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Goodman

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[54] **CURRENT MONITORING SYSTEM FOR ELECTRIC ARC FURNACE CONDUCTORS**

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[52] **U.S. Cl.** **13/12**

[51] **Int. Cl.** **F27d 11/10**

[58] **Field of Search** 13/12, 13

[56] **References Cited**

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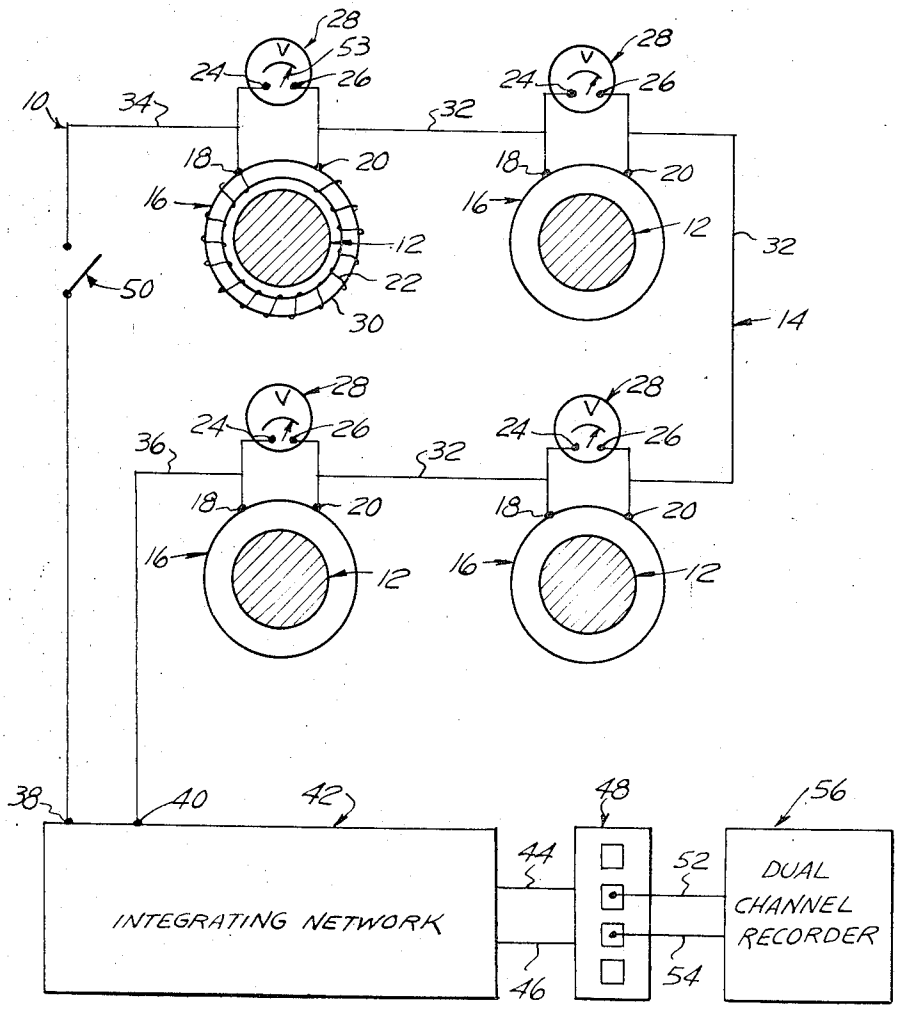
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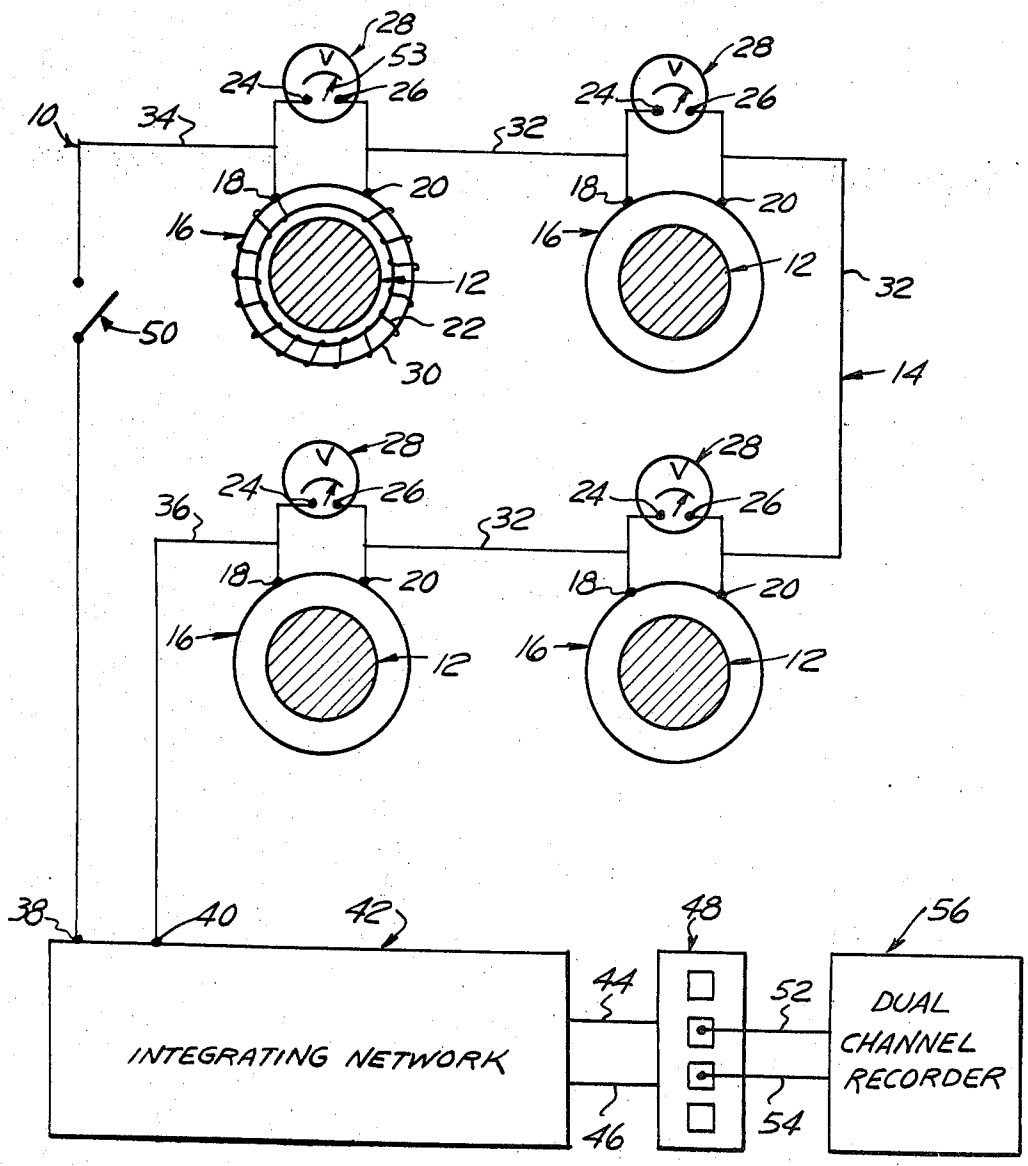
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[57] **ABSTRACT**

