July 8, 1941. R. L. RUTHERFORD 2,248,825

ELECTRIC MINE SHAFT SIGNAL SYSTEM

Filed March 16, 1939 3 Sheets-Sheet 1

Fig. 1.

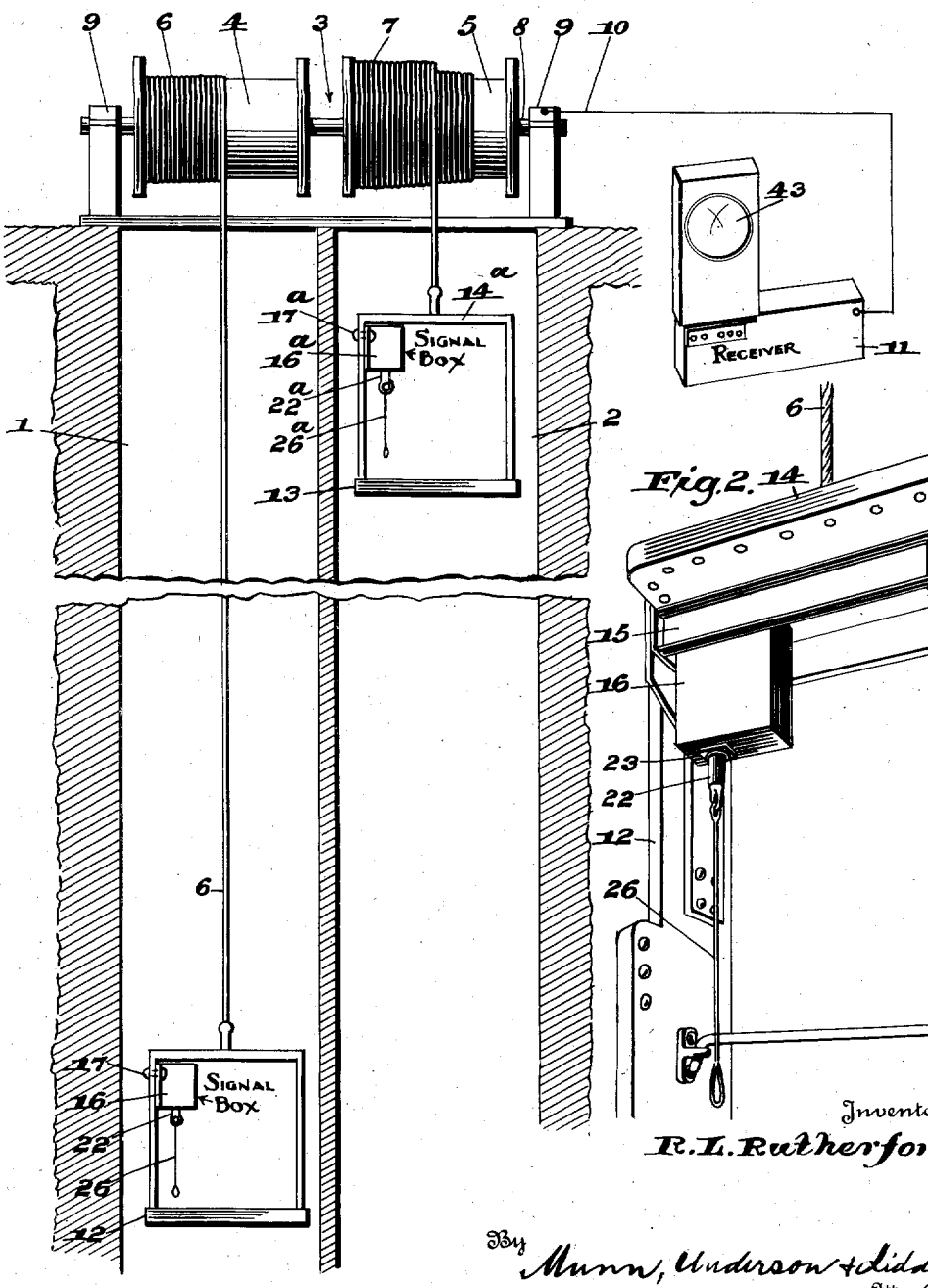



Fig. 2.




