

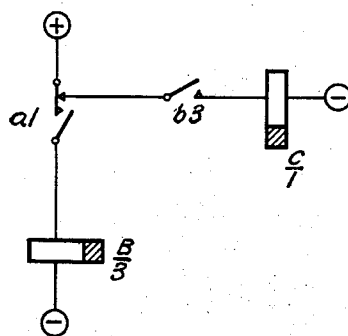
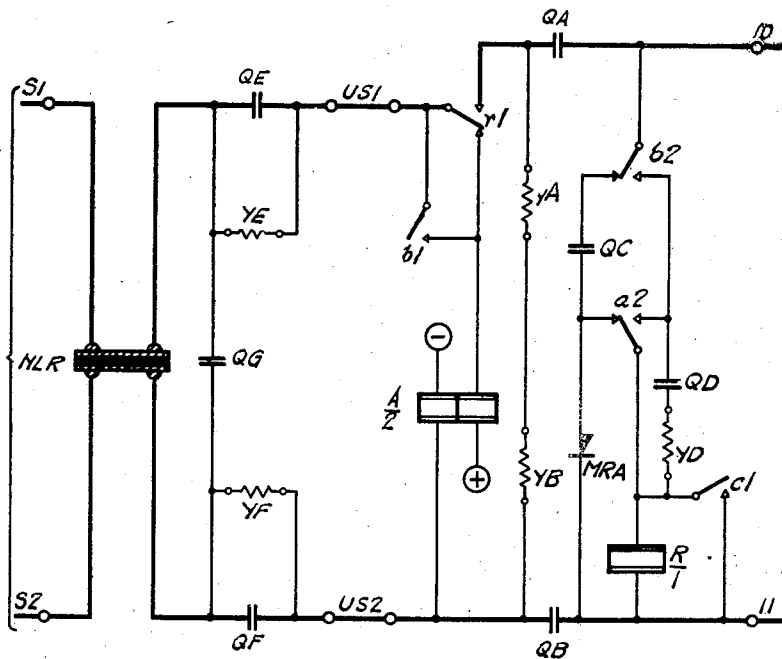
Jan. 18, 1944.

G. W. THOMPSON

2,339,438

TELEPHONE SYSTEM

Filed Dec. 4, 1941



INVENTOR
GEORGE WILLIAM THOMPSON

BY *Charles W. Condy*
ATTORNEY

UNITED STATES PATENT OFFICE

2,339,438

TELEPHONE SYSTEM

George William Thompson, Liverpool, England,
assignor, by mesne assignments, to Automatic
Electric Laboratories, Inc., Chicago, Ill., a cor-
poration of Delaware

Application December 4, 1941, Serial No. 421,600
In Great Britain January 18, 1941

12 Claims. (Cl. 179--16)

The present invention relates to telephone systems in which connections are adapted to be set up through, or from, localities such as mines in which explosive or inflammable gases may exist and it is more particularly concerned with protective arrangements for enabling such systems to be operated with safety.

The type of telephone system generally to be found in use in fiery areas is of the magneto type and is rendered "intrinsically safe" by restricting the power output of the magneto generators and by utilising high impedance signalling bells and the like so that the line currents and voltages will be limited to such a value that if the line should be accidentally broken while carrying current or if bare wire signalling leads are utilised, no sparking can be caused of sufficient intensity to produce an explosion. It is possible to couple such a safe system with an unsafe or potentially unsafe system, for example, a surface system in the case of a mine, without impairing the intrinsically safe characteristic of the former, by employing a coupling unit comprising essentially a bridging non-linear resistance unit and series impedances comprising condensers shunted by resistances. Such a coupling unit is described in British Patent No. 515,805, and offers little attenuation to speech currents but restricts to a safe value the amount of ringing or signalling energy which can pass therethrough.

These arrangements readily permit the coupling of an intrinsically safe underground telephone instrument or manual telephone system with a standard manual surface system but difficulties arise if coupling is attempted between an underground telephone or manual system and a surface system of the automatic type since the inclusion of the coupling unit in the dialling circuit to the automatic exchange so seriously affects the operation of the impulse receiving relay of the selecting switch or apparatus taken into use at said exchange as to render its operation unreliable. It is the general object of the invention to provide arrangements whereby a line or lines of a standard automatic telephone exchange extending into a fiery area can be rendered intrinsically safe.

According to one feature of the invention in an automatic telephone system including one or more stations of the intrinsically safe type as used in fiery mines, operation of the automatic equipment from such a station is rendered satisfactory by associating with it a repeating unit arranged to respond to impulses transmitted from

the station and to repeat them to the automatic equipment.

