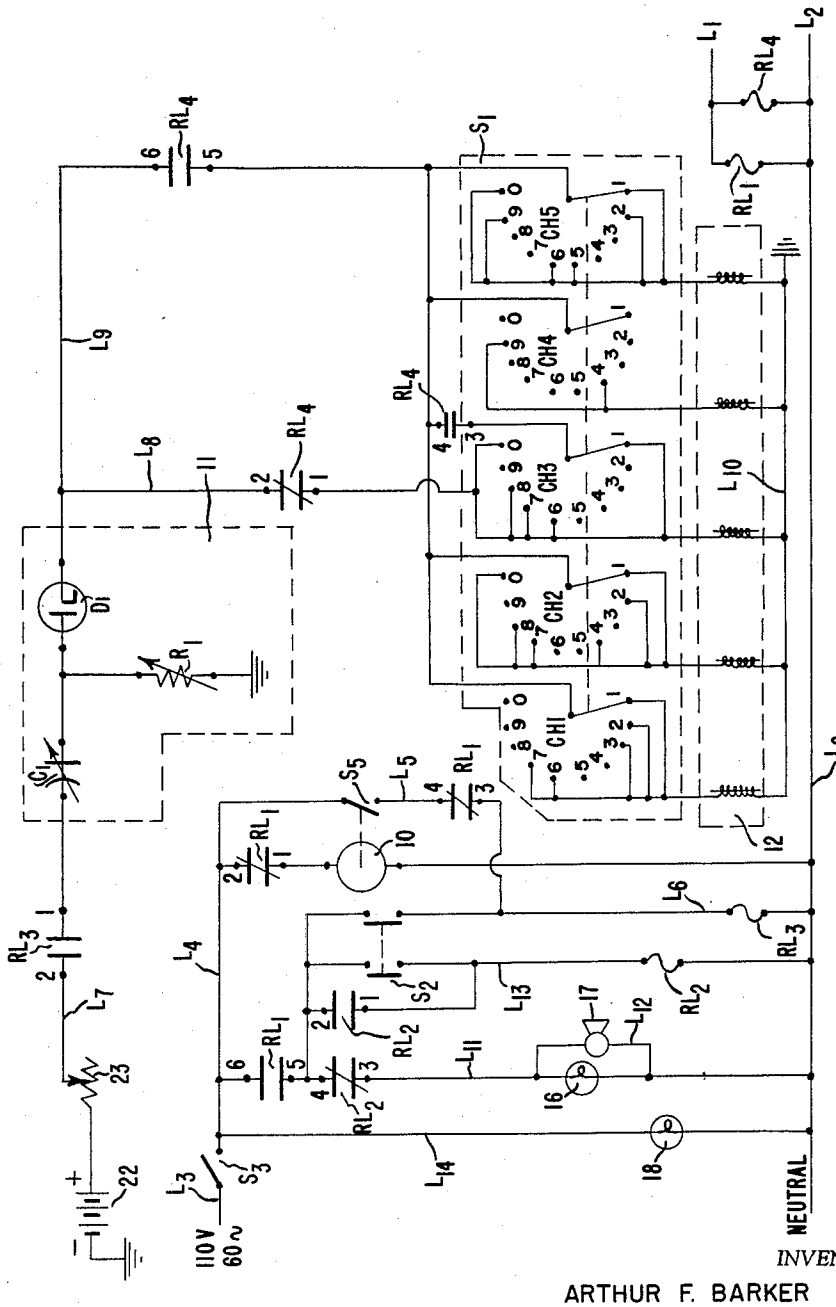
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RECORDING APPARATUS

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RECORDING APPARATUS

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This invention relates to a recording apparatus, and particularly to a recording apparatus which is adapted to register the fact, duration and reason for downtime of manufacturing machinery in a code which can be handled by conventional computer apparatus.