Each conductor cable of the set of conductor cables for each phase, extending from the furnace transformer to the electric arc furnace, is encircled by an annular close-wound current transformer coil, the terminals of which are connected to a low-voltage voltmeter. All of the voltmeters for each phase are interconnected and in turn are connected to an integrating network, the output of which is connected to a terminal strip or block for further connection to a suitable recording instrument. Each voltmeter may, if desired, be provided with an additional audible or visual signal device. If any furnace conductor, cable is for any reason carrying less than its proportion of the current, thereby reflecting a deterioration of that particular cable, that condition is immediately indicated by a lowered voltage reading on its particular voltmeter, so that the operator can take immediate corrective action.

9 Claims, 1 Drawing Figure




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INTEGRATING NETWORK
DUAL CHANNEL RECORDER

CURRENT MONITORING SYSTEM FOR ELECTRIC ARC FURNACE CONDUCTORS

BACKGROUND OF THE INVENTION

The electrodes of electric arc furnaces for steel production are customarily supplied with three-phase alternating current carried by multiple conductor cables, such as flexible water-cooled cables, in each phase. Individual cables of each set of cables for each phase can deteriorate over the period of their working life, with the result that a deteriorating cable carries less than its allotted share or proportion of the current. This requires the remaining cables of that phase to carry more than their allotted share, thereby overloading them. Hitherto, detection circuits or devices have been provided for indicating the overall condition of each set of cables, but such devices have not indicated the condition of each individual cable of the set, which may include as many as four cables per phase. Iron-core transformers have been used for this purpose, but their excessive weight has required strong mechanical support. Their exposed locations have also subjected them to the adverse effect of high heat, dirt and atmospheric pollution. Furthermore, the heavy supporting frame, which is usually of steel, by its close proximity to the iron-core transformer has led to electrical and mechanical interference therewith.

In a second prior installation, a current transformer has been built into the secondary winding of the furnace transformer, for the purpose of indicating variations in the current draw therefrom, but this prior circuitry has proved to be very dangerous for the reason that the opening of the circuit in changing from one tap to another of the primary winding of the transformer has produced sudden extremely high voltage current flows or surges. A third prior arrangement places current transformer coils adjacent the primary winding of the furnace transformer, but because the latter has a variable voltage ratio, a special transformer is required to cause the tap change ratio to be identical with the tap ratios of the furnace transformer. Furthermore, a switch-over arrangement is also required for a delta (Δ) arrangement to a wye (Y) arrangement.

SUMMARY OF THE INVENTION

The present invention, by placing a current transformer coil and coupled voltmeter around each conductor cable of each set of cables for each phase, indicates the current-carrying condition of each such cable or other conductor, so that corrective measures may be taken the instant a lowered voltage reading is indicated on any one of the voltmeters. Such a reduction in current-carrying capacity can result not only from deterioration of the cable but also from an accidental reduction or cessation in the cooling water flow through the cable, causing the heat therein to rise disastrously unless the condition is immediately corrected. The voltages generated in the current transformer coils are low, hence present no hazards.

The single FIGURE shows a wiring diagram of a current monitoring system for electric furnace conductor cables, according to one form of the invention, as applied to a set of cables for one of the three phases of current supply from the current supply transformer to the electric arc furnace.

Referring to the drawing in detail, it shows a current monitoring system, generally designated 10, for the individual water-cooled conductor cables 12, of a set 14 of such cables for carrying the current of one phase from a conventional current supply transformer (not shown) to the electrodes (not shown) of a conventional electric arc furnace. The cables 12, together with the current supply transformer, electrodes, and electric arc furnace are conventional and their details, being well-known to those skilled in the electric furnace art, are beyond the scope of the present invention. It will be understood that a similar current monitoring system is provided for each of the other phases of the current supply arrangement to the electric arc furnace.

Each conductor cable 12 is encircled by an annular current transformer coil 16, preferably located at the top thereof near its connection to the furnace current supply transformer. The terminals 18 and 20 of each winding 22 are connected to the terminals 24 and 26 of a low-voltage voltmeter 28. The term "low voltage" is used to apply to a control circuit voltage of less than 25 volts and preferably less than 10 volts in order to eliminate any current hazard to workmen. Each winding 22 is close-wound, to an approximately eighty per cent fill, upon an annular or toroidal core 30, preferably of elastomeric non-magnetic material, such as rubber. The volt-meters 28 are interconnected in series by lines 32.

Output lines 34 and 36 lead to the input terminals 38 and 40 of a conventional integrating network 42. Such integrating networks 42 are known to electrical engineers for altering wave forms, and are here employed for the purpose of smoothing out irregularities in the signal wave forms emitted by the currents induced in the windings 22 by the flow of of current through the furnace cables or other conductors 12 from the furnace current supply transformer to the electric arc furnace. The output lines 44 and 46 from the integrating network 42 are in turn connected to a terminal strip or terminal block 48 from which connection is made to any desired recording instrument or to an audible or visual alarm device adapted to audibly or visually warn the operator of a serious decline in the current flow in any one of the conductor cables 12 of the set 14 for each phase, as indicated by the voltage drop indication of any of the voltmeters 28. A switch 50 is provided in one of the output lines 34 or 36 for switching the current monitoring system 10 of each phase on or off.

