane indicated by the line 4—4 of Fig. 2;

Fig. 5 is a vertical section through one set of interphase connecting members as seen on the plane of line 5—5 of Fig. 3;

Fig. 6 is an enlarged fragmentary vertical section as seen on the plane of line 6—6 of Fig. 3;

Fig. 7 is an enlarged and fragmentary perspective view of connecting members that extend between bus bars of the outer windings of the three phase transformer; and

Fig. 8 is a similar enlarged fragmentary perspective view of connecting members that join bus bars of an adjacent pair of transformer windings.

In Fig. 1 of the drawings, the reference characters T identify generally the conventional step-down transformers, with multiple section secondary windings, of the individual phases A, B, C of the supply system for a Heroult electric furnace. For convenience of description, the polarities of the secondary winding terminals at a given instant are indicated by + and — signs and the associated bus bars will be referred to as of positive and negative polarity. The secondary winding terminals alternate in polarity in each phase and the relative arrangement of the polarities may be the same in all phases, as illustrated, or may be reversed in one of the phases.

The secondary windings of each phase are to be connected in parallel, and delta connections to the three electrodes or groups of electrodes of the Heroult furnace call for the connection of the + terminals of one phase to the — terminals of the adjacent phase. As indicated at the left of Fig. 1, the delta supply system is established by connecting the — terminals of the C phase secondaries to the + terminals of the A phase, connecting the — terminals of the A phase to the + terminals of the B phase, and connecting the — terminals of the B phase to the + terminals of the C phase.

A bus bar, or preferably a pair of bus bars, extends horizontally from each secondary winding terminal, and the bus bars of opposite polarity are of different lengths. As illustrated in Fig. 1, short bus bars 1*a*, 1*b*, 1*c* are connected to the — terminals of the secondary windings of phases A, B and C, respectively, and longer bus bars 2*a*, 2*b*, 2*c* are connected to the corresponding + terminals of the several phases. These bus bars are alined horizontally and with their larger surfaces arranged vertically. Inverted L-shaped plates

3a and 3c are secured to the + conductor bars 2a of the A phase and to the — bars 1c of the C phase, and pairs of cross bars 4 extend transversely across the bus system to connect the ends of the correspondingly arranged plates 3a and 3c. The horizontal arms of the sets of plates 3a and 3c are of different length to space the connecting bars 4 from each other, but the total length of each cross-connection is substantially the same, since the short horizontal arm of an inner plate 3a of the A phase is connected to a long horizontal arm of the correspondingly arranged plate 3c of the C phase.

Bars or risers 5a, 5c extend upwardly from the — conductors 1a, 1b of the A and B phases, respectively, and similar bars 6b, 6c extend upwardly from the + conductors 2b, 2c of the B and C phases. These sets of vertically arranged bars extend above the level of the cross bars 4 of the +AC— phase connections and are connected by the diagonally arranged sets of parallel bars 7, 8 of the —AB+ and —BC+ connections, respectively. All of the connecting bars of each set are of the same length, and the bars 7 that join the riser bars 5a, 6b have the same length as the bars 8 that join riser bars 5b and 6c when, as is customary, the B-phase bars 1b, 2b are centrally located between the main bus bars of the other phases.

An appropriate physical construction for establishing the schematically illustrated circuit connections of Fig. 1 is shown in Figs. 2 to 8, inclusive. The transformer windings are housed in an oil filled transformer casing T' that is spaced from the furnace room by a wall W. The bar terminals 9 of all transformer secondary windings extend the same distance above the casing T' to receive the horizontally alined sets of main bus bars. All sets of bus bars are connected to the transformer terminals 9 in the same manner but only the connections for the C-phase bars 1c and 2c are illustrated in Figs. 2 and 3. A bus bar is arranged at each face of each terminal bar 9, and is secured to the terminal by the plates 10 that are drawn towards each other by bolts 11, within insulating sleeves 12, to compress the assembly of conducting members and insulating spacers 13, 13' that are located between the adjacent bus bars and between the clamping plates 10 and the outer bus bars, respectively. The insulating spacers extend beyond the overlapped portions of the terminals and bus bars, and are notched at their corners to receive the clamping bolts.

The sets of bus bars 1c, 2c, etc. extend through and are supported by an insulator 14 that is mounted in the wall W, and the longer positive polarity bars 2a, 2b, 2c are additionally supported by notched insulator strips 15 that are bolted together and carried by brackets 16 fixed to the furnace room side of the partition wall W.

The vertical risers of the interphase cross-connections are preferably each individually bolted between the associated pair of bus bars, as shown in Fig. 4 with respect to the riser bars or plates 3c, to permit the replacement or repair of any one cross-connection without disturbing the other interphase connections. The plate 3c and associated bus bars 1c have alined openings to receive the short stud bolts 17 that are threaded into a sleeve or bushing 18. The stud bolts may be backed out of the sleeve in the narrow space between the bars 1, 1c and the adjacent bus bars 2c of opposite polarity.

As shown in Figs. 2, 3 and 4, the sets of cross-connecting bars are rigidly supported in spaced parallel relation by clamps comprising notched strips 19 of insulating material and bolts 20.

The electrical and mechanical connections between the several cross bars and the associated riser bars or plates are preferably established by milling grooves 21 in the riser members, and sweating or brazing the cross connecting bars into the grooves, Figs. 7 and 8.

The connections from the bus system to the furnace electrodes may be of any desired flexible type but the connections are preferably established at the points where cross-connections are made to the main bus bars. As shown in Figs. 2 and 3, the furnace leads 22 terminate in yokes 23 that extend over the several pairs of bus members 2a, 2b and 2c, and are clamped to the same by the bolts 24 that extend through the bus members and the associated riser members 3a, 6b and 6c.