Manufacturing has grown to be an exceedingly complex activity which has created urgent problems for management as regards the obtaining of timely intelligence bearing on apparatus availability or nonavailability. In addition, equipment maintenance and the intelligent appraisal of machine performance necessitates the prompt identification of the causes and duration of machine shutdowns, thus affording a constant check of machine performance which makes it possible to determine with certainty what inventory of replacement parts is necessary, what the obsolescence status of the machine is, and a number of other factors which have an important bearing on the profitable conduct of the business.

The object of this invention is to provide a relatively simple and inexpensive apparatus which can be placed in circuit with the manufacturing equipment to be monitored, either temporarily or permanently, and will automatically record the duration of a machine shutdown as well as provide a facility for permitting maintenance personnel to record the cause of failure in a code suitable for processing in commercially available automatic computing equipment. The recording operation may optionally be conducted at the machine location itself or, if desired, the pertinent electrical signal information may be transmitted to a relatively distant central location, thus effecing a telemetering operation. Another object of this invention is to provide a highly versatile apparatus for the code reporting of machine shutdowns while utilizing only a relatively small number of recording channels. The manner in which these and other objects of this invention are obtained will become apparent from the following detailed description and the drawing of a preferred embodiment utilizing only five channels for information encoding.

Generally, the apparatus of this invention comprises the combination of a pulse generator which is adapted to emit a code signal immediately upon shutdown of the machine monitored, and during the full duration of the shutdown, with a multi-channel encoding apparatus which enables the maintenance personnel to manually record electrically in code the cause for machine shutdown promptly after the machine is restored to operation.

Referring to the drawing, a preferred embodiment of the invention can best be understood by considering it as made up of a combination of three sub-assemblies, the first being a transducer or detector in circuit with the motor of the machine being monitored, the transducer in this embodiment being represented as the relay RL_1. The second sub-assembly includes the clock timer **10** and its associated relay coils RL_2 and RL_3 and double contact push button switch S_2. The third sub-assembly consists of the pulse generator indicated generally at **11**, which is

in circuit with the multiple channel selector switch S_1 which controls the teletype punch head **12**.

At the outset it should be mentioned that all of the relay contacts are represented in the drawing in the positions they assume when a monitored machine is shut down, as through breakdown, or for repairs or adjustment. The primary control of our inventive circuit is effected by the transducer, in this embodiment relay RL_1, the coil of which is connected to leads L_1 and L_2, the latter of which is electrically neutral, which leads are shunted across the powering motor or apparatus control switch, whichever is desired, of the apparatus to be monitored. For purposes of explicit description, the usual case of electrically powered or electrically controlled equipment to be monitored is assumed; however, it will be understood that our invention is not limited to such equipment but may be employed with hydraulically, pneumatically, or optically powered or controlled devices as well as with many other types, so long as the proper transducer responsive to the equipment is employed. Thus, a suitable transducer for hydraulically or pneumatically powered or controlled equipment is a conventional pressure switch, and a very wide variety of other transducers are available for monitoring other types of equipment. Relay RL_4 is connected in parallel with RL_1 and has functions hereinafter described.

The second sub-assembly includes electrical conductor L_3 which is connected on one side to a 110-v., 60 c. source and on the other through single-throw, single-contact switch S_3 with lead L_4. A number of electric leads are connected in parallel one with another from L_4 to neutral lead L_2. The principal one of these is that containing clock timer **10**, which is connected in series with relay contacts RL_1 **1—2**. Timer **10** is a commercially available synchronous motor-driven, cam-operated switch such as a model HG–92 "Flexopulse" Repeat Cycle Timer, marketed by the Eagle Signal Co., which alternately opens and closes switch S_5 through the mechanical connection indicated as a broken line, switch S_5 being connected in series with relay contacts RL_1 **3—4** in lead L_5. The circuit from L_5 to neutral conductor L_2 is completed through L_6 which is connected in series with relay coil RL_3.

