A Learning Guide for

MODEL ROCKET LAUNCH SYSTEMS

by Robert L. Cannon

Including Schematics, Electrical Theory and Study Problems

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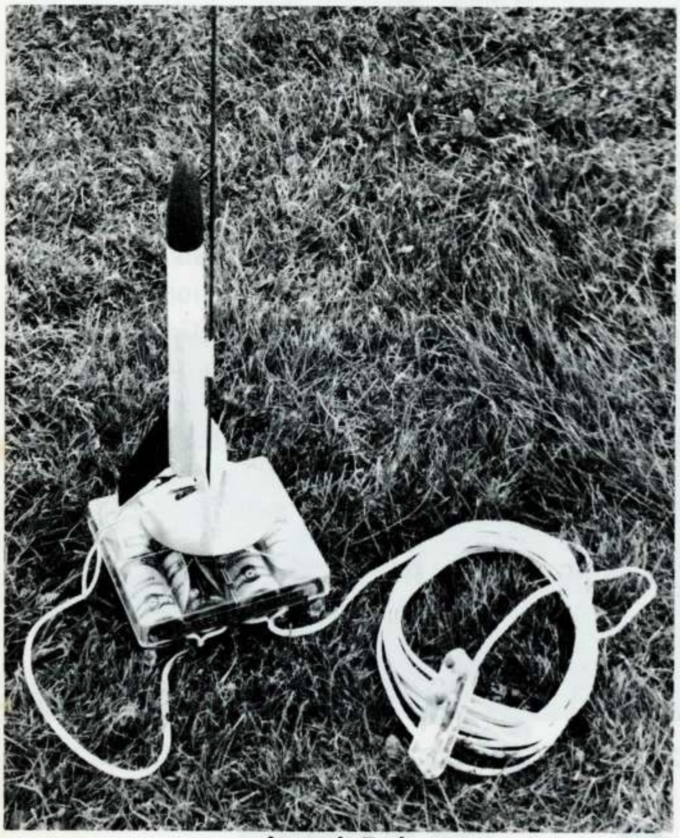
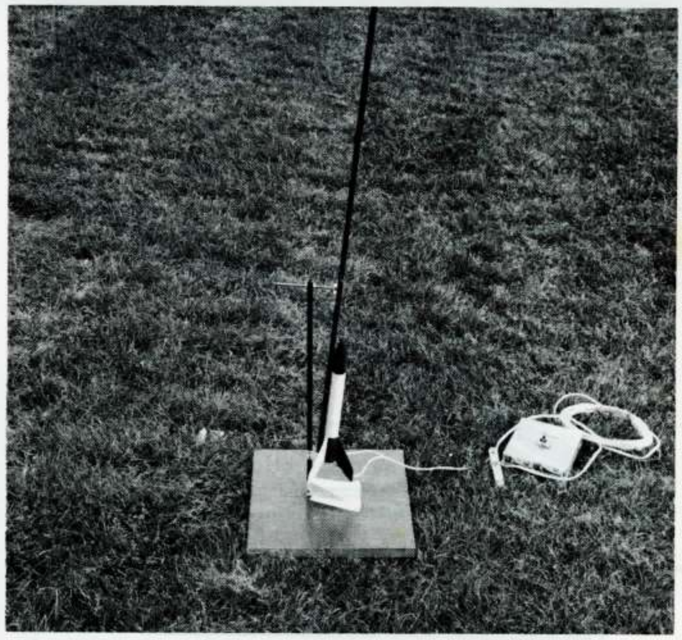
Model Rocket Launch Systems

A launching system for model rockets must perform two different jobs. The first job is to hold the rocket before and during launch. The second job is to ignite the rocket's engine.



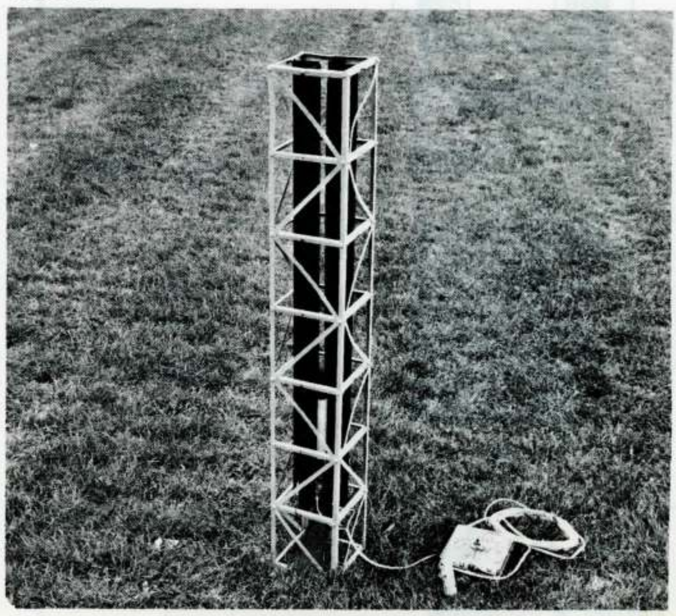
Launch Rod

The Electro-Launch, a complete launch system, uses a metal rod to perform the function of guiding the model rocket at launch. A small tube (launch lug) on the model fits over the rod keeping the rocket straight on the rod. By the time the model rocket's launch lug leaves the launch rod the rocket is going fast enough for its fins to provide adequate guidance to keep it moving in the desired direction.



Launch Rail

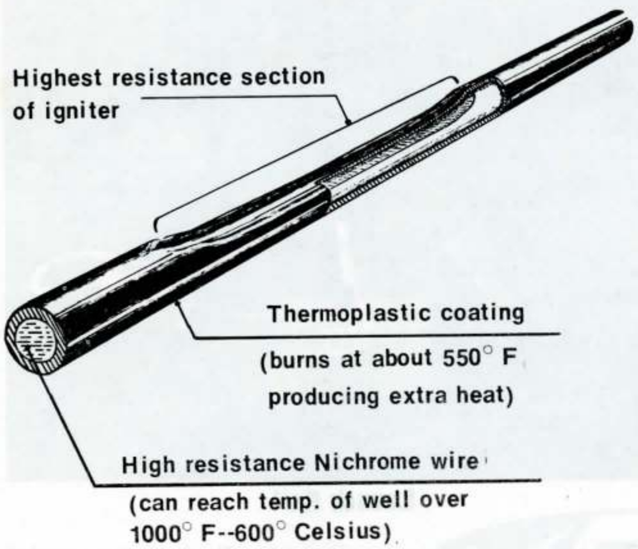
To have a safe, predictable flight, the model rocket must be held in position before launch and guided during the first fraction of a second of flight until it is going fast enough for its fins to keep it flying in the proper direction. The device performing this function should be designed to aim the rocket straight up. It may be made adjustable so that the model can be "aimed" either vertically or within 25° to any side of vertical to correct for wind conditions.



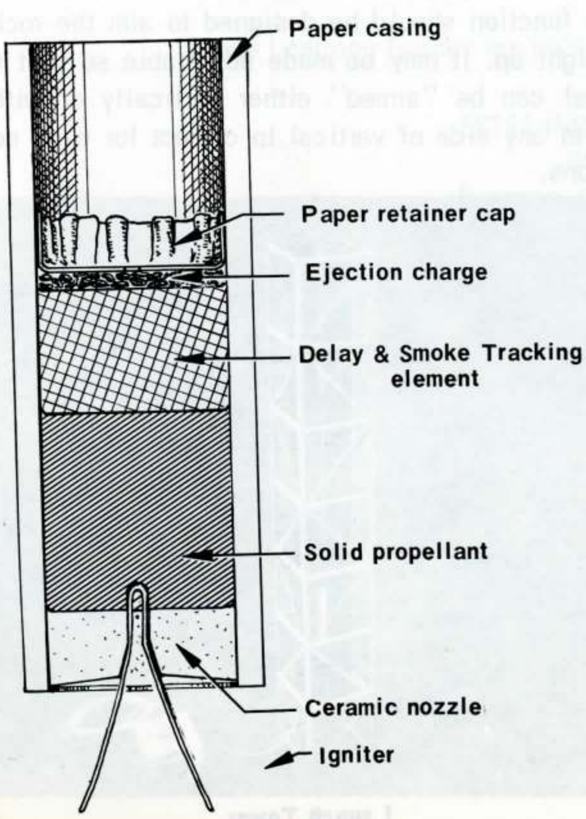
Launch Tower

The second function a launch system must perform is to provide adequate electrical current to cause engine ignition. The electrical current accomplishes engine ignition by heating the igniter which produces enough heat to cause the solid propellant to ignite.

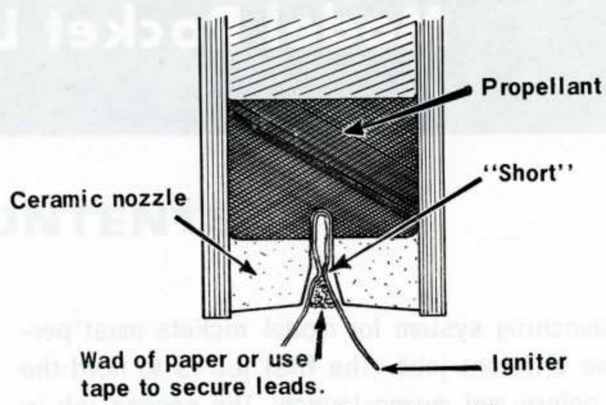
IGNITER



MODEL ROCKET ENGINE



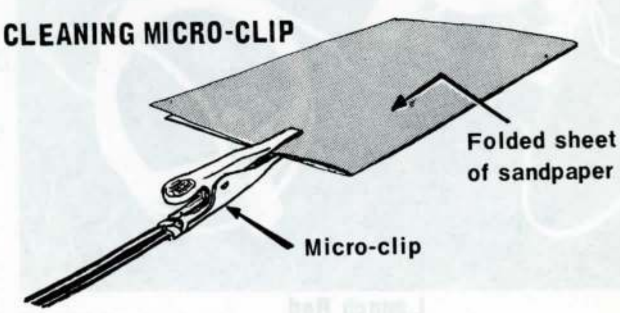
WITH UNCOATED NICHROME



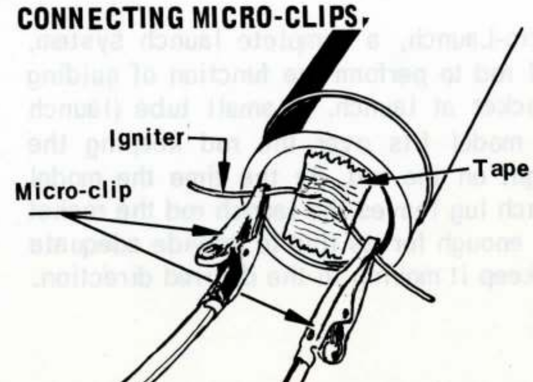
Electrical "short" with uncoated nichrome. (Electricity will not flow to tip of igniter bend, so propellant will not receive enough heat to cause ignition.)