According to another feature of the invention a conversion unit for enabling a station connected to an automatic telephone system to be rendered intrinsically safe comprises limiting equipment for preventing the production of dangerous potentials combined with a repeating unit arranged to compensate for the distorting effect of the limiting equipment sufficiently to give satisfactory impulse repetition.

A further feature of the invention is that in a repeating unit for connection between an intrinsically safe station and associated automatic telephone exchange equipment a relay adapted to respond to impulses from the station is arranged to control a relay bridged across the speaking conductors on the exchange side which relay in turn controls a contact in the speaking conductors on the station side.

The invention will be better understood from the following description of one method of carrying it into effect, reference being had to the accompanying drawing which shows circuits of a known form of coupling unit and of an impulse repeating unit which in combination enable the object of the invention to be attained.

Referring to the drawing, the leads S1 and S2 are assumed to extend to an automatic telephone instrument or to an operator's switching position equipped with dialling out facilities, the equipment in either case being located in a fiery area and being in itself intrinsically safe. Leads US1 and US2 extend from the other side of the coupling unit to the impulse repeating unit which connects with an unsafe or potentially unsafe automatic telephone exchange which would usually be a private automatic exchange but might be a public automatic exchange.

As described in British Specification No. 515,805, the coupling unit interposed between the safe and unsafe leads S1 and S2 and US1 and US2, respectively, utilise a conventional series impedance network comprising a condenser and shunt resistance in each lead, while on the safe side of these networks a block NLR of non-linear resistance material is arranged as a shunt thereon. The non-linear resistance material is of a type having a characteristic such that for small values of voltage its resistance is very high, while for higher values of voltage it is considerably smaller. As in the prior arrangement the material preferably comprises a mixture of silicon carbide with carbon and tungsten or molybdenum which is agglomerated under pressure and

subsequently baked. Such material has a voltage/resistance characteristic which is substantially hyperbolic. Moreover, the resistance is substantially the same for both directions of current flow so that the material is suitable for limiting the transfer of alternating currents and/or voltages through the coupler. The non-linear resistance material is preferably made up in the form of a disc with both sides metal-sprayed and soldered connections made thereto. As shown there are two such connections to each side and the speaking circuit extends over each of the metal-sprayed surfaces. This arrangement has the advantage that if one of the connections becomes detached, the whole circuit is rendered unworkable and there is no danger of its continued use under the mistaken impression that it is still fully protected. The impulse repeating unit comprises essentially an impulse repeating relay which is suitably adjusted to take care of the distorting effect of the coupling unit on the dialled impulses together with a further relay arranged to respond to ringing current and connect it through from the unsafe system to the safe system.

For the purpose of example the leads S1 and S2 will be assumed to extend to an automatic telephone instrument situated in the fiery area of a mine, while the leads 10 and 11 on the automatic exchange side of the impulse repeating unit will be assumed to extend to a private automatic exchange located on the surface and serving the various workings and offices of the mine in question.

It will be understood that the coupling unit and the repeating unit need not be closely adjacent to one another and either can be located at any suitable point between the substation and the exchange provided that the coupling unit is on the substation side of the repeating unit. It will normally be most convenient to accommodate both of them close to the exchange equipment.

Private automatic exchanges are generally designed to operate from a 50 volt D. C. supply and the function of the non-linear resistance unit NLR in the coupler is to offer a negligible leakage path to low voltage speech currents and to provide an effective shunt to ringing currents at a voltage of the order of 75 volts or more so as to limit the amount of energy transferred to the safe system when ringing current is being extended thereto. In these circumstances it will be appreciated that if the voltage of the battery feed supply to the impulse repeating relay A in the repeating unit is reduced to a value considerably less than 50 volts the shunting effect of the unit NLR on this relay is rendered negligible particularly when dialling is taking place. For this purpose the battery supply to the impulse repeating unit is arranged to be of the order of 24 volts D. C. and is connected to the leads marked negative and positive in a circle. If it is considered objectionable to use an earthed signalling battery in connection with the fiery area in question, the 24 volt supply will be separate from the automatic exchange 50 volt battery and will not be obtained by tapping therefrom.

Considering now the operation of the arrangement shown, if a call is being set up from the automatic mine telephone connected to leads S1 and S2, the lifting of the receiver from the switch-hook extends a loop forward to operate relay A in the impulse repeating unit in series with the loop and resistances YE and YF. Relay A on operating, at armature a1 brings up the slow-to-

release relay B and this relay at armature b1 shunts armature r1, at armature b3 prepares a circuit for relay C, and at armature b2 extends a seizing loop forward over leads 10 and 11 to the surface automatic exchange connecting therewith, the loop being completed over armatures b2 and a2 and the winding of relay R which operates in series with the line relay at the automatic exchange.