The push button switch S_2 is a double contact type, one pair of contacts of which is in series with L_6 and the other of which is in series with lead L_{13} which is in turn in series with relay coil RL_2. This latter set of contacts is shunted by relay contacts RL_2 **1—2** and the parallel network of L_6 and L_{13} is connected as a unit to L_{11} below relay contacts RL_1 **5—6**, in turn connected to L_4. The lead L_{11} is provided with relay contacts RL_2 **3—4** and power signal lamp **16** in parallel with warning horn **17**. Finally, the sub-assembly is provided with a signal lamp **18** in circuit with lead L_{14} interposed straight across leads L_4 and L_2 to provide indication when switch S_3 is closed and power is applied to the circuit through lead L_4.

The third sub-assembly, which is the indication-producing circuit, consists of a D.-C. power source **22**, which may conveniently be a 60-v. B battery the positive terminal of which is connected through voltage divider **23** to lead L_7, which latter is provided with relay contacts RL_3 **1—2**, and thence to the input side of pulse generator **11**. The pulse generator is of the general design provided with a variable capacitor C_1 connected to a grounded variable resistor R_1 and to the plate of a rectifier diode D_1. Thus, the time constant of generator **11** may be preselected within relatively wide limits by suitable adjustment of C_1 and R_1 as dictated by the electrical characteristics of teletype punch head **12** in relationship to power source **22**. The output side of pulse generator **11** is connected to L_9 which is in circuit with relay contacts RL_4 **5—6** and also with lead L_8 which, in turn, is

in series with relay contacts RL_4 1—2. L_8 is connected to the switch contact side of channel 3 of selector switch S_1 and thence to an individual one of the relay coils of teletype punch head 12, all of the coils of which are grounded to lead L_{10}.

In the embodiment described selector switch S_1 is a 5-channel, parallel-connected switch, which may be a model 1351L Mallory Rotary Switch, each channel of which is provided with 10 separate contacts and the switch arms of all of the channels of which are ganged for common movement as indicated by the broken line drawn from one to another. It will be noted that the several contacts of each of the five channels are connected to the output side of the channels in a different relationship so that each position of the ten which can be taken by the switch arm corresponds to a unique switching connection for S_1 as a whole. Accordingly, with ten switch contacts, the primary digits can be represented in code through selective energization of the several relay coils of teletype punch head 12. Power for all channels other than channel 3 is provided solely from L_9 connected to all of the switch arms, including channel 3, relay contacts RL_4 3—4 being interposed before the switch arm of channel 3 for the reasons hereinafter described.

In operation, apparatus of this invention automatically measures the duration of the downtime of the machine monitored as the initial operation. This is accomplished by simultaneous de-energization of relays RL_1 and RL_4 through leads L_1 and L_2 connected in circuit with the machine being monitored when its drive motor stops. At this instant contacts RL_1 1—2 in series with clock timer 10 close. With switch S_3 closed, power is thereby impressed on L_4 and, during the periodic closure of S_5 by timer 10, a succession of electrical pulses passes through L_5 and closed contacts RL_1 3—4 to relay coil RL_3. Energization of relay RL_3 periodically closes contacts RL_3 1—2 and sends electrical pulses through L_7 to pulse generator 11. The pulse output of generator 11 passes to L_8 and L_9 but, contacts RL_4 1—2 being closed and contacts RL_4 5—6 being open, power is impressed on the contact side of channel 3 of switch S_1 only. Accordingly, the relay coil associated with channel 3 of teletype punch head 12 alone is energized periodically, which thereby punches a tape with a succession of punch marks limited solely by channel 3. By feeding the tape into conventional computer apparatus used for analyzing taped data generally, the duration of machine downtime can be ascertained automatically by a count of the punch marks impressed, as will be understood by persons skilled in the art.

