OPERATION MANUAL

for the

BM175-10PT SERIES

SEQUENTIAL BLASTING MACHINE

including the

ET175-10 ENERGY TESTER,

BO1999-10 BLASTER'S OHMMETER,

BMS-10 MULTIMETER SWITCH,

EC15 SERIES EXTENSION CABLE

and

TB15 TERMINAL BOARD

SEE PAGE 12 FOR USER INFORMATION AND LIMITED WARRANTY

RESEARCH ENERGY OF OHIO, INC.
200 East Bluegrass Drive Norwalk, Ohio 44857
Phone: 419-660-8832 Fax: 419-660-8833
E-mail: sales@researchenergy.com
Web: www.researchenergy.com

TABLE OF CONTENTS

INTRODUCTION

The Research Energy of Ohio, Inc. (REO) BM175-10PT series Blasting Machines are ten circuit capacitor discharge type blasting machines with a minimum output energy of 9 joules per circuit. Each circuit of the blasting machine can initiate electric detonators wired in a single series circuit of up to 175 ohms total resistance (including lead wires and connecting cable), based on 20 millijoules per ohm delivered in 5 milliseconds. The energy for each detonator circuit is supplied by a capacitor with a nominal capacitance of 100 microfarads and charged to 450 VDC. Primary power to charge the capacitors and to operate the system is derived from ten internal 1.5 volt alkaline "D" cell batteries.

The BM175-10PT series Blasting Machine is available as a Master and as a Slave. There is no limit to the number of Slaves that may be connected to the Master. The Slave contains an additional socket so that additional Slaves may be added. The Slaves receive the charge and fire signals from the Master, therefore there is no need for a charge and fire switch on the Slave. The Master is model BM175-10PT-M. The Slave is model BM175-10PT-S.

The BM175-10PT series Blasting Machine is also available in two remote control models. The model BM175-10PT-RC Remote Control Blasting Machine operates up to 2000 feet from the RC70 battery operated Remote Control unit using 20 gauge or heavier duplex wire. The model BM175-10PT-RM Remote Mains Blasting Machine operates from 200/250 volts, 50/60 Hz mains power.

There are nine three-digit pushbutton switches on the BM175-10PT, BM175-10PT-M, BM175-10PT-RC and BM175-PT-RM Blasting Machines. There are ten three-digit pushbutton switches on the BM175-PT-S Blasting Machine. These switches are used to select the delay period between series. The delay can be set from 001 to 999 Milliseconds in one millisecond increments, (000 is approximately 0.46 milliseconds and is not intended as an instant setting). For example, if 100 is chosen on each of the switches, each electric detonator circuit will be initiated 100 milliseconds after the previous circuit and the blasting machine will "sequence" at a rate of 100 milliseconds.

ACCESSORIES

The accessories listed below are available for the BM175-10PT series Blasting Machines. Please refer to the APPENDIX for additional information and use for these accessories.

Note	Accessory
#1	AD5 Load Plug.
#1,#2	ET175-10 Energy Tester and EC15-2 Connecting CAble. (An EC15-2 Connecting Cable is necessary to connect the tester to a blasting machine, and is provided with the tester.)
#1	BO1999-10 Blaster's Ohmmeter.
#3	BMS-10 Blaster's Multimeter Switch. (This is used with a BO1999-1 Blaster's Ohmmeter or a blaster's multimeter instead of a BO1999-10 Blaster's Ohmmeter.)
#1	EC15-500 or EC15CW-500 Extension Cables, 500 feet long. The EC15 cables have PVC insulation. The EC15CW cables have thermoplastic rubber insulation for cold weather applications. The EC15-500 and EC15CW-500 cables are used with the TB15 Terminal Board. Other length extension cables are available on

request.

#1 TB15 Terminal Board.

#1 CR50 Cable Reel. (This is used with an extension cable.)

Notes:

#1 Needed for a complete Sequential Blasting System.
#2 Measures the blasting machine energy output.
#3 May be used with a BO1999-1 Blaster's Ohmmeter, a blasting multimeter or blaster's galvanometer instead of the BO1999-10 Blaster's Ohmmeter.

CAUTION: WE URGE YOU TO USE ONLY RESEARCH ENERGY OF OHIO, INC. REPLACEMENT PARTS AND ACCESSORIES. We are aware of other replacement products for the REO system, and feel that they do not meet all of our technical and safety standards. We have observed in products manufactured by others frayed and poorly made solder connections that may allow circuit to circuit and/or circuit to case shorts, unprotected connectors that may allow excessive leakage current and subsequent voltage breakdown, unshunted circuits during shot wiring and connection of the electric detonators and incorrect wiring that may result in misfires and may present a shock hazard. Furthermore, some of these products violate, in our opinion, the Federal Coal Mine Safety Standard 30CFR77, Part 77.1303 "Explosives Handling and Use."

GENERAL INFORMATION

The CHARGE and FIRE pushbutton switches and the MILLISECONDS timing selection switches are on the top panel of the Blasting Machine.

The BLASTING CABLE connector is also on the top panel of the Blasting Machine. The extension cable is plugged into this connector. A screw on dust cover attached to the top panel is provided to keep water and dirt out of the BLASTING CABLE connector when not in use.

CAUTION: Keep the dust cover on the BLASTING CABLE connector when not in use.

The READY TO FIRE indicator on the panel illuminates when the energy storage capacitors reach design voltage. It does not indicate energy and therefore does not guarantee that the energy storage capacitors have enough energy output to initiate the electric detonators. Energy output must be determined as discussed in the Operational Test.

Each of the CAP CIRCUIT indicators illuminates as the firing sequence progresses if its electrical circuit has continuity. The blasting machine cannot differentiate between a shorted electric detonator circuit and one of desired resistance and therefore will sequence through a shorted electric detonator circuit.
All ten electric detonator circuit outputs are shunted for safety reasons when the FIRE switch is not depressed.

CAUTION: The blasting machine will shut down during the firing sequence on any open cable, open detonator circuit, or release of the CHARGE or FIRE pushbutton switch.

The machine cannot be fired until the voltage on the energy storage capacitors reaches the design voltage and the safety circuit is released.

INDICATORS

Quantity	Indicator (LED)	When lit indicates
1	READY TO FIRE	The capacitors are charged to the desired voltage. (Does not indicate energy. Energy output must be determined as discussed in the Operational Test.)
10	CAP CIRCUIT	The blasting machine sequenced through the electric detonator circuits that are lit.

ELECTRICAL SPECIFICATIONS

Output (each circuit):

Number of Blasting Circuits: 10
Nominal Capacitance: 100 microfarads.
Nominal Voltage: 450 volts.
Internal Resistance: 10.7 ohms.
Minimum Energy: 9 joules.
Maximum Load Resistance: 175 ohms, Single Series Circuit Only, assuming 0.02 joules/ohm delivered in 5 milliseconds. Series-Parallel circuits are not permitted.

Power Source:

Type: Internal "D" cell 1.5 volt ALKALINE batteries.
Quantity: 10.
Voltage: 15 volts DC (Ten 1.5 volt batteries wired in series.)
Capacity: Provides more than to 450 charge-fire cycles.
Access: Remove four screws and yellow cover on the side of the case.

OPERATION

Operational Test

WARNING: BLASTING PROCEDURES, ELECTRIC DETONATOR SELECTION, CIRCUIT DESIGN AND TIMING ARE THE RESPONSIBILITY OF THE USER. Consult with the Explosives Engineer and with the explosives suppliers for necessary information and training for safe, efficient blasts.

