Notes on FX firing systems

Thoughts by Mike Craven

There are many factors affecting the success, reliability, and safety of firing systems used in the motion picture industry. Some of them are obvious, some are easily remembered, and others are almost never examined or understood.

These notes are on specific factors pertaining to the motion picture industry. This information is not intended as, nor should it be used as safety information pertaining to the general handling and use of explosives, squibs, initiators, etc. Other reference books must be consulted for such information. As well, standard industry wide safety rules and regulations must be followed when working with explosives.

Factors are:

1. Training of people (and whether they remember!).
2. Length and gage of the wire/cable to the squibs.
3. Capacity and quality of batteries used.
4. Quality of wiring connections in the field.
5. Possibly of wiring damage due to previous explosions.
6. Overloading of the wire (Methods of field wiring).
7. Mixing of different loads on one circuit.
8. Series connected systems.
9. High voltage systems.
10. Limits on low voltage Klunker boxes.
11. Shunting of wiring systems.
12. Static electricity.
13. Klunker box shunts and limits.
14. Electrical tape.
15. Computer sequencers.

1) Training of people

It is possible that people are the most unreliable part of any firing system. They forget what they have been taught, and also, remember erroneous information as the gospel truth. My experience is that about ½ of the effects personal do not understand the difference between parallel and series electrical circuits. Most also have a hard time with complex electrical hookups, especially ones involving relays.

Employees must be trained in safe methods of handling explosives and safe procedures when wiring and going hot to fire. This includes guarding the batteries when brought to set, not connecting them until everyone is clear, and even not carrying devices and batteries in the same pocket (I have heard of the last being done!).

A different problem happens if there is a problem, failure, or accident. Most people want to 'cover their ass' if it is their fault, or might be their fault. Also, they tend to place the blame on the easiest thing to find fault with, usually the thing that is the most complex and least understood. I have seen fault assigned to both Klunker boxes and radio controls when the problem is either miss-wired hits, shorted wiring, wiring left shunted, or shorted squibs in trips. Failure to properly investigate and understand failures prevents learning and the ability to not repeat mistakes.

2) Length and gage of wire

Just like an extension cord for tools, the wire to a squib(s) must be of a size to carry the necessary current to fire the device. As the wire becomes longer either a larger size wire is needed or more voltage must be used to push the current down the wire. I figure 1 (one) amp of current for each squib to be fired. The resistance of copper wire (in ohms per 1000 feet (or meters)) is found in many books. The battery voltage is divided by the wire resistance to find the current flow in amps. A chart that I have prepared gives some guidance on this subject.

If more than one device is connected to the wire then more current is needed. At some point it is better to run additional wire than to add too many devices to one wire run. Our experience is that up to 5 squibs properly connected to the correct size wire will work ok. We would never connect more than 10 devices to a single wire run.

Check out the rules in section #6 for information on how to connect multiple squibs / devices to a single output or button.

3) Batteries used

SAFETY NOTE: As stated in explosive manuals – ONLY battery-powered systems must be used. Any AC mains powered system, whether directly connected or through a transformer is not allowed. This is due to inductive pickup on AC wiring that will induce a current / voltage on the firing lines. It is possible to have a miss fire the moment the first wire is connected (not even completing the circuit!). I have demonstrated this on the bench and it **has** happened in the field.

Most of the following information pertains to lead acid / gel cell batteries in the 6 – 48 volt range. Other types of batteries will be mentioned later. We tend to use gelled batteries since there is no liquid acid to leak.

Batteries must have enough current capacity so that the terminal voltage does not fall too low as the squibs are fired. As the terminal voltage falls two things will happen; 1st – the current delivered down the wire will decrease, possibly until the squibs won't fire. 2nd – if the voltage falls too low with an electronic / relay Klunker box the box will cease to function.

One thing that is sometimes not thought of is a short circuit in the firing lines. During a shorted condition many times the normal current will flow in the wiring. The battery must supply this current without loosing too much terminal voltage.

All lead acid based batteries do poorly if run completely dead and recharged. Allowing a 12-volt lead battery to go below 10 volts permanently looses some of its' capacity. Several discharges below 10 volts will ruin it. Any lead battery that I find with a terminal voltage below 9 volts is considered unsuitable; it will never recharge properly and is scrapped.