The electrical current delivered by the Electro-Launch is adequate to heat the igniter, which causes the propellant to ignite. The thermoplastic coating on the center of the igniter helps protect against the igniter "shorting out" against itself resulting in inadequate heat reaching the propellant to produce ignition. The coating on the igniter also burns when the igniter is heated, producing additional heat for rapid engine ignition. Loose connections will not properly conduct the full electrical current required. The micro-clips which attach to the igniter provide good connections to securely hold the igniter and provide a good path for the electrical current. Micro-clips should be cleaned before each flight.

CLEANING MICRO-CLIP

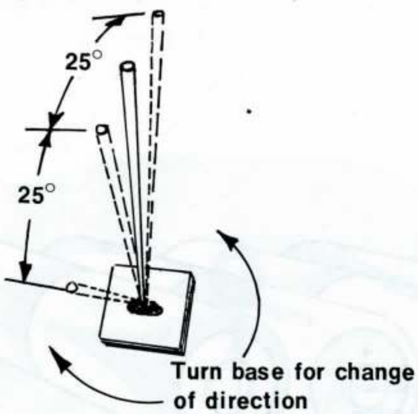


CONNECTING MICRO-CLIPS

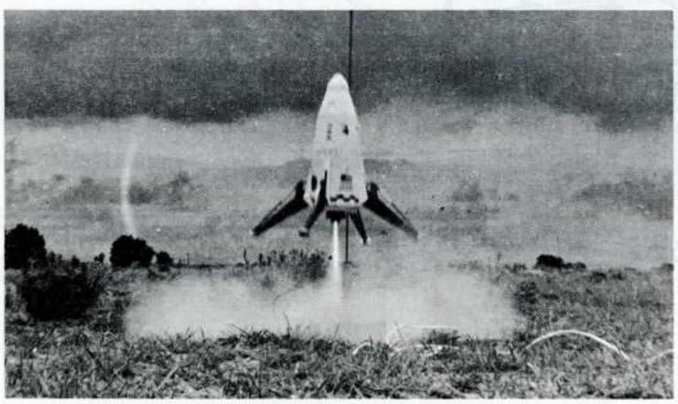


The base of the Electro-Launch holds the size D photoflash dry cells. Besides providing electric current, the weight of these dry cells makes the Electro-Launch a firm base for holding the model rocket in launch position. Adjusting the pivot for the launch rod and moving the base permits almost any possible adjustment of the launch angle within 25° of vertical.

ADJUSTING LAUNCH ANGLE



A blast deflector plate is used to protect the plastic base of the Electro-Launch from the heat of the rocket's exhaust.

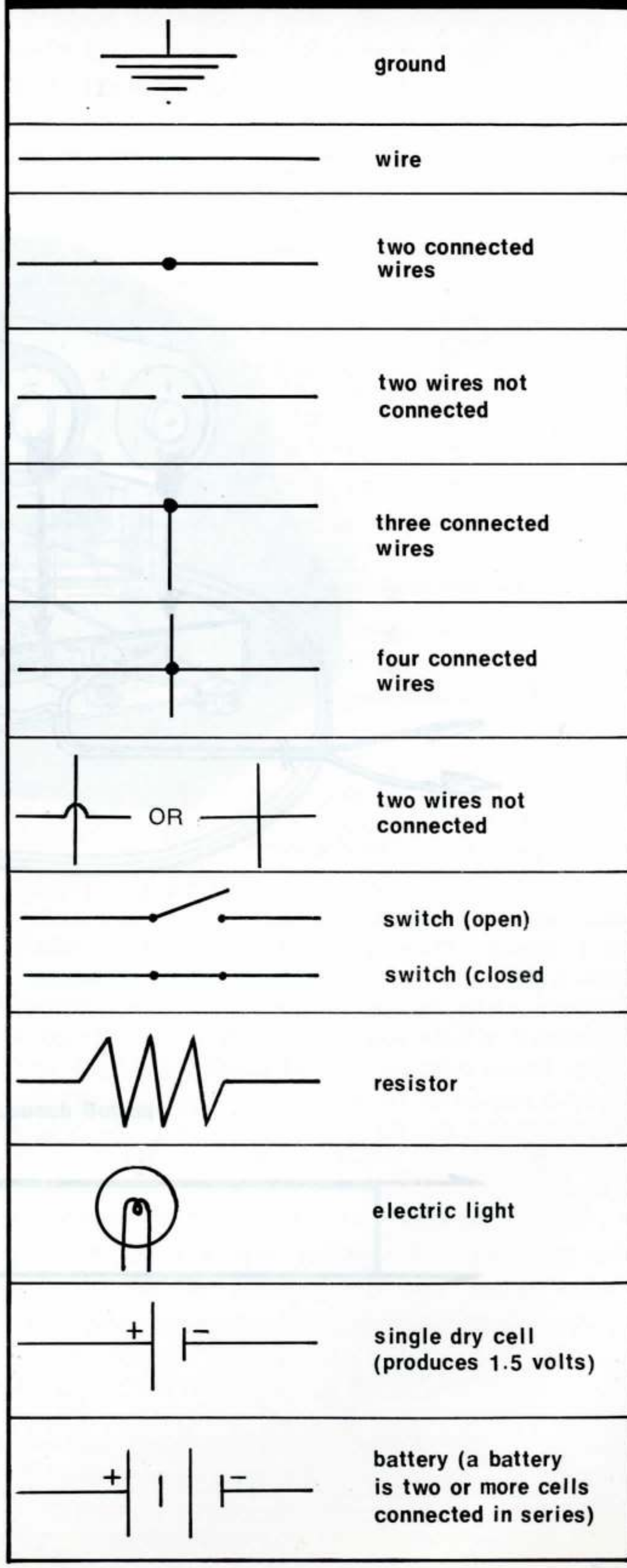


NOTE

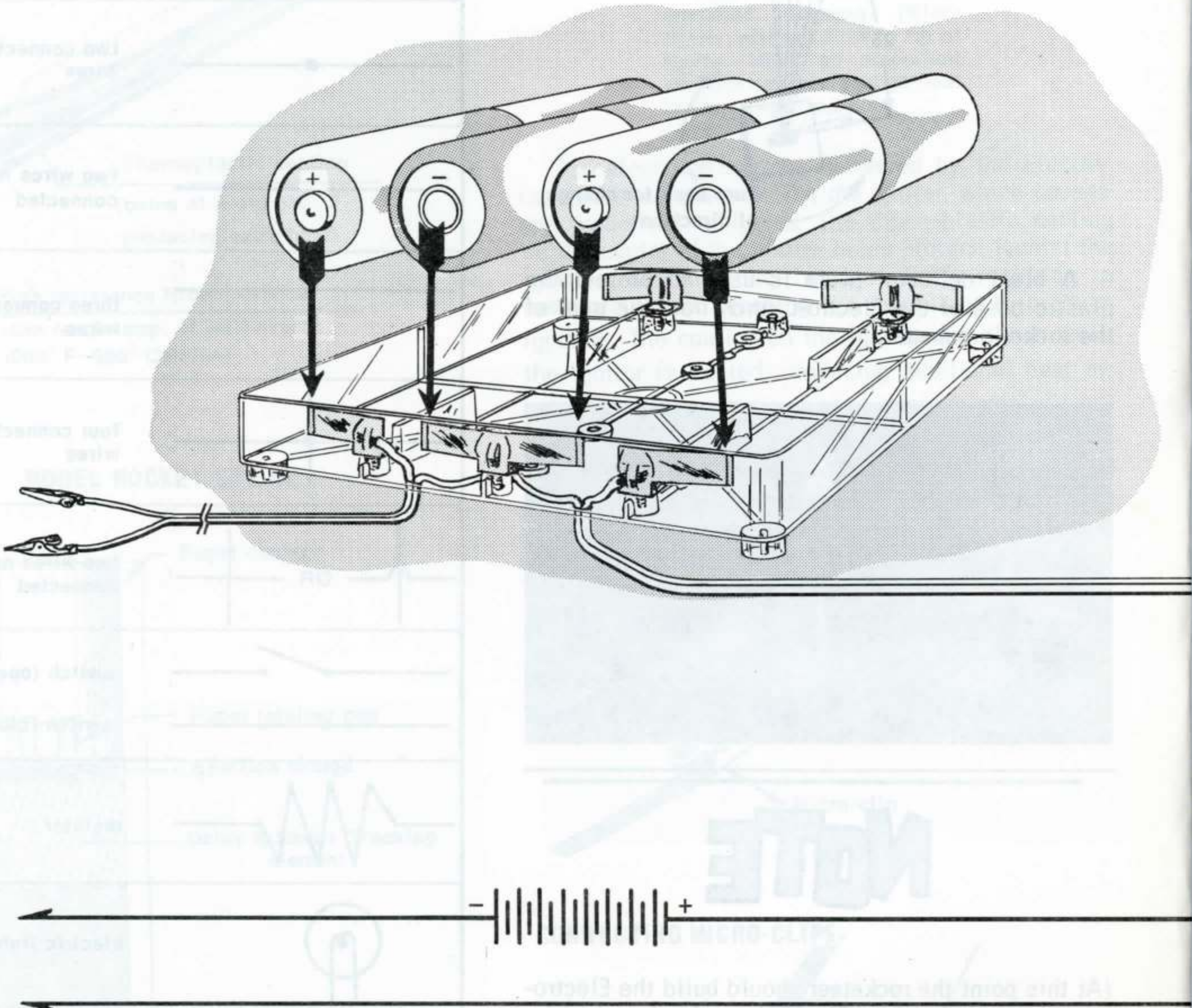
(At this point the rocketeer should build the Electro-Launch using the Electro-Launch Instructions booklet.