To determine if a BM175-10PT series Blasting Machine is operating satisfactorily, three parameters need to be evaluated:

1. Sequencing at maximum load resistance.

2. Sequence order.

3. Energy output.

4. Timing accuracy.

CAUTION: The output of the Blasting Machine is a "pulse" of energy of relatively short duration. Multimeters, voltmeters and other field instruments cannot respond accurately to this short duration voltage and therefore cannot be used to determine if the blasting machine output voltage is normal.

Although these parameters may be measured from time to time in the laboratory, the BM175-10PT series Blasting Machine must be tested in the field before each use to reduce the possibility of using a malfunctioning blasting machine. The ET175-10 Blasting Machine Tester (APPENDIX A) was developed specifically to measure the energy output of a sequential blasting machine and is highly recommended. Please note that the ET175-10 Energy Tester does not determine the sequence order or the timing accuracy of a Blasting Machine. Please refer to APPENDIX E for alternative methods to check the operation of the BM175-10PT series Blasting Machine.

The AD5 Load Plug is used to determine if the blasting machine sequences at maximum load resistance.

The following procedure will check out most of the functions of the BM175-10PT series Blasting Machine.

1. Set all delay periods to 500 milliseconds.

2. Insert the AD5 Load Plug into the BLASTING CABLE connector.

3. Charge and fire the blasting machine. Verify that all ten CAP CIRCUIT indicators light in order 1 to 10.

4. Determine the energy output of the blasting machine using an ET175-10 Energy Tester. Please refer to APPENDIX A for instructions on using this tester.

   IMPORTANT: Since the stored energy output can only be measured when expended, before each use the blasting machine must be connected to an ET175-10 Energy Tester to determine if the energy output of each circuit of the blasting machine is sufficient to initiate the electric detonators.

   Please refer to APPENDIX E for alternative methods to check the operation of the BM175-10PT series Blasting Machine.

   WARNING: DO NOT TEST THE BLASTING MACHINE NEAR ACTIVE BLAST SITES. DO NOT USE LIVE OR DANGEROUS EXPLOSIVE DEVICES TO TEST THE ENERGY OUTPUT OF BLASTING MACHINES.

General Operating Procedure

Note: The following procedure is intended as a guide only, and each user must prepare and verify his own procedure consistent with Local, State, and Federal regulations. Complete Operating Instructions appear in the lid of the blasting machine.

CAUTION - USE OF THIS MACHINE REQUIRES THAT THE OPERATOR HAS BEEN TRAINED AND CERTIFIED IN BLASTING TECHNIQUES.

WARNING: BATTERIES ALONE CAN FIRE ELECTRIC DETONATORS. KEEP BATTERIES AWAY FROM THE BLASTING CIRCUITS.

WARNING: NEVER CONNECT THE BLASTING CIRCUIT TO THE BLASTING MACHINE UNTIL YOU ARE READY TO FIRE THE BLAST.

1. Perform the Operational Test (including measurement of energy output) before bringing the blasting machine into the blast area.

2. Obtain electric detonator firing recommendations from the detonator manufacturer. Check the blasting circuit calculations prior to connecting to the blasting machine.

3. Set the desired delay period on each of the 3-digit timing switches.

4. Connect the electric detonator wires to the terminal board. The electric detonators in each circuit must be wired in a single series circuit. SERIES-PARALLEL CIRCUITS ARE NOT PERMITTED.

   CAUTION: When using an extension cable, keep it shunted during wiring of the electric detonators by inserting the cable plug into the SHUNTED socket on the cable reel. When using a terminal board, keep it shunted during wiring of the electric detonators by inserting the AD5 Load Plug into the cable socket on the Terminal Board.

   CAUTION: EACH CIRCUIT MUST HAVE ITS OWN RETURN WIRE CONNECTED TO THE BLACK TERMINAL OF THE TERMINAL BOARD. The use of a single electrical return wire is contrary to accepted methods and may cause a misfire or excessive bench movement thus breaking hookup wires and interrupting the sequence prematurely.

   WARNING: DO NOT CONNECT A CIRCUIT BETWEEN TWO RED OR BETWEEN TWO BLACK TERMINALS. Visually check that each circuit is connected between a pair of RED and BLACK terminals on the terminal board.

5. The terminal board is connected to the extension cable. Make sure that the extension cable is shunted at the cable reel.

6. MAKE SURE THAT ALL PERSONNEL HAVE BEEN REMOVED TO A SAFE LOCATION.

7. Check the electric detonator circuit continuity and resistance (including the cable) using the BO1999-10 Blaster's Ohmmeter or using a BMS10 Blaster's Multimeter Switch and an approved blasting galvanometer. (See APPENDIX B for instructions on using the BO1999-10 Blaster's Ohmmeter or APPENDIX C for instructions on using the BMS10 Blaster's Multimeter Switch.)

8. After checking the circuits, Shunt the extension cable by inserting the cable plug into the SHUNTED socket on the cable reel.

9. Verify that the MILLISECONDS timing switches are set to the desired Delay Time.

10. Remove the plug from the SHUNT socket on the cable reel and plug it into the BLASTING CABLE socket on the BM175-10PT Blasting Machine. KEEP HANDS AND BODY CLEAR OF CONDUCTORS. CONTACT WITH ELECTRICAL CONDUCTORS COULD CAUSE SERIOUS INJURY OR DEATH.

11. Depress the CHARGE switch and hold it down. The READY TO FIRE indicator illuminates when the capacitors reach the design voltage.

    CAUTION: The READY TO FIRE light does not indicate energy and therefore does not indicate that the blasting machine has sufficient energy output to detonate the electric detonators. Energy output must be determined as discussed in Operational Test.

12. When the READY TO FIRE indicator is illuminated, continue holding the CHARGE switch down, and firmly depress the FIRE switch. Continue holding both switches down until the firing sequence is complete.

13. After the firing sequence is complete, wait 5 seconds then release both switches.

    NOTE: Each CAP CIRCUIT indicator illuminates as the firing sequence progresses if its electrical circuit has continuity. If an electrical circuit is open, its CAP CIRCUIT indicator will not light, and the firing sequence will stop at the defective circuit. The blasting machine cannot differentiate between a shorted electric detonator circuit and one of desired resistance and therefore will sequence through a shorted electric detonator circuit.

14. Disconnect and shunt the blasting cable.

15. The blaster should secure the machine after use.

16. If the blasting machine should fail to fire, release both switches, disconnect and shunt the blasting cable, notify personnel of blast delay and consult APPENDIX F of this manual.

Master and Slave Blasting Machine Connections

A Slave Blasting Machine must be connected to a Master Blasting Machine or to other Slave Blasting Machines that are connected (daisy chained) to a Master Blasting Machine. A Slave Blasting Machine can not be used by itself.

To use a Slave Blasting Machine, connect one end of the short cable provided with the Slave to the TO SLAVE connector on the top panel of the Master Blasting Machine. Connect the other end of the cable to the FROM MASTER OR SLAVE connector on the top panel of the Slave Blasting Machine.

A second Slave (Slave #2) may be connected to the first Slave (Slave #1) already connected to the Master using the short cable provided with the Slave. As before, connect one end of the short cable to the TO SLAVE connector on the top panel of Slave #1. Connect the other end of the cable to the FROM MASTER OR SLAVE connector on Slave #2. Additional Slaves may be connected to previous Slaves in the same manner. There is no limit to the number of Slaves that may be used with the Master Blasting Machine.

