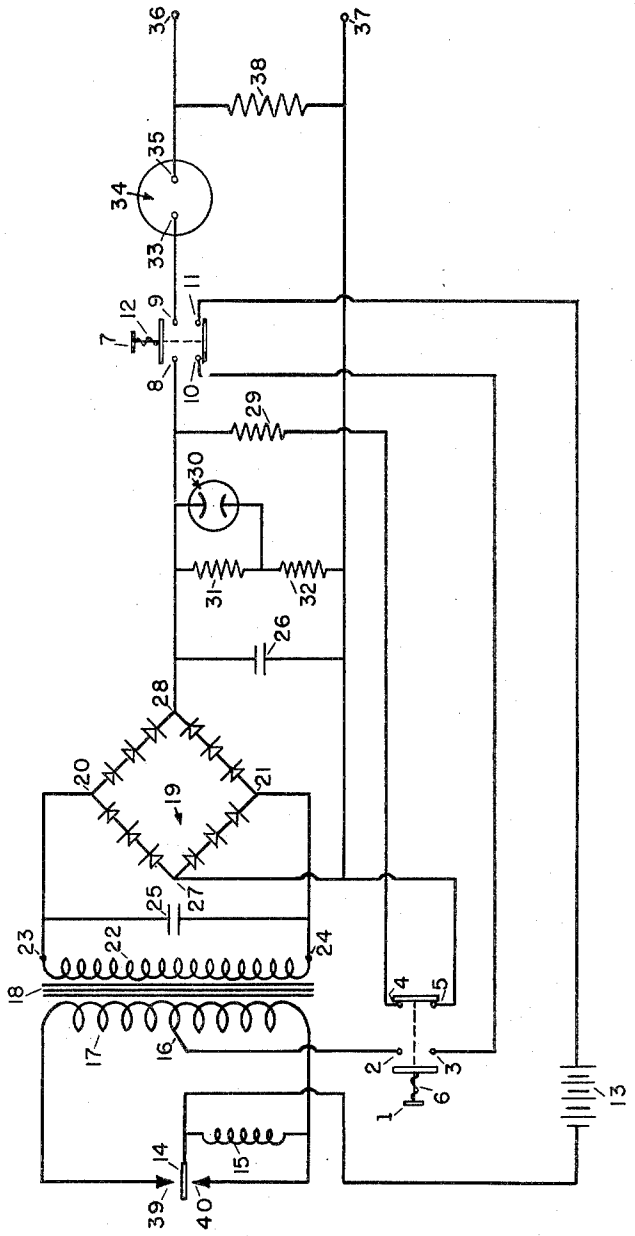
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BLASTING MACHINE

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BLASTING MACHINE

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This invention relates to a blasting machine and more particularly to a condenser type multiple shot machine whereby large numbers of initiators may be simultaneously detonated.

In recent years there has been a trend toward firing increasing numbers of electric blasting initiators in a single shot. For a long time the standard blasting machine in the art has been the push-down or rack-bar, manually operated device which is limited to about 120 caps in a single shot. Where it became desirable to employ larger numbers of initiators in a single shot, it generally has been the practice to employ an engine driven generator or a service power line for the firing potential. Both of these techniques are inordinately complicated by the limited portability of the necessary equipment.

More recently battery operated condenser type machines have been developed which are capable of firing large numbers of caps. In these machines a charge is built up on a storage condenser which is manually or automatically released to the firing line. These machines have constituted a significant step forward in the art but still leave much to be desired from the standpoint of reliability, safety, and economy. Some of these machines have still lacked sufficient power to fire several hundred initiators. Others having sufficient power output have required such large and heavy batteries or hand generators for a power source that necessary portability has been sacrificed. Moreover, in all the prior condenser types there has been the possibility and danger of a condenser discharge to the firing circuit of a charge incapable of firing all the initiators. Such performance results in highly dangerous missed holes.

It is an object of the present invention, therefore, to provide an improved battery operated condenser type machine which is capable of detonating simultaneously large numbers of electrical blasting caps whether connected in series, in parallel, or in series-in-parallel. It is a further object of the invention to provide such a blasting machine which is portable, durable, relatively inexpensive, and simple to operate. It is a further object of the invention to provide a blasting machine which is safe to operate from the standpoint of the blasting engineer and is eminently reliable in that partial shots due to discharge of insufficient firing potential from the condenser are completely eliminated.