Batteries should be tested once in a while (before each day of use? – you have to decide) to check their state of charge and if they can supply a reasonable current. We have 4 different methods of performing these tests. A voltmeter gives some information, but is not always correct. As an example – a 12 volt battery has the following readings: 12.6 V is fully charged, 12.4 V is about ½ charged, 12 V is dead (has no current capacity left). The problem is that an old battery with sulfated plates will give these readings and still have only a fraction of its capacity.

Next, we might use a load tester of the type for car batteries. This works well on the large size batteries. On the small gel cell batteries the tester draws too much current and the voltage tests low. It is still possible to use a large load tester on smaller batteries. What you do is test several new and fully charged batteries to find out exactly what voltage and current they will supply under the applied load. These values are then used as a comparison for your older batteries that have been charged.

The 3rd method is to use our newest trick tester. Manufactured by ACT Meters LTD, (www.actmeters.com). This small (2" x 2" x 4") device draws current in high-speed pulses and then calculates exactly how many amp-hours of capacity are left in the battery. By comparing this number with the battery's stated capacity you can decide whether to use, charge, or replace the battery. This tester was purchased at a store that supplies batteries and although it wasn't cheap, it is the most accurate test we have found.

4th, some of our assembled battery boxes have built in chargers and load testers. These testers have a push button that applies a load to the battery and a voltmeter to allow you to watch the voltage drop with the applied load. These self-contained battery boxes are very useful with smaller firing setups.

Notes on why we use large batteries

The tendency is to always use larger batteries than might be necessary. A lot of this is the 'just in case' factor. This is not necessarily a bad idea. The batteries could be old, or not fully charged, or a short in one of the firing lines might drain a lot of power. The point is that we don't need to use 2 car sized batteries to fire a run of 10 squibs connected one at a time to 10 different points (fired one at a time).

Do not be fooled by the claims for increased capacity with some types of gelled batteries. There is a tendency to use batteries with very high amp output numbers (Optima, Dry Cell, and other brands). These batteries do have a very high output capacity for engine starting service, but not any more total energy capacity. The energy capacity of a lead based battery is approximately 1 (one) amp / hour of power per pound of weight. The ability to supply 1000 amps instead of 300 amps is meaningless when the wiring will only carry 25 amps! See section #6.

Deep cycle batteries are not a bad investment. They hold their charge longer in storage, supply more current when partially discharged, and recharge better from a dead state.

Other batteries

We use other batteries, besides lead acid, on many occasions. Usually we use one type of the Ni-cad batteries used for drill motors (Makita, Dewalt, etc). Hand held striker boxes with a battery holder built in have been built for this. They work very well for bullet hits (machine gun runs) with one squib per output / per wire.

The problem is that we have found no method of testing the capacity of a Ni-cad battery. The voltage can be measured and although this gives an approximate state of charge, it is not a reliable indicator of charge. As an example, notice how a battery drill runs at full power until the end when the battery just dies. Compare this to a flashlight with alkaline batteries that slowly goes dim giving you plenty of time to get new batteries. There is also the ‘memory effect in Ni-cad batteries.

Until we can find a way to test the remaining charge in Ni-cad and Metal-hydride batteries I do not see their use in larger firing setups.

There are some obscure rules pertaining to discharging / recharging Ni-cads, I will cover them elsewhere. (Appendix 1)

Also, lithium batteries are of limited value. A special charger designed for the packs is required and there is a limit to how much current can be drawn out in a surge condition. They are also subject to catastrophic failure without warning if stored in too high of a temperature.(Appendix 1 has more info)

4) Field wiring connection quality

It is important that field connections are made properly so as to carry the current. Low voltage systems are much more sensitive to poor connections than a high voltage system (mains voltage).

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Obviously wiring connections must be clean. Squib and device wires must be scraped / sanded clean if no longer copper colored. Wiring looms need to be checked for corrosion and continuity. Plug and jack connectors need to be clean, tight fitting, have loose pins replaced, and fastened / taped together so as to not come loose. Enough bare wire is needed at each connection point so as to have enough wire to make a secure connection. Each connection must be insulated.

One thing is often missed is tape residue on connections. Battery terminals and wire ends are often taped over to prevent shorts. Over time (and with heat) a sticky residue is left on terminals. This material will cause a marginal connection that may not show up until under load.

This problem also occurs when extension wires are added to the lifters we use. The extensions are added days before the lifter is used. Normally this is OK, but sometimes these lifters are not used and then stored for months until the next show. After about 6 months the sulfur in the black powder corrodes the copper under the tape. This causes miss fires. When examined the copper is completely black, covered in copper sulfate and black tape residue.