The rocketeer should proceed through page 11 to "Preparing For Launching" section before coming back to this booklet.)

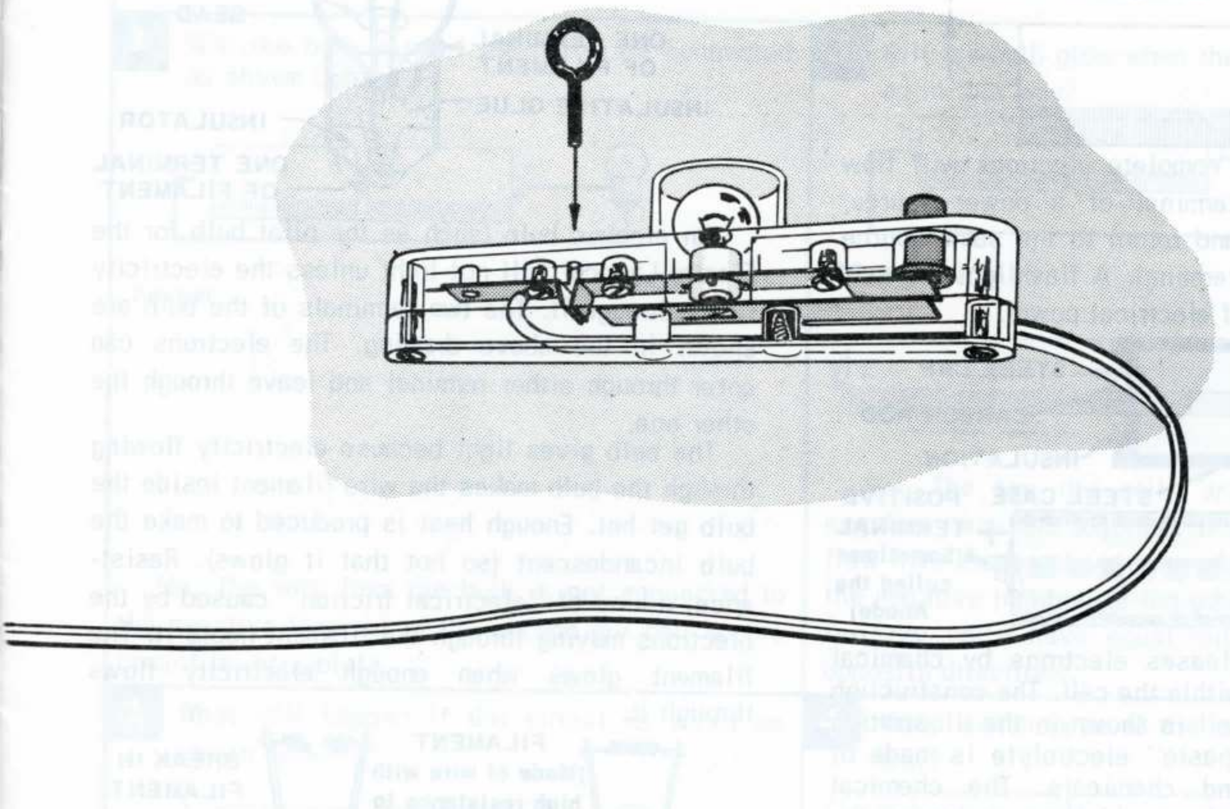
Symbols Used in Electrical Circuits



Understanding the Electro-Launch

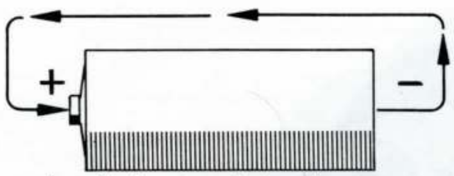


Understanding how the Electro-Launch system actually operates will help you in building other model rocket electrical ignition systems, including multiple launchers.

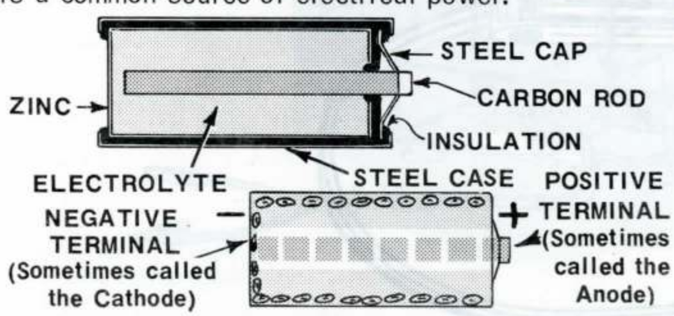


Principles of Electrical Circuits

An electrical current is a flow of electrons. A circuit is the path the electric current follows. The electrons will flow only when a circuit is complete. In effect, electricity must come from some place and have somewhere to go. Any point beyond which the electrons cannot go, because of a loose connection or unconnected wire, interrupts the path the electrons should follow and hence breaks the circuit.

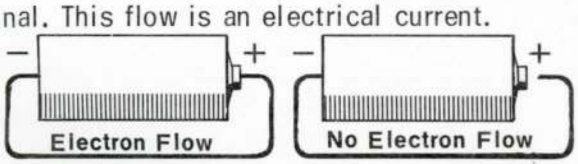


When a circuit is complete electrons will flow from the negative terminal of a power source, through the circuit, and return to the same source through its positive terminal. A flashlight dry cell is a common source of electrical power.



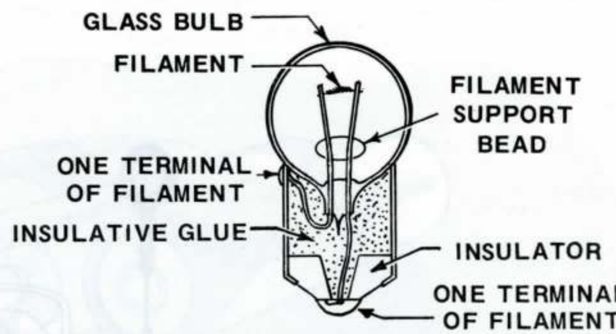
A "dry" cell releases electrons by chemical reactions occurring within the cell. The construction of a typical "dry" cell is shown in the illustration above. The black "paste" electrolyte is made of carbon particles and chemicals. The chemical reactions release electrons which accumulate on the zinc. These electrons travel through the zinc since it is a conductor of electricity. This concentration of electrons on the zinc produces a surplus of electrons at the negative (zinc) terminal of the "dry" cell.

When a complete circuit is made by connecting the two terminals together with a wire, the electrons which are concentrated at the negative terminal will flow through the wire to the positive terminal. This flow is an electrical current.



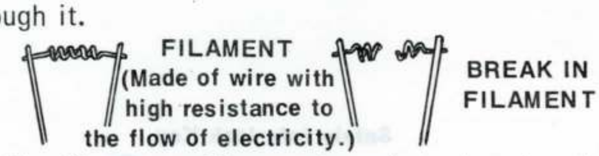
COMPLETE CIRCUIT (Closed Circuit) INCOMPLETE CIRCUIT (Open Circuit)

These electrons cannot leave the negative terminal unless they have a way to flow back into the cell through the positive terminal. When this pathway exists we say we have a complete circuit or a closed circuit. If there is a break in the pathway we call it an open circuit.



An electric bulb (such as the pilot bulb for the Electro-Launch) will not light unless the electricity flows through it. The two terminals of the bulb are shown in the above drawing. The electrons can enter through either terminal and leave through the other one.

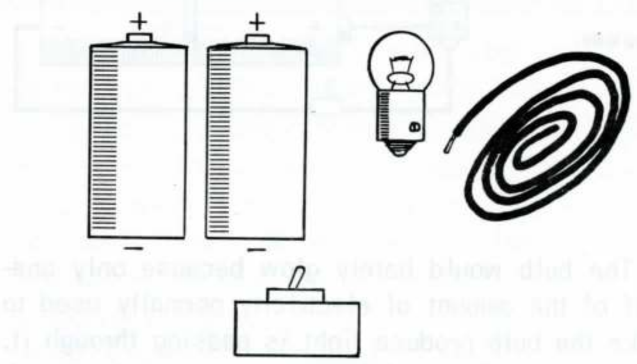
The bulb gives light because electricity flowing through the bulb makes the wire filament inside the bulb get hot. Enough heat is produced to make the bulb incandescent (so hot that it glows). Resistance, a kind of "electrical friction" caused by the electrons moving through the filament heats it. The filament glows when enough electricity flows through it.



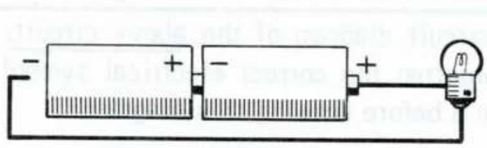
The filament will not glow when the electrical circuit is not complete. The most common type of failure in electrical bulbs occurs when a portion of the filament melts or breaks, thus making the circuit incomplete. Since the filament is enclosed inside a sealed glass bulb, once it is broken or melted into two separate parts, the bulb is useless. Breaking the bulb to reconnect the two pieces of filament may complete the circuit, but only temporarily as breaking the bulb lets oxygen into contact with the filament. Once the filament reheats, it will rapidly oxidize ("burn") and be destroyed. A sealed bulb contains nitrogen or an inert gas which will not react with the hot filament.