BATTERIES

Battery Life

Under normal use, Alkaline type batteries will last more than 450 charge-fire cycles. Battery replacement is required when the time required to charge the blasting machine (i.e., the time required for the READY TO FIRE indicator to illuminate after depressing the CHARGE pushbutton switch) exceeds about 30 seconds. This is an arbitrary figure and is chosen only because an operator usually feels uncomfortable if the charge time is greater than about 30 seconds. When the READY TO FIRE indicator does illuminate, even if the charge time is greater than 30 seconds, the BM175-10PT series Blasting Machine is charged to design voltage.

Test firing a blasting machine into a tester or charging to test the READY TO FIRE indicator depletes battery life the same as firing an actual blast.

Battery Type and Replacement

The BM175-10PT series Blasting machines (except the BM175-10PT-RM Blasting Machine which has no batteries) use ten Alkaline "D" cell batteries, Eveready E95 or equal, available in most department stores, drug stores and electronic supply stores.

To replace the batteries, remove the four screws and the yellow cover on the side of the case. Five batteries are placed in each of the two battery tubes. Remove the old batteries and insert the new alkaline batteries observing the polarity indicated by the label inside each battery tube. After battery replacement, make sure that the gasket on the yellow cover is sealing properly and that the screws are securely tightened.

WARNING: USE ONLY ALKALINE TYPE BATTERIES. Do not use carbon-zinc type batteries as they do not have the amperage capacity to operate the BM175-10PT Blasting Machine.

CAUTION: OBSERVE POLARITY WHEN REPLACING THE BATTERIES. INCORRECT POLARITY WILL DAMAGE THE BLASTING MACHINE. The correct battery polarity is marked on the inside surface of the battery tubes.

CAUTION: EXAMINE BATTERIES AT LEAST EVERY 3 MONTHS FOR CHEMICAL LEAKAGE. REPLACE BATTERIES AT LEAST YEARLY EVEN IF NOT EXHAUSTED. REMOVE BATTERIES FROM THE BLASTING MACHINE IF IT IS NOT GOING TO BE USED FOR TWO OR MORE MONTHS.

REPAIRS

The BM175-10PT series Blasting Machine, ET175-10 Energy Tester, BO1999-10 Blaster's Ohmmeter and BMS10 Blaster's Multimeter Switch must be repaired only at the factory to ensure quality workmanship, and for updating to current

production standards. Quality control tests are performed and exact replacement parts are used. Each item repaired is subjected to the same quality control tests as new production. Such procedures and the specialized test equipment required are not available in the field or at other generalized repair shops.

The extension cable and terminal board should be repaired at the factory. However, temporary field repairs are sometimes required. See Appendix D for checkout and repair instructions.

If repair is required, please return the item with shipping charges prepaid to the factory at the address listed below. Include a note or letter describing the problem and include the name and telephone number of the person(s) knowledgeable of the problem. If the equipment is sent by Greyhound Bus Lines, there is a pickup charge that will be added to your repair charges.

Research Energy of Ohio, Inc.
200 East Bluegrass Drive
Norwalk, Ohio 44857

Phone (419) 660-8832 Fax (419) 660-8833
E-mail: repair@researchenergy.com
Web: www.researchenergy.com

USER INFORMATION AND LIMITED WARRANTY

Disclaimer

The information contained in this manual is the instructions and recommendations of Research Energy of Ohio, Inc. Federal, State and/or Local laws, rules and regulations may alter the sequence of operating the equipment. It is the responsibility of the purchaser and user to ensure use consistent with Federal, State and/or Local laws, rules and regulations. It is the responsibility of the receiving office to register this document to the appropriate department and person(s) responsible for mine and blasting safety.

WARNING: BLASTING PROCEDURES, ELECTRIC DETONATOR SELECTION, ELECTRIC DETONATOR CIRCUIT DESIGN, SHOT LAYOUT AND TIMING ARE THE RESPONSIBILITY OF THE USER. Consult with the Explosives Engineer and with the explosives suppliers for necessary information and training for safe, efficient blasts.

Limited Warranty

Each unit is tested extensively before shipment and carries a 90 day LIMITED WARRANTY. If the unit fails to test or perform due to a defect in material or workmanship, please return it to the factory. The unit will be repaired or replaced at our option. This LIMITED WARRANTY is void if the equipment has been dismantled, altered, or otherwise abused in any way.

The above LIMITED WARRANTY is exclusive and in lieu of all warranties, express or implied, including any implied warranty of merchantability or fitness for a particular purpose. Under no circumstances shall Seller or Manufacturer be liable for damages of any description occasioned by or resulting from operation or use of this equipment.

We cannot anticipate all conditions under which this information and our products, or our products in combination with the products of other manufacturers, may be used and therefore accept no responsibility for the results obtained, or the suitability or the safety of our products when used alone or in combination with other products. The user must make his own tests to determine the suitability and safety of each product and product combination for his own purpose. We sell the product without warranty and the buyers and users assume all responsibility and liability for all losses (including anticipated profits), consequential damages, or incidental damages arising from the use of our products alone or in combination with other products.

Use of this equipment by persons not trained in blasting techniques will make the warranty null and void.

APPENDIX A

ET175-10 ENERGY TESTER

GENERAL INFORMATION

The Research Energy of Ohio, Inc. (REO) model ET175-10 Energy Tester provides nominal test values of the energy output (measured in percentage of rated energy) for each of the ten circuits of the REO model BM175-10 series Blasting Machines. A light emitting diode (LED) bar graph display allows the user to view the energy output of the blasting machine under test. The ET175-10 Energy Tester has a self test function, and contains internal load resistance. The tester turns on automatically when the blasting machine is fired and turns off automatically after approximately thirty seconds. The ET175-10 Energy Tester requires an ET15-2 Connecting Cable, which is included with the energy tester.

IMPORTANT: The ET175-10 Energy Tester is not intended to be a precise instrument such as would be used for laboratory measurements of output energy from sequential CD blasting machines. It is intended to be used in the field before and after each blast (1) to compare the output of a sequential CD blasting machine with initial measurements made by a ET175-10 Energy Tester when the true output of the sequential CD blasting machine was known, and (2) to check a sequential CD blasting machine which may be suspected of having poor or weak capacitors, low voltage (batteries etc.) or some other malfunction when there have been no prior measurements made with the ET175-10 Energy Tester on that particular blasting machine. If any questions arise as to the output of a CD blasting machine, please consult with the manufacturer before shipping the machine back for laboratory tests.

Note: For safety considerations and performance verification, REO recommends that the energy output of every blasting machine be tested before and after each use. The data obtained should be recorded in a log and kept for future reference.

ACCESSORIES

The EC15-2 Connecting Cable is available to connect the ET175-10 Energy Tester to the BM175-10 series Blasting Machine.

OPERATION

Note: The following procedure is intended as a guide only, and each user must prepare and verify his own procedure consistent with Local, State, and Federal regulations. Complete Operating Instructions appear in the lid of the ET175-10 Energy Tester.

CAUTION - USE OF THIS EQUIPMENT REQUIRES THAT THE OPERATOR HAS BEEN TRAINED AND CERTIFIED IN BLASTING TECHNIQUES.

WARNING: BATTERIES ALONE CAN FIRE ELECTRIC DETONATORS. KEEP BATTERIES AWAY FROM THE BLASTING CIRCUITS.