Watch for shunted wiring. Obviously wiring is shunted on the end away from the squibs until just before connecting / arming to prevent miss fires. The problem arises when runs of wire are laid down. People tend to shunt both ends of the run. Later squibs are connected to one end of the wire. Later still the other end is tied into the main truck line or firing equipment. The problem occurs when a squib tie in is missed or a squib is removed. This wire is left shunted and causes a short circuit during firing, possibly causing other devices to not fire. This is a training issue; people must understand which end to shunt and which end remains open. See notes on shunting wiring in section 11.

5) Wiring damage

During the firing of any run of charges it is always possible for earlier charges to damage the wiring to later ones. I will state the obvious ones and then some that are not so obvious.

Wiring should not be run near the direction of the blast as well as directly behind it since the recoil could go backwards. Falling debris or recoiling objects must be watched out for, their path must not cut the wiring. Special care needs to be taken with cars and other metal structures that are being smashed or crushed at the same time. The wiring must be routed in a way to avoid being cut too soon. If gasoline or propane is used then the wiring may need insulation so that the fire will not burn through it before the last shot is fired.

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There is argument over the best way to insulate wiring. In the old days asbestos insulated wire was sometimes used. Today a wire with silicone / fiberglass insulation is available (high temp oven wire). I have not tested this wire enough to make a recommendation. Some people wrap the wire in aluminum foil; this may not help as much as one would think. Aluminum has a low melting point (1100 F) and since it is a metal, conducts the heat inside almost instantly. Better is to wrap the wire with a fiberglass cloth and then foil to keep the flames from flowing through the cloth. Outside, between mortars, the wire can be covered by a thin layer of dirt.

Most mortars (shotgun with sand or gasoline, or V pan) will melt the wiring together due to the heat of their explosion. This in itself is not a problem since all of them on a circuit go off together. The problem comes if the same circuit is used to operate a device that needs to stay on longer (valve on a propane mortar). The melted wiring shorts out the power and the valve closes too soon. Separate firing lines should be used. See section #7.

6) Methods of wiring

There is almost too much information to cover on this subject. Some setups with only single bullet hits on individual wires are almost too simple to bother discussing. The largest setups with multiple devices of different types on long wires are so complex that the definitive answer on wiring has yet to be determined.

Check out Figure 1.

Notes on FX firing systems

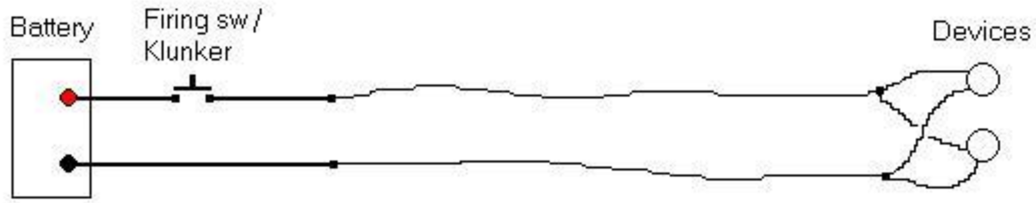

Fig. 1a Basic connection with a few squibs at the end of wire run.

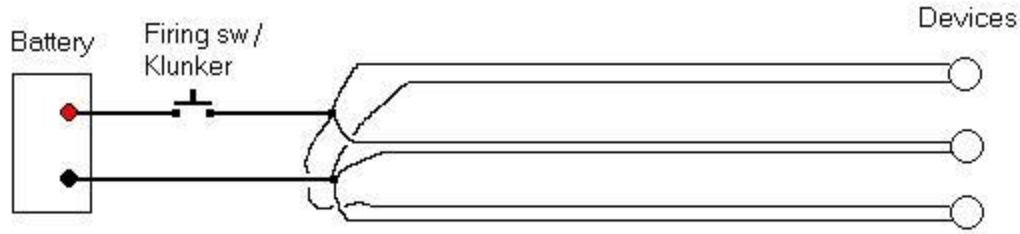

Fig. 1b Each device on its own run of wire tied together back at the button / klunker box.

