

[72] Inventors **Peter G. Bartlett;**  
**Donald E. Henry, both of Davenport, Iowa**  
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 [73] Assignee **Struthers-Dunn, Inc.**  
**Pitman, N.J.**

*Primary Examiner—J. D. Miller*  
*Assistant Examiner—Harry E. Moose, Jr.*  
*Attorney—Hall, Pollock & Vande Sande*

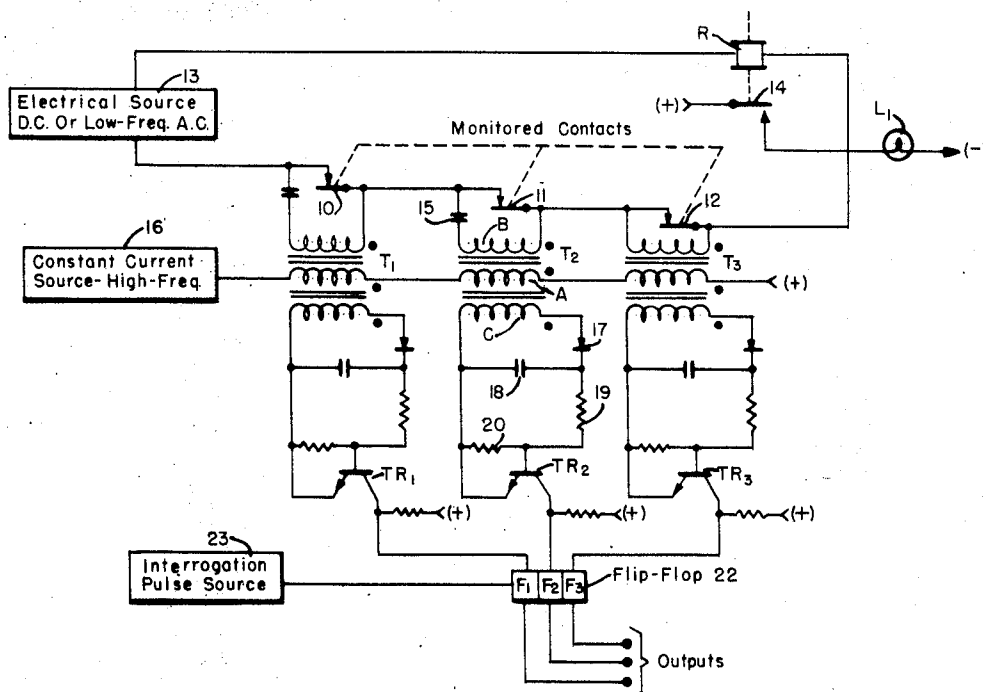
[54] **CONTACT MONITORING SYSTEM**  
**4 Claims, 2 Drawing Figs.**

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**250; 324/51; 317/9; 323/6, 85**