To check what you have learned about electrical circuits, study each question and the accompanying diagram carefully, then decide upon an answer to the question.

If we take two 1.5 volt flashlight dry cells (often incorrectly called flashlight "batteries"), a switch, wire, and a flashlight bulb we can make a type of flashlight.



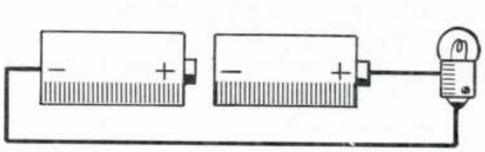
1 Will the bulb glow if the parts are connected as shown below?



Answer:

No. The wire from the bulb is not connected to the negative terminal of the second dry cell so the circuit is incomplete.

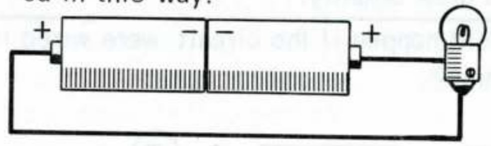
2 What will happen if the circuit is wired as shown here?



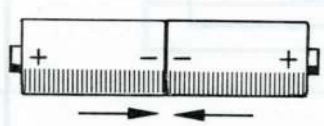
Answer:

Nothing. The circuit is still incomplete. The electricity cannot flow since the terminals of the two dry cells do not touch.

3 Will the bulb glow when the circuit is connected in this way?

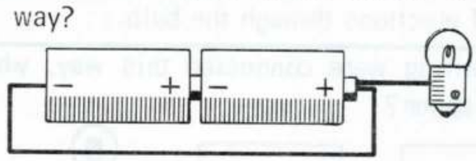


Answer:



No. The two dry cells are placed with their negative terminals together. The electricity will not flow from the negative terminal of one dry cell into the negative terminal of the other dry cell since the two dry cells have equal voltages which act in opposite directions.

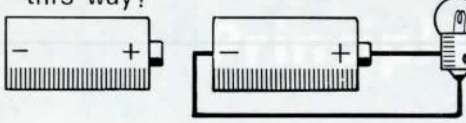
4 What will happen if the circuit is wired this way?



Answer:

The two dry cells will quickly become discharged. The bulb will not light since the electricity does not flow through the bulb. The circuit is complete without the bulb. The wire carrying the electricity will heat. This heating occurs because of the large amount of electricity passing through the wire as it "short-circuits" the dry cells and allows all of the electrical energy to be wasted.

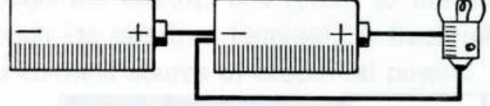
5 What would happen if the circuit were wired this way?



Answer:

The bulb would barely glow because only one-half of the amount of electricity normally used to make the bulb produce light is passing through it. This amount of electricity does not produce enough "electrical friction" to cause the filament to get hot enough to glow brightly.

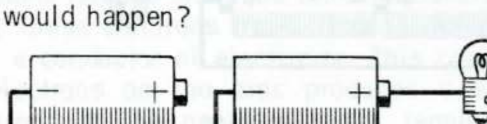
6 What would happen if the circuit were wired in this manner?



Answer:

The bulb would glow weakly just as it did last time since the second dry cell, being connected only at its positive terminal, could not contribute to the flow of electrons through the bulb.

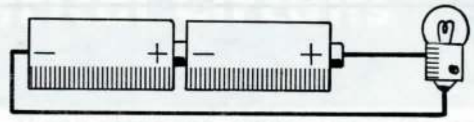
7 If the wiring were connected this way, what would happen?



Answer:

The bulb would still glow weakly. Even though the second dry cell is connected to the circuit at its negative terminal, the second dry cell is not connected at the positive terminal to form a complete circuit so it cannot contribute electrons to the flow of electricity through the bulb.

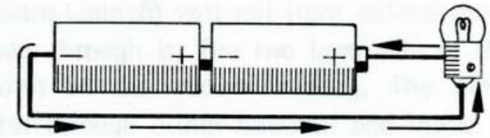
8 What would happen if we connected the circuit in this way?



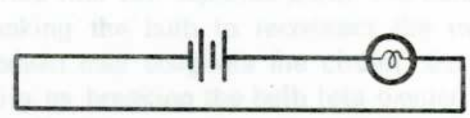
Answer:

The bulb would glow brightly! This is the way the circuit should be wired. The electricity (electrons) can flow from the negative terminal of the second dry cell, through the second dry cell and out at the negative terminal. The electrons then flow through the filament of the bulb, out the base of the bulb and into the positive terminal of the first dry cell, completing the circuit.

9 Draw a circuit diagram of the above circuit. If you have forgotten the correct electrical symbols, refer to page 3 before drawing this diagram.



Answer:

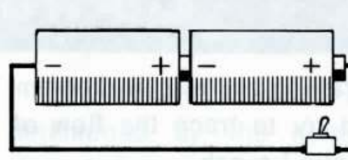


Using symbols in a circuit diagram like this is a kind of shorthand used to clearly show the parts of a circuit and the way they are connected.

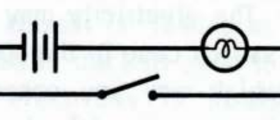
10

One draw-back is that if we left this circuit connected as in step 9, the dry cells would soon lose their ability to produce electricity. This occurs because all of their chemical energy would be converted to electrical energy and heat and light energy, thus the cells would become unable to produce more electricity. Instead of connecting and disconnecting the wires each time we want to turn the flashlight off and on, we can simply install a switch.

Draw a circuit diagram of this electrical circuit.



Answer:



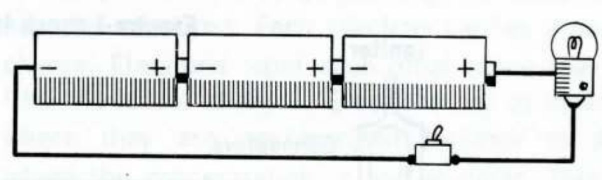
11

What would happen if an extra dry cell were properly added to the circuit?

Answer:

The bulb will produce more light because more electrons will flow. As a result of the increased flow of electrons, the bulb produces more light (and more heat).

Draw an electrical diagram of this circuit.



Electrical Operation of the Electro-Launch

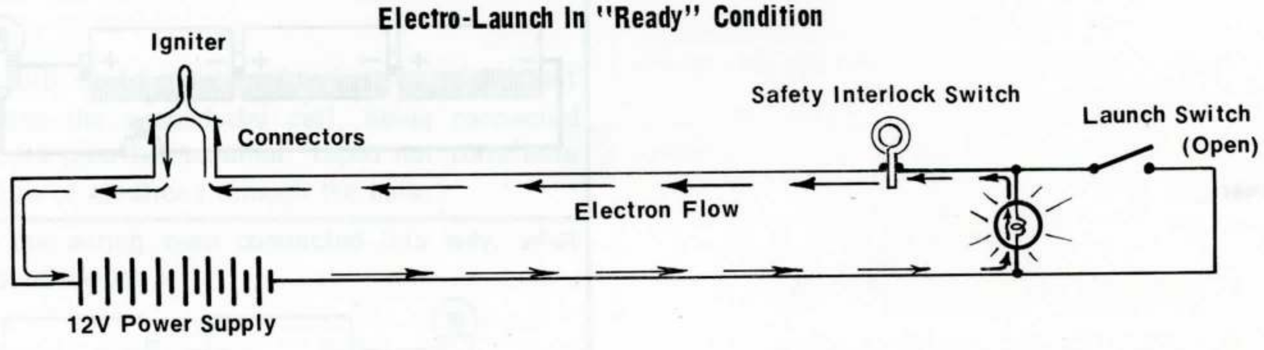
Now turn back to the drawing and circuit diagram of the Electro-Launch and try to trace the flow of electricity through the Electro-Launch.

You probably noticed that the safety interlock switch is an unusual kind of switch. It is always open (incomplete circuit) unless the safety interlock key is inserted into it to complete the circuit. Once this key is inserted, the electricity can flow from the dry cells, through the igniter attached to the micro-clips, through one of the long pair of wires to the bulb, through the safety interlock key, through the pilot bulb, and back to the dry cells through the other wire in the long pair of wires connecting the launcher base and the switch case. (NOTE: The electricity may flow through the parts in the switch case in the opposite order, depending upon which way you connected the long pair of wires between the launcher base and the control switch case.) This flow will occur only if all of the connections are properly made. If electric current does not flow, check the wiring of the system and make certain all of the dry cells are properly positioned. The instruction booklet for the Electro-Launch contains trouble-shooting tips.

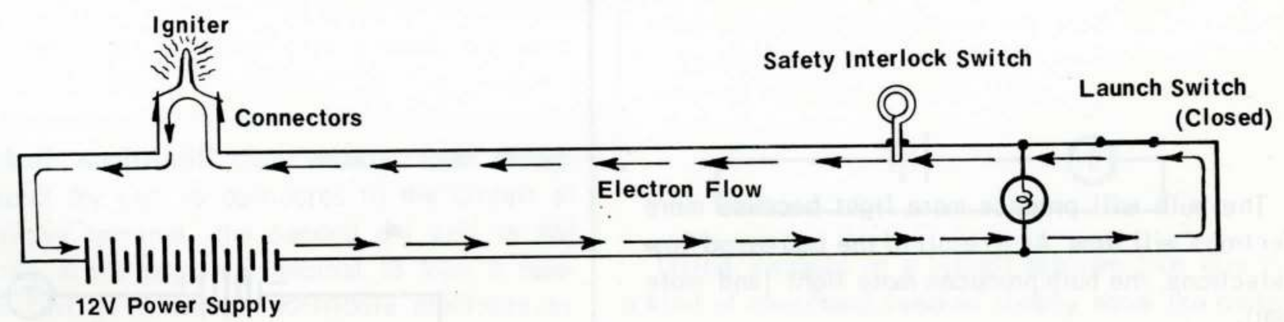
With the safety interlock key inserted, the continuity bulb will glow if the igniter is properly connected to the micro-clips. The bulb will not light unless electricity is flowing through the igniter or the micro-clips are shorted. In a series circuit, all parts are connected together, one after the other, like beads on a necklace. The resistance of the bulb is so great that not enough electricity can flow in this series circuit to cause the igniter to become hot.