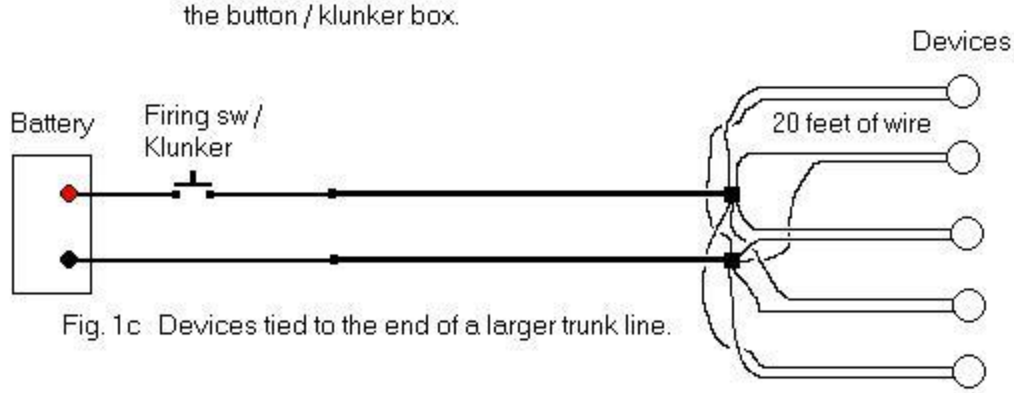

Fig. 1c Devices tied to the end of a larger trunk line.

Each of these connections might appear to be same, each connecting multiple squibs to a single button or Klunker box output. However, they are not the same electrically, as to how the current divides. In an ideal world the current would divide equally and the same amount flow to each of the branches. In practice, the way current divides depends a lot on the method of connecting the loads, especially if there is a short in one of the load branches.

The first diagram is how we usually connect multiple squibs to the end of a firing line. This works OK to a point, up to 4 squibs / igniters of the same type. The problem occurs if one of the devices has low resistance and draws more current than the others. This reduces the current in the others, possibly below their firing point.

However, when this first one fires the current now increases in the rest, firing them. This action takes place so fast that it is not noticed.

The problem occurs when one of the devices is shorted (defective from the factory, miss wired, left shunted, or shorts during firing). This short drains all the power in the firing wire and the other squibs may not fire. Larger batteries will not help. Connecting more batteries in series may help since the larger voltage will force more current down the wire, overcoming the short.

The second picture shows one method of overcoming this problem. Since each squib is on its' own wire the current flow to each is more balanced. A short on one wire may draw a lot of current on that wire, but the other squibs will still receive a fair share. This assumes that the battery can supply enough current and the button wires are large enough to carry the total current without too much loss (14 gage or so). We have had good success with this idea; almost no miss fires. We might use this when we have a mixture of squibs and black powder lifters on the same position. It just takes a lot of wire to set up.

The 3rd picture shows an intermediate solution. A large trunk wire is run to the firing area and then split into smaller wires to the squibs. The trunk wire should be at least 4 wire gages heavier that the 20-foot tails to the squibs. We would use a 14-gage main line with 22 gage wires to the squibs.

This connection also divides the current evenly. If there is short on one of the branch lines the trunk line still supplies enough current to fire the other branches. A mistake is to wire the branches with the large wire size. If a short takes place on a branch with large gage wire the result is the same as if all small wire used. A similar result takes place if the branch wires are too short. Branch wires that are only 2 – 3 feet long do not have enough resistance to divide the current properly.

Which of these choices to use is up to the user. Experience and whether or not you can accept a few squibs not firing is the deciding factor.

BIG setups

We have done a couple of explosions that require even a more complex setup. These explosions consisted of a mixture of squibs, black powder lifters, primer cord detonators, and propane mortars. A total of more than 200 connection points / devices were used. The main concern is enough power to set everything off, with timing being the next big concern.

Figure 2 shows the plan of a relay board we make to provide power to multiple loads. The coil terminals of the relay go back to the Klunker box or a battery button setup. The relay board and its' batteries are placed fairly close to the devices with the button and its' batteries much further back with the firing person.

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There is a specific order of going hot to use this safely.

a) All batteries un-hooked.
b) The shunt must be on the relay board.
c) The wires to the relay coil must be shunted at the firing position.
d) All squibs and devices are connected to the buss bar terminals.
e) The relay contacts are tested for an open condition with a digital VOM.
f) The batteries are connected to the relay board.
g) The shunt removed at the relay board. You are now HOT at the board.
h) Go back to the firing position
i) Go HOT at this position by connecting the coil leads to your source.
j) Fire when ready.

