April 25, 1950 R. L. RUTHERFORD 2,505,144

SIGNALING SYSTEM FOR USE IN MINE SHAFTS

Filed Feb. 27, 1948

Fig. 1.

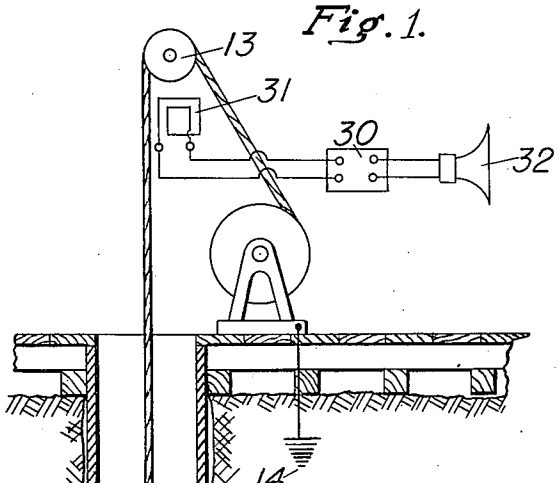



Fig. 2.

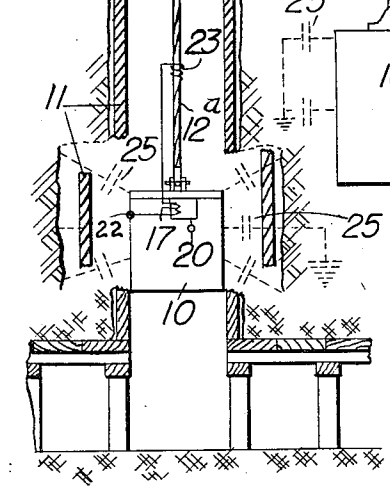
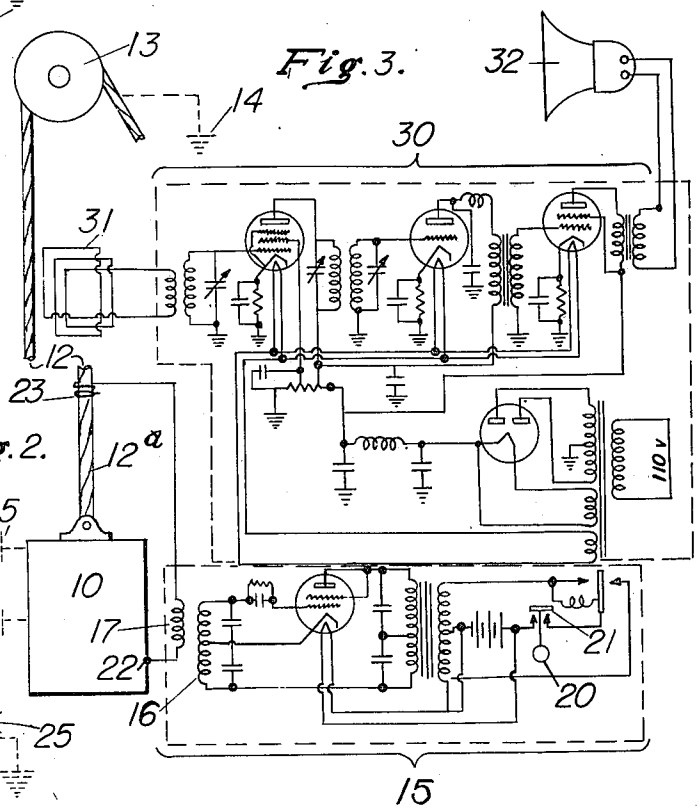



Fig. 3.




INVENTOR.
Richmond L. Rutherford
BY
Murray, Liddy, Glaccum & Aic
Attys

Patented Apr. 25, 1950 2,505,144

# UNITED STATES PATENT OFFICE

2,505,144

## SIGNALING SYSTEM FOR USE IN MINE SHAFTS

Richmond L. Rutherford, Superior, Ariz.

Application February 27, 1948, Serial No. 11,768

4 Claims. (Cl. 177—336)

1

My present invention has for its object to provide an improved signaling system for use in mine shafts as a means of communication between the hoist operator and the operator on the cage, or skip, during the movement of the latter irrespective of its position, or depth, in the shaft, or conditions therein which may cause variations in the capacitance between the cage and walls of the shaft.

Another object of my invention is to provide a signal system specially adapted for use in mine shafts which may be either vertical or inclined, and of open irregular cross section or timbered and which by reason of surrounding conditions due either to the presence of water may be damp, or to the nature of the strata penetrated and materials handled on the cage, may be difficult to maintain in a clean condition, either of which conditions singly or in combination create difficulties in maintaining proper insulation of electrical conductors.