Operational Test

1. Depress the TEST switch and hold it down. Rotate the CIRCUIT switch through

all ten positions while observing the BAT. OK and CAL. OK LED bars. Both LED bars should be lit and remain illuminated for all ten circuits indicating that the battery is OK and that the tester is in calibration. The battery should be replaced if one or both LED bars do not light, or if the intensity of the LED bars decreases during the self test.

2. Release the TEST switch.

General Operating Procedure

1. Connect the tester to the BM175-10 series Blasting Machine using an EC15-2 (formerly CS10) Connecting Cable, or no longer than a ten foot Extension Cable.

2. If the ET175-10 Energy Tester has just been used, wait until the FIRED light goes off.

3. Charge and fire the BM175-10 series Blasting Machine into the ET175-10 Energy Tester. The tester will turn on automatically and the FIRED light will come on if energy is present on any circuit.

4. The bar graph will indicate the percentage OF RATED ENERGY output from the blasting machine for the circuit indicated on the CIRCUIT switch. Rotate the CIRCUIT switch to the other circuits, noting the energy indicated on the bar graph for each circuit.

   IMPORTANT: RECORD THE DATA IN A LOG BOOK FOR ANALYSIS AND FUTURE REFERENCE.

   Note: The tester will remain on for approximately 25 seconds after the FIRED light comes on. The energy measured on each circuit is stored and may be selected to be displayed on the bar graph as long as the FIRED light is on. All data is lost after the FIRED light goes off.

   WARNING: DO NOT USE THE BLASTING MACHINE IF THE ENERGY OUTPUT OF ANY CIRCUIT IS LESS THAN 100 PERCENT.

5. The tester turns off automatically after use.

BATTERIES

Battery Life

Under normal use, Alkaline type batteries will last more than 200 blasting machine tests. Battery replacement is required when the BAT. OK or CAL. OK LED bar does not illuminate, or decreases in intensity, during self test of the ET175-10 Energy Tester.

Battery Type and Replacement

The ET175-10 Energy Tester uses two 9 volt Alkaline batteries, Eveready 522 or equal, available in most department stores, drug stores and electronic supply stores.

To replace the batteries, loosen the two captive screws on the battery cover on

the panel of the tester. Remove the battery cover. Remove the old batteries and insert the new alkaline batteries, observing polarity. After battery replacement, make sure that the gasket on the battery cover is sealing properly and that the two captive screws are securely tightened.

WARNING: USE ONLY ALKALINE TYPE BATTERIES. Do not use carbon-zinc or any other type batteries as they do not have the capacity to operate the ET175-10 Energy Tester.

CAUTION: OBSERVE POLARITY WHEN REPLACING THE BATTERIES. INCORRECT POLARITY WILL DAMAGE THE BLASTING MACHINE.

CAUTION: EXAMINE BATTERIES AT LEAST EVERY 3 MONTHS FOR CHEMICAL LEAKAGE. REPLACE BATTERIES AT LEAST YEARLY EVEN IF NOT EXHAUSTED. REMOVE BATTERIES FROM THE ENERGY TESTER IF IT IS NOT GOING TO BE USED FOR TWO OR MORE MONTHS.

APPENDIX B

BO1999-10 BLASTER'S OHMMETER

GENERAL INFORMATION

The REO BO1999-10 Blaster's Ohmmeter provides nominal values of circuit resistance on a large easy-to-read digital display. A rotary switch selects one of ten sequential blasting cable circuits, or selects the two terminals on the ohmmeter for single circuit testing. The BO1999-10 Blaster's Ohmmeter measures resistance of 0 - 1999 ohms in one ohm increments, with an accuracy of +1 ohm. The maximum test current is 2 milliamperes. The ohmmeter turns on automatically when a circuit is detected, and turns off automatically when the circuit is disconnected.

OPERATION

Operational Test

1. Do not connect a sequential blasting cable to the BO1999-10 Blaster's Ohmmeter until this Operational Test has been performed.

2. Short the SINGLE CIRCUIT terminals on the ohmmeter with a short piece of wire.

3. Rotate the CIRCUIT switch to the SINGLE position. The ohmmeter should turn on and indicate 000 (+/- 1) ohm.

4. If the battery is in need of replacement, BAT appears on the display.

5. Rotate the CIRCUIT switch to positions 1 - 10. The ohmmeter should turn off and remain off for all positions.

General Operating Procedure

Note: The following procedure is intended as a guide only, and each user must prepare and verify his own procedure consistent with Local, State, and Federal regulations. Complete Operating Instructions appear in the lid of the BO1999-10 Blaster's Ohmmeter.

CAUTION - USE OF THIS EQUIPMENT REQUIRES THAT THE OPERATOR HAS BEEN TRAINED AND CERTIFIED IN BLASTING TECHNIQUES.

WARNING: BATTERIES ALONE CAN FIRE ELECTRIC DETONATORS. KEEP BATTERIES AWAY FROM THE BLASTING CIRCUITS.

WARNING: KEEP THE BLASTING CIRCUITS (SEQUENTIAL BLASTING CABLE AND SINGLE CIRCUITS) SHUNTED WHEN NOT CONNECTED TO THE OHMMETER. MINIMIZE THE TIME THE BLASTING CIRCUITS ARE CONNECTED TO THE OHMMETER BY TAKING

RESISTANCE VALUES QUICKLY. RECORD THE DATA IN A LOG BOOK FOR ANALYSIS AND FUTURE REFERENCE.

Sequential Circuit Testing

1. Perform the Operational Test.

2. Verify that all personnel have been removed from the blast area and that the electric detonator circuits are ready to be checked.

3. Connect the sequential blasting cable to the CABLE 1-10 connector on the BO1999-10 Blaster's Ohmmeter.

4. Rotate the CIRCUIT switch to positions 1 through 10, noting the resistance displayed for each circuit.

   Note: 1--- will be displayed if the resistance exceeds 1999 ohms.

5. Disconnect and shunt the sequential blasting cable after testing.

Single Circuit Testing

1. Perform the Operational Test.

2. Connect the blasting circuit to the SINGLE CIRCUIT terminals on the BO1999-10 Blaster's Ohmmeter.

3. Rotate the CIRCUIT switch to the SINGLE position. Note the resistance displayed.

   Note: 1--- will be displayed if the resistance exceeds 1999 ohms.

4. Shunt the blasting circuits after testing.

BATTERY

Battery Life

Under normal use, an Alkaline type battery will last more than 2000 hours of operation. During use of the ohmmeter, BAT will appear on the display when the battery is in need of replacement.

Battery Type and Replacement

The BO1999-10 Blaster's Ohmmeter uses one 9 volt Alkaline battery, Eveready 522 or equal, available in most department stores, drug stores, and electronic supply stores.

To replace the battery, loosen the two captive screws on the battery cover on the top panel of the tester. Remove the battery cover. Remove the old battery and insert the new alkaline battery, observing polarity. After battery replacement, make sure that the gasket on the battery cover is sealing properly and that the two captive screws are securely tightened.

WARNING: USE ONLY AN ALKALINE TYPE BATTERY. Do not use a carbon-zinc type battery as it does not have the capacity to operate the BO1999-10 Blaster's Ohmmeter.

CAUTION: OBSERVE POLARITY WHEN REPLACING THE BATTERY. INCORRECT POLARITY WILL DAMAGE THE BLASTING MACHINE.