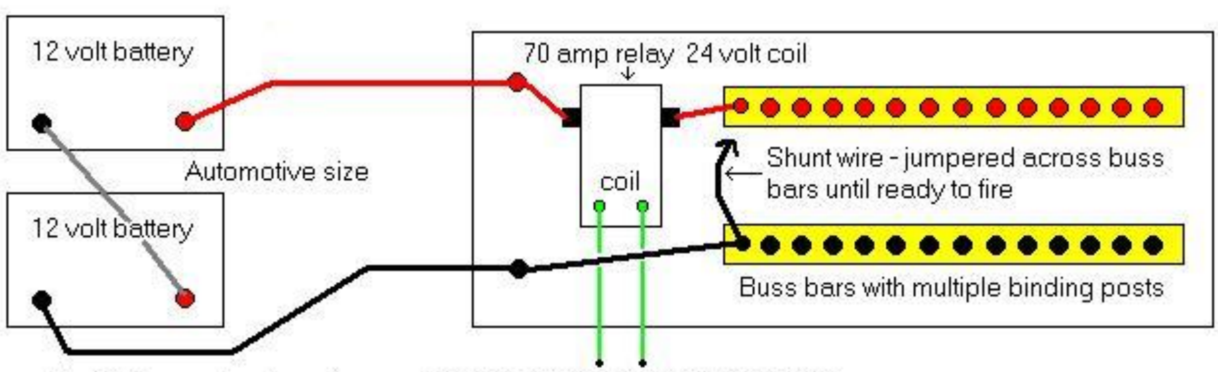

Fig.2 Power relay board

This relay setup provides a huge amount of current to the squib wires on the buss bars. Each device or squib is run to the buss bars separately. A short on one wire has no effect since the battery source is close enough to burn it off if needed. The relay board is normally placed no more than 50 feet away – behind the set, with the coil wires going to the firing position.

This setup has several advantages. Less wire is used since the runs are all short. Lots of power is available with the batteries so close. Finally, the firing line to the relay coil carries little power. This is a more complex setup. People must be trained in its use and understand the order of connections so as to not have an accident.

(No fig. 3)

Figure 4 is a diagram of a relay board controlled by a single push button switch. We would use this setup when we have a lot of squibs to fire a once and don't want to run all the power through the button. Once again the relay board is placed near the hits and the button with it's' battery run back to the firing position. This setup has been used with 25 squibs / hits on a single relay board.

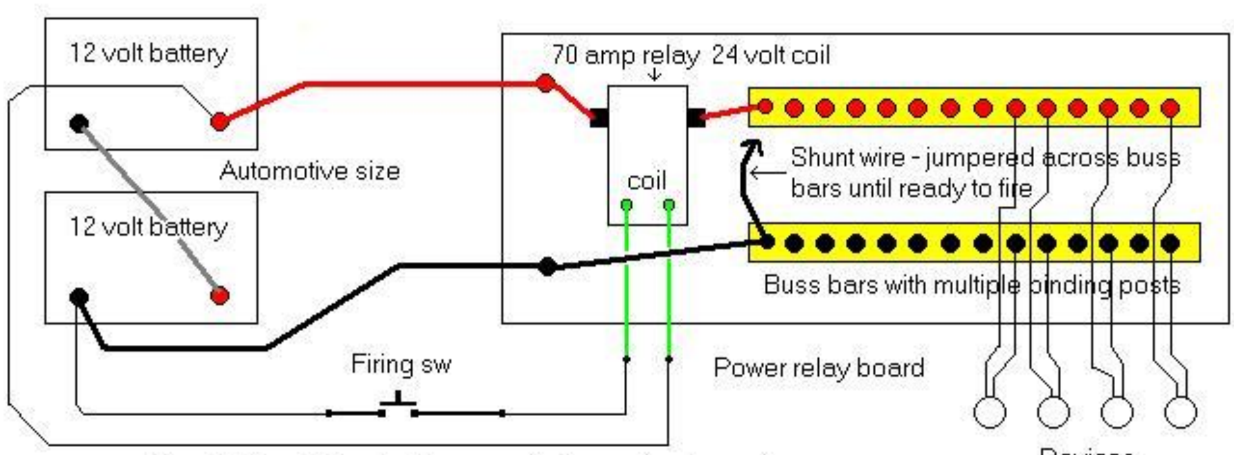

Fig. 4 One firing button controling relay board

The output of the relay board can also run mixed loads such as valves on propane mortars and squibs and igniters. There is enough battery power that the limitations discussed in the next section (#7) don't apply.