Inventor

R. L. Rutherford

By Munn, Anderson & Liddy

Attorneys

July 8, 1941. R. L. RUTHERFORD 2,248,825

ELECTRIC MINE SHAFT SIGNAL SYSTEM

Filed March 16, 1939 3 Sheets-Sheet 2

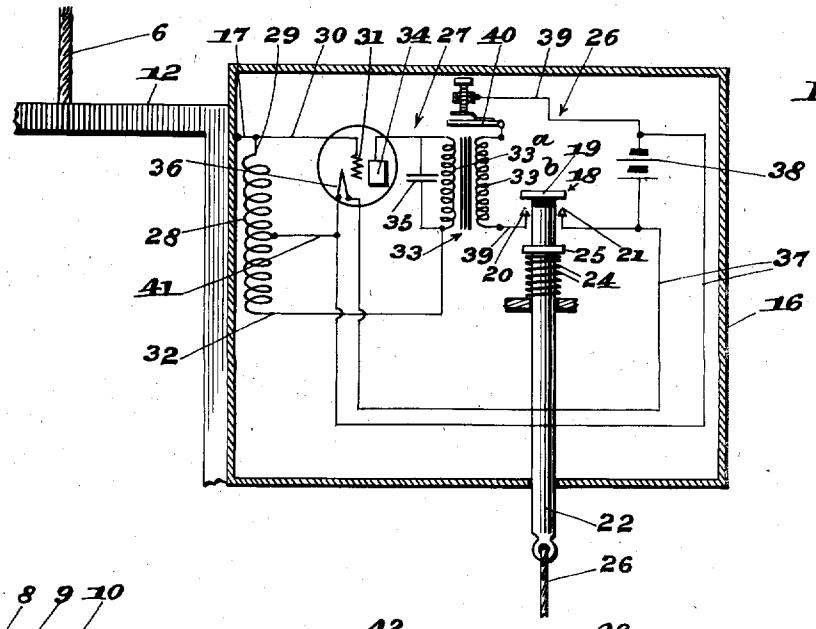



Fig. 3.

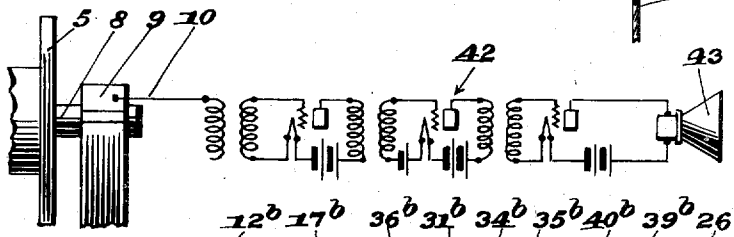



Fig. 4.