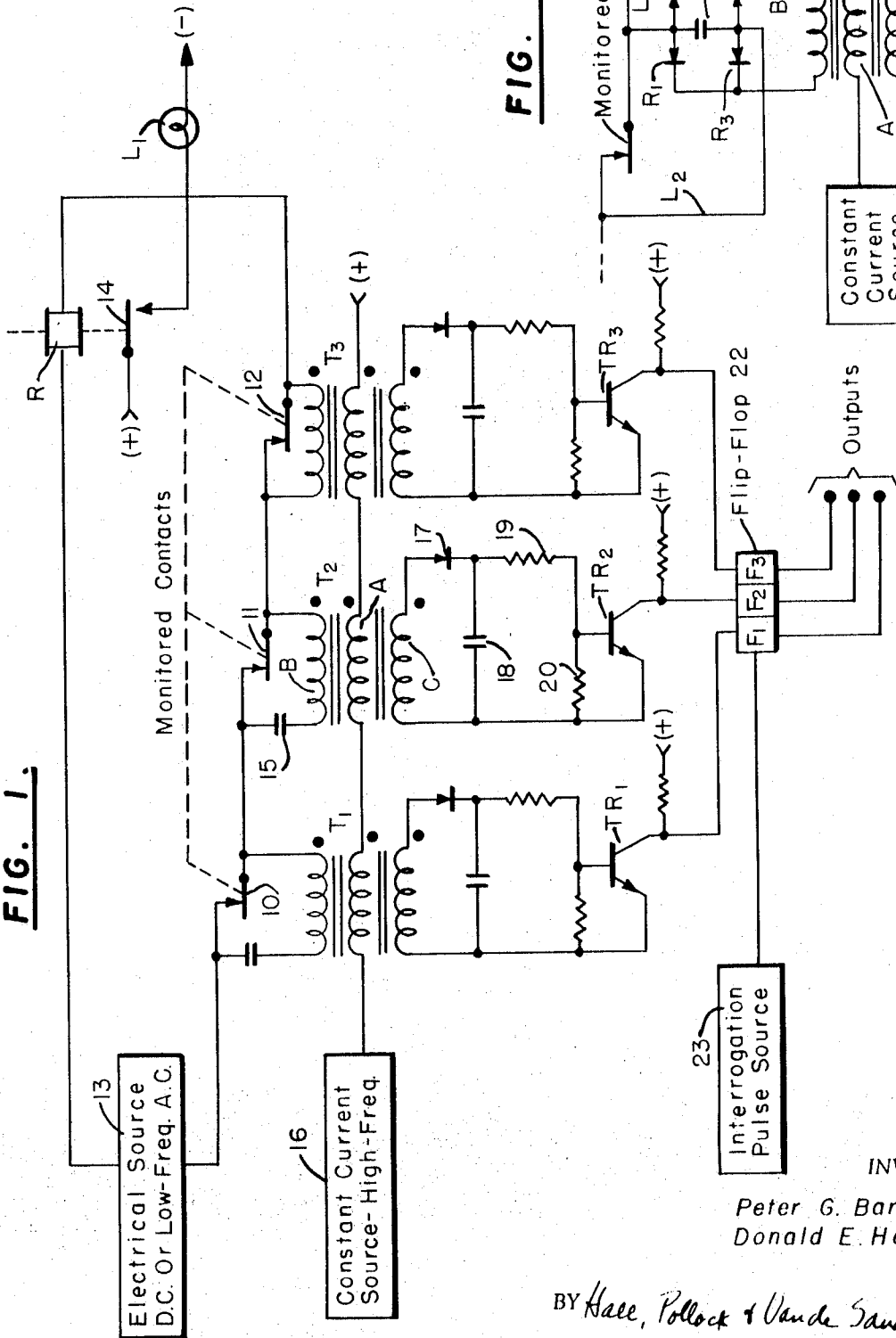
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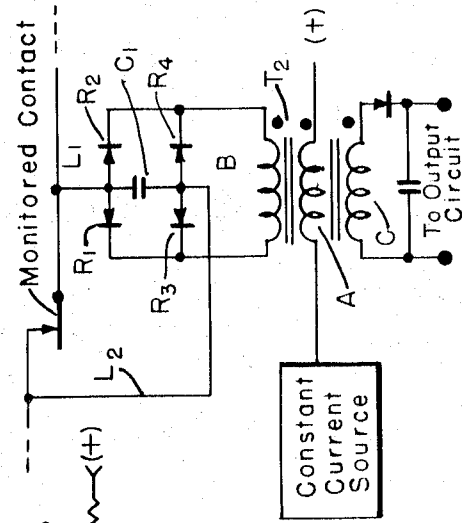
**ABSTRACT:** Circuit means for monitoring the conditions of a plurality of contacts, thereby making it possible to determine at each instant which contact is open and which is closed. The output of each contact monitoring circuit is electrically isolated from all of the monitored contacts and also from any circuit in which a monitored contact is included. The monitoring circuit comprises a three-winding transformer for each monitoring contact, with the primary windings of the transformers connected in series and energized from a constant current source of relatively high frequency. A secondary winding of each transformer is connected in shunt with a respective one of the monitored contacts, and a second secondary winding of each transformer has its output voltage rectified and used to control the conductive state of an associated transistor, with the latter transistor, by its conductive state, providing a manifestation of the closed or open condition of the associated monitored contact.