7) Different types of loads

It is a bad practice to mix different types of loads on the same wiring run. In fact, it may be bad to even put these loads on the same button or battery.

Putting squibs on the same line with igniters for black powder is normally OK. The speed at which these items ignite / fire is so fast that normally all of them have fired before wiring damage can cut them off. The exception seems to be too many devices on the run causing some to not get enough current to fire them quickly (over 10 devices per run). Also, black powder lifters inside of wet sand mortars may absorb enough water to slow down their firing speed.

A big problem exists with valves / mechanical devices tied to the same line with igniters. The wiring may short out once the explosion starts thereby cutting power to the valve. An example of this is a propane mortar lit by a pyrotechnic igniter; the short will shut the valve before much of a fire ball even forms. The solution may be separate buttons or firing output connections. Latching or timing relays are also sometimes used (with valves).

It may even be necessary to use separate battery sources to insure that the short on the firing line doesn't drain power from the valve controls. This, by the way, is the reason that we tend to use batteries that are much larger than the load would seem to require (section #3).

8) Series connected circuits

We use very few series connected circuits. Most people are used to parallel connected circuits and would have a very hard time getting the connections for series circuits correct. Example: If you wish to add a hit to an existing line in parallel you just splice into the existing run anywhere. In series you can also do it anywhere, but you cut just one wire of the pair and splice in the new run so that the current loops through it. This is very confusing to the untrained.

A bigger problem exists due to the type of squibs and devices we use. Many of the squibs and such have not been tested or qualified to work in series. It is possible for some to fire and cut the circuit to others before they fire. This is especially true if we use a mixture of squibs, detonators, and igniters on the same line. Professional blasting detonators are tested for series circuits and are often used that way with high voltage firing circuits. Most professional devices are also millisecond delay devices. With these every device is ignited internally before the first one fires externally.

In short, I have little experience with series circuits and can't offer much guidance.

9) High voltage systems

Most of our present experience with high voltage is using a capacitive discharge system running at 300 – 350 volts. This can be a device with one output (our Mini Blaster) up to a box with 8 outputs, each with its' own capacitor. We often use these units to fire squibs on short wire runs because it's convenient and they have safe / arm / fire positions.

High voltage systems are used where the devices / squibs are far away. This often used as series circuit with approved devices. Often only one of two wires are run out. These wires start the firing line which then consists of a non-electric system such as primer cord (det cord) or Nonel (shock tube system).

I do not have a lot of experience high voltage systems and will present more information as I find it. Most high voltage systems are used by mining and demolition companies, and have limited application in our field.

10) Klunker box systems - limits

Most Klunker box systems are low voltage (12 – 24 volt) devices and are designed to be used for bullet hits and strafing runs with no more than 300 feet of wire. Usually only one or two squibs are connected to each wiring point. A problem occurs as more distance or more squibs are used. As more squibs or more wire is added the amount of current available to fire the devices goes down. Eventually the shot becomes unreliable.

There has been some discussion of designing and using a higher voltage box, in the 48 – 60 volt range. These designs are difficult for several reasons (voltage stress on components, regulation of the internal logic voltage, and control of the magnitude of short circuit currents). Further research in this area is on going and a new design may be possible.

Even with a higher voltage the same problems with shorted wiring or too much load on the firing lines remains. The only solution is careful design of large layouts and an understanding of the limits of your equipment. The diagrams in section 6 should be studied, tested, and adapted to your needs. The problems in some layouts with mixed loads and large distances can only be solved with multiple firing sources or non-electric methods.

The speed control on standard Klunker boxes is not a precision adjustment. The knob indications are a reference to return to the same place, not an indication of a precise speed. You must time how many hits go by in 1 second and adjust the time by eye. The fastest speed is approximately 40 hits per second (25 milliseconds per), this is not a millisecond timing box for miniature work.

Obviously, the switches (arm, one/rapid, fire int. / ext.) must be in the correct position or nothing will happen. The easiest switch to get wrong is the internal / external firing button selector switch. (This switch is no longer on the newer boxes) If you are using a hand held firing button the switch must be in the external position. Use the hand held switch even for testing. Do not use the button on the box, as switching back and forth makes it very easy for the switch to be in the wrong position when the cameras roll.

