

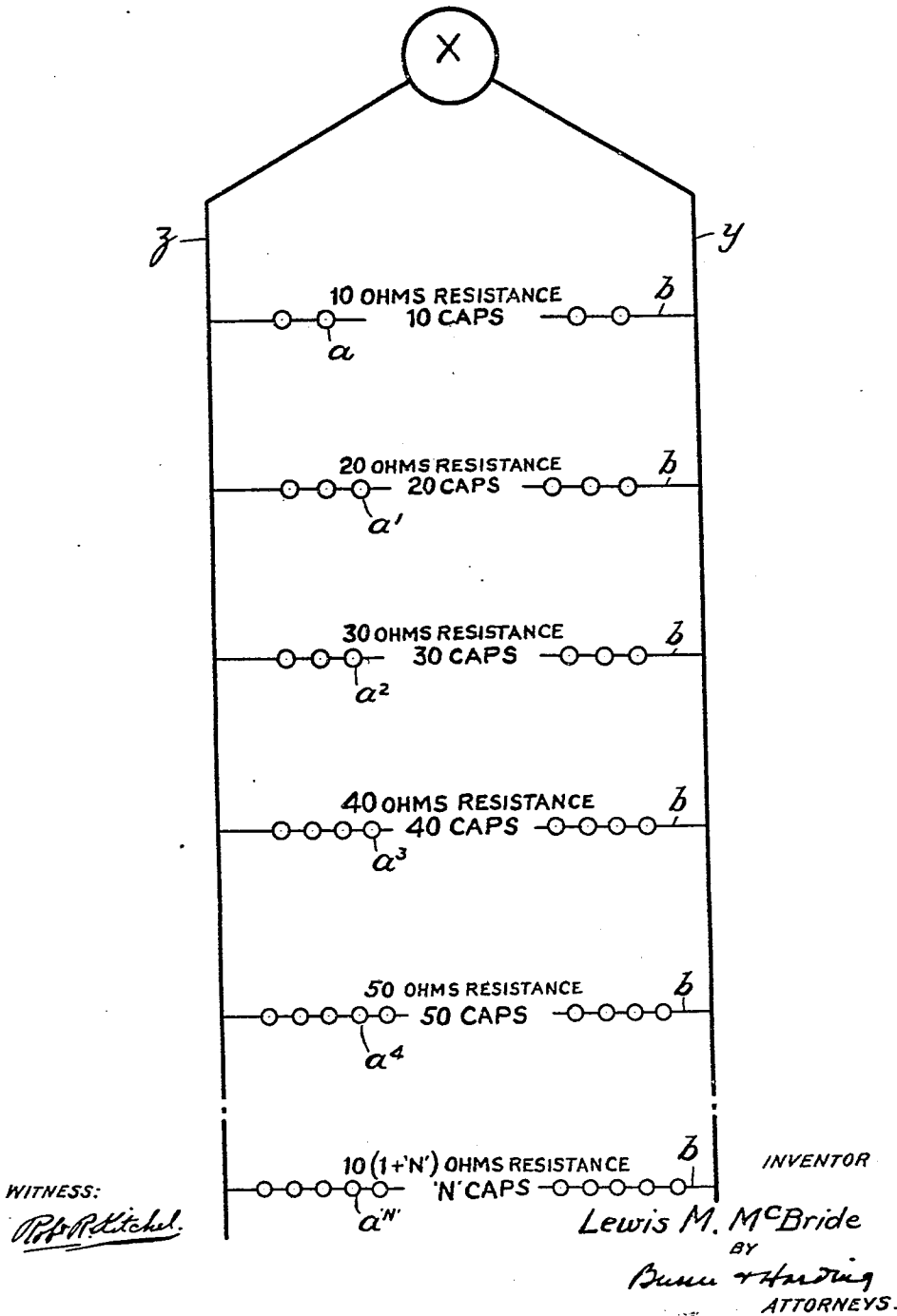
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L. M. McBRIDE

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METHOD FOR FIRING EXPLOSIVES

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UNITED STATES PATENT OFFICE

LEWIS M. McBRIDE, OF BOSTON, MASSACHUSETTS, ASSIGNOR TO HERCULES POWDER COMPANY, A CORPORATION OF DELAWARE

METHOD FOR FIRING EXPLOSIVES

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My invention relates to a method for firing explosives and more particularly to a method for firing blasting charges, though as will appear hereinafter, my invention is adaptable to a wide field of use including the firing of guns.