Generally described, the present invention is a blasting machine having in combination a D. C. input, a reed vibrator connected to the D. C. input, a voltage multiplying means connected to the vibrator, a charging switch and a firing switch, said input and vibrator being connected to the voltage multiplying means when the charging switch is closed and the firing switch is open, a rectifier conected to the secondary coil of the voltage multiplying means, at least one condenser connected in parallel with the output of the rectifier, and a breakdown tube connected in series with the firing switch and the output of the machine, said breakdown tube having a breakdown voltage at least equal to the firing voltage desired.

In preferred embodiments of the blasting machine of the invention, a gas-filled glow tube is connected across the condenser to indicate the charge stored up therein. The rectifier may be a single rectifier tube or a plurality of such tubes arranged, for example, to form a bridge. High vacuum rectifier tubes or cold cathode tubes may be employed. Selenium rectifiers may also be employed and preferably the rectifier will be a bridge type selenium rectifier.

The combination of the firing switch and the breakdown tube connected in series is a special feature of the blasting machine in accordance with this invention and completely prevents discharging of the condenser through the firing circuit until adequate potential has been developed on the condenser to fire all of the initiators in the circuit. Thus, if a glow tube is connected across the condenser but functions improperly, a premature closing of the firing switch will not cause discharge of the condenser into the firing circuit. In like manner, the condenser wil not discharge prematurely if the firing switch is accidentally depressed prior to the build-up of the desired charge on the condenser. As set forth above, the breakdown tube employed always will have a breakdown voltage at least equal to the firing voltage desired.

Having generally described the invention, a preferred embodiment of a blasting machine in accordance therewith will be specifically illustrated in conjunction with the circuit diagram of Figure 1.

In the drawing, a charging switch **1** is provided which has two sets of contacts **2** and **3** and **4** and **5**, respectively. The switch is maintained in its normal or open position by spring **6** and in this open position connects contacts **4** and **5**. In the closed or operating position the switch **1** connects contacts **2** and **3**. A similar firing switch **7** is likewise provided with two sets of contacts **8** and **9** and **10** and **11**, respectively. The switch **7** is maintained in the normal or open position by means of spring **12** and in this position connects contacts **10** and **11**. In the operated or closed position the switch **7** connects contacts **8** and **9**. A 6-volt dry-cell battery **13** is connected to vibrating reed **14** and magnetic coil **15** and to contact **3** of the charging switch **1** through contacts **10** and **11** of firing switch **7** when the firing switch **7** is in the open position as shown. Contact **2** of charging switch **1** is connected to the center tap **16** of the primary coil **17** of a step-up transformer **18**. The vibrating reed **14** is positioned in a gap between contacts **39** and **40** which are connected across the primary **17** of the transformer **18**. A bridge type selenium rectifier **19** is connected by means of terminals **20** and **21** across secondary **22** at terminals **23** and **24**. A buffer condenser **25** is also connected across the secondary **22**. The storage condenser **26** is conected across the output of the rectifier **19** through output terminals **27** and **28**. Terminal **28** of the rectifier **19** is connected with contact **4** of the charging switch **1** through resistor **29**, while contact **5** of the charging switch **1** is connected to terminal **27** of rectifier **19** to discharge the condenser **26** when the charging switch **1** is in the open position as shown. A neon glow lamp **30** is connected across condenser **26** to indicate the charge on the condenser. Resistors **31** and **32** are provided to form a voltage dividing network which determines the potential at which the neon glow lamp **30** will glow. One electrode **33** of a breakdown tube **34** is connected to contact **9** of the firing switch **7**. Electrode **35** of the breakdown tube **34** is connected to output terminal **36**. Output terminal **37** is connected to condenser **26**. A resistor **38** is connected across output terminals **36** and **37** to provide a discharge path for condenser **26** in the event the machine is fired without an initiator circuit connecting terminals **36** and **37**.