11) Shunts

There is much discussion on shunting of the wires going to the squibs. Shunting is needed for safety and is required by most rules and regulations. However, shunting does not make a system 100% safe; there are conditions that will fire a shunted system anyway. And shunts left in a system may stop firing from occurring, causing even more problems. To understand shunts and their limitations it is necessary to understand all the possible ways the squib bridge wire (or the squib itself) may be heated up to the ignition point. It is the current that heats the bridge wire inside the squib, not the voltage. The voltage only serves to push the current down the wire.

Shunting the wiring does make the system safer. It prevents someone from accidentally hooking the wires to the firing board. They have to actually un-twist the wires and connect them to the terminals. Hopefully they think about whether they should do this or not. Also, dropping the bare wire ends, even on a battery post will not fire the squib. If the wire ends were open you could drop them on a battery and touch both terminals and fire the squib. This is unlikely, but could happen. And finally, the people hooking up the squibs like to know the other end is shunted. Not just a bunch of bare wires lying about on the ground.

There are limitations on what a shunt can prevent from happening. Some events will induce enough energy into the wiring system to fire the squib anyway.

AC voltages induce voltage through transformer action and capacitor charging effects. This is the reason we do not use AC power to fire things. The moment the first wire of AC system is connected, a current flows. This is due to the AC voltage charging and discharging the capacitance of the wire and causing an inductive current flow with the earth. If the wire is long enough (over 50 feet?) the current flow will fire the squib. This may happen even if the wires are shunted since the current flows back and forth in both wires from capacitive charging even on an open circuit.

As a note, the mining industry does use AC power sometimes. They will use a shunted DPDT (double pole, double throw) switch to un-shunt and apply AC power in the same throw of the handle. This is used to fire one large shot down in the mine from outside, at a distance of thousands of feet of wire.

A large enough radio transmitter will cause a similar problem. The firing wire acts as an antenna, picks up energy, and has a current flow in it. The exact amount of current depends on the transmitter power, how close it is to wire, orientation to the transmitter antenna, total length of wire, and if the length is close to the resonate frequency length. All this makes it hard to determine a safe transmitter size and distance, so usually we avoid any transmitters within 50 feet.

There are exceptions to this even. It is hard to believe that a cell phone could transmit enough power to fire something, but I wouldn't chance it without extensive testing. In the opposite case, I would not run firing lines within ½ mile of high tension power lines or 1 mile of 50,000 watt radio station transmitters without running the wire out and testing for residual current in the wiring before connecting the squibs.

Shunts will not prevent firing if enough power is applied to the wiring. The shunt can only carry so much power, depending on its connection quality, wire size, and distance to the squib. It is possible to apply 12VDC to 1000 feet of wire that has a shunt only one foot away and still fire the squib at the end of the wire. This is because the shunt carries 70 amps of current and burns up, but still a half an amp flows down the other wire and fires the squib.

12) Static electricity

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I have no good information on static electricity safety as pertains working with the squibs commonly used in our business. Certainly some level of charge and spark would fire the squib.

One should never work with squibs if a storm with lighting is coming or nearby. I have seen an electrician shocked while holding a stretched out 200 foot long piece of wire when a strike hit the ground 1 mile away. This was caused by the ground current flowing to the impact point inducing a current in the wire he was holding. Would this have fired a squib? No way to tell. If work must be done where lighting is common, there are radio like electronic devices that can warn of approaching lighting storms.

Obviously one should not wear any synthetic clothing that causes static charge while working with squibs. Basically any time you are wearing something that causes static shocks every time you touch something that is grounded is a bad idea. Also, I wouldn’t work with squibs on carpet or wrap squibs and squibbed items in plastic.

In summary, I do not know how to determine what level of static is safe, but I would do my best to avoid all sources.

13) Klunker box shunts and limits

Most Klunker boxes do not have internal shunts on the outputs. This is due to a couple of reasons.

In an electronic klunker box relays have to be added to shunt the outputs until the box is armed. This adds a complexity and cost to the box. Although safety should not have a price assigned to it, the added complexity can make the box less reliable. Since there is no way to rapidly test all the shunts without metering every output before each use, shunts could be defective and the user would not know it. This could lead to a false sense of security. Internal self checking could be added, but this adds still more complexity, therefore reducing reliability. Simple might be better.