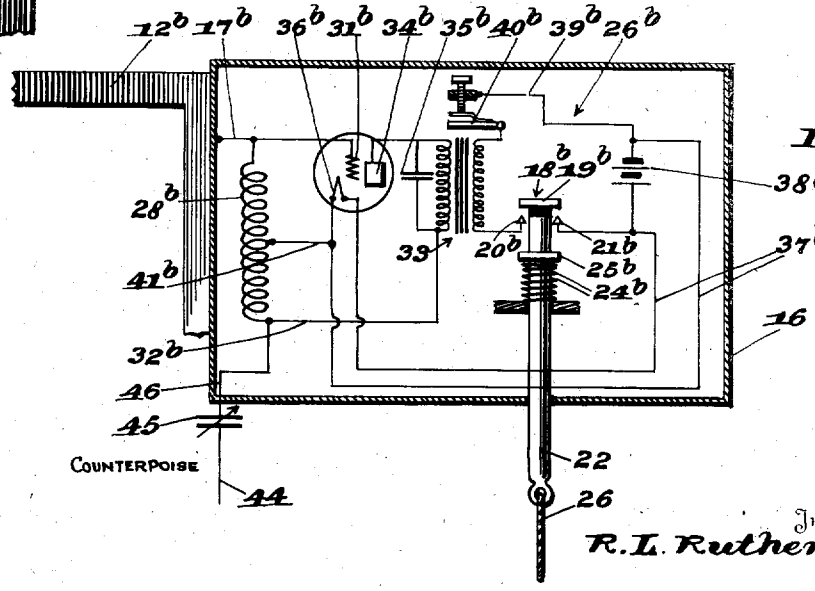



Fig. 5.