The operation of the line relay at the automatic exchange causes a selector switch to be associated with the calling line in known manner over the wipers and banks of either a line finder switch or a rotary line switch and dial tone is thereupon returned to the calling party. This finds a circuit through to the calling automatic telephone instrument via condensers QA and QB in the impulse repeating unit, operated armature r1 and condensers QE and QF and parallel resistances YE and YF respectively in the coupling unit. It will be understood that owing to the low value of this tone voltage the resistance of the material NLR in the coupling unit remains at its normal high figure, and the material therefore imposes a negligible shunt on the lines, so that the only attenuation suffered by the tone before reaching the calling party will be that produced by the various condensers and resistances in circuit with the line.

The calling party on hearing the dial tone now proceeds to dial the first digit or possibly the single digit of the calling number. On the transmission of the first break impulse, relay A releases and at armature a2 opens the loop to the automatic exchange and at armature a1 operates the slow-to-release relay C. On the next operation of relay A the loop to the automatic exchange is reclosed by the armature a2, while at armature a1 the circuit to relay C is opened but this relay remains held due to its slug. Relay C is re-energised on each subsequent break impulse of the train and it will be understood that it will remain operated throughout the train and at armature c1 maintains a short-circuit on relay R so as to provide an impedance-free impulse repeating loop through to the automatic exchange. At the end of the impulse train, relay C releases but relays A and B remain held and relay R re-operates. The operations already described are repeated when the subsequent digits, if any, are dialled.

Regarding the maintenance of the automatic telephone in the mine in an intrinsically safe condition during dialling, inductive voltages generated by the impulsing relay A will be partially absorbed by condenser QG which is connected across the lines in the coupling unit, this condenser also assisting in preventing the non-linear resistance material NLR from partially breaking down and so lowering its resistance sufficiently to provide a holding path for relay A which would interfere with the satisfactory response of this relay to the dialled impulses. The use of the 24 volt power source for the impulse repeating unit also plays an important part in preventing relay A from being held or at least influenced to any great extent by the non-linear resistance material NLR. Some distortion of the dialled impulse train is however produced by the coupling unit and relay A is suitably adjusted to counteract this effect as far as possible so that the impulses repeated from the relay set into the automatic exchange are restored to substantially their original form.

When the mine automatic telephone is being

called from the automatic exchange, ringing current is applied to leads 10 and 11 and traverses a circuit including armature b2, condenser QC, armature a2 and the winding of relay R which at this time is shunted by the metal rectifier MRA. With this well-known arrangement of series impedance and shunt rectifier, relay R operates and remains held in response to the received ringing current, whereupon at its armature r1 it disconnects one winding of relay A from the line so as to prevent the operation of this relay by the ringing current, and at the same armature it extends the ringing circuit through via the coupling unit to the mine telephone instrument.

At the low frequency ringing voltage utilised the line condensers offer some considerable impedance, but the main factor which limits the amount of energy which can extend into the mine locality is the non-linear resistance NLR. In response to the application of the ringing voltage it will be understood that the resistance of this material decreases and so provides a considerable shunt across the line, the effect of which is increased with each increase of voltage. As the shunt lowers its resistance, the voltage drop across the line impedances in the coupling unit increases and it will be understood that as a result the amount of ringing energy which can be delivered into the mine area over leads S1 and S2 will be limited to a value which will be sufficient to produce effective ringing of the telephone bell or bells, but which will not exceed the predetermined value required to give a condition of intrinsic safety.

When the call is answered during a ringing pause, at which time relay R will be de-energised, relay A is operated and brings up relay B. Thereupon a direct current bridge is connected across the leads 10 and 11 and this may serve to trip the ringing if it is automatic. In any event relay R is now maintained steadily energised and at armature r1 completes the speaking circuit, relay A being held over armature b1. Relays A and B release when the subscriber hangs up at the end of the conversation.

The resistances YA and YB connected across the line in the impulse repeating unit are of a very high value and merely serve to allow a very small current to flow via the armature r1 which is operated throughout speech conditions so as to avoid the microphonic noises which are liable to be produced if "dry" contacts are connected in series with a line.

The resistance YD and condenser QD together serve for spark quenching purposes across the impulse repeating armature of relay A and they also serve to improve the response of the impulse responding relay concerned at the automatic exchange.

