Operation of the Bisun P51m caving light

The rotary switch in the headset containing a P51m is used to control both wide and spot beams.
To understand the lamp operation, it should be understood that the control circuits for the two beams are quite independent, and each is connected to a different contact on the switch. Effectively a P51 is two lights in one headset.
Initially, it is best to consider only a single beam and its 'half' of the switch. The other beam works in exactly the same way, but is controlled by the other half of the switch.

Each time the switch contact for a beam closes or opens, the beam will change state - either altering its power level, or switching off. The key thing to remember is that whenever the switch for a beam is closed, the beam will be at high power, and whenever the switch is open, the beam will either switch to a lower power level, or turn off.

The P51m has a selection of different operating modes to suit different users.
Changing modes involves opening the headset and disconnecting/reconnecting power and removing/adding the 'jumper' - the small rectangular plastic block which slides onto the two pins protruding from one end of the circuit block.
The available modes differ in the number of power levels available (from 1 to 4), the presence or absence of various features.

By default, a P51m is supplied with both beams operating in mode 1, and most users are probably likely to leave it in that mode.

The operation of a beam in mode 1 is described in the following table:

Switch:	Already opened twice in last three seconds?	Previous 'open' state	First opening after beam turned on?	New beam state
Closes	N/A	N/A	N/A	High
Opens	Yes	Any	N/A	Off
Opens	No	Low	-	Medium
Opens	No	Medium	-	Low
Opens	No	Off	N	Low
Opens	No	Off	Y	Extra-low

If the switch is operated occasionally (only every couple of seconds or longer) the beam will go through an indefinite cycle of
off->high->extra-low->high->medium->high->low->high->medium->high->low, etc, with the beam always high when the switch is closed.

To turn a beam off in a 4-level mode, its switch should be opened three times in three seconds. This means that accidentally turning a beam off in normal underground use is unlikely, but deliberately turning off is easy once familiar with the light.

If turning on a beam that is off, the beam will go high when the switch is closed, and will then drop to extra-low power when the switch is first opened.
This means that the extra-low level doesn't get in the way of the normal operation of the light, but is relatively easy to access if required, which is why it is referred to as an 'extra' power level, and why operating modes with such a lowered first level will be described as having '2+1' or '3+1' power levels, rather than 3 or 4 levels.

Because the beams run on entirely independent electronics, any blend of power levels is possible, apart from having both beams high at the same time (since only one half of the switch can be closed at any one time, and so only one of the two beams can be high at any instant.)

Typically, for general caving, people use either a pure flood, or a mix of a flood beam with a lower level of spot.

While familiarising yourself with the lamp operation, it should be noted that since the LEDs are very bright, it is best to practice using the light while it is mounted on a helmet, or otherwise pointed away from the eyes, and in a space sufficiently dark to enable the various power levels to be investigated, or with a suitable relatively unlit surface to use as a target for the unit.

Practicing 'blipping' the switch - (quickly turning it from off to on and then back to off via a small movement of thumb and forefinger) is recommended. Delicate movements are probably the easiest way to successful operation.

Headsets can vary greatly in the amount of tactile feedback they provide to the user from the switch-control knob. Some headsets use a round knob which gives no indication of the switch position, and in some headsets, friction masks any mechanical feedback caused when contact is made or broken by the rotating switch contact, though cleaning and greasing the switch shaft can ease such friction in most cases.

Some people find it preferable to have the headset switch configured so that it can't be turned through a full 360 degrees, since that makes it easier for them to work out the position of the switch contact, and which way to turn the switch to control the spot and flood beams.
In an Oldham headset, this is normally easy to achieve by temporarily removing the rotating switch contact and withdrawing the switch knob, then removing the screw for the central switch contact plate, refitting the screw with a suitable metal washer underneath to raise the level, and finally replacing the switch knob and reattaching the rotating contact.
With the newly-raised central switch contact screw, the grub screw on the switch contact then prevents the switch from making a complete revolution.
If this alteration is done, one beam ends up being operated by a turn 'forwards' from the new central position, and one operated by a turn 'backwards'. Which is which depends on the connections between the two white control leads and the outer switch contacts in the headset, which can be swapped if the arrangement isn't the desired one.