Inventor
R. L. Rutherford

By Munn, Anderson & Liddy
Attorneys

July 8, 1941. R. L. RUTHERFORD 2,248,825

ELECTRIC MINE SHAFT SIGNAL SYSTEM

Filed March 16, 1939 3 Sheets-Sheet 3

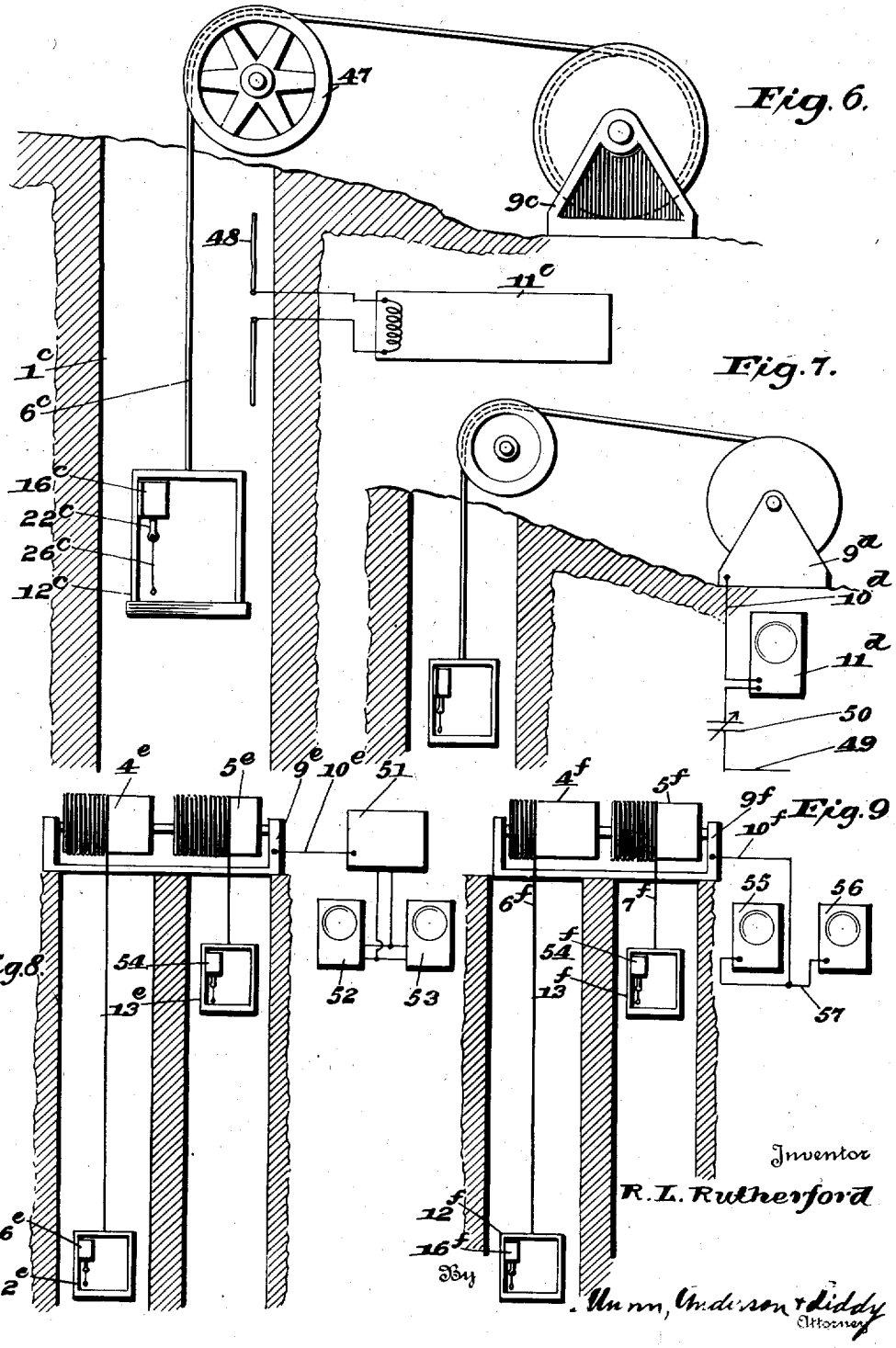



Fig. 6.

Fig. 7.

Fig. 9

Fig. 8.

Inventor

R. L. Rutherford

By Munn, Anderson & Liddy

Attorneys

Patented July 8, 1941 2,248,825

# UNITED STATES PATENT OFFICE

2,248,825

## ELECTRIC MINE SHAFT SIGNAL SYSTEM

Richmond L. Rutherford, Superior, Ariz.

Application March 16, 1939, Serial No. 262,279

6 Claims. (Cl. 177—336)

This invention relates to improvements in signal systems, especially of the type adapted for use in vertically driven mine-shafts. Mines of this type employ cages by which the miners, supplies, etc. are hoisted up and down in the shaft, these cages being carried by wire cables.

The current practice is to employ an electrical signal system so that communication may be had between the hoist operator and some designated person on each unit. This system involves the use of wiring, and that in turn necessitates insulating supports and a number of other necessary accessories. It frequently occurs that falling rocks will strike against the wiring and break it, thus seriously interrupting the signal service. It has also been discovered that both the insulators and wiring are subject to attack by water having metal in solution, this making it difficult to maintain good insulation.

The cost of wiring in a two-compartment shaft is known to be high, and as the shaft is advanced it becomes repeatedly necessary to add to the signal wiring in order to take care of the increasing depth. The latter factor is another and important one in the high cost of signalling by the employment of electrical wiring.

The instant invention does away both with the disadvantage of serious interruptions to the signal service as well as the cost of installation and maintenance. This is accomplished by eliminating the wiring.

The objects of the invention are, therefore, as follows:

First, to provide an electrical signal system for mines and the like, wherein all wiring of the mine shaft is dispensed with, thereby avoiding the disruption of the service currently happening by the breaking of wires and insulators from falling rocks.

Second, to provide an electrical signal system which is automatically adaptable to the increasing depth of the mine shaft as the latter is driven into the ground, thus eliminating the need of constantly adding to the wiring as when a system of the latter type is employed.

Third, to provide a system for signalling in mine-shafts by the use of a sharply but differently tuned respective radio transmitter and receiver, the fact of the system being that of radio producing a system not affected either by falling rocks or failures from similar causes nor by the changing length of the hoisting cable.

Fourth, to provide an electrical signalling system of the character described wherein such tuning of the transmitter and receiver as is necessarily done is not carried to the point of resonance, but is used to provide an automatic increase in current as the length of the hoisting cable increases.

Fifth, to provide a signal system of the character described wherein signals from each of the cages in a two-cage mine are distinguished by differently pitched tones, thus enabling the hoist operator to tell from which of the two cages the signal impulses are being sent.