Pressing the launch button closes a switch which lets the electricity by-pass the continuity bulb. This "shorts out" the bulb and lets the electricity flow through the igniter without also flowing through the high resistance continuity bulb. Enough electricity now flows through the igniter to heat it to the propellant's ignition temperature. Very quickly after the propellant ignites, the rocket takes off.

Electro-Launch In "Ready" Condition

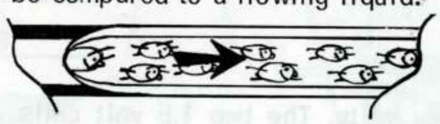


Electro-Launch As Electricity Flows Through Igniter

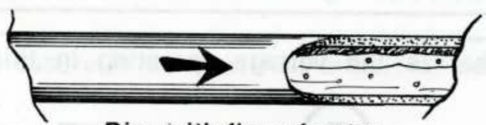


Electrical Mathematics

An electric current is a flow of electrons. This flow may be compared to a flowing liquid.

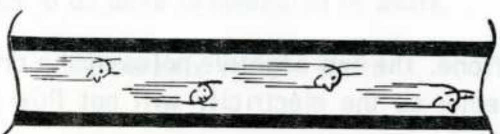


Wire with flow of electrons



Pipe with flow of water

Any substance that easily conducts or carries a flow of electricity is called a conductor. Most metals are good conductors of electricity. Some other materials are also good conductors of electricity.

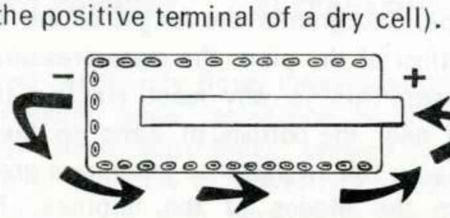


Electrons moving through Conductor

Some substances are not good conductors of electricity. These substances which do not readily conduct electricity are called insulators. Many nonmetals, such as glass, wood, and porcelain, are good insulators.

Electrons moving through insulator

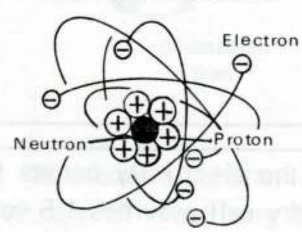
Electrons will flow from a place where they are concentrated (as at the negative terminal of a dry cell) to a place where they are less concentrated (as at the positive terminal of a dry cell).



Electron Flow

The amount of electric current which flows is determined by the number of electrons moving through the conductor. The unit used to measure this flow of electric current is coulomb. (A coulomb is equal to about 6,250,000,000,000,000,000 electrons. Although this number is very large, you will recall that an electron is extremely tiny.)

One idea of an Atom



The protons and neutrons occur in the central portion, the nucleus. The electrons occur as orbital electrons around the nucleus. The tiny electrons make up only a very small portion of the mass of an atom.

When one coulomb of electrons flows through a wire in one second, the current is flowing at a rate of one ampere. The ampere is the unit used to measure the rate at which electricity is flowing. An ampere is equal to one coulomb per second.

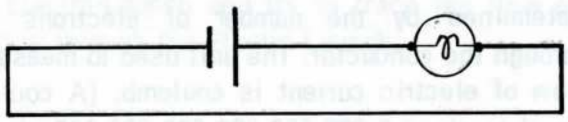
The pressure or force pushing the electrons can also be measured. Each electron carries a negative charge. Electrons repel each other since they carry like electrical charges. Electrons try to move from where they are concentrated together to places where the concentration is not so great. This tendency of electrons to move produces electrical pressure. This force is sometimes called electromotive force. A volt is the unit used to measure this electromotive force. This force is also called electrical potential.

The greater the difference is in the concentration of electrons at two points connected by wires, the greater is the pressure on the electrons trying to move from the area of greater concentration (the negative pole or terminal) to the area of lesser concentration (the positive pole or terminal). The greater this pressure, the greater the voltage in the circuit.

Electrical power is measured in watts. One ampere of electricity along with one volt of electrical potential is one watt of electrical power. Watts are the units used to measure the amount of electricity at work in a circuit.

1 watt = 1 ampere × 1 volt

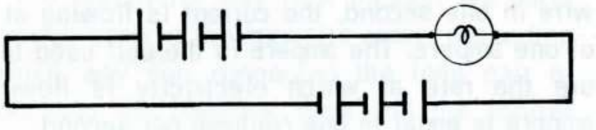
What is the voltage in this circuit?



answer:

The answer is 1.5 volts.

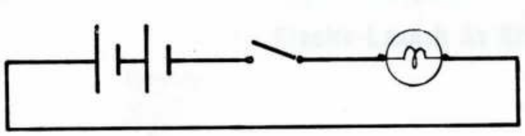
What is the voltage of the electricity across the bulb in this circuit? Each dry cell provides 1.5 volts in these problems.



answer:

Nine volts. Six dry cells, each supplying 1.5 volts of electrical pressure, produce nine volts. (6 x 1.5 volts = 9.0 volts)

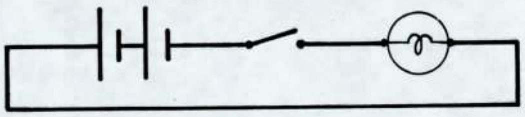
How much electricity is flowing in this circuit?



answer:

None. The switch is open so the circuit is not complete, and electrons cannot flow.

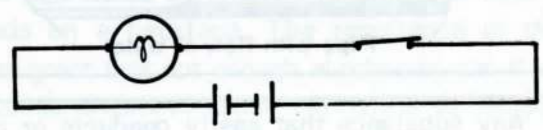
How much voltage is provided in this circuit?



answer:

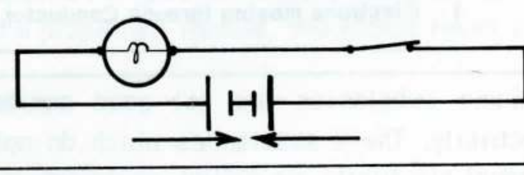
Three volts. The two 1.5 volt cells are wired in series to produce 3 volts. When two or more cells are connected together we call it a battery.

What is the voltage operating in this circuit?



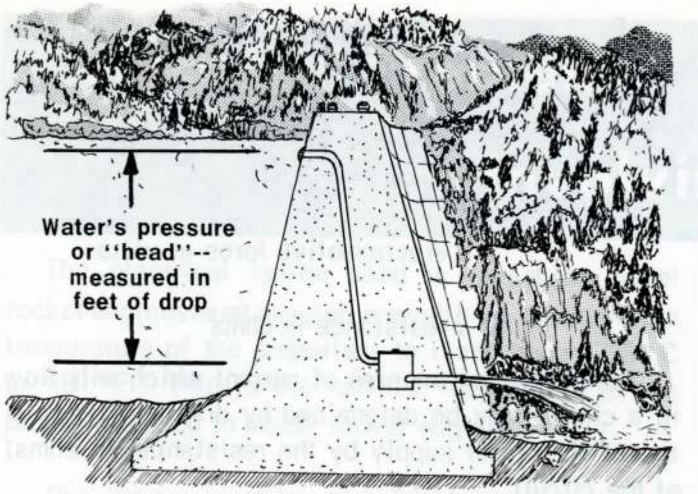
answer:

None. The two negative poles of the dry cells are together so the electricity will not flow in the circuit.



Some people like to compare an electric current to the flow of water in a pipe. The amount of water flowing is measured in gallons per second. The amount of electrons flowing is measured in amperes (coulombs of electrons per second).

The force with which the water moves is determined by the pressure of the water. The water pressure in a gravity-powered water system is determined by the height of the column of water in the pipe. The greater the height of the water above the bottom of the pipe, the more pressure the water possesses. This is why most electric turbines are placed near the bottoms of dams so the water can effectively fall in pipes to produce a great pressure to turn the blades of the turbines. The water's pressure is sometimes measured by measuring the number of feet the water can fall.

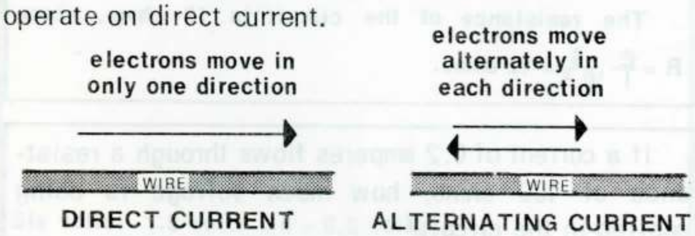


The pressure in an electrical circuit is measured in volts.

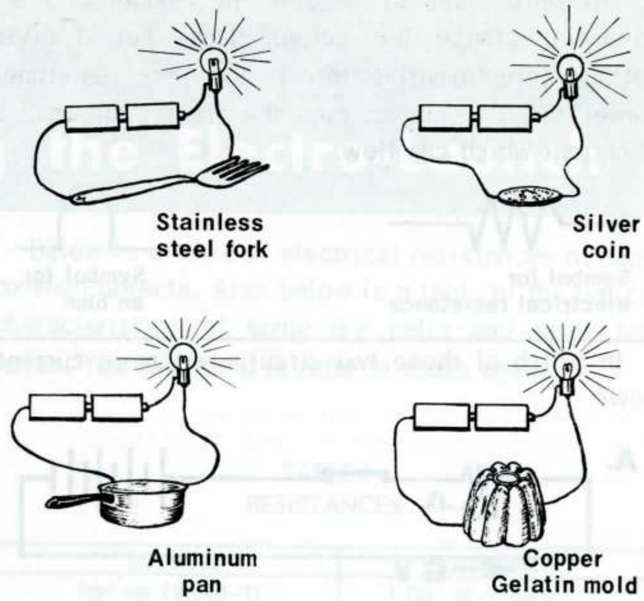
The power of the water moving in a pipe is determined by how much water is moving and the pressure of the water. The power of the electricity flowing in a circuit is determined by how many amperes of electricity are flowing and the voltage "pushing" them. This total amount of electricity with which to do work is measured in watts.