On a P51, the power levels for each beam are persistent - battery disconnection while a unit is running will cause a temporary loss of light, but on reconnection the beams will power up at the brightnesses they were previously running at.

It may be noticed that when low or extra-low power are selected, the LED will flicker a little for the first few seconds, and then stabilise. This is an entirely normal part of the circuit operation.

Changing operating modes
To change modes (with both beams to go into the same mode):
a) Work out which mode number you wish to use
b) Disconnect the battery, and open the headset, taking care to apply pressure to the glass to avoid the glass and P51 rotating.
c) Rotate the switch through at least 360 degrees, and leave the switch so that the centre contact is not touching either of the outer contacts.
d) Pull the jumper from the circuit block
e) Reconnect the battery. Both beams should repeatedly be showing a cycle of one pulse of light, followed by a longer gap.
f) Replacing and removing the jumper once would cause the beams to give two pulses, followed by a longer gap, further replacements/removals will increase the number of pulses, all the way up

to seven, after which the light would revert to a single pulse.
g) When the number of pulses matches the number of the desired mode, the jumper should be replaced, the battery disconnected, the headset reassembled, and the battery reconnected.

Mode	Power levels	Lowered first level	Intelligent high	Power range
1	4 (3+1)	Yes	No	Normal
2	3 (2+1)	Yes	No	Normal
3	1	n/a	No	Normal
4	4 (3+1)	Yes	No	Economy
5	3(2+1)	Yes	Yes	Normal
6	4(3+1)	Yes	Yes	Normal
7	2	No	No	Normal

Modes with fewer than 4 power levels 'lose' the lower power levels, so modes 2 and 5 have high/medium/low levels, mode 7 has high/medium, and mode 3 has only high power.

Practically speaking, it is likely that most people would use mode 1 (or mode 2 if they wanted simpler operation). Mode 3 is mainly there to enable lending a light to someone who just wants an on/off setup. The other modes are there for historic reasons, or to satisfy specific customer requests.

The 'intelligent high' in modes 5 and 6 is something that some people may find useful.
In a mode with intelligent high, if a beam that is off is turned on and then turned off having been on for between 0.5 and 10 seconds, it goes off, rather than dropping to a low brightness setting.
This allows someone who typically uses just the flood beam for much of their caving to turn the spot beam on for a quick check along a side passage or up a pitch, and then turn the beam off immediately without having to do multiple manipulations of the switch.

Since most lamps are likely to be left on factory settings, the presence of the other modes won't affect operation of the lamp, though their existence is worth bearing in mind if a lamp does start to operate differently, especially if someone with tinkering tendencies might have had access to the lamp.
To quickly restore a unit to mode 1, disconnect the battery, open the headset, remove the jumper, reattach the battery, replace the jumper and then close the headset.

If desired (unlikely), it is possible to set each beam to a different operating mode. This is done by working out which switch contact relates to the beam with the lowest-numbered desired mode and following the steps above until the number of pulses matches that mode number, and then operating the switch to turn that beam on. This will set the mode for that beam, while the other beam can be advanced to its desired beam number and then step g) performed.

Battery life

If/when the battery becomes depleted to the point where it cannot sustain a beam at the desired power level, the beam will simply be run at whatever power the battery can sustain, and will slowly decline in brightness.
A good indication of battery depletion is if switching between medium and high power settings produces little or no change in brightness.

The approximate nominal capacities of various batteries are given below

NiMH AA	2000-2700mAh
Alkaline AA	~2700mAh

Headlite (NiCd, high capacity) 3000mAh
NiMH '18670' cells 4500mAh
4.5V alkaline 'flat pack' (Duracell MN1203 or equivalent) 5500-6000mAh

Current consumption (in milliamps) and light output (in lumens) per beam is approximately:

	Extra-low	Low	Medium	High
Economy (mode 4)	11mA/4lm	30mA/12lm	100mA/40lm	300mA/120lm
Normal range	16mA/6lm	50mA/20lm	165mA/70lm	500mA/200lm

On a normal range, it might be expected that an MN1203 or equivalent battery would deliver approximately 11 hours of high power, 33 hours of medium power, or 110 hours of low power. In real-life situations, things are a little more complicated.