Moreover my invention has as a principal object the utilization in conjunction with a metal hoisting cable and the cage supported thereon of a modulated radio frequency oscillator comprising an output winding of a transformer coil which is connected to separated points on the cable whereby the entire length of the cable becomes an autotransformer rendering it possible to detect the signals at the hoist above ground and reproduce them in a suitable receiver without diminution and in reality at increased volumes when existing conditions in the shaft increase either the capacity or conductance between the cage and shaft walls.

To these and other ends my invention comprises further improvements and advantages as will be further described in the accompanying specification, the novel features thereof being set forth in the appended claims.

In the drawings:

Figure 1 is a diagrammatic illustration showing a mine shaft, a hoist and elevator cable with a cage or skip suspended thereon, there being an oscillator on the cage and a radio frequency receiver on the surface with a pick-up loop adjacent the cable.

Figure 2 is a diagrammatic view illustrating a suitable form of radio frequency oscillator.

Figure 3 is a schematic illustration of a radio frequency receiving circuit.

Similar reference numerals, in the several figures, indicate similar parts.

In the mining industry where vertical shafts are driven to any considerable depth it is customary to timber the side walls and use either wooden guide rails, or steel rails for guiding the cage and heretofore it has been thought necessary, in connection with the signalling systems in use at the present time, to insulate the cage so far as possible to preserve the integrity of the signal transmitted aloft. But due to the impossibility of maintaining such insulation and further in preventing variations in the capacity between the cage and shaft walls at various points, as the cage descends or ascends, changes in signal strength frequently occurred when the cage comes in contact with or is in near contact with the shaft thereby short circuiting the oscillator output, or partially short circuiting such signal sending circuit. In many instances, especially in wet and dirty shafts I have found that where the cage touches the side of the shaft that the signal is rendered either faint, or unintelligible, or is obliterated.

2

In carrying out my present invention I take advantage of the existing capacity which is always present between the cage 10 and the walls of the shaft 11 in which is is suspended and utilize the length of the wire hoisting cable 12 as an autotransformer, its upper end being grounded through the sheaves 13 and their bearings and the metal parts of the housing machinery, as indicated at 14. A radio frequency oscillator 15 is carried on the cage 10. This may be of any suitable construction, such as the circuit shown in Fig. 2 and therefore requires no detail description, save reference to the primary winding 16 and the secondary winding 17, which may be elements of an output transformer. The output is controlled by a hand operated plunger 20 by means of which a normally open set of spring contacts 21 may be closed when a signal impulse is to be sent.

One of the terminals of the secondary winding I connect to cage 10, as indicated at 22 and the other I attach directly to the cable, as indicated at 23, in a position elevated from ten to twenty feet above the cage, the distance being such that the impedance between the points of connection is equivalent to that of the coil. Since the output radio frequencies of the oscillator may be of an order of from 100 kc. to 500 kc. it will be appreciated that the section of cable between points 22 and 23 offers a considerable impedance and hence there exists between them an appreciable voltage which I am able to utilize. I have found in practice that a 40 turn two inch coil, as the secondary 17, is quite satisfactory in operation and that its impedance may be closely matched

to that of the intervening section 12a of the cable 12, between points 22 and 23, by adjusting the terminal 23 either up or down, however, experience indicates that this matching of impedances is not critical.

From the above described connections it will be observed from the capacitance, indicated in dotted lines at 25, existing between the cage and walls of the shaft, that a radio frequency signal circuit is completed throughout the length of the cable, even under conditions of perfect insulation of the cage, which circuit is improved in transmission qualities in the event the cage happens to be grounded or partially grounded.

In Fig. 3 I have shown a conventional receiver 30 to which signals are fed from a loop antenna 31 preferably located adjacent the upper end of the cable at the mouth of the shaft and between the latter and the sheave 13. It is understood that the modulated radio frequency currents picked up by the loop are, after amplification detected and thereby stepped down to audio frequency for broadcasting by a loud speaker 32 located in the vicinity of the operator's position on the hoist stand.