Other objects and advantages will appear in the following specification, reference being had to the accompanying drawings, in which:

Figure 1 is a diagrammatic view of the hoisting apparatus of a two-cage mine, particularly illustrating the mode of application of the improved signal system.

Figure 2 is a fractional perspective view of one of the mine cages, illustrating the location of the signal box.

Figure 3 is a diagrammatic view of the electrical mechanism in the signal box, showing how the former is coupled to the cage cable.

Figure 4 is a diagram of the receiver circuit, illustrating how it is connected to the hoist frame.

Figure 5 is a diagram of a slightly modified type of mechanism in the signal box.

Figure 6 is a diagram illustrating a modified form of receiver wherein an antenna is employed.

Figure 7 is a diagram of another modification of receiver according to which the circiut is adjustable to an approach to resonance at either top or bottom of the mine-shaft.

Figure 8 is a diagram illustrating a method of low frequency amplification for the reduction of interfering noises and to make easier the identification of the cage from which a signal emanates.

Figure 9 is a diagram of an arrangement similar to that in Figure 8, illustrating a simplified arrangement for identifying the cage from which the signal comes.

For the purpose of disclosing one application of the invention, the drawings illustrate a mine which consists of two shafts herein commonly designated 1 and 2. This is the two-compartment mine previously referred to, and its illustration constitutes a preferred embodiment of the invention although the principles of the latter are readily applicable to other and generally similar installations.

A hoisting apparatus 3 on the surface of the earth, usually in the hoist house (not shown), includes drums 4, 5, the cables 6 and 7 of which are so directed and guided as to extend to the

respective mine-shafts 1, 2. The drum shaft 8 is chiefly illustrative of a means for supporting and revolving the drums but in practice said drums are only a part of heavy engine-driven gearing, and the hoisting apparatus includes brakes (not shown) for stopping and holding the drums.

The standards 9 are to be regarded as symbolic of the metal hoist frame in the hoist house because it is to the latter that a wire 10 is joined so as to place the radio receiver 11 in electrical connection with the metal framework. The cables 6, 7, have attached cages 12, 13, a portion of one of which is illustrated in Fig. 2.

Here the cage 12 is shown to include a roof 14 with supporting channels 15 from an appropriate one of which a metal signal box 16 is hung in any secure way. The hanging of the signal box is done in such a manner as to readily permit replacement thereof in the event of failure of the signal circuit. Said circuit (Fig. 3) is in direct electrical connection both with the signal box 16 and the cage 12 as at 17.

No external wire is used for said connection, and the electrical impulses delivered by the signal circuit are transmitted directly to the cable 6, through the metal superstructure (drums 4 and 5, shaft 8, standards 9, etc.), and wire 10 to the radio receiver 11. At this point it is well to emphasize the absence of all exposed wiring in the mine-shaft, and from the description so far it can be understood that the current dangers to exposed electrical wires is eliminated by utilizing the hoist cable as the electrical conductor.

The signal box 16 of the cage 12 is herein used for specific description. The signal box in the cage 13 is identical, such parts as appear there being denoted by the same reference numerals but distinguished by the exponent letter *a*. The signal circuit in the box 16 is adapted to be actuated by a switch 18 (Fig. 3), comprising the contactor 19 and contacts 20, 21.

Said switch has a heavy plunger 22 which extends out of a hole in the bottom of the box 16. The hole is desirably guarded at 23 (Fig. 2). A suitably supported spring 24 (Fig. 3) bears up against an abutment 25 on the plunger, thus normally opening the switch 18. A cord 26 attached to the plunger 22 extends down into reach of the signal operator riding the cage 12.

Attention is now directed to Fig. 3 for the preferred type of signal circuit. This is a series feed Hartley oscillator circuit and it is now generally designated 27. It comprises the fixed inductance 28, one terminal 29 of which is commonly joined to the connection 17 and its wire extension 30 of the grid 31 of a vacuum tube. The other terminal 32 of said inductance comprises a wire connected to one end of the secondary winding 33*a* of an iron core transformer 33, the other end of said winding 33*a* being connected to the plate 34. A condenser 35 is connected in parallel across the terminals of the same winding.