The voltage of alkaline batteries drops gradually during discharge, from an initial 1.5V/cell to about 1.0V/cell at the end of their life, whereas a NiCd or NiMH cell tends to give a broadly constant 1.2V/cell until nearly depleted.

Additionally, everyone should note that at high current drains, *a*n alkaline battery will not supply ***anything like*** the nominal amp/hour capacity. For example, alkaline AA cells of ~2700mAh nominal capacity may only supply ~900mAh before exhaustion with a 1A drain, or 1800mAh with a 500mA drain), and so the battery life at high power may be much less than expected.

A depleted 4.5V alkaline battery may fail to supply enough voltage to fully power a beam at high power, but may still be capable of supplying a medium-power beam for many more hours. In contrast, with a 3xNiCd or 3xNiMH battery, something closer to the simplistically calculated life should be obtainable. Once a rechargeable battery is exhausted to the point where noticeable dimming occurs on high power, it is generally a relatively short further time before the battery is incapable of supporting even a medium power beam.

The main purpose of the economy range was to give an alternate set of powers with a longer worst-case runtime than the high range, particularly for use on expeditions, away from easy recharging of battery packs.
However, if someone is careful in their use of the high power range, avoiding the high power setting except for brief bursts, and used medium and low on the high range where they might otherwise use high and medium on the economy range, they could get longer runtime by staying on the high range.
The choice of range or whether to switch ranges really is down to personal taste and usage habits.

Though extra-low level is intended mainly for sitting around, in many kinds of passage, a beam on extra-low power can give adequate light for moving around in emergency situations once night vision has been achieved, with a quite usable short-range spot beam.
In such a situation, seriously long battery life can be obtained - running a single beam on extra-low power in modes 1 or 6, around 2 weeks of continuous runtime could be obtained from a single 4.5V alkaline flatpack, or 3 weeks in mode 4.

The power controller has a very low power consumption when a beam is off, and as a result, disconnection of the battery when the lamp is not in use is not strictly necessary as long as the user is confident that the switch will not accidentally get turned on. However, for long periods of non-use, it is probably advisable to disconnect the battery.

Warning - The supply for a P51 should be limited to no more than 4.5 Volts, which realistically usually means a 3-cell alkaline, NiCd or NiMH battery*, or a 3.7V Lithium pack. 4 or 5-cell NiCd/NiMH packs would have excessive voltage, and would be liable to cause damage to a P51.
Connection of a battery with the wrong polarity should not cause problems or significant current drain.

Safety
Avoid looking directly into the LEDs, or shining them into other people's eyes.

Care of your unit.
Whilst the circuitry is potted in resin and will run in a damp headset for extended periods, it is still advised to avoid getting water in the headset, primarily because of the potential effect on the reflector silvering and general electrical contacts. If the headset does get water inside, it should be opened and allowed to dry thoroughly as soon as possible after exit. Mud should be gently rinsed off, ideally not with hard water. Care should be taken not to touch or otherwise damage the reflector surface, as this may allow water to penetrate the thin lacquer coating and corrode the metal reflective layer underneath, impairing spot-beam performance.
One case of significant loss of reflector silvering seemed related to the use of Vaseline or similar on the rubber sealing ring, so such substances are best avoided.
Reflector replacement is possible if it becomes necessary.
If the unit is to be fitted to a headset known to have leaked in the past, it is best to address the waterproofing issues of the headset before fitting the unit.

Though it has not been a reported issue from any users so far, it is recommended to avoid placing a P-series light unit where it may end up pointing directly at the sun - optics work in both directions, and LEDs do not like high temperatures.

Finally, despite the effort put into making the P51 as reliable as possible, with independent control circuits for each beam, and built-in redundancy within each control circuit, it is still recommended to carry backup lights when caving, as one would with any other light source.

(*NiMH battery packs and chargers are available)

For any furter information, contact: sales@bisun.co.uk