Herein I have referred to the suspension end of the hoist cable acting on the principle of an autotransformer since it is possible to comprehend how by a proper choice of circuit parameters a matched condition can be obtained between the generator 15 and transmission circuit existing between any and all parts of the cable and the ground return path formed by the shaft walls resulting in an efficient transfer of energy which can be picked up at the mouth of the shaft. Another and equally accurate concept of my invention may be had by recognizing that the cable 12 extending centrally of the shaft 11 becomes a central or coaxial conductor with the earth comprising the outer or surrounding conductor. Thus it will be seen that the capacitance between cage 10 and earth, anywhere in the shaft, is at all times and under all conditions an effective by-pass condenser at the modulated radio frequency used. Hence matching the oscillator to the coaxial transmission line is accomplished by tapping the inner conductor, as at the point 23, so that impedance is presented to the coupling coil 17. If the coupling coil impedance is the same as that at the point of said tap a maximum transfer of energy occurs which exists throughout the length of the cable. This impedance I adjust with the cage 10 at or near the bottom of the shaft 11, wherever the signal strength appears to be the weakest, presumably at a nodal point, and while it is recognized, theoretically at least, that the impedance at the tap point will change as the cage ascends and the cable length decreases this, from a practical standpoint, is often times immaterial. This impedance change exists because of the standing wave effect produced in the transmission circuit and I have found that because said circuit is very "lossy" and because the total footage depth of most mine shafts is only a small fraction of a wave length at the radio frequencies employed, said wave effect is not large.

In cases where the depth of a mine shaft is an appreciable fraction of the radio frequency wave length used and the resulting attenuation between the cage and surface receiver is therefore comparatively large the standing wave effect is used to advantage. The oscillator and the tap point on the cable in this case are adjusted to provide maximum transfer of energy for the resulting impedance conditions in the vicinity of the bottom of the shaft. This assures a more constant radio frequency signal to the receiver on the surface because the transfer of energy from the oscillator to the transmission path is most efficient when the cage is near the bottom of the shaft when the attenuation is the largest, there being no diminution of the signal, as will be understood, when the cage rises. As the cage rises the attenuation becomes less and the energy required becomes correspondingly less.

This decrease in the transfer of energy is brought about by the change in the oscillator load impedance as the cage rises.

One of the advantages of the circuit arrangement above set forth is that I am able to impose the radio frequency signalling energy upon the cable at a point between the cage and the upwardly extending length of cable without physically parting the cable and depending upon the imposition of an insulator as a means of suspending such lower end of the cable with the cage suspended thereon.

Another advantage that will be appreciated in mine workings is that I am able to completely obviate the use of circuit conductors leading upwardly from the cage which must needs be wound and unwound as the cable is shortened and lengthened and yet assure a proper transmission of signals under the worst operating shaft conditions that may exist.

I claim:

1. In a mine shaft signalling system comprising a hoisting cable and a cage suspended thereon, of a radio frequency oscillator carried on the cage having primary and secondary output transformer coils, the terminals of the secondary coil bridging a section of the said cable adjacent the cage and substantially matching the same to the impedance of said section, and a modulated radio frequency receiver having a pick-up circuit associated with the upper end of the cable.

2. In a signalling system for use in mine shafts, the combination with a hoisting cable having lossy electrical transmission characteristics and a cage suspended thereon, of a modulated radio frequency generator having an output feeding into the lower end of the cable and comprising an impedance matched to the circuit formed by the cable and the return ground path through the shaft walls, and a receiver having a circuit associated with the upper end of the cable for detecting said frequencies directly therefrom and rendering the same distinguishable.

3. In a signalling system for use in mine shafts, the combination with a hoisting cable having a cage suspended thereon, of a radio frequency generator having an output coil the terminals of which are in electrical communication with two different points at the lower end of the cable which are separated a distance to match the impedance of the intervening cable section to that of the coil and render the remainder of the cable an autotransformer of impressed signals, and a surface receiver of modulated radio frequency signals comprising a secondary winding associated with the upper end of the cable receiving the current variations therein.

4. In a signalling system for use in mine shafts, the combination with a hoisting cable having a cage suspended thereon, of a radio frequency generator on the cage having an output coil the terminals of which are in electrical communication with two different points at the lower end of the cable, one of said terminals being adjust-

able longitudinally of the cable to match the impedance of the intervening section of the cable to that of said coil thus rendering the upwardly extending portion of the cable an autotransformer for impressed radio frequency signals, and a surface receiver of modulated radio frequency signals comprising a secondary winding associated with the upper end of the cable receiving the current variations therein.

RICHMOND L. RUTHERFORD.




## REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

| Number | Name | Date |
|---|---|---|
| 1,098,528 | Reineke | June 2, 1914 |
| 1,739,613 | Russey | Dec. 17, 1929 |
| 2,001,847 | Lockrow | May 21, 1935 |
| 2,248,825 | Rutherford | July 8, 1941 |
| 2,368,532 | Fearon | Jan. 30, 1945 |