The filament 36 is part of a low-voltage circuit 37. This filament circuit embraces a battery 38 which supplies the direct, low-voltage current. The battery terminals are also the terminals of the transformer circuit 39, said circuit embracing the primary transformer winding 33*b*, the switch 18 and the adjustable vibrator 40 of the transformer 33. The adjustment of the vibrator changes the tone of the signal.

Actually the filament and transformer circuits 37, 39 are in series. Both are supplied with current by the battery 38. But the connection of the battery in parallel across the wires constituting said circuits produces a header, so to speak, for each. Current is supplied the filament 36 without normal interruption, but not to the transformer 33. The switch 18 holds that circuit normally open, but this switch does not control the filament circuit. A wire 41 connects one side of the filament circuit to the approximate mid-section of the inductance 28.

Up to this point it is understood that closure of the switch 18 by pulling the cord 26 closes the transformer circuit 39. The filament 36 is presupposed to be hot. Its positively and negatively discharged electrons are successively attracted to the plate 34 which is conformably negatively and positively charged by the A. C. in the plate circuit 28, 30, 32. The alternating space current thus established between the filament 36 and plate 34 is under direct control of the grid 31, the result of said control being the flow of a small current into the connector 17 and so into the cable 6 by way of the cage frame 12.

Attention is next directed to Fig. 4 which illustrates the electrical circuit 42 inside of the receiver 11 (Fig. 1). This receiver may comprise any well known circuit. The particular circuit disclosed employs tuned high frequency amplification, power or biased detector, transformer-coupled low frequency amplification and the usual loud speaker 43 (see also Fig. 1) at one terminal of the circuit. The other terminal of said circuit is connected to the hoist standard 9 by the previously mentioned wire 10.

Inasmuch as the signal circuit 26 (Fig. 3) delivers sharply tuned high frequency currents to the cable 6, it follows that said current delivered to the receiver circuit 42 (Fig. 4) by way of the metal framing and wire 10 is also sharply tuned. The circuit 42, however, transforms this current to audio frequency and the signal is heard as a buzz in the loud speaker 43.

Fig. 5 is an alternate of the signal circuit in Fig. 3. Since the majority of the parts are identical the corresponding reference numerals are applied, being distinguished by the added exponent letters *b*. The distinction of the circuit in Fig. 5 from the circuit 26 (Fig. 3) is addition of the counterpoise 44. This is shown as a mere wire below the variable condenser 45, but in practice may comprise any convenient form of antenna. The condenser 45 is connected in the circuit 32*b* by a wire 46.

The advantage of using the counterpoise 44 (in instances where such use is practicable) lies in its low resistance. According to the arrangement in Fig. 5 the circuit 26*b* is more capable of being tuned than the circuit in Fig. 3. But the tuning is not carried to the point of resonance. The circuit in Fig. 5 permits adjustment to an approach to resonance at the bottom of the mine-shaft and thus provides an increase in signal strength as the distance from the hoist increases.

Fig. 6 depicts fundamentally the same set-up as occurs in respect to either mine-shaft in Fig. 1. The mine-shaft 1*c* is occupied by the cage 12*c* which is suspended by the cable 6*c*. The idler 47 is an inconsequential mechanical variation. The signal impulses from the cage signal box 16*c* are delivered to the cable 6*c* as before, but instead of using an all-metal path to the receiver 11*c* by way of the framing 9*c* the sig-

nals are now transmitted inductively from the cable.

To this end an antenna **48** of the Hertz type is emplaced in the top of the mine-shaft **1***c* and as close as possible to the cable **6***c*. This arrangement is disclosed at a possible variation of the invention from the preferred type in Figs. 1 to 4. The presence of the antenna might not be desirable in all installations, but the fact that signal impulses can be transmitted inductively to a receiver by a moving, charged cable in a mine-shaft is one which is not to be overlooked.