**FIG. 1.**



**FIG. 2.**



INVENTORS

Peter G. Bartlett  
Donald E. Henry

BY *Hale, Pollock & Vande Sande*

ATTORNEY

## CONTACT MONITORING SYSTEM

## BACKGROUND OF THE INVENTION

In industrial control and/or surveillance systems, it is common to provide a plurality of switch or relay contacts, and to interconnect such contacts in any of various fashions. Quite often, such contacts may be connected in series with a source of direct current or low-frequency alternating-current energy, and with a relay or other responsive device included in the circuit. With such an arrangement, the condition of all the contacts may be continually checked.

A typical example of such a circuit arrangement is one wherein a large number of responsive devices are positioned along a conveyor line, one such device being associated with each station or position along the conveyor and each perhaps checking the presence of a particular item or condition. The plurality of contacts associated with such devices, one contact for each device, may be connected in series with an energy source and a relay and with the circuit being completed to energize the relay and thereby indicate a no-fault condition as long as each contact is in its normal position. The presence of a fault anywhere in the system can then be detected since the opening of any one of the plurality of contacts will deenergize the relay and provide an indication of a fault.

A system such as this just described, although of considerable utility in determining that a fault has occurred, is in no way capable of providing information as to the location of that fault, and it is therefore frequently required that a protracted trouble-shooting operation take place, with each monitoring condition along the conveyor line being examined to determine whether it is operating properly.

By use of the circuit organization of this invention, it is readily possible to monitor the condition of each contact individually and thus determine which contact or contacts is not in its normal condition. This may be done, in accordance with the present invention, without in any way interfering, for example, with the above-described circuit organization which is effective to detect the presence of a fault somewhere in the system. Thus, the circuit organization of the present invention operates in shunt with each contact but without affecting the series arrangement involving the various monitored contacts.

## SUMMARY OF THE INVENTION

In accordance with the present invention, each monitored contact has connected in shunt therewith the secondary winding of a three-winding transformer, one such transformer being provided for each contact to be monitored. The primary winding of each three-winding transformer is energized from a constant current source which provides a high-frequency energization which may, for example, be in the order of 100 kHz. The second secondary winding of each transformer has its output rectified and filtered to provide a direct-current voltage which controls the energization of an associated transistor. The transistor is thus controlled between conductive and nonconductive conditions, and its state at any instant thus provides a manifestation indicative of the condition of the associated monitored contact. The output of the transistor may, for example, be used to control an associated flip-flop stage.

## BRIEF DESCRIPTION OF THE DRAWINGS

In describing the invention, reference will be made to the accompanying drawing in which:

FIG. 1 comprises a circuit and block diagram illustrating the combination of elements of the invention; and

FIG. 2 illustrates an alternative form of a portion of the circuit organization of FIG. 1.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. 1, the various monitored contacts are designated as 10, 11, and 12. Only three such contacts are

shown, but it will be understood that any desired number of contacts may be used. The front contacts 10-12 may be connected in series with each other and with an electrical source 13 which provides energy of direct-current or of a low frequency alternating-current which may, for example, be of 60 Hz. The series circuit just described may also include the winding of a relay  $R_1$ , and if it is assumed that each front contact 10-12 is normally in the closed condition, then relay  $R_1$  will normally be energized and its back contact open so that indicator light L1 will not be energized. However, upon opening of any of the series contacts 10-12, relay  $R_1$  will release, thereby closing back contact 14 and energizing indicator lamp L1 to provide an indication that at least one of the series-connected contacts has now opened.

Connected in parallel with each of the contacts 10-12 is a series circuit comprising a capacitor and the winding of a transformer. For example, in parallel with contact 11 is a series circuit arrangement of capacitor 15 and the secondary winding B of transformer  $T_2$ . The function of capacitor 15 is to provide a relatively high impedance to the frequency of the source 13, and this capacitor of course also blocks direct current from flowing in transformer winding B in the event that source 13 provides direct current.