CAUTION: EXAMINE BATTERY AT LEAST EVERY 3 MONTHS FOR CHEMICAL LEAKAGE. REPLACE THE BATTERY AT LEAST YEARLY EVEN IF NOT EXHAUSTED. REMOVE THE BATTERY FROM THE BLASTER'S OHMMETER IF IT IS NOT GOING TO BE USED FOR TWO OR MORE MONTHS.

APPENDIX C

BMS-10 BLASTER'S MULTIMETER SWITCH

GENERAL INFORMATION

The Research Energy of Ohio, Inc. (REO) model BMS-10 Blaster's Multimeter Switch is to aid in checking for errors and broken wires in multiple blast circuits.

The BMS-10 Blaster's Multimeter Switch provides easy connection of a BO1999-1 Blaster's Ohmmeter or an approved Blaster's Multimeter or a Blasting Galvanometer to the electric detonator circuits for measurement of electric detonator circuit resistance.

The electric detonator circuit to be tested is selected by the CAP CIRCUIT rotary switch on the BMS-10 Blaster's Multimeter Switch.

The blasting cable is inserted into the connector at the bottom of the BMS-10 Blaster's Multimeter Switch after the shot is wired, but prior to using the Blasting Machines. Select the electric detonator circuit to be tested with the CAP CIRCUIT rotary switch. The resistance of the electric detonator circuit is measured using an approved Blasting Galvanometer or Blaster's Multimeter connected to the two multimeter terminals (jacks) located at the top end of the BMS-10 enclosure.

WARNING: ALL DETONATOR CIRCUITS ARE OPEN (NOT SHUNTED) WHEN THE BLASTING CABLE IS CONNECTED TO THE BMS-10 BLASTER'S MULTIMETER SWITCH.

WARNING: THE BLASTING CABLE IS TO BE CONNECTED TO THE BMS-10 BLASTER'S MULTIMETER SWITCH ONLY WHEN TESTING THE ELECTRIC DETONATOR CIRCUITS. WHEN TESTING IS COMPLETE, DISCONNECT THE CABLE FROM THE BMS-10 BLASTER'S MULTIMETER SWITCH AND RECONNECT IT TO THE SHUNTED SOCKET ON THE CABLE REEL.

OPERATION

Operational Test

1. Insert any REO Load Plug into the socket marked BLASTING CABLE located at the bottom of the BMS-10 Blaster's Multimeter Switch.

2. Connect an approved Blaster's Multimeter or Blasting Galvanometer to the meter terminals located at the top end of the BMS-10 Blaster's Multimeter Switch.

3. Rotate the CAP CIRCUIT switch to each circuit while observing the Blaster's Multimeter or Blasting Galvanometer for each circuit. These instruments will measure the nominal resistance in each of the ten circuits. The following are the nominal resistance for the REO Load Plugs.

AD3 ..... 68 ohms

AD4 ..... 110 ohms

AD5 ..... 160 ohms

AD6 ..... 220 ohms

If a circuit tests faulty, rightist, using a different load plug as the fault may be in the load plug and not in the tester.

4. Upon completion of the operational test, remove the REO load plug.

General Operating Procedure

Note: The following procedure is intended as a guide only, and each user must prepare and verify his own procedure consistent with Local, State and/or Federal safety laws, rules and regulations.

1. Verify that all personnel have been removed from the blast area and that the electric detonator circuits are ready to be checked.

2. Remove the blasting cable plug from the shunted socket on the cable reel and insert it into the socket marked BLASTING CABLE located at the lower end on the BMS-10 Blaster's Multimeter Switch enclosure.

3. Connect a BO1999-1 Blaster's Ohmmeter or an approved blaster's multimeter or blasting galvanometer to the BLASTER'S MULTIMETER terminals located at the end of the BMS-10 Blaster's Multimeter Switch enclosure.

   WARNING: USE ONLY METERS APPROVED FOR BLASTING TO MEASURE ELECTRIC DETONATOR CIRCUIT RESISTANCE. DO NOT USE REGULAR MULTIMETERS.

4. Rotate the CAP CIRCUIT switch through each of its 10 positions while observing the ohmmeter for the resistance of each of the 10 circuits.

   The detonator circuit resistance (consisting of electric detonator resistance plus the blasting cable resistance) should be as follows for the REO Blasting Machines.

   BM75 ..... 75 ohms or less

   BM125 ..... 125 ohms or less

   BM175 ..... 175 ohms or less

   BM225 ..... 225 ohms or less

   Note: If the calculated resistance does not match the measured resistance, a short circuit, broken detonator wire, defective cable, or a wiring error exists.

5. Upon completion of testing rotate the CAP CIRCUIT switch to OFF. Remove the blasting cable from the BMS-10 Blaster's Multimeter Switch socket and insert it into the SHUNTED socket on the cable reel.

APPENDIX D

EXTENSION CABLE AND TERMINAL BOARD

GENERAL DESCRIPTION

The extension cable and terminal board are the fragile parts of the system, and are considered expendable. The life expectancy is dependent on the conditions to which they are subjected and subsequent care. It is vital that the extension cable and terminal board be inspected and maintained after each blast.

The multi conductor cable used to make an extension cables consist of twelve #22 gauge tinned copper stranded wire color coded conductors. The outer jacket of the cable is yellow PVC. Should the cable be damaged or severed and a field repair is necessary, it may be spliced (solder joint preferred but a mechanical crimp joint acceptable) and taped, matching color to color and adhering to standard electrical repair procedures.

The multi conductor cable used is designed to provide 10 separate circuits of 1 conductor each and 2 common grounds (returns) for all 10 circuits. The color code of the circuits is as follows:

Circuit #	Wire Color
1	Red
2	White
3	Blue
4	Pink
5	Gray
6	Green
7	Orange
8	Yellow
9	Black
10	Purple
Ground	Light Brown and Dark Brown (Two wires connected together)

The TB15 Terminal Board and EC15-500 or EC15CW-500 Extension Cable allow for easy connection of the electric detonators and hookup wires to the blasting machine output circuits and to remove the blaster and blasting machine to a safe distance from the blast area. The TB15 Terminal Board consist of 20 binding posts (two for each circuit) and a socket. The AD5 Load or Test Plug inserted into this socket provides the shunting requirement during connection of the electric detonators to the terminal board. For safety, the terminal board must always be used with an extension cable. The EC15-500 and EC15CW-500 Extension Cables are 500 feet long (other lengths are available) and each has plugs on both ends. The EC15 cable has PVC insulation. The EC15CW cable has thermoplastic rubber insulation for cold weather applications. One end of the extension cable plugs into the socket on the TB15 Terminal Board and the other end plugs into the cable socket on the blasting machine. The EC15-500 and EC15CW-500 Extension Cables can only be used with the TB15 Terminal Board. However, an EC1O-500 Extension Cable and a CS1O Cord Set may be used in place of an EC15-500 Extension Cable.

CABLE CHARACTERISTICS

The EC1O-500, EC10CW-500, EC15-500 and EC15CW-500 Extension Cables all have the

same circuit resistance of a nominal 12 ohms, but may vary slightly (+/- 1 ohm) due to wire alloys, exact gauge, and meter accuracy.

The two ground conductors in the extension cable are connected at the plug and at the socket of the extension cable.

CONDITIONS WHICH CAUSE CABLE FAILURE

1. If the cable or terminal board is pulled or jerked by the blast, they may weaken and break or become intermittent. Also, this occurrence may disconnect the leading wires to the electric detonators. To prevent this, allow enough hookup wire or leg wire to wrap around a small 10 to 15 pound rock. The rock will be jerked instead of the cable or terminal board. See APPENDIX F for methods of preventing lead line breakage and equipment damage.