It is assumed that maintenance personnel make the necessary repairs or adjustments to the machine monitored as promptly as practicable, it being understood that while this is going on channel 3 continuously records pulses as a result of the continuous operation of clock timer 10. It may be that maintenance personnel will have to operate the equipment for brief trial periods, as by "inching" to thereby check whether repair efforts are successful, and freedom in this regard is preserved, it being understood that the code record will then display a succession of intermittent equipment start-ups and stops which, with proper interpretation, need cause no confusion in the evaluation of the record. At the conclusion of repairs it is desirable that the nature of the machine breakdown be identified in code by the maintenance personnel. The necessity for this is called to the repairman's attention by signal lamp 16 and horn 17, which are immediately actuated upon energization of relay RL_1 from leads L_1 and L_2 when the monitored machine's motor starts up, which closes contacts RL_1 5—6. In this connection, contacts RL_2 3—4 are in closed position when relay RL_2 is de-energized, which is its condition at this particular time. The repairman is thus placed on notice to record a suitable code designation of the type of machine failure encountered by suitable manual operation of selector switch S_1. This he does by moving the ganged switch arms of S_1 to the proper switch position. Relay contacts RL_4 5—6 are at this time closed by energization of relay RL_4 and contacts RL_4 1—2 are open, but pulse generator 11 is not operating because clock timer 10 is halted by energization of RL_1 which has previously opened relay contacts RL_1 1—2 and RL_1 3—4. It is thus necessary for the repairman to manually switch in the indication he has set up on S_1, and this he does by momentarily depressing push button switch S_2 on its double contacts. Closure of S_2 on its right-hand contacts in series with L_6 energizes RL_3 for an instant, thus closing contacts RL_3 1—2 in the indication circuit and transmitting a single pulse from generator 11 through lead L_9 and relay contacts RL_4 5—6, thence through the completed circuits of the several channels of S_1, thereby energizing the characteristic relay coil combination of teletype punch head 12. If an elaborate code is to be utilized, the repairman can operate switches S_1 and S_2 a number of times in succession, thereby encoding the cause of failure as a succession of appropriate punch marks spaced longitudinally along the tape, each consisting of the appropriate transverse multichannel representation corresponding to each individual switch arm setting.

Depression of switch S_2 simultaneously deactivates both signal lamp 16 and horn 17 by energization of relay RL_2 which opens relay contacts RL_2 3—4. Relay RL_2 remains energized by continuation of the electrical circuit to it through locking contacts RL_2 1—2 in shunt with S_2. Contacts RL_4 3—4 are, of course, closed when relay RL_4 is energized and provide a shunting connection for channel 3 to prevent spurious signal generation in the event that clock timer 10 happens to be in closed position when the timer is stopped by operation of relay RL_1. The entire circuit is thus restored to a state permitting automatic detection of the next machine shutdown which happens to occur. It will be understood that the apparatus of this invention can be made conveniently portable in form so that it can be employed to monitor selected apparatus on a temporary basis or, if permanent surveillance is desired, then the circuit can be permanently connected across the operating motor of the particular equipment whose operation is to be monitored. Also, magnetic tape coding can be substituted for punch coding by employing commercially available equipment for the purpose.

From the foregoing it will be understood that this invention may be modified in numerous respects by persons skilled in the art without departure from the essential spirit and it is intended to be limited only within the scope of the appended claims.

What is claimed is:

1. A recording apparatus for monitoring the duration and cause of shutdown of powered or power-controlled equipment comprising in combination a transducer deactivated upon occurrence of said shutdown, an electrical pulse generator responsive to deactivation of said transducer emitting electrical pulses at predetermined time intervals, a multiple channel selector switch connected in series electrical circuit with said pulse generator so as to complete a unique electrical circuit through said selector switch corresponding to the set position of its switch arm, one channel of said switch of which is connected in closed electrical circuit with said pulse generator during the duration of said shutdown, means responsive to the termination of said shutdown and upon the halting of operation of said pulse generator by activation of said transducer for substantially simultaneously closing the electrical circuit between said pulse generator and a multiple number of the channels of said selector switch, code recording means connected in electrical circuit with the output sides of said multiple number of the channels of said selector switch, and a manual switch for actuation of said pulse generator to send an electrical pulse through at least one

of said multiple number of channels of said selector switch for each predetermined setting of said selector switch to thereby actuate said code recording means to record said cause of shutdown.