What I claim as new and desire to secure by Letters Patent is:

1. In an automatic telephone system wherein the subscribers' lines normally connect directly to automatic exchange equipment, a particular subscriber's line, a conversion unit inserted between said particular subscriber's line and said exchange equipment, said conversion unit including, in combination, a voltage limiter connected to said line to hold the line voltage in check, and apparatus for receiving impulses over said line and repeating them to said exchange equipment.

2. In an automatic telephone system wherein the subscribers' lines normally connect directly

to the automatic exchange equipment, a particular subscriber's line, a conversion unit inserted between said particular subscriber's line and said exchange equipment, said conversion unit including, in combination, a voltage limiter connected to said line to hold the line voltage in check, said limiter tending to distort impulses transmitted over said line to the exchange equipment, and apparatus tending to compensate for the distorting effect of said voltage limiter upon impulses transmitted over said line to said exchange equipment.

3. In an automatic telephone system wherein the subscribers' lines normally connect directly to the automatic exchange equipment, a particular subscriber's line, a conversion unit inserted between said particular subscriber's line and said exchange equipment, said conversion unit including, in combination, a non-linear resistance bridged across said line, a condenser in series with each side of said line, a resistance shunting each said condenser, and apparatus tending to compensate for the distorting effect of said resistances and condensers upon impulses transmitted over said line to said exchange equipment.

4. In an impulse repeater, an incoming line and an outgoing line each comprising two conductors, a relay having an operating winding connected in series with the conductors of one of said lines and having a contact connected in series with the conductors of the other of said lines, and a second relay having an operating winding connected in series with the conductors of said other line and having a contact connected in series with the conductors of said one line, whereby each of said relays is under the control of the other relay.

5. In an impulse repeater, an incoming line and an outgoing line, a relay bridged across said outgoing line, said relay having, in said incoming line, a contact operated responsive to operation of said relay over said outgoing line, a relay responsive to impulses received over said incoming line, and means under control of said last relay for controlling the operation of said first relay.

6. In an impulse repeater, an incoming line and an outgoing line, a relay bridged across said outgoing line and normally operated responsive only to the receipt of ringing current thereover, a relay responsive to impulses received over said incoming line, means controlled by the operation of said last relay for rendering said first relay responsive to the receipt of direct current over said outgoing line, and a contact in said incoming line operated by said first relay upon operation of said first relay over said outgoing line.

7. In an impulse repeater, an incoming line and an outgoing line, a relay connected to said outgoing line and normally responsive only to the receipt thereover of current to which a condenser is transparent, means controlled by said relay responsive to its operation for linking said two lines together for the transmission therebetween of such current, said last means effective to prevent the transmission of direct current between said two lines, a relay connected to said incoming line, and means controlled by the operation of said last relay over said incoming line for rendering said first relay responsive to the receipt of direct current over said outgoing line.

8. In a repeater as claimed in claim 7, a voltage limiter connected to said incoming line to check any tendency of the voltage thereon to increase above a certain value.

9. A repeater as claimed in claim 7, wherein

said first means includes a contact on said first relay, and wherein said last relay is connected to said incoming line over said contact when said first relay is at normal.

10. In a telephone system, the combination with a subscriber's line terminating at an automatic exchange of a non-linear resistance bridged across the line, and an impulse repeater intermediate said line and the exchange for receiving impulses over said line and repeating them to said exchange, said repeater including an impulse receiving relay and a source of direct current connected to said line via the winding of said relay, the voltage of said source being lower than the exchange voltage of said automatic exchange.

11. In a telephone system, wherein impulses transmitted over a calling line control automatic switching equipment at the exchange, a voltage limiter connected to said line for protective purposes, said limiter having the effect of distorting said impulses transmitted over said line, and an impulse correcting repeater intermediate said

line and said switching equipment for receiving said distorted impulses and repeating them to said switching equipment substantially in the form which said impulses would take if transmitted directly to said equipment over said calling line without said voltage limiter connected thereto.

12. In a telephone system, wherein impulses transmitted over a calling line control automatic switching equipment at the exchange, a non-linear resistance bridged across said line to protect same against an over-voltage, said resistance having the effect of distorting said impulses transmitted over said line, a relay associated with said line for receiving the distorted impulses, and a contact on said relay operated to repeat the received impulses to said switching equipment substantially in the form which said impulses would take if they had been transmitted directly to said equipment over said calling line without said non-linear resistance connected in bridge thereto.

GEORGE WILLIAM THOMPSON.