In the operation of the invention, let it be assumed that current is flowing through the cables 12 of each set 14 thereof for each phase, from the furnace current supply transformer to the electric arc furnace, particularly in the refining stage of the steel production. To detect the condition of each of the cables 12, the operator closes the switch 50. The flow of current through the cables 12 induces a current in each winding 22 of each current transformer coil 16, this induced current flowing to its respective voltmeter 28 and causing an indication of voltage thereon, as by a shifting of its needle 53. The integrating network 42 smooths out irregularities in the current signals produced within the winding 22 of the current transformer coils 16, as is known to those skilled in the electrical engineering art. If the voltage indication on any one of the voltmeters 28 falls below a previously-agreed value, such as, for example, 5 volts, the operator is thereby warned visually that this particular cable 12 is carrying less than its allotted amount of current. Such allotted current flow per cable might, for example, be 3.5 kilo-amperes per cable.

Upon observing such a voltage reading of decidedly less than normal on any one of the voltmeters **12**, the operator, as soon as possible, will pull down that particular cable **12** and inspect it for defects. If the observed voltage drop is sudden and of considerable magnitude, the operator will immediately inspect the cooling water supply circuit for that particular cable to be sure that cooling water is flowing properly through the cable and that its flow has not been obstructed, such as by wire splinters. Such obstructions of the cooling water flow have been known to cause explosions of the cables from the steam pressure generated inside the hoses thereof when the water flow has been obstructed or cut off, with consequent danger to bystanders. The present invention thus enables the current-carrying condition of each cable to be constantly known, so that it may be immediately repaired or replaced, if deemed advisable.

This invention possess the further advantage that it can inform the operator of the actual voltages and amperages which the furnace current conductor cables **12**, are actually impressing upon the furnace electrodes (not shown), and hence upon the batch in the furnace. As the resistance of this batch varies from time to time according to its composition, the voltage and amperage of the furnace current applied thereto by the furnace electrodes also vary. In order to measure the actual voltages and amperages being thus applied to the furnace electrodes, a conventional dual channel recorder **56** is connected as by lines **52** and **54** to two of the terminals of the terminal block **48**. The irregular signals received from the current monitoring system **10** of each phase served by each set **14** of furnace conductors **12** are smoothed out by the integrating network **42** and transmitted therefrom to the dual channel recorder **56**. The latter then accurately shows the actual voltage and amperage of the furnace current of each phase being impressed upon the furnace electrodes at any particular moment or during any particular period of time. The dual channel recorder is preferably calibrated to read proportionately in amperages and voltages actually being applied to the furnace electrodes, although the voltages and amperages actually flowing through the recorder are, of course, only a tiny fraction of the former.

I claim:

1. A monitoring system for indicating the current-carrying condition of each of the individual furnace conductor cables connecting a multi-phase electric arc furnace transformer to an electric arc furnace, said system comprising

a monitoring current transformer coil encircling each furnace current conductor cable of each phase,

said coil being responsive to the flow of furnace transformer current through its respective furnace current conductor cable to effect flow of induced current through said coil,

each coil including a winding wound on a core encircling its respective furnace current conductor cable,

and a voltmeter so connected to each coil as to indicate the voltage of said induced current flowing through said coil, whereby to immediately detect any adverse current flow condition in any conductor cable at any desired time and thereby to enable remedying said adverse condition at once.

2. A monitoring system, according to claim **1**, wherein said core is of non-magnetic material.

3. A monitoring system, according to claim **1**, wherein said core is of toroidal configuration.

4. A monitoring system, according to claim **3** wherein said winding is also of toroidal configuration and has its convolutions closely wound upon said core.

5. A monitoring system, according to claim **1**, wherein said voltmeter is an alternating current voltmeter.

6. A monitoring system, according to claim **1**, wherein an integrating network is connected to said voltmeter.

7. A monitoring system, according to claim **1**, wherein all of the voltmeters for the monitoring current transformer coils encircling the furnace current conductor cables of each phase are connected to one another in a circuit, and wherein the output of said circuit is connected to the input of an integrating network.

8. A monitoring system, according to claim **7** wherein a current characteristics indicating instrument is connected to the output of said integrating network.

9. A monitoring system, according to claim **8**, wherein the current characteristics indicating instrument is a dual channel recorder indicating the variation of volts and amperes in the current passing therethrough.

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