Operation of the Bisun P51caving light

The rotary switch in the headset containing a P51 is used to control both wide and spot beams. The control circuits for the two beams are entirely independent, and each is connected to a different contact on the switch. To understand the overall lamp operation, 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 P51 has two power ranges, a 'high' range and an 'economy' range. Switching between these two ranges is achieved by disconnecting the battery, opening the headset, and using the jumper (the small plastic block with metal insert to either connect the two pins ofn the side of the circuit block together (high range), or not (economy range). When in the economy range, it is best to store the jumper by sliding it onto just one of the pins.
The P51 only reads the state of the pins when a new battery is connected.

The high range has different power settings for each level than the economy range, but operation of the two ranges is identical.

Each range has three basic power levels (high, medium, and low), with an added extra-low power level, though in normal use, the three basic levels will be the ones that are most encountered/ used. The operation of a beam is described in the following table:

Switch:	Already opened twice in last three seconds?	Previous 'open' state	Beam was turned back on quickly after last 'off'	New beam state
Closes	-	-	-	High
Opens	Yes	-	-	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 less frequently) the beam will go through the indefinite cycle of

off->high->low->high->medium->high->low->high->medium, etc, with the beam always high when the switch is closed.

To turn a beam off, 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 given a few minutes practice.

If turning on a beam that has been off for more than a few seconds, the beam will go high when the switch is closed, and will then drop to low power when the switch is opened.

If a beam is turned back on within a couple of seconds of having been turned off, the first (and only the first) low power level will be an extra-low.
This means that the extra-low level doesn't complicate the normal operation of the light, but is relatively easy to access if required.

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.) Frequently, a mix of a flood beam with a dimmer spot beam is a good choice for a lot of caving movement.

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 best way of operation.
To turn off a beam, as an alternative to three successive blips, it is worth experimenting with a 'through' manouvre - a half-turn from one off position to the other off position through the on position for the beam in question. Three through manouvres in short succession (alternating in direction) will turn the beam off.

It should be pointed out that headsets can vary greatly in the amount of tactile feedback they provide to the user via the switch-control knob. Some headsets use a round knob which gives no indication of the switch position, and in some headsets, the friction on the switch knob largely masks any mechanical feedback caused when contact is made or broken by the rotating switch arm, though a few minutes of cleaning and greasing of the shaft can greatly ease such friction in most cases.

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, giving a unit which operates much as a regular bulb would do, even with an intermittent power supply.

The actual power settings (low, medium, or high) being used by the beams are not stored until they have been unchanged for a few seconds, so a battery disconnection *immediately* after changing power levels may result in powering up at previously stored power levels. This should not be a problem in practice, and is only likely to happen in the case of particularly bad battery connections, which should in any case be attended to for other reasons.

General Usage
If sitting around waiting with other cavers, it is considerate to avoid running the wide-angle beam at high britghtnesses - at any given power level, the spot beam will be less dazzling for other people as long as the beam is directed below the level of their face

Some frugal cavers with good vision may find the lowest settings of the wide beam adequate for general use use when moving steadily in known cave passage, with occasional use of spot beam when distance illumination is required. In such a situation, very long battery life can be obtained - running a beam on extra-low in economy mode, something over a month of continuous runtime should be obtained from a single 4.54V alkaline flatpack.

It may be noticed that when low and extra-low power is 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.

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 maximum level the battery can sustain, and slowly decline in brightness. A good indication of battery delpetion is if switching between medium and high power settings produces little or no change in brightness.

Battery life

The approximate nominal capacities of various batteries are given below

NiMH AA	2000-2700mAh
Alkaline AA	~2800mAh
Headlite (NiCd, high capacity)	3000mAh
NiMH '18670' cells	4500mAh
4.5V alkaline 'flat pack' (Duracell MN1203 or equivalent)	5500-6000mAh

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

	Extra-low	Low	Medium	High
Economy	8mA/3lm	30mA/12lm	100mA/40lm	300mA/120lm
High range	15mA/6lm	40mA/17lm	165mA/70lm	500mA/200lm

On the economy range, it might be expected that an MN1203 or equivalent battery would deliver approximately 15 hours of high power, 45 hours of medium power, or 170 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, at high current drains, an alkaline battery will not supply anything like the nominal amp/hour capacity (for example, alkaline AA cells of ~2700mAh nominal capacity may only supply ~800mAh before exhaustion with a 1A drain, or 1600mAh with a 500mAh drain), and so the battery life at high power may be much less than expected.

A part-depleted 4.5V alkaline battery may just 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.

Low temperature *can* reduce the output of alkaline cells, though above freezing point, this effect is often not very severe.

With a prototype lamp, using LEDs about a sixth as efficient as those in a P51, a caver executed one 8-hour trip, and two subsequent three-day underground camping trips, (generally using one beam on medium power) on a single Duracell MN1203. Though the eventual output had declined below the regular medium power level, the user was still quite satisfied with the light output after his seven days of use.

The main purpose of the economy range is 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. If someone was disciplined in their use of the high power range, avoiding using the maximum setting except for very brief bursts, and using medium and low 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 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 gives adequate light for moving around in emergency situations once night vision has been achieved, with a quite usable short-range spot beam.

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 ~5 Volts, which realistically usually means a 3-cell alkaline, NiCd or NiMH battery*, or a 3.7V Lithium pack.
Use of 4xNiMH/NiCd cells would give no extra runtime compared to 3 cells, and would simply waste heat in the circuitry.
Use on an FX5 battery would risk serious damage and should not be considered.
Connection of a battery with the wrong polarity should not cause problems or significant current drain.

Care of your unit.
Whilst the circuitry is potted in resin and will appily 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 backs and charges are available)

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