Heretofore in the commercial use of explosives, as in blasting for one purpose or another, it has been customary to fire the charges electrically, through the medium of a firing element as, for example, a detonating cap or a fuse head, the caps or fuse heads for a number of charges being connected to an electric firing circuit in parallel, in series, or in series parallel. The customary methods of electric firing have served well enough where only a small number of charges are fired, but where it is desired to fire any large number of charges, the customary methods are impractical because of the high current values required to overcome the sum of the resistances of the firing elements necessary to fire the desired number of charges and which may easily exceed the capacity of the usual blasting machines. Thus, present methods of electrical firing limit the number of charges which may be fired on one circuit.

Now, it is the object of my invention to provide a method of firing explosives whereby a very large number of charges may be fired with a minimum amount of electrical energy and whereby the number of charges capable of being fired on a single circuit and within the capacity of the ordinary blasting machine will be greatly increased.

According to the method embodying my invention broadly, I arrange a plurality of electric firing elements, as detonating caps or fuse heads, in a firing circuit and provide differential resistance to the flow of a current to the different firing elements so that when electric energy, as an electric current, is imparted to the firing circuit, the current, taking the path of least resistance, will actuate the firing elements connected to the circuit through the least resistance and will subsequently actuate the firing elements connected to the circuit through greater resistance. Thus, it will be observed that in carrying

out my method, the current requirement is defined by that necessary to overcome the maximum resistance used in connecting the firing elements in the circuit, rather than by the sum of the resistances of the firing elements.

More specifically, in accordance with my invention, I arrange in parallel in an electric firing circuit a plurality of series of firing elements and provide a differential resistance in different series; and still more specifically, I arrange in parallel in a firing circuit a plurality of firing elements in series of varying resistance.

In putting into practice the method embodying my invention, a plurality of series of firing elements, as, for example, detonating caps, each associated with an explosive charge, may be connected in parallel in an electric firing circuit and differential resistance between two or more series obtained by providing in two or more series a different number of firing elements, since the resistance in each series is equal to the sum of the resistances of the several firing elements in each series.

Referring now to the accompanying drawing, in which the figure is a diagrammatic illustration of an electric firing circuit with a plurality of series of explosive charges to be fired by the method embodying my invention, x indicates any convenient source of electric energy, which may be a power line, generator, or ordinary blasting machine and which may be a source of either alternating or direct current. y and z respectively, indicate leads connected to the source of electric energy. $a, a_1, a_2, a_3, a_4,$ and a_n indicate a plurality of graded series of electric firing elements, the several series being connected across the leads y, z , by means of wire b . The several series a to a_n comprise, respectively graded series of resistances obtained, in the circuit illustrated, by the provision of varying numbers of firing elements in each series.

The variation of the number of firing elements, in order to obtain the desired graded series of resistances, may be made according to any suitable and desirable method, such as an arithmetical or geometrical progression;

or it may be based upon some value of a , which varies either directly or inversely as some constant; upon a percentage basis of a , or by any other suitable system.

5 As each of the firing elements indicated in the series a to a_n inclusive, have the same or a proportionate resistance and are separated and isolated in the same manner under the same conditions, then the heat required to
10 fuse the bridge wire, or other element of each firing element is the same.

With a given voltage E , across the firing circuit formed by the conductors y and z , a current flowing through the several series a
15 to a_n inclusive, varies inversely with the resistance R of those circuits.