Secondly, there is a limit to the power handling capability of any shunt. A large enough voltage spike will overload the shunt and it would not function as a shunt. A large current surge or static discharge could fire the squibs even if shunted through the box. This level is hard to determine since these boxes are used in such widely varying conditions.

In short, shunts would be useful to increase the safety of a klunker box (and may be included on future versions), but could not be counted on to prevent the firing of squibs under all conditions. A Klunker box with internal automatic shunting relays might also give the user the impression that they are protected fully from accidental firing, but that is not the case.

14) Electrical tape

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There has been a report in the mining industry journals of static electricity from using plastic electrical tape (Scotch 33) setting off squibs and explosives. I have not read this myself.

The possibility of this can be seen in a dark room. As the tape is pulled off the roll a faint blue glow can be seen at the point where the tape separates from the roll. This is static electricity being generated. However, it is doubtful if there is enough power generated to charge up a person's body and then fire a squib.

I worked as an electrician for 15 years and never felt even the slightest tingle of static electricity while using any type of tape. Just generating static electricity is not enough, the charge must be generated and then charge something to produce the spark. Like when you walk across carpet on a cold dry day, which charges up your body compared to the ground, and then touch a metal object. Holding a roll of tape in your hand and unrolling it with the other will not charge up your body with respect to the ground or other object.

There is probably more to the chain of events than just using plastic tape. I think that the chance of plastic tape causing a misfire is tiny. Also, most of the time paper tape is used to insulate the connections we make since it is quick and the connections are temporary.

15) Computer sequencers

Computer controller sequencers are widely used to fire pyrotechnics. All large aerial displays use a computer system to sequence the display to music. These control systems are amazing in their ability to control large events spread over large areas. Precise timing of each output event is built in.

However, I feel they are of limited use to the average special effects pyro-technician. Specialized control modules and cables are required. There may be limits to power available on each output, not allowing multiple squibs to be connected to one pin. The biggest drawback is learning the control system language and how to program it. Most people do not have enough time to become proficient enough to program the system in a hurry and not make mistakes. This is especially true after 12 hours on set and suddenly changes have to be made.

A simple firing system or Klunker box is much easier to use for the average setup.

BATTERIES:

APPENDIX #1

Notes on FX firing systems

Most people have a misconception pertaining to Ni-cad batteries. Everyone knows that Ni-cad batteries have a memory effect and must be run down to a dead condition before recharging to prevent this. This is not completely correct.

A Ni-cad cell (part of a battery) can be run down to a dead state without harm and recharged. This also prevents the memory effect. The problem occurs in a battery made up of many cells. As the battery goes dead, some cells die before others (due to manufacturing differences). You notice this in a drill motor as it starts to slow down 5 minutes before it finally doesn't have enough power to do the work. As the cells die the good cells are now forcing current through the dead cells and attempting to reverse charge them. This reverse charging eventually damages the cells and finally causes a shorted cell.

The way to prevent this is use the battery until it no longer easily provides enough power (the drill has trouble driving the screws), and recharge it at this point. Do not continue until the battery has no power left (the drill motor won't even turn). This use of 95% of the battery's power will prevent the memory effect and prolong its' life.

This information is direct from Ni-cad battery manufacturers.

Metal Hydride batteries are of similar characteristics as Ni-cad, and can be used the same way.

APPENDIX #2

Lithium and Lithium-ion batteries are a relatively new development. They are touted as the new long lasting, high power, light weight energy source. However, they might not be the answer to powering firing systems, at least not yet.

The batteries require a special charger. Using the wrong charger will cause the battery to explode / catch fire! There is no way to check the charge level in a battery without specialized equipment. A battery designed for a drill motor might supply enough current under most conditions, but all lithium batteries reduce the output current when they are overloaded. Without manufacture's specs there is no way to know where the overload point is.

Also, many charger / battery packs do not properly cycle the cells in a pack. This results in a total power capacity of no better than a Ni-cad battery after a few dozen cycles.

At the moment there is no advantage in using lithium batteries for our needs.

LIMITATIONS OF THIS INFORMATION

Notes on FX firing systems

This document is intended to provide ideas and insights on different methods of firing squibs and devices for the Motion Picture Industry. I do not pretend to have covered every possibility. Each person / team should use these ideas in conjunction with their own to perfect the best system. No one should try a setup that they are not comfortable with and that they have not tested off camera. All local safety rules must be followed. I can not be held responsible for one's inability to follow directions, work safely, or connect wires in the proper order.

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