2. Reeling or pulling the cable through loose rocks or soil can also the cable. Care must be taken to prevent the cable and the connectors from catching in rock piles or crevices.

   WARNING: IF UNCERTAIN RESISTANCE EXIST AND ARE NOT CORRECTED, A MISFIRE MAY OCCUR.

EXAMPLE OF FIELD CHECK PROCEDURE

Note: The following example is provided as a training exercise and a method by which to approach blasting in a professional manner. The resistance values shown are approximate. Also, expect multimeters and galvanometers to differ. Check the manufacturers' specifications regarding the accuracy of the instruments. Each user must prepare and verify his own procedure consistent with Local, State, and Federal regulations.

Example:

1. Assume that each of the 10 blasting circuits is to have 10 electric detonators with 80 ft. leg wires and that each electric detonator has a resistance of 3 ohms.

2. Assume that extra hookup wire per circuit (to connect the electric detonator leg wires to the terminal board) is 2 ohms.

3. Before connecting the electric detonator wires to the terminal board, measure the total circuit using a BO1999-1 Blaster's Ohmmeter, a BO1999-10 Blaster's Ohmmeter or an approved blasting galvanometer.

   WARNING: USE ONLY METERS APPROVED FOR BLASTING TO MEASURE ELECTRIC DETONATOR CIRCUIT RESISTANCE. DO NOT USE REGULAR MULTIMETERS.

   A. The resistance of the electric detonator circuit should be 10 x 3 + 2 = 32 ohms.

   B. If the resistance measured in each of the 10 circuits is not equal and/or is not near 32 ohms, check the circuit(s) in question for shorted electric detonator wires, wiring errors (such as a mismatch of wires at a multi deck type shot) or lead wires touching at the

splices.

WARNING: IF UNCERTAIN RESISTANCE EXIST AND ARE NOT CORRECTED, A MISFIRE MAY OCCUR.

4. After verifying the resistance of each circuit, connect the electric detonator wires to the terminal board.

   CAUTION: EACH CIRCUIT MUST HAVE ITS OWN RETURN WIRE CONNECTED TO THE BLACK TERMINAL OF THE TERMINAL BOARD. The use of a single electrical return wire is contrary to accepted methods and may cause a misfire or excessive bench movement thus breaking hookup wires and interrupting the sequence prematurely.

   WARNING: DO NOT CONNECT A CIRCUIT BETWEEN TWO RED OR BETWEEN TWO BLACK TERMINALS. Visually check that each circuit is connected between a pair of RED and BLACK terminals on the terminal board.

5. Use a BO1999-10 Blaster's Ohmmeter (see APPENDIX B) or a BMS-10 Blaster's Multimeter Switch and a BO1999-1 Blaster's Ohmmeter, a blaster's multimeter or a blasters galvanometer (see APPENDIX C) to measure the resistance of each of the 10 circuits.

   A. The resistance of each circuit should be:

10 electric detonators @ 3 ohms each	30 ohms
Hookup wire	2 ohms
Cable resistance	12 ohms
Terminal board resistance	0 ohms
	44 ohms

   B. Observe the same actions and warnings stated on previous page.

CHECKOUT AND REPAIR

Note: The following procedure is intended as a guide for field checkout of cables and terminal boards using accessories normally purchased with the blasting machine. Actual circuit resistance may be determined using a BO1999-10 Blaster's Ohmmeter or a BMS-10 Blaster's Multimeter Switch and a BO1999-1 Blaster's Ohmmeter or blaster's multimeter (USE ONLY APPROVED MULTIMETERS IN AND NEAR BLAST AREAS) connected to the BMS-10 Blaster's Multimeter Switch (See APPENDIX C). When the cable and terminal board are new and occasionally thereafter, each operator should check the equipment to determine the actual circuit resistance and to observe changes that indicate the need for repair.

Extension Cable Checkout

1. Unwind the cable and inspect it for visual damage. Look particularly for cuts, tears, kinks, punctures, smashed areas, severed wires and improvised splices have all damaged areas properly repaired.

2. Check all connectors carefully. All pieces must lock tight to each other. If any part can be turned loose from its mating part by hand, the connector should be replaced.

3. Connect one end of the Extension Cable to be tested to a BO1999-10 Blaster's

Ohmmeter (See APPENDIX B) or to a BMS-10 Blaster's Multimeter Switch (See APPENDIX C).

4. Connect the other end of the Extension Cable to a TB15 Terminal Board that has been tested and found to be in good working order.

5. Connect a jumper wire of 22 gauge or heavier across the circuit #1 terminals only on the terminal board, leaving all other pairs of terminals open.

6. Rotate the CIRCUIT switch on the BO1999-10 Blaster's Ohmmeter or the CAP CIRCUIT switch on the BMS-10 Blasters Multimeter Switch to #1.

7. Observe the resistance indicated on the ohmmeter.

   A. The resistance should be 12 (+/- 1) ohm for a 500 ft. cable.

   B. Continue observing the ohmmeter and flex the cable where it comes out of the connector in both vertical and horizontal directions. A flicker or change in the resistance indicates a broken or shorted circuit.

   C. Continue observing the ohmmeter and flex the cable along the entire length. A flicker or change in the resistance indicates a broken or shorted circuit.

8. Rotate the CIRCUIT switch to the next circuit.

   A. The ohmmeter should indicate infinite resistance (open circuit).

   B. Continue observing the ohmmeter and flex the cable where it comes out of the connector in both vertical and horizontal directions. A flicker or change in the resistance indicates a shorted circuit.

   C. Continue observing the ohmmeter and flex the cable along the entire length. A flicker or change in the resistance indicates a shorted circuit.

9. Rotate the CIRCUIT switch to the next detonator circuit and repeat step 8 above until all detonator circuit positions have been tested. If the ohmmeter indicates any resistance in any position other than the circuit that is jumpered on the Terminal Board, the circuit(s) is shorted.

   Important: The ohmmeter may momentarily indicate a resistance when the CAP CIRCUIT switch is rotated. This is normal, and does not indicate a shorted circuit.

10. Rotate the CIRCUIT switch to the #2 position.

11. Remove the jumper wire from the terminals on the terminal board and connect it to the next higher circuit terminals only leaving all other pairs of terminals open.

12. Repeat Steps 5 through 11 until all circuits are tested.

Terminal Board Checkout

Terminal Boards are tested in the same manner as described above and are also plugged directly into the BO1999-10 Blaster's Ohmmeter or into the BMS-10 Blaster's Multimeter Switch. Check the boards for cracks and breaks and for loose, broken and bent binding posts. Repair all damage.

Repair of Cables and Terminal Boards

Repair of cables and terminal boards is best performed at the factory. Temporary field repairs are, of course, necessary but these should always be permanently repaired as soon as possible by competent electricians or at the factory.

The correct way to splice the #22 gauge wire is to stagger the splices over approximately a 3" length of cable. The splice on each conductor should be 1/2" to 5/8" long and of the "lineman" type and be tightly wrapped with no wire ends protruding to pierce the insulation. Each splice should be soldered using rosin core "radio" solder. Each splice should be insulated using 1/8" diameter shrink tubing. The entire spliced area should then be taped with several overlapping layers using a good quality all weather vinyl tape such as Scotch brand #88.