Assuming that the number of firing elements, and consequently the resistance, is varied in an arithmetical progression whereby
20 each term is obtained from the preceding term by adding a constant difference d having for instance a resistance of ten ohms; a being for example a series of firing elements having a total resistance of ten ohms, then $a_1 = a + d$;
25 $a_2 = a + 2d$; $a_3 = a + 3d$; $a_4 = a + 4d$; $a_n = a + nd$; or otherwise stated, the resistance of a is equal to 10 ohms; of a_1 to 20; of a_2 to 30; of a_3 to 40, of a_4 to 50 and of a_n to 10 $(1+n)$
30 ohms, respectively. It will be seen from the foregoing proportions that the circuit a having one-half of the resistance of a_1 passes twice as much current. However, as the heating effect varies as the square of the current there is produced four times as much
35 heat in each firing element, inasmuch as the resistance R of each, is the same. In a like manner the heat generated in the firing elements in the circuit a is nine times that in the circuit a_2 ; sixteen times that in the circuit a_3 ;
40 twenty-five times that in the circuit a_4 and $(n+1)^2$ times that in the circuit a_2 .

The time required to actuate a firing element varies inversely as the square of the current, therefore doubling the current, as in the
45 case of series a over series a_1 , the time of firing the series a is four times faster than series a_1 .

It will be seen from the above that with a suitable value of voltage impressed across the
50 firing circuit that current will flow through the several graded series circuits a to a_n inclusive, with values inversely proportional to their individual resistances and that the resultant heating effect in the individual firing
55 elements of those circuits will vary as the square of the current values therein. Consequently the graded series of connected firing elements are actuated in a regular turn of order from the series of lowest resistance progressively through those of succeeding higher
60 resistance.

As each series of firing elements is actuated, that particular circuit is ruptured and opened,
65 and the load on the source of current is reduced by the amount of current which was

flowing in that series. The initial load will therefore progressively diminish as the series circuits open successively. This progressive diminishing or reduction of the current tends to cause a correspondingly successive increase or rise in the voltage of the system thereby increasing the current in the remaining series circuits and further augmenting the heating effect and the actuation of the successive series.

By this method of connection and firing, it is apparent that the capacity of the source of current need not be such as would be required to fire the entire number of connected firing elements instantaneously or simultaneously, and by this arrangement of circuits a greater number of charges can be fired with a given energy value of electricity, therefore the size and weight of a firing mechanism for firing any given number of charges can be
75 materially reduced.

It will be understood that in accordance with my invention, the resistances of the several series a to a_n may be varied by any convenient means other than by the use of varying numbers of firing elements in the several series, as described; and further, that the several series need not be respectively of different resistance, it being only necessary, depending upon the number of charges to be
85 fired, that two or more series be of different resistance.

It will be understood that I do not intend that my invention shall be limited to the firing of commercial explosives, nor to the use
100 of any particular type of firing element, since it is adaptable to other uses, as for example, the firing of guns and may be used with any form of electrically operated firing element, as for example, a detonating cap or fuse head,
105 whether such acts directly or indirectly to fire the explosive charge.

Having now fully described my invention, what I claim and desire to protect by Letters Patent is:—

1. The method of firing explosives, which comprises arranging in parallel in an electric firing circuit a plurality of series of explosive charge firing elements, providing differential resistance to the flow of current in
115 different series by variation in the number of firing elements in different series and imparting electrical energy to the firing circuit.

2. The method of firing explosives, which comprises arranging in parallel in an electric firing circuit a plurality of series of explosive charge firing elements, providing a differential resistance to the flow of current in a plurality of such series by providing a different number of firing elements in one series from
120 that in another series and imparting electrical energy to the firing circuit.

3. The method of firing explosives, which comprises arranging in parallel in an electric firing circuit a plurality of series of explosive
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charge firing elements, providing a differential resistance to the flow of current in such series by providing a different number of firing elements in each series and imparting electrical energy to the firing circuit.

5 In testimony of which invention, I have hereunto set my hand, at Boston, Mass., on this 10th day of May, 1927.

LEWIS M. McBRIDE.

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