Fig. 7 discloses another type of input receiver **11***d* wherein the receiver circuit is adjusted to approach resonance at either the top or bottom of the mine-shaft. This receiver circuit is connected to the metal framing **9***d* by the wire **10***d* as in Fig. 1, but it is now supplemented with a counterpoise **49** which is subject to limited tuning by the variable capacitance **50**.

The arrangement here causes the signal to be stronger at some given length of cable. In practice the cage would be lowered to the position whereat it is desirable to increase the signal strength whereupon the condenser **50** is adjusted to produce the desired increase by tuning the receiver input to approach resonance. Since this tuning (or any tuning) is done by the proper ratio of inductance to capacity and, since the cable is a part of the inductance it follows that the desired signal increase would always take place at the same length of cable.

It further follows that by the proper selection of frequency and the size of the condenser **50** and the length of the counterpoise it would be possible to have this increase come on gradually over a considerable length of cable. This is so because resonance with its sudden increases in signal strength is not used, but rather that portion of the resonance curve where the increase is more gradual.

Figure 8 discloses a method of low-frequency amplification to reduce interfering noise and to make it easier to identify the cage the signal came from. The frame **9***e* of the twin hoist **4***c*, **5***c* has a wire connection **10***c* as in Fig. 1, but this time to a high-frequency amplifier **51**. This is tuned to a frequency of 450 k. c. and it is connected in parallel to a pair of low-frequency amplifiers **52**, **53**. These are tuned to 200 and 700 cycles respectively, and these tunings agree with the tuning of the signal circuits in the boxes **16***e*, **53** in the cages **12***e*, **13***e*.

From this it will be understood that separate amplifiers and speakers are tuned to two different low frequencies. The signal from one cage would be loudest from one speaker because the amplifier is tuned to that frequency. The reason for this arrangement's helping to reduce noise is that frequencies other than those used have little effect upon the amplifiers.

Fig. 9 illustrates another twin mine hoist **4***f*, **5***f*, the cables **6***f*, **7***f* of which suspend the cages **12***f*, **13***f*. The signal circuits in the boxes **16***f*, **54***f* of these cages are tuned to 400 k. c. and 450 k. c. respectively. The signal impulses transmitted therefrom to the respective cables are conducted from the framing **9***f* by way of the wire **10***f* to the amplifiers **55**, **56**. These are respectively tuned to 400 k. c. and 450 k. c. as are the previously mentioned signal box circuits. Said amplifiers are joined by a wire **57**. The wire **10***f* is connected to this wire, whereby the amplifiers **55**, **56** are in parallel with the metal framing **9***f*.

The method used here of telling which cage the signal came from is very simple. By using the two different high frequencies and the two complete receivers the situation is much the same as though two radio receivers were tuned to two different sending stations at the same time. One receiver does not respond to the signals to which the other responds.

The foregoing signalling apparatus consists, in a broad sense, of a form of wired radio. Instead of employing a stationary wire or wires as in wired radio, the moving mine-cage cable is substituted. The distinction is that the cable is rarely of any given length, the latter changing constantly as it is uncoiled and coiled by the hoisting apparatus. This factor of changeability of the cable or conductor requires compensation in the volume of current delivered to said cable.

Said cable constitutes part of the system, as has been pointed out above. Although the cable itself is untuned yet it has a variable tuning effect upon the otherwise constant tuning of the transmitter of which it is a virtual extension. The electrical connection of the transmitter with the cable incorporates the cable in the tuning circuit of the transmitter, and it is because of this arrangement that the signalling function is automatically had.

In practice the circuit of the receiver at the entrance of the mine is tuned to a chosen frequency, for example 450 kc. With the cage initially at the top of the shaft the transmitter circuit is tuned to a slightly higher frequency, for example 455 kc. At this time practically none of the cable is unreeled.