WARNING: DO NOT OVERHEAT THE CONDUCTORS DURING SOLDERING. Use only a low wattage (60 watts or less) soldering iron with a 1/8" maximum tip size. Overheating the conductors causes the solder to "wick" along the length of the stranded wire which makes the conductor rigid and much more easily broken when flexed. Also, overheating causes the vinyl insulation to melt thus exposing the wires.

WARNING: DO NOT OVERHEAT THE CONDUCTORS OR INSULATION DURING SHRINKING OF THE SHRINK TUBING. DO NOT USE OPEN FLAMES FROM A MATCH OR GAS BURNER. Use a low temperature heat gun.

For repair, return the item to the factory at:

Research Energy of Ohio, Inc.
200 East Bluegrass Drive
Norwalk, Ohio 44857

Phone:419-660-8832 Fax:419-660-8833
E-mail: repair@researchenergy.com
Web: researchenergy.com

APPENDIX E

FIELD CHECK FOR PROPER SEQUENCING, TIMING AND RELATIVE ENERGY OUTPUT OF SEQUENTIAL BLASTING MACHINES

The following test may be performed to verify that the blasting machine is sequencing properly and to provide a reasonable indication of the relative energy output of the blasting machine circuits.

Note: The ET175-10 Energy Tester (see APPENDIX A) is available and designed to measure the energy output (in percent of rated energy) of the BM175-10PT series blasting machine. However if the energy tester is not available, the following procedure provides a reasonable idea of the relative energy output (i.e., relative output between circuits of the same machine) of the blasting machine.

CAUTION: This test is not to replace actual energy output and timing measurements, which must be performed from time to time by more sophisticated equipment. Multimeters, voltmeters and other field instruments cannot respond accurately to the relatively short duration output pulse of the blasting machine and therefore cannot be used to determine if the output is normal.

1. Set all delay periods (timing between each CAP CIRCUIT) to 500 milliseconds.

2. Connect a 75 watt 120 volt standard incandescent lamp (use 10 lamps from the same manufacturer and of the same lot, if possible, to nullify variations between lamps) to each set of terminals on a TB15 Terminal Board. Use "pigtail" type sockets for easy connection to the terminal board.

3. Use an EC15-2 Extension Cable to connect the TB15 Terminal Board to the BLASTING CABLE socket on the blasting machine. (See item 5 below for using a longer extension cable.)

4. Charge and fire the blasting machine. Observe the lamps and note the sequence and the relative brightness of each compared to the others. One or more lamps significantly dimmer may indicate low energy output of that circuit. One or more lamps lighting out of sequence indicates a defective machine or terminal board.

5. Charge and fire the blasting machine again. Use a stop watch to measure the time between CAP CIRCUIT 1 and CAP CIRCUIT 10 lamp illumination. Divide the time measured by 9. The result should be 0.5 second.

   CAUTION: This test only estimates the timing accuracy of the blasting machine because the method (using a stop watch) is limited in accuracy. However, it will indicate if a major timing error exists.

6. The above procedure may be performed with the terminal board connected to an extension cable and the extension cable connected to the blasting machine. The lamps will be dimmer because of the extension cable resistance, but the test is still valid. One or more lamps lighting out of sequence indicates a defective cable and/or terminal board if the blasting machine checked OK.

7. To check if the blasting machine shuts down on an open circuit, remove the lamp in that circuit and repeat the above test. The CAP CIRCUIT indicator on the blasting machine corresponding to the open circuit and all indicators after the open circuit should be unlit. Also, all incandescent lamps after the open circuit should have remained unlit during sequencing of the blasting machine.

APPENDIX F

MISFIRES

IF A MISFIRE OCCURS

If a misfire occurs for any reason, determine which holes are live and/or safe to fire. Also determine if insufficient burden, stemming or back break is observed, and the desirability of firing these holes.

WARNING: REVIEW FEDERAL, STATE, LOCAL, AND COMPANY REGULATIONS AND PROCEDURES IF A MISFIRE OCCURS.

SOME CAUSES OF MISFIRES

1. Open or overloaded circuits (too many electric detonators) will cause misfires. Note that sequencing will stop at the detonator circuit which is open or severely overloaded.

2. Improper millisecond selection (timing) on the blasting machine can cause misfires. The combination of very close hole spacing and slow milliseconds selections (long shot duration times) usually cause cutoffs and misfires.

3. Deviation from a good program such as substituting detonator times and skipping time periods can cause cutoffs and misfires.

4. Wet hole conditions, especially where deck charges are required, may cause misfires.
5. Water seeping into the holes may cause nitrate prills to melt, in turn allowing stemming to sink thus breaking the detonator leg wire.

6. Leaking bags may also allow stemming to settle thus breaking the detonator leg wire.

7. Floating bags of explosives must be prevented so that the stemming can settle without breaking the detonator leg wires.

8. Tamping pole use must be exercised with caution to prevent skinning or breaking the detonator leg wires and/or damage to the detonator.

9. Failure to test the blasting machine, cable and terminal board before a shot to determine if the equipment is functioning properly.

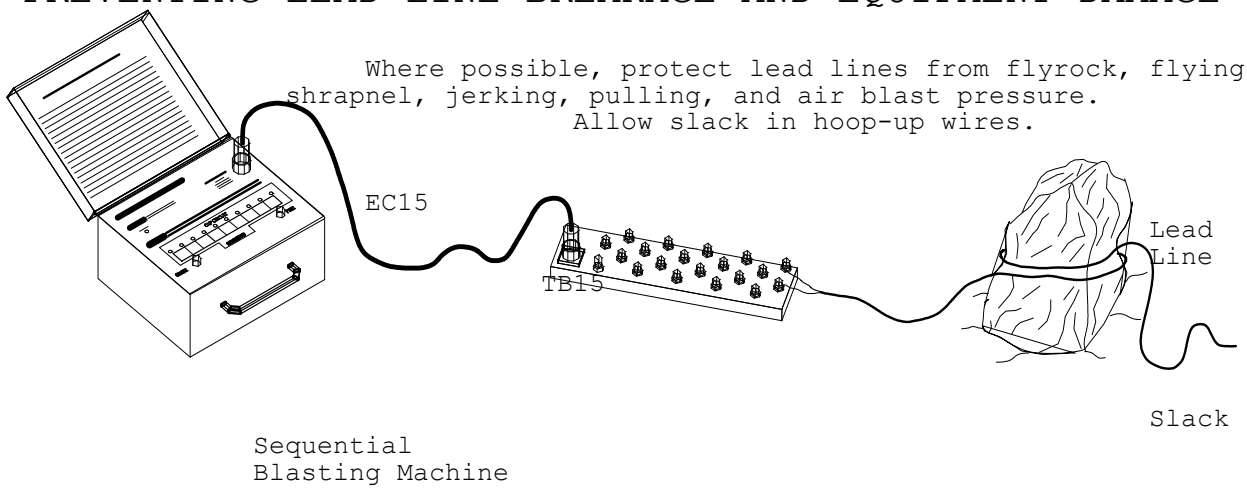
10. Failure to test the electric detonator circuits before and after connecting them to the terminal board, or failure to test the entire wiring including the sequential cable may result in a misfire.

11. Poor wiring practices, failure to double check the electrical connections and the wiring, and poor supervision may allow undetected circuit errors, thus causing misfires.