Attention is directed to the fact that all of the flat bus and connecting bars are vertically arranged to present minimum area surfaces upon which dust or dirt may collect, and that the cross-connections are arranged at only two levels above or below the main bus conductors. The interlacing of the positive and negative leads is maintained throughout substantially the length of the bus system to reduce induction to a minimum, the length of the connecting members in each phase is the same, and the lengths of all connecting members are or may be identical. As distinguished from prior "three level" delta connection systems such as that shown in Nye 1,370,989, the bus bars are interleaved, and the connecting members are all vertically arranged and of the same length. Attempts have been made to improve the mechanical and electrical characteristics of the prior delta connections for electric furnaces but the prior designs materially increased the total amount of copper and the space requirements. One prior proposal called for an assembly of bus and connecting members at five horizontally alined levels or stages, the length of the assembly as measured from the partition wall to the furnace leads was over 20% above the corresponding dimensions of a bus system embodying this invention, and the overall height of the prior system was 100% more than the overall height requirement for a three level delta connection system according to this invention. Ample space is usually available in a furnace room for any bus system but the pertinent fact is that the total amount of copper is materially increased when the overall volume of the bus system is increased by some 240%.

The embodiment herein shown and described is typical of the invention but it is to be understood that changes may be made in the several parts, and their relative size, shape and arrangements without departing from the spirit of my invention as set forth in the following claims.

I claim:

1. In a bus system for establishing delta output connections for a three-phase transformer having for each phase multiple section secondary windings with transversely alined and interleaved positive and negative terminals, sets of horizontally alined bus bars with alined end portions to be secured to the terminals of the windings of the several phases, and connecting members joining the bus bars of opposite polarity of adjacent phases; said connecting members including horizontally alined connecting bars spaced vertically from said bus bars, and the

connecting bars between adjacent sets of bus bars being spaced from said bus bars by a greater distance than that between the bus bars and the connecting bars that extend between the outer sets of bus bars.

2. In a bus system, the invention as claimed in claim 1, wherein all bus bars that are to be connected to transformer terminals of the same polarity are of equal length and the bus bars that are to be connected to transformer terminals of opposite polarity are of unequal length, the connecting bars between the outer sets of bus bars extending transversely of the bus bar assembly, and the connecting bars between adjacent sets of bus bars being parallel and inclined to the sets of bus bars.

3. In a bus system for establishing delta connections to a three-phase power source having for each phase a plurality of alternately arranged terminals of opposite polarities, sets of interleaved bus bars having transversely alined portions to be connected to the opposite polarity terminals of the several phases, vertically arranged members secured to the bus bars, and connecting members extending between the vertically arranged members of opposite polarity of adjacent phases, the total lengths of the vertically arranged members and associated connecting members of each interphase connection being substantially identical.

4. In a bus system for establishing delta connections to a three-phase power source having for each phase a plurality of alternately arranged terminals of opposite polarities, sets of interleaved bus bars having transversely alined portions to be connected to the opposite polarity terminals of the several phases, vertically arranged members secured to the bus bars, and connecting members extending between the vertically arranged members of opposite polarity of adjacent phases, the total lengths of the vertically arranged members and associated connecting members of all interphase connections being substantially identical.

5. In a heavy duty delta connection system for use between an electric furnace and a three-phase transformer having in each phase a plurality of secondary windings, a plurality of sets of vertically arranged and horizontally spaced bus bars of rectangular cross-section to be connected to the transformer secondary windings of the respective phases, all bus bars of the same polarity being of the same length and the bus bars of opposite polarities being of different lengths, plates secured to and extending vertically from the opposite polarity bars of the outer sets of bus bars, connecting members joining the correspondingly arranged pairs of plates, bars extending vertically from the other bus bars and of greater height than said plates, and sets of connecting bars joining the correspondingly arranged vertically extending bars of opposite polarity of adjacent phases.

6. In a heavy duty delta connection, the invention as recited in claim 5, wherein said plates are of L-shape, and the connecting members joining said plates are of the same length and extend transversely across the bus bar assembly.

7. In a heavy duty delta connection, the invention as set forth in claim 5, wherein said connecting bars are parallel and all of the same length, said connecting bars extending across said bus bar assembly at a substantial angle to said bus bars.

8. In a heavy duty delta connection, the invention as claimed in claim 5, wherein said vertically extending bars have a height substantially greater than said plates, and the length of all vertically extending bars and associated connecting bars is substantially equal to the height of said plates plus the length of the connecting members joining the said plates.

9. In a heavy duty delta connection, the invention as claimed in claim 5, wherein said vertically extending bars are all of the same height and the connecting members joining said vertically extending bars are all of equal length and horizontally alined.

10. In a heavy duty delta connection, the invention as claimed in claim 5, wherein said vertically extending bars are all of the same height and the connecting members joining said vertically extending bars are all of equal length, horizontally alined and spaced vertically from the bus bars and the connecting members joining said plates.

11. In a heavy duty delta connection, the combination with a plurality of interleaved and horizontally alined bus bars of opposite polarities for each phase of a three-phase supply system, one set of the ends of said bus bars being transversely alined for connection to current-supply terminals, the other ends of the bus bars of one polarity being transversely alined and constituting current-output terminals and the other ends of the remaining bus bars terminating short of said current-output terminals, and means including connecting bars horizontally alined at two levels connecting the opposite polarity bus bars of adjacent phases.

12. In a heavy duty delta connection for a transformer having multiple section secondary windings for each phase, bus bars having transversely alined ends for connection to the secondary winding terminals, members extending vertically from said bus bars, said members having grooves formed therein, and connecting members seated in said grooves and extending between the vertically extending members of opposite polarity of adjacent phases.

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