The blasting machine shown in the drawing operates

as follows: The switch 1 being in its normal open position leaves contacts 2 and 3 open, thus isolating the battery 13 from the principal blasting machine circuit. With switch 1 in the open position contacts 4 and 5 are closed, thus placing resistor 29 in parallel with the condenser 26. This removes any residual charge which may be on the condenser as a result of previous use.

By closing the switch 1 contacts 2 and 3 are brought into conductive relationship and the low potential of the battery 13 is applied on part of the primary 17 of the transformer 18 and across the magnetic coil 15 of the reed vibrator. The reed 14 is magnetically attracted toward coil 15 and is drawn into engagement with contact 40. This engagement shorts out the coil 15 and removes the attraction allowing the reed 14 to swing back past its mid position to engage the contact 39. However, as soon as engagement between contact 40 and reed 14 is broken, attraction is again built up causing the reed 14 to swing back and again engage contact 40. As long as the switch 1 is closed, this cycle is repeated continuously. The frequency of vibration may be controlled by the design of the natural period of the reed 14. Thus, as the reed 14 engages first the contact 40 and then the contact 39 an alternating flux is set up in the primary winding 17 of the transformer 18 and an alternating voltage is induced across the terminals 23 and 24 of the secondary winding 22 of the transformer 18. The buffer condenser 25 which is connected across terminals 23 and 24 produces optimum wave form and increases the life of the vibrator.

The alternating voltage produced across the secondary terminals 23 and 24 of the transformer 18 is applied to terminals 20 and 21 of the selenium bridge rectifier 19. When terminal 24 of the transformer 18 is of negative polarity, with respect to the terminal 23 of the transformer, electrons will flow from terminal 24 to input terminal 21 of bridge rectifier 19, to output terminal 27 of the rectifier, to storage condenser 26, to output terminal 28 of the rectifier, to input terminal 20 of the rectifier, to terminal 23 of the transformer 18, and through the secondary winding of the transformer 18 to the terminal 24. By the nature of the rectifier electrons can flow through it in only one direction. Therefore, for the other half of the alternating voltage cycle terminal 24 of the transformer 18 becomes positive with respect to the terminal 23 and electrons then flow from the terminal 23 to input terminal 20 of the rectifier to output terminal 27 of the rectifier, to storage condenser 26, to output terminal 28 of the rectifier, to input terminal 21 of the rectifier, to terminal 24 of the transformer and through the secondary winding to terminal 23.

It will be seen that for both halves of the alternating voltage cycle the current flow with respect to the condenser 26 is toward the negative plate and away from the positive plate of the condenser. Thus, electrons are flowing away from the positive plate of condenser 26 causing a deficiency of electrons at the positive plate. At the same time electrons are moving on the negative plate of the condenser 26 causing a surplus of electrons at the negative plate. This process continues until the potential difference between the positive and negative plates of the condenser 26 is equal to that across terminals 27 and 28 of the rectifier 19. When condenser 26 is charged, neon lamp 30 will glow. The exact potential at which lamp 30 lights depends on the values of the resistors 31 and 32 which form a voltage dividing network. The tube 30 will give a visual indication that the potential on condenser 26 has reached the desired and predetermined value.

In order to release current to blasting initiators disposed between output terminals 36 and 37, the firing switch 7 is closed. The operation of the switch 7 opens contacts 10 and 11 and opens the line from the battery 13 to the center tap 16 of the primary winding 17 of the transformer 18. Contacts 8 and 9 are closed to connect

the condenser 26 to electrode 33 of breakdown tube 34. When the breakdown voltage is applied to the tube 34, electrodes 33 and 35 are placed in conductive relationship and output terminal 36 is thus connected to one plate of the condenser 36. Output terminal 37 is connected directly to the other plate of the condenser 26.

It will be seen, therefore, that the blasting machine of the invention cannot be operated until the condenser 26 is charged at least to the firing potential predetermined as necessary to fire all of the initiators in the firing circuit. Thus, misfires due to insufficient firing voltage cannot occur unless the capacity of the machine is purposely exceeded.