Each transformer such as transformer  $T_2$  comprises three windings, and, with respect to transformer  $T_2$ , the winding A can be considered as the primary winding and windings B and C comprise individual secondary windings. It will be noted that the primary windings of each of the transformers  $T_1$ - $T_3$  are connected in series and all are energized by a constant-current source 16 which is arranged to provide a relatively high frequency of alternating-current energization of the primary windings a typical frequency value being in the order of 100 kHz. The use of a constant-current source for the source 16 is necessary in order that each of the contact monitoring circuits in the series of such circuits will have the same magnitude of voltage across the primary winding of its respective transformer irrespective of which of the monitored contacts are open or closed at any instant. More specifically, if a constant-current source were not provided, then the available voltage would be distributed amongst the transformers in series connection equally only when all of the contacts were closed, but as soon as any one contact opened, then substantially all of the voltage would appear across the primary winding of the transformer associated with that contact. By use of a constant-current source this difficulty is avoided.

Irrespective of the number of contacts employed in the system and whose condition is to be monitored, the current through the primary windings of the associated transformers is always at the same value because of the use of a constant current source 16 to provide the required energization.

If it is now assumed that contact 11 is open, a voltage is induced in both the secondary windings B and C of transformer  $T_2$ . The secondary winding C of each transformer has connected in parallel therewith a diode 17 and a capacitor 18, which components provide halfwave rectification and filtering of any alternating-current voltage induced in secondary winding C. The resulting direct-current voltage appearing across capacitor 18 then appears also across the parallel combination of series-connected resistors 19 and 20 which function as a voltage divider so as to provide between the emitter and base of transistor  $TR_2$  a suitable direct-current voltage which will turn this transistor on. When transistor  $TR_2$  is turned on, a voltage drop appears across collector resistor 21 which produces a distinctive input voltage to stage S2 of flip-flop 22.

If, on the other hand, contact 11 is closed, then the secondary winding B of transformer  $T_2$  is short circuited, and this has substantially the same effect as does a short circuiting of the other secondary winding C. As a consequence, no voltage can then appear across capacitor 18 nor across resistors 19 or 20, so that transistor  $TR_2$  remains in the nonconductive condition.

In the manner just described, each of the stages F1-F3 of flip-flop 22 may selectively be provided either with a substantially zero voltage or a positive voltage, dependent upon

whether the associated contact 10-12 is closed or open, thereby conditioning the respective stage of flip-flop 22 to be conditioned for operation to either its "0" or "1" state. Actual operation of the various stages of the flip-flop 22 does not occur until a pulse is provided from the interrogating pulse source 23. When such pulse does occur, however, each stage of the flip-flop is operated to its "0" or "1" state dependent upon which of the two inputs it is then receiving from the associated transistor. A suitable output device can be connected to each stage of flip-flop 22 to provide a visual indication or any other suitable type of output to indicate whether the respective contact is open or closed. The circuit described provides complete electrical isolation between the monitored contacts and including any circuitry connected therewith, and the indication circuitry including the control transistors such as TR<sub>2</sub> and flip-flop 22. Moreover, it makes possible the use of the various monitored contacts such as contacts 10-12 in a circuit arrangement for other purposes while still permitting the same contact to be monitored and an indication provided as to its operative condition.