Amperes x Volts = Watts

In the type of electrical circuit we have worked with so far the electricity flows in one direction only. When the electricity flows in only one direction in a circuit, we call the flow of electricity direct current. When the flow of electricity rapidly changes direction back and forth we say that we have alternating current. The electricity flowing in your house is alternating current. We will study only direct current here. Many things such as flashlights, your car's electrical system, and the Electro-Launch operate on direct current.

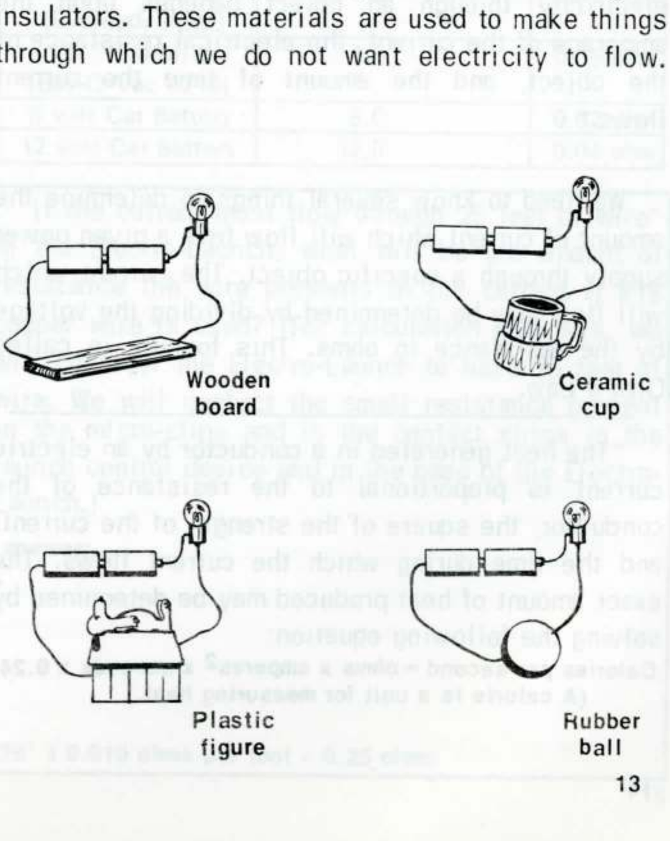


Whenever electricity flows through an object, the object presents some resistance to the flow of electricity. Some substances present very little resistance to the flow of electricity. Such objects conduct electricity with very little loss and are called conductors. Most metals are good conductors.



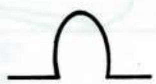
Whenever a substance presents resistance to the passage of electricity through it, part of the electricity is changed to heat. Unless we want heat this is wasted energy. Even good conductors have a little resistance to the flow of electricity through them so they change a little electrical energy into heat energy.

Substances which have a high resistance to the passage of electricity are called insulators. They are very poor conductors. Such substances as rubber, wood, many plastics, and porcelain are good insulators. These materials are used to make things through which we do not want electricity to flow.



The units used to measure the amount of electrical resistance are called ohms. For a given voltage (electromotive force), the less resistance (fewer ohms) an object has, the greater the amount of current which can flow.

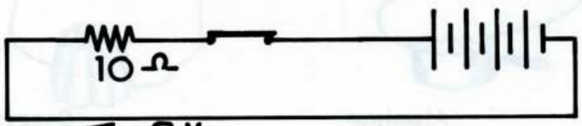
Symbol for electrical resistance



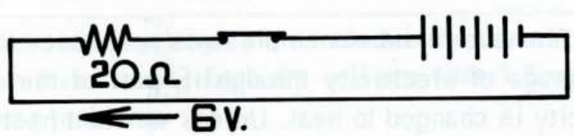
Symbol for an ohm

In which of these two circuits will more current flow?

A.



B.



answer:

More current will flow in circuit A because it has less electrical resistance.

The amount of heat produced by the passage of electricity through an object depends upon the amperage of the current, the electrical resistance of the object, and the amount of time the current flows.*

We need to know several things to determine the amount of current which will flow from a given power supply through a specific object. The current which will flow may be determined by dividing the voltage by the resistance in ohms. This formula is called Ohm's Law.

*The heat generated in a conductor by an electric current is proportional to the resistance of the conductor, the square of the strength of the current, and the time during which the current flows. The exact amount of heat produced may be determined by solving the following equation:

Calories per second = ohms x amperes^2 x seconds x 0.24
(A calorie is a unit for measuring heat.)

$I = \frac{E}{R}$ Current = $\frac{\text{Electromotive Force}}{\text{Resistance}}$

I = amperes of current flowing in the circuit

E = electromotive force in volts

R = resistance in ohms

The number of amperes of current which will flow in a circuit may be determined by dividing the voltage of the power supply by the resistance (in ohms) of the circuit.

For example, if a 6 volt supply is connected into a circuit where total resistance is found to be 2 ohms, three amperes of electrical current will flow.

$\frac{E}{R} = I$ $\frac{6 \text{ volts}}{2 \text{ ohms}} = 3$ amperes

This relationship is useful for determining either the number of amperes which will flow, the voltage used, or the resistance of the circuit if the other two are known.

The formula $I = \frac{E}{R}$ can also be stated $R = \frac{E}{I}$ or $E = R \times I$. Problems can be solved using any of these versions of the formula.

For example, if six volts causes a current of 0.5 amperes to flow, what is the resistance of this circuit?

answer:

The resistance of the circuit is 12 ohms, since $R = \frac{E}{I}$, $\frac{6}{0.5} = 12$ ohms.

If a current of 0.2 amperes flows through a resistance of 100 ohms, how much voltage is being applied in the circuit?

answer:

A voltage of 20 volts is being used. E = R x I = 100 x 0.2 = 20 volts.

Electrical Problems Involving the Electro-Launch

The electrical igniter used in launching model rocket engines must develop enough heat to cause the temperature of the propellant to reach about 288° C or 550° F.* This is the ignition temperature of the propellant used in model rocket engines.

The igniter must have at least two amperes of of electricity flowing through it to produce enough heat to cause rapid ignition of the propellant. The special insulator-igniter coating burns when it reaches a high temperature producing extra heat for extremely rapid engine ignition.

If your Electro-Launch has eight "D" size photo-flash dry cells in it, what will be the voltage available to your igniter?

answer:

Twelve volts. 1.5 volts x 8 = 12.0 volts

If your Electro-Launch had only four of these dry cells in it, what would be the voltage available to your igniter?

answer:

Six volts. 1.5 volts x 4 = 6.0 volts

*(F stands for Fahrenheit, a temperature scale. Celsius, abbreviated "C", is the temperature scale used by scientists. The formula to find the Celsius temperature when the Fahrenheit temperature is known is $C = \frac{5(F-32)}{9}$. This scale was formerly known as the Centigrade temperature scale.)

Below is a table of electrical resistances of some common objects. Also below is a table of the typical characteristics of some dry cells and some batteries. You will need to refer to these again.

TABLE I
RESISTANCES

Material	Resistance
Igniter (#NWI-1)	1.00 ohm each
#32 Nichrome Wire	0.88 ohm per inch
#30 Nichrome Wire	0.56 ohm per inch
#16 Copper Wire	0.006 ohm per foot
#18 Copper Wire	0.010 ohm per foot
#20 Copper Wire	0.016 ohm per foot
#51 Pilot Bulb (6volt)	30 ohms each
#53 Pilot Bulb (12 volt)	120 ohms each

TABLE II
TYPICAL BATTERY CHARACTERISTICS
(FRESH)

Type	Voltage	Internal Resistance
"D" Flashlight (Eveready #950)	1.5	0.38 ohm
Lantern (4 "F" Cells) (Eveready #509)	6.0	0.86 ohm
"D" Photoflash (Ray-O-Vac #210)	1.5	0.15 ohm
6 volt Car Battery	6.0	0.02 ohm
12 volt Car Battery	12.0	0.04 ohm

If the current must flow through 25 feet of wire* in the Electro-Launch, what will be the amount of resistance the wire presents to the current if #18 copper wire is used? (For calculation purposes, we will consider the Electro-Launch to have 25 feet of wire. We will neglect the small resistance present in the micro-clips and in the contact strips in the launch control device and in the base of the Electro-Launch.)

answer:

25' x 0.010 ohms per foot = 0.25 ohms

*1'9'' x 2 =	3'6''of wire in the two igniter leads
10'6'' x 2 =	21'0''of wire connecting central unit and launcher base (a pair of wires 10'6'' long)
2'' =	2''of wire inside the launcher base
5'' =	5''of wire inside the control unit
25'1''	

C4 If #16 wire were used instead, what would be the resistance of the wire?

Answer:

25' x 0.006 ohm/ft. = 0.15 ohm

C5 If #20 wire were used, what would be the resistance of the wire?

Answer:

25' x 0.016 ohm/ft. = 0.4 ohm

C6 What will be the resistance offered by a standard igniter, no matter which type of lead wire is used?

Answer:

1Ω

C7 What will be the resistance in the eight 1.5 volt ''D'' photoflash dry cells?

Answer:

8 x 0.15Ω = 1.20Ω

C8 What will be the total resistance in the circuit when the launch button is pushed (just before the igniter melts) if the launcher is wired with #18 wire (size normally used) and 8 ''D'' photoflash dry cells and a standard ignitor?