As previously indicated, any desired battery of either the dry cell or storage type may be employed as the D. C. power source. The battery may be a single cell or may be composed of the requisite number of individual cells to produce the desired voltage. As the voltage is changed, of course, the characteristics of the vibrator and transformer will also be changed. As has been indicated, equivalent rectifying means may be substituted for the bridge rectifier illustrated in Fig. 1 which is made up of a number of low voltage selenium rectifiers connected in series. For example, high voltage selenium rectifiers may be connected in a bridge circuit or any commercially available rectifier may be substituted. Other types of semi-conductive rectifiers such as copper oxide, germanium, and silicon may also be employed as long as the components are made large enough to accommodate the voltage developed either by constructing a large unit or by wiring a number of smaller units in parallel. Other rectifiers such as high vacuum rectifiers, mercury rectifiers, or cold cathode rectifiers may be used. The cold cathode type generally will not charge the condenser to as high a voltage as the selenium type due to the fact that cold cathode rectifiers cease to function at the low currents, which occurs when the condensers approach full charge. Both the mercury and high vacuum type rectifiers generally require additional power from the battery to heat their cathodes. Therefore, from the standpoint of efficiency, economy, and performance the selenium type rectifier is preferred.

The number and capacitance of the storage condenser 26 may be changed without altering the mode of operation of the blasting machine of the invention. Such condensers may be connected in parallel, in series, in series-in-parallel, or in parallel-in-series. Electrolytic condensers are preferred since they combine high capacitance with low weight and small physical size. Other types of condensers such as paper, oil, mica, or ceramic could be substituted.

The breakdown tube employed in accordance with the invention will have at least two electrodes surrounded by an ionizable gas. The potential at which a particular tube will break down is determined largely by the distance separating the electrodes and the nature and pressure of the gas. Tubes containing more than two electrodes may be employed, but the extra electrodes do not enter into the operation of the machine.

Blasting machines built in accordance with the invention are safer to operate and more reliable in performance than any other condenser type, battery operated units available. If a 6-volt battery is employed as an input, the maximum voltage present in the unit when not in operation is 6 volts. Due to the presence of the breakdown tube, it is impossible to discharge the condensers into the firing line accidentally or prior to their becoming fully charged. Still, the release of current to the firing circuit may be positively controlled. Machines in accordance with this invention are light in weight and readily portable. With a 6-volt battery as an input, firing voltages of 500 volts are readily obtainable. Such voltages have made it possible for machines in accordance with this invention to fire more than 2000 initiators in a single shot.

Since various modifications of the machine disclosed will occur to those skilled in the particular art without departing from the scope of the invention as disclosed, it is intended that the invention shall be limited only by the scope of the appended claims.

What we claim and desire to protect by Letters Patent is:

1. A blasting machine having in combination a D. C. input, a reed vibrator connected to the D. C. input, a voltage multiplying means connected to the vibrator, a charging switch and a firing switch, said input and vibrator being connected to the voltage multiplying means when the charging switch is closed and the firing switch is open, a rectifier connected to the secondary coil of the voltage multiplying means, at least one condenser connected in parallel with the output of the rectifier, and a breakdown tube connected in series with the firing switch and the output of the machine, said breakdown tube having a breakdown voltage at least equal to the firing voltage desired.

2. A blasting machine in accordance with claim 1 in which a gas-filled glow tube is connected across the condenser.

3. A blasting machine in accordance with claim 1 in which the rectifier consists of at least one rectifier tube.

4. A blasting machine in accordance with claim 1 in which the rectifier is a selenium bridge rectifier connected across the secondary of the transformer.

5. A blasting machine having in combination a D. C. input, a reed vibrator connected to the D. C. input, a step-up transformer connected to the vibrator, a charging switch and a firing switch, said input and vibrator being connected to the voltage multiplying means when the charging switch is closed and the firing switch is open, a selenium bridge rectifier connected to the secondary of the transformer, at least one condenser connected in parallel with the output of the rectifier, a gas-filled glow tube is connected across the condenser, and a breakdown tube connected in series with the firing switch and the output of the machine, said breakdown tube having a breakdown voltage at least equal to the firing voltage desired.

References Cited in the file of this patent

UNITED STATES PATENTS

2,391,611	Back	Dec. 25, 1945
2,516,209	Henninger	July 25, 1950