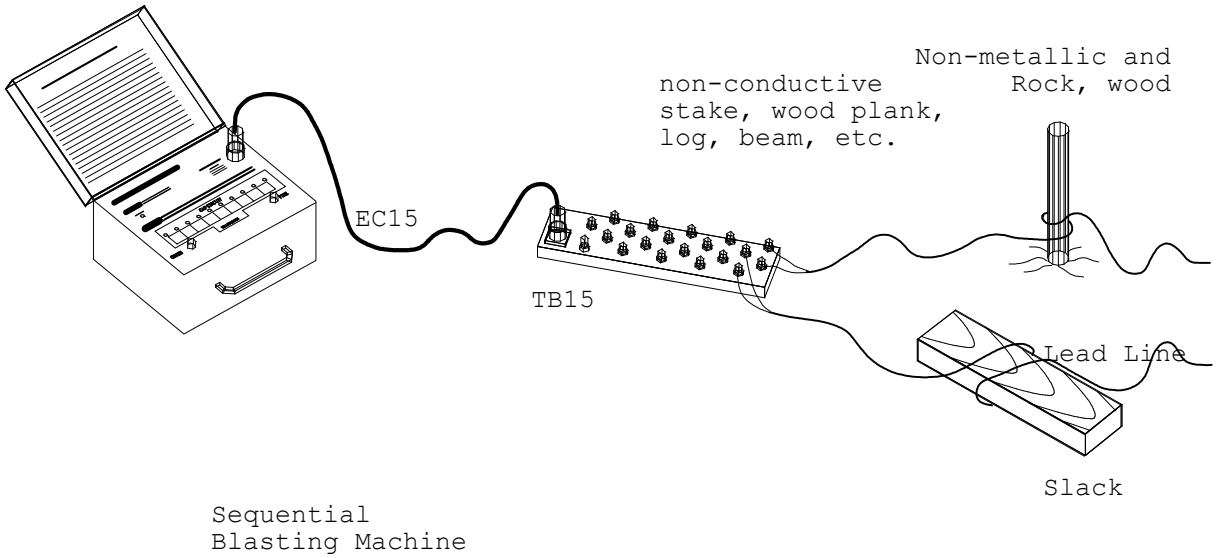
12. Connections that lay in water (including connections to the terminal board), or skinned insulation on the electric detonator leads can shunt electrical current thus causing insufficient electric detonator current and a misfire.

13. Tight hookup wires from hole to hole may cause misfires. During the blast, when the earth begins to shift, the wires of the de-energized circuits on top of the ground must have enough slack to allow for bench movement. Rock faults, block, or shifting types of sand rock may move on the slower shot sequences. The sketch below illustrates several methods of preventing lead line breakage and equipment damage.

PREVENTING LEAD LINE BREAKAGE AND EQUIPMENT DAMAGE



Wrap Lead Lines around rocks, stakes, beams or <u>any</u> <u>non-metallic,</u> <u>non-conductive</u> structure that is well secured or is of sufficient weight to allow the Lead Line to the explosive site to break in the event of a jerk or pull.



Lead Line slack: In single circuit firing, most blasters are trained to lay out a nice, neat, tight line to the blast site. Where multiple blast circuits are used, the timing of detonations has the tendency to pull these wires apart due to slower sequencing of the timed circuits. Therefore, Lead Lines need feed-out loops or built-in slack This is also a requirement for close hole-to-hole or

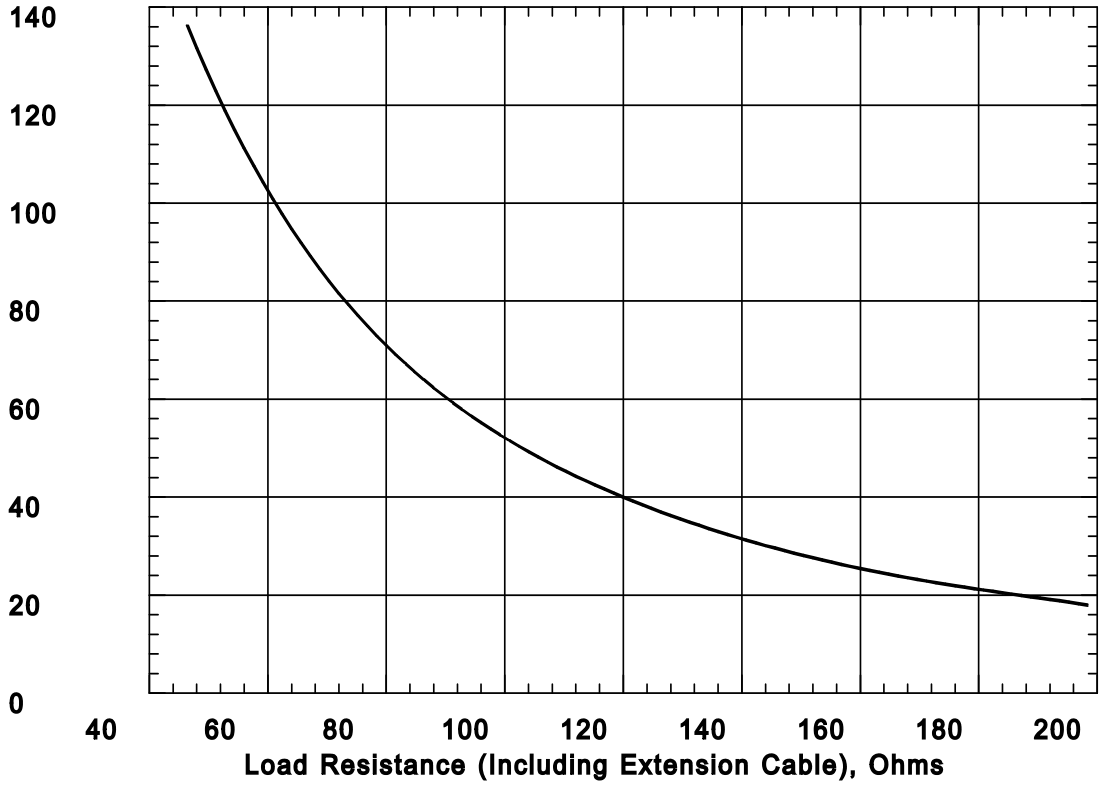
detonator-to-detonator placement. These suggestions prevent Lead Line cut-off and pulling or jerking of the TB15 Terminal Board and blasting equipment.

APPENDIX G

ENERGY AND RMS CURRENT FOR VARIOUS LOAD RESISTANCE

The capacity of each REO Blasting Machine listed in the literature and on the technical data sheets is based on U.S. standard detonator (cap) rating of 20 millijoules per ohm delivered in 5 milliseconds. Based on the U.S. standard detonator, the maximum load resistance per circuit for the REO BM175-10 Series Sequential Blasting Machine is 175 ohms, including the extension cable and all detonator lead wires.

The energy delivered to each detonator in a single series circuit varies with the voltage output of the blasting machine and with the resistance of the blasting circuit. The relationships between the series circuit resistance, the energy delivered to the detonator and the RMS (equivalent constant DC) current for a single series circuit are shown in the following two graphs. These graphs are useful in choosing a circuit resistance which provides the desired energy and RMS current to the detonators in that circuit. Always obtain electric detonator firing recommendations from the detonator manufacturer.



SERIES CIRCUIT, ENERGY DELIVERED IN 5 MILLISECONDS
Energy, Millijoules Per Ohm

BM175-10 SERIES SEQUENTIAL BLASTING MACHINE