Answer:

0.25Ω wire

1.00Ω igniter

1.20Ω dry cells

2.45Ω total resistance in the circuit when #18 wire is used

The pilot light in the Electro-Launch serves two basic purposes. (Refer to picture on opposite page.) It lights when electricity flows through it to show that the circuit is complete. It also limits the amperage which can flow through the circuit, preventing ignition of the engine before the the launch button is depressed. The circuit is complete only when the igniter is in good electrical contact with each of the two micro-clips and the safety interlock key is properly inserted.

Notice that the igniter must be properly connected or the circuit will not be complete. Once the igniter is in place, the circuit still is not complete until the safety interlock key is inserted.

C9 When the safety interlock key is inserted to complete the circuit, the electricity flows through the circuit. However, the pilot light (#53 pilot bulb for 12 volts) has a resistance of 120 ohms. The total resistance of the circuit is now how many ohms if #18 wire is used for the wiring?

Answer:

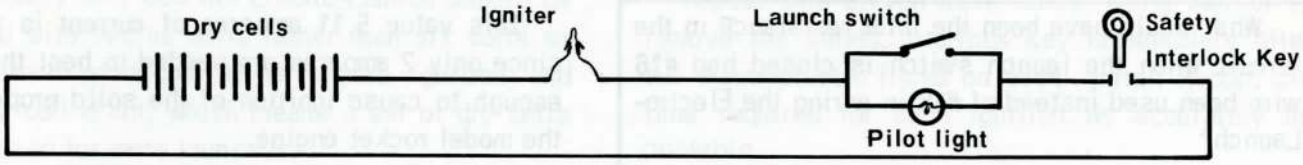
0.25Ω wire

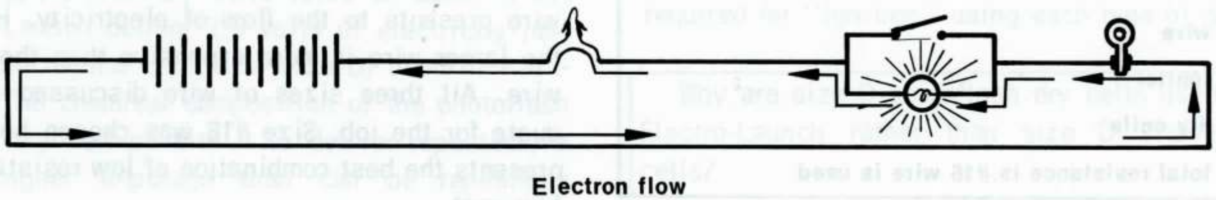
1.20Ω dry cells

1.00Ω igniter

120.00Ω #53 pilot bulb

122.45Ω total resistance

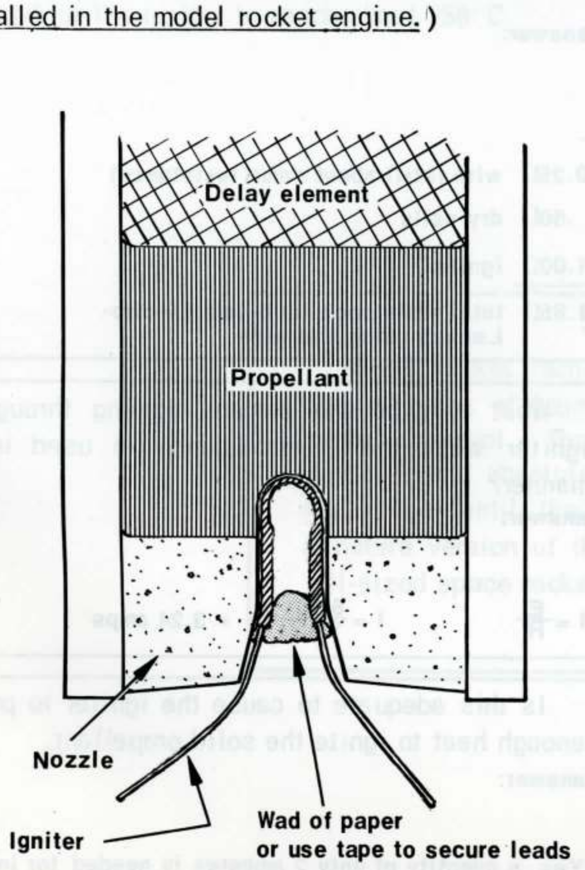




The total current which can flow in the completed circuit before the launch button is pushed is how many amperes?

$I = \frac{E}{R}$ $\quad$ $I = \frac{12v}{122.45\Omega} = 0.098$ amps

This current is not sufficient to heat the igniter enough to cause ignition, but is adequate to light the pilot bulb. The pilot bulb is used as a <u>continuity check</u> to be sure the igniter is properly connected to make a complete circuit. When the circuit is complete the pilot light glows, indicating the connections to the igniter are good. (However, <u>the igniter will not cause ignition if it is not properly installed in the model rocket engine.</u>)



The circuit has a resistance of 2.45 ohms (see page 18 step 8C). when #18 wire is used, the igniter is in place, the safety interlock key is in place and the launch button is held down completing the circuit. If all connections are correct, the current flow will rapidly heat the igniter to ignite the engine. Usually the igniter will either melt from the heat or the exhaust will force the igniter out of the nozzle and forcibly break the electrical connections.

[Refer to drawing above]

The pilot light and the launch button (the momentary switch which completes the circuit only while it is held down) are wired into the circuit in series with the rest of the circuit. However, these two parts are wired in parallel to each other (wired side by side so the electricity can flow through either or both at the same time). When the launch button is not pushed, the switch stays open so the electricity has to flow through the high resistance pilot light (120 ohms for the #53 bulb used in the 12-volt Electro-Launch). When the launch button is held down, the launch switch is closed permitting the electricity to readily flow through this part of the circuit. Since electricity will flow through the path of least resistance when more than one path is open to it, nearly all of the electric current will now flow through the switch. Very little electrical current will flow through the bulb so it will not light. In effect the lamp circuit is now by-passed by electricity flowing through the switch. This prevents electricity from flowing through the bulb since an alternate path of much lower resistance is available to the eleciricity.

What would have been the total resistance in the circuit when the launch switch is closed had #16 wire been used instead of #18 in wiring the Electro-Launch?

answer:

0.15Ω wire
1.00Ω igniter
1.20Ω dry cells
2.35Ω total resistance is #16 wire is used

What total resistance would have been present in the circuit when the launch switch is closed had #20 wire been used?

answer:

0.40Ω wire
1.00Ω igniter
1.20Ω dry cells
2.60Ω total resistance if #20 wire is used

Calculate the amperes which will flow when the launch button is pushed on an Electro-Launch wired with #18 wire.

answer:

$I = \frac{E}{R}$ $\quad I = \frac{12.00 \text{ volts}}{2.45 \text{ ohms}} = 4.90$ amperes

This value of 4.90 amperes is easily adequate to cause igniter ignition in less than one second. As the dry cells age and are used, the amount of electricity they can produce decreases so the time required for ignition increases.

What amperage would have flowed had #16 wire been used?

answer:

$I = \frac{E}{R}$ $\quad I = \frac{12.00\text{v}}{2.35\Omega} = 5.11$ amps

This value 5.11 amperes of current is adequate since only 2 amperes are needed to heat the igniter enough to cause ignition of the solid propellant in the model rocket engine.

The larger the size (the smaller the number) of the electrical wire used, the less resistance the wire presents to the flow of electricity. However, the larger wire is more expensive than the smaller wire. All three sizes of wire discussed are adequate for the job. Size #18 was chosen because it presents the best combination of low resistance and low cost.

Had only four dry cells been used in the Electro-Launch, what would have been the voltage available?

answer:

4 x 1.5 volts = 6.0 volts

If #18 wire had been used in the six-volt Electro-Launch, what would have been the current flow through the igniter? (An extra three inch piece of wire is needed to connect the dry cells when the Electro-Launch is used for 6-volt operation.)

answer:

0.25Ω wire (still about same resistance)
.60Ω dry cells
1.00Ω igniter
1.85Ω total resistance for 6-volt Electro-Launch using #18 wire

What will be the current flowing through the igniter when the Electro-Launch is used in this manner?

answer:

$I = \frac{E}{R}$ $\quad I = \frac{6.00\text{v}}{1.85\Omega} = 3.24$ amps

Is this adequate to cause the igniter to produce enough heat to ignite the solid propellant.

answer:

Yes, a quantity of only 2 amperes is needed for ignition.

For heavy-duty use the Electro-Launch should be operated with twelve volts rather than six volts as this method produces faster engine ignition and less dry cell drain, which means a set of dry cells can be used for more launches.

The photoflash dry cells (size D) used in the Electro-Launch deliver 1.5 volts of electricity just as do the regular dry cells (size D) used in flashlights. The chemical composition of the photoflash type of dry cell permits it to deliver repeatedly a much higher amperage than can be repeatedly delivered by regular dry cells. This can be easily proven by experimentation.

Secure a few dozen extra igniters and eight regular size D dry cells if you wish to perform this experiment. Replace the eight size D photoflash dry cells in the Electro-Launch with the eight regular size D dry cells. Reassemble the Electro-Launch and place an igniter properly in position. Do not use an engine since we are interested now only in testing the effectiveness of regular dry cells. Ignite the igniter in the usual way and observe the time it takes for the thermoplastic (blue plastic coating on the middle of the igniter) to burn. This gives a good indication of the length of time required for the igniter to reach about 288°C.

Repeat this eleven more times, being careful to remove the safety interlock key immediately after the thermoplastic flares on each igniter. Record the time required for each ignition as accurately as possible.

Repeat this series of twelve tests but use size D photoflash dry cells this time. Compare the time required for "ignition" using each type of dry cell.

Why are size D photoflash dry cells used in the Electro-Launch rather than size D standard dry cells?