2. A recording apparatus for monitoring the duration and cause of shutdown of electrically powered or controlled equipment comprising in combination a first electrical relay with coil connected in electrical circuit with said equipment so as to be de-energized upon occurrence of said shutdown, an electrical pulse generator responsive to de-energization of said first electrical relay emitting electrical pulses at predetermined time intervals, a multiple channel selector switch connected in series electrical circuit with said pulse generator so as to complete a unique electrical circuit through said selector switch corresponding to the set position of its switch arm, a second electrical relay with coil connected in parallel electrical circuit with said first electrical relay and with a first set of contacts closed when said first electrical relay and said second electrical relay are de-energized connected in series circuit between said pulse generator and a preselected one of the channels of said multiple channel selector switch, a second set of contacts of said second electrical relay closed when said first electrical relay and said second electrical relay are energized connected in parallel circuit with said first set of contacts and in series circuit between said pulse generator and a multiple number of the channels of said selector switch, code recording means connected in electrical circuit with the output sides of said multiple number of the channels of said selector switch, and a manual switch for actuation of said pulse generator to send an electrical pulse through at least one of said multiple number of channels of said selector switch for each predetermined setting of said selector switch to thereby actuate said code recording means to record said cause of shutdown.

3. A recording apparatus for monitoring the duration and cause of shutdown of electrically powered or controlled equipment comprising in combination a first electrical relay with coil connected in electrical circuit with said equipment so as to be de-energized upon occurrence of said shutdown, a clock timer, an A.-C. electrical power source connected in circuit with said clock timer and supplying operative power thereto, a third electrical relay with coil connected in electrical circuit with said A.-C. electrical power source through the output switch of said clock timer and thence to an electrical circuit-completing lead, a set of relay contacts of said first electrical relay closed when said first electrical relay is de-energized connected in series circuit between said A.-C.

electrical power source and said clock timer, a pulse generator, a D.-C. electrical power source connected in circuit with the input side of said pulse generator and supplying operative power thereto, a set of relay contacts of said third electrical relay open when said third electrical relay is de-energized connected in series circuit between said D.-C. electrical power source and said pulse generator, a second electrical relay with coil connected in parallel electrical circuit with said first electrical relay and with a first set of contacts closed when said first electrical relay and said second electrical relay are de-energized connected in series circuit between said pulse generator and a preselected one of the channels of a multiple channel selector switch, said selector switch establishing a unique electrical circuit therethrough corresponding to the set position of its switch arm, a second set of contacts of said second electrical relay closed when said first electrical relay and said second electrical relay are energized connected in parallel circuit with said first set of contacts and in series circuit between said pulse generator and a multiple number of the channels of said selector switch, code recording means connected in electrical circuit with the output sides of said multiple number of the channels of said selector switch, and a manual switch for actuation of said pulse generator to send an electrical pulse through at least one of said multiple number of channels of said selector switch for each predetermined setting of said selector switch to thereby actuate said code recording means to record said cause of shutdown.

4. A recording apparatus for monitoring the duration and cause of shutdown of electrically powered or controlled equipment according to claim 3 provided with an electrical sub-circuit connected in shunt relationship with said clock timer from a point between said A.-C. electrical power source and said set of relay contacts of said first electrical relay in series circuit between said A.-C. electrical power source and said clock timer to an electrical circuit-completing lead, said electrical sub-circuit consisting in series relationship in order from said point of a set of relay contacts of said first electrical relay open when said first electrical relay is de-energized and electrical signal alarm means actuated by electric current drawn from said A.-C. electrical power source.

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