The circuit arrangement also provides substantially complete isolation between the low frequency alternating-current or direct current provided by source 13 and the much higher frequency provided by constant-current source 16. Thus, as previously mentioned, the direct current or low-frequency alternating-current source 13 is prevented from flowing through the secondary winding of any transformer T<sub>1</sub>-T<sub>3</sub> by reason of the blocking capacitors such as capacitor 15 associated with secondary winding B of transformer T<sub>2</sub>. Under the condition where the monitored contacts are connected in series as shown in the accompanying drawing, and only one of such contacts is open, it is then apparent that an alternate circuit will exist which represents a partial shunt across the associated transformer secondary winding. Thus, assuming that contact 11 is open but that contacts 10 and 12 are closed, it is of course desired that under such circumstances, there be no substantial shunt across the secondary winding B provided by any other circuit path since, if any other shunt were to be effective, it would be impossible to distinguish this condition from the bonafide shunt which does occur when contact 11 is closed. However, under the conditions just described, there is some shunting effect across transformer winding B through contact 10, source 13, relay R<sub>1</sub>, and through closed contact 12 to the other terminal of winding B. Under ordinary circumstances, however, the various contacts 10-12 are not all at the same locations so that rather substantial lengths of wire are used to interconnect these contacts in a series circuit arrangement. At the relatively high frequency of source 16, the inductance present in the relatively long leads provides sufficient inductive reactance to provide a fairly significant impedance in the circuit just described, and if this impedance is noticeably greater than the impedance provided through contact 11 when it is closed, then the difference in impedance across winding B between the two different conditions of contact 11 is sufficient to produce distinctively different signals which can quite readily control the associated stage of flip-flop 22. Additional inductive reactance may, if desired, be included in the above-described alternate circuit to ensure that such alternate circuit presents a substantially higher impedance than does the circuit through the shunting contact.

Under some circumstances, it may be desirable to avoid having the contact monitoring apparatus feed an alternating-current signal at the frequency of source 16 back to the monitored contact and any circuitry associated with such contact. For example, when the circuitry involving the contacts includes electrical leads extending over fairly substantial lengths, then the feeding back of alternating current at the

frequency of source 16 may very well result in undesired electromagnetic radiations causing undesired interference with other electrical apparatus. Also, when the leads from the monitoring apparatus to the contacts being monitored are of substantial length, it may then be impractical to feed to such contacts the alternating-current with the frequency of source 16 because of the rather substantial inductive reactance provided by such long leads. In either of the circumstances described, it may then be desirable to use instead the circuit arrangement shown in FIG. 2. In this modification, any alternating current voltage induced in winding B of transformer T<sub>2</sub> from winding A is subjected to fullwave rectification by the rectifiers R<sub>1</sub>-R<sub>4</sub> connected in a bridge circuit across winding B. The rectified output of this fullwave rectification circuit is filtered by capacitor C<sub>1</sub> with the result that a direct-current voltage is then applied by leads L<sub>1</sub> and L<sub>2</sub> to the terminals of the monitored contacts. As with the embodiment of FIG. 1, when a monitored contact is open, a voltage is induced in secondary winding C which can be used to control an output circuit. However, when a monitored contact is closed, a shunt is effective across winding B which then has an effect substantially the same as shunting the winding C of this transformer so that any voltage is then available to control the associated output circuit.

What I claim is:

1. A system for monitoring the conditions of a plurality of circuits to determine with respect to each said circuit whether it is open or closed, said system comprising in combination, a multiwinding transformer for each circuit to be monitored and having a primary winding and at least two secondary windings, means for energizing all said primary windings in series with alternating current from a constant-current source, means for connecting a first primary winding of each said transformer in shunt with a respective circuit to be monitored, and means coupled to each said transformer and responsive to the voltage induced in a second of said secondary windings of the associated transformer for providing a manifestation representative of whether said circuit is closed or open, whereby a voltage is induced in said other secondary winding to thereby cause said manifestation to be produced only when the associated first secondary winding is not shunted by the respective monitored circuit.
2. The combination of claim 1 in which said responsive means includes means for rectifying the alternating-current voltage induced in the secondary winding of the associated transformer and a transistor controlled by the direct-current voltage provided by said rectifying means.
3. The combination of claim 2 in which said responsive means includes a flip-flop stage associated with each monitored circuit, means for coupling the direct-current voltage provided by the corresponding rectifying means as a gating input to said stage, and means for at times applying a pulse to all said flip-flop stages to operate each to a condition in accordance with whether such stage is then receiving said direct-current voltage from the respective rectifying means.
4. The combination of claim 1 which further includes means comprising a circuit connection including in series a plurality of said contacts in their normal respectively open or closed conditions, and means providing a distinctive indication only when said series circuit connection is completed to provide a manifestation that all said plurality of contacts are in their normal conditions.

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