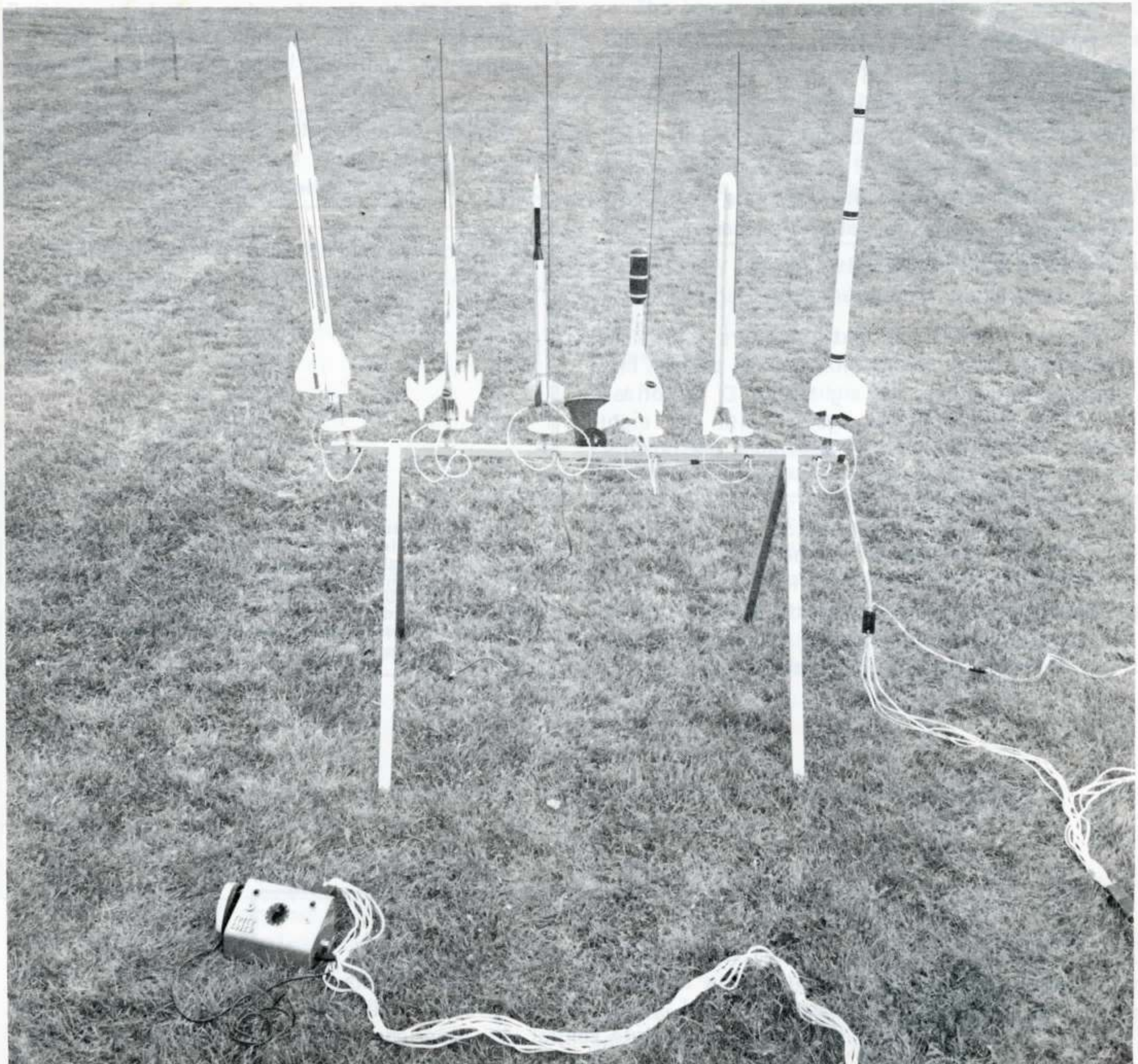
answer:

The photoflash dry cells can repeatedly deliver the surges of electricity (rapid deliveries of high amperages) needed for reliable ignition. The regular dry cells are soon too weakened by the rapid discharges required for ignition to be able to deliver the necessary high amperages. Regular dry cells were not designed for rapid discharge use, while photoflash dry cells were designed for this type of operation.

SAFETY

Model rocket launch systems provide safe, reliable means of launching your model rockets by remote control. The safety circuits, guidance devices, and absolute control you experience over the rocket until the instant of launch provide a minature version of the system used to launch our full-sized space rockets.

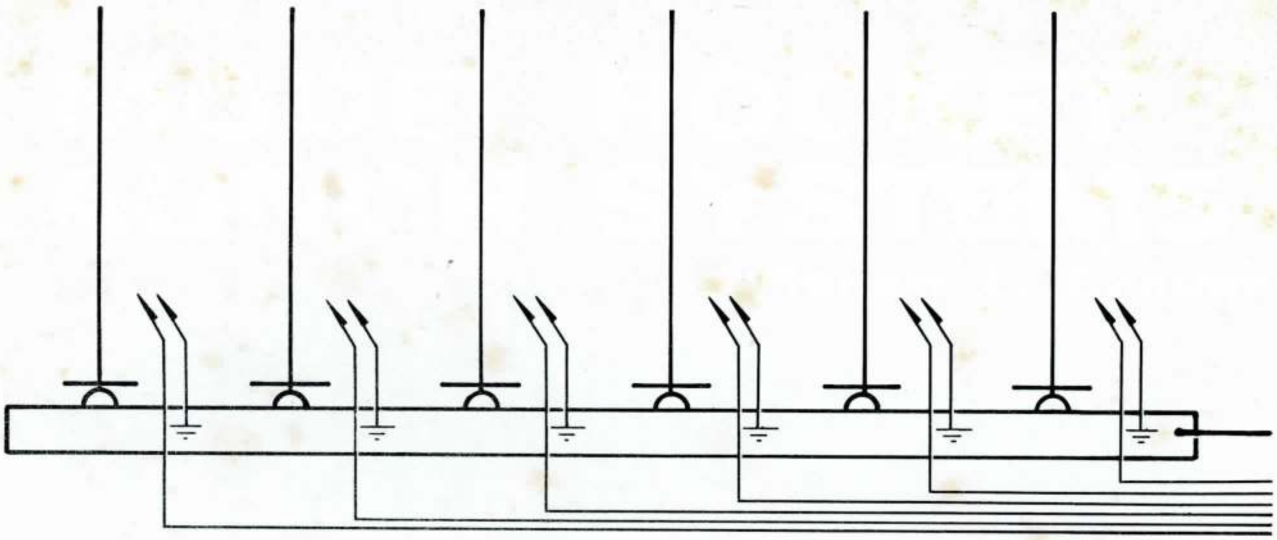
Multiple Launcher Circuits



A Typical Multiple Launcher

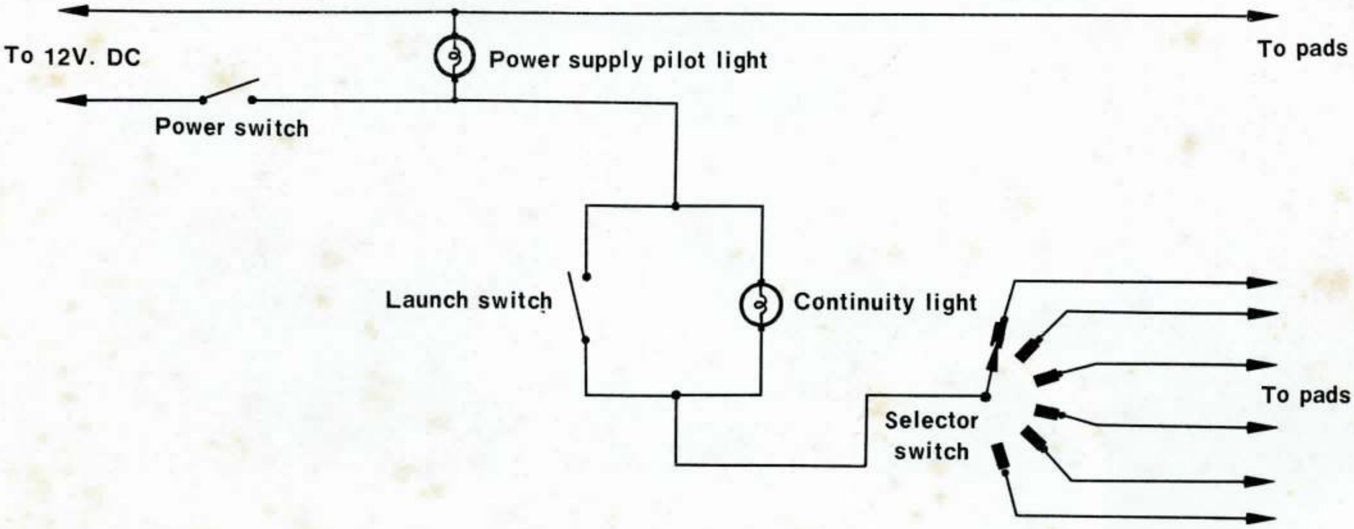
A launcher with several launch pads is a convenient device for flying many model rockets in rapid sequence. A multi-pad system provides a number of launcher set-ups (adjustable rods or rails, blast deflector plates, and micro-clip connectors) attached to one power supply and control unit.

The electrical power supply to the micro-clips is usually a separate wire to each launch pad to carry the electrical current to that pad and a common (shared) return or "ground" wire.



The control panel for a multiple launcher usually incorporates a key-operated power supply switch (to turn power supply off and on), a power supply pilot bulb (to indicate when the power supply is on), a rotary selector switch (to direct current to the pad in use only), a continuity light to indicate if the electrical circuit through the igniter is complete, and a launch switch.

The Estes Multi-Pad provides a compact, well-engineered launch complex for groups.



Partial schematic diagram for a typical multiple launcher

ESTES

A SUBSIDIARY OF DAMON