Ordinarily the strength of signals received at the receiver from the transmitter as the cage moves into the mine would decrease with considerable rapidity with the increase of distance. But because of the sharp tuning of the transmitter and receiver to different frequencies the unreeling cable extends the oscillator circuit of the transmitter, thereby increasing the total inductance and capacity of the transmitter circuit as the actual frequency thereof decreases.

Thus the frequency of the transmitter approaches the frequency of the receiver and instead of there being a decrease in strength of the receiver signal, there is a compensation for the increase in distance and an automatic tuning of the transmitter progressively close to that of the receiver.

I claim:

1. A mine-shaft signal system comprising the combination of a twin hoist, twin metal cables dependent therefrom and cages suspended from the cable, radio signal transmitting means on each of the cages, each means comprising an oscillator circuit in electrical connection with the cage end of the respective cable and adjusted for the delivery of sharply tuned signal impulses of respectively different frequency to said cables, a sharply but differently tuned receiver in electrical connection with the hoist end of said cables, and a pair of low frequency amplifiers in electrical connection with said receiver, said low frequency amplifiers respectively being tuned to the signal frequencies of said cage transmitting circuits.

2. A mine-shaft signal system comprising a hoisting apparatus at the entrance of the shaft and a cage, radio signal transmitting means in the cage for producing sharply tuned impulses, a metal cable having the cage attached to one of

its ends and being secured at its other end to the hoisting apparatus, said cable being in electrical connection with said signal transmitting means and constituting part of the oscillator circuit thereof, and a radio receiver tuned sharply to a different frequency from that of the signal transmitting means and being in electrical connection with the hoisting apparatus to respond to said impulses.

3. A mine-shaft signal system comprising a hoisting apparatus at the entrance of the shaft and a cage, a radio receiver tuned sharply to a chosen frequency and being in electrical connection with said apparatus, radio signal transmitting means carried by the cage and being tuned to a higher frequency than that of said receiver, and a metal cable suspending the cage from said hoisting apparatus, said cable being in electrical connection with said signal transmitting means, and constituting part of the oscillator circuit thereof.

4. A mine-shaft signal system comprising a hoisting apparatus having a depending metal cable subject to be unreeled into the mine shaft and having a cage suspended therefrom, a radio receiver tuned sharply to a chosen frequency, being located adjacently to said apparatus and in electrical connection therewith, a signal transmitting means in the cage and being tuned to a higher frequency than that of the receiver, said transmitting means being in electrical connection with the cable to include said cable as part of the oscillator circuit thereof, thereby increasing the total inductance and capacity in the transmitter circuit as the cable is unreeled and as the actual frequency of said transmitter tends to decrease with the increase of distance from the receiver.

5. A mine-shaft signal system comprising a hoisting apparatus, a radio receiver electrically connected with said apparatus and being tuned sharply to a chosen frequency, a cage adapted to travel up and down in the mine shaft and having signal transmitting means therein; said means being tuned sharply to a frequency higher than that of the radio receiver, and a metal cable by which the cage is suspended in the shaft from the hoisting apparatus, said cable having the signal transmitting means electrically connected therewith to embrace said cable in the oscillator circuit of the transmitting means and serve to automatically vary the tuning of the transmitting means to compensate for the diminution of signal reception at the receiver with an increase of distance of the transmitter from the receiver.

6. A mine-shaft signal system comprising a hoisting apparatus at the entrance of the shaft and a cage, radio signal transmitting means in the cage for producing sharply tuned impulses, a metal cable having the cage attached to one of its ends and being secured at its other end to the hoisting apparatus, said cable being in electrical connection with said signal transmitting means and constituting part of the oscillator circuit thereof, and a radio receiver tuned sharply to a different frequency from that of the signal transmitting means and having an antenna in inductive relationship to the cable.

RICHMOND L. RUTHERFORD.