Operation of the Bisun B17 caving light

The rotary switch in the headset containing a B17 is used to control both wide and spot beams, in a similar (though slightly more complicated) way to operation with conventional incandescent bulbs.

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 be at medium or low power, or off. When this document refers to a *switch* being on (or off), it should be understood that means the same as the switch being closed (or open), and it does not refer to the state of the beam that switch is controlling.

<u>Bulb mode</u>
In bulb mode, a beam is on at high power whenever its switch is closed, and off whenever its switch is open, just like a regular filament bulb would.

<u>Simple Mode</u>
In simple mode, a beam is on at high power whenever its switch is closed. When its switch is open, a beam is either at medium power or off, depending on the recent history of operation. If the switch is opened twice within ~3 seconds, the beam will be off, otherwise the beam will be on at medium power.

Put another way, what this means is that if the switch is alternately closed and opened quickly, the lamp will go through the simple cycle:
off->high->medium->high->off
If the switch is operated occasionally, and is not opened **twice** within 3 seconds, the beam will switch between high and medium power with each closing or opening of the switch. This means that occasional changes to the power level underground will not result in the beam turning off, but the beam is easy to turn off when desired.

<u>Advanced mode</u>
Advanced mode is similar to simple mode, but with an extra low-power setting available.
If the switch is operated quickly, the basic advanced-mode cycle is:
off->high->low->high->medium->high->off
If the switch is operated occasionally, and is not opened **three** times within 3 seconds, the beam will go through the indefinite cycle of high->low->high->medium, etc.
If a beam in advanced mode is on, and the switch hasn't been operated in the last 3 seconds, 3 switch openings in quick succession will turn the beam off.

The high power setting corresponds to a current consumption of ~360mA, with a light output of upwards of 30 lumens.
Medium power is ~1/3 of the high power setting in terms of current consumption and light output
Low power is ~1/4 of the medium power setting in terms of current and light output.

Note: B17s are normally supplied pre-programmed to run both beams in advanced mode, to enable users to experiment with this mode without the need for programming the beams.

While familiarising yourself with the lamp operation, it should be noted that since the LEDs are more than bright enough to leave temporary dark spots in your vision, 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. In a headset mounted on a helmet, this is probably easiest if the switch is in the off position such that turning the switch clockwise (top forwards) will operate the contact for the beam in question. In real-life usage, it is most common for the spot beam to be turned on and off more often than the wide beam - many people leave the wide beam on medium or low throughout a trip, and turn the spot beam on briefly when desired. For such operation, it is suggested that the switch is habitually left in the 'off' position such that a brief turn forwards (clockwise) will operate the spot beam, since a forwards blipping of the spot beam to turn it on or off is easy, and it can be convenient to leave the switch in one standard position to make it easier to know which way to turn it. Particularly if using advanced/advanced mode, just turning the switch round and round is unlikely to select any particular desired combination of lighting levels.
To examine the state of the wide-angle beam, it is best to turn the spot beam off, as an operating spot beam may make comparison of the various wide-angle power levels difficult.
To turn off a beam in advanced mode, 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 through the on position for the beam in question. Three through manouvres (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 can greatly ease such friction in most cases.

Jumper-in and jumper-out operation.
As well as the choice of three power modes per beam (bulb, simple, and advanced), the B17 can operate in one of two overall modes, depending on the state of the two-pin 'jumper' which can be seen protruding from one end of the resin-encapsulated control circuit block behind the reflector.
These two overall modes are known as ***traditional*** and ***programmed*** mode. Irrespective of the power-mode states of individual beams, the whole B17 unit runs in either traditional or programmed mode, since both controller circuits read the state of the single jumper.

Traditional mode overview

Connecting a battery to a B17 with the jumper removed (jumper pins visible) will cause it to start up in traditional mode (the way the previous 'Mig 134' model operated).
(If you do not wish to alter the programmed settings of a B17, make sure you do not re-connect the jumper while a B17 is connected to a power source.)
In traditional mode, the individual power-modes for each beam can be selected during a brief power-up period when the battery is changed, and each beam will also give a low-battery warning by a brief flickering. (The low-battery flicker-warning is given a maximum of three times per battery change, after which it is assumed the user will be aware of the battery problem, and will not desire any more reminders of the battery state.)
With good battery connections, traditional mode provides the ability to easily change the power modes for each beam with a closed headset simply by manipulating the heasdset switch at battery connection.
However, if used with a poor battery connection (typically a problem with some aged or corroded plug-and-socket battery connections subject to mechanical stresses), the unit may be repeat-

edly forced into its power-up sequence, which can be annoying for the user.
However, even for someone planning to use the B17 permanently in programmed mode, (ie most people), it is worth understanding traditional mode to some extent, since traditional mode is briefly used when selecting the power-level modes to be programmed into the unit for use in programmed mode.

Power-mode selection in traditional mode.
If the jumper is absent, and the battery is disconnected for more than a few seconds, when it is reconnected, the unit will enter its start-up sequence, during which the power-modes are selected.
a) If the switch for a beam is already closed when the battery is reconnected, the beam will be set to operate in advanced mode until the next battery disconnection.
b) If the switch for a beam is open when the battery is connected, the LED for that beam will start flickering. If the switch is left open, the flickering will carry on for ~5 seconds, the LED will then shine steadily for ~0.5 seconds, and will then extinguish. In this case, the beam will be in simple mode until the next battery reconnection.
c) If the switch for a beam is open at battery connection, but is closed while the LED is flickering, the beam will be set to bulb mode.

Programmed mode overview

Programmed mode was designed specifically to cope with poor battery connections, but also gives some advantages in terms of simplicity of use, and it is expected that the most users will use their B17 in programmed mode. In programmed mode, the power-modes (bulb, simple, or advanced) for each beam are programmed into the B17 by a specific process, and once programmed, the power-mode settings are retained indefinitely until deliberately changed by the user.
Not only is there no power-up sequence, (with the power modes for each beam being persistent across battery disconnection), but the actual power *levels* for each beam are also 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 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.
There is **no** low power warning in programmed mode. In practice, when running in either simple or advanced mode, a reasonable indication of battery state can be obtained by switching between high and medium power - if little difference in beam brightness can be observed, the battery is approaching depletion.

Powering up a unit in programmed mode
If the jumper is present when a battery is connected, the unit will power up in programmed mode. Subsequent removal of the jumper will have no effect unless power is later interrupted while the jumper is absent (in which case, the unit will power up in traditional mode).
In programmed mode, both the power-modes for each beam and the actual power settings for each beam are preserved through power-off - if the unit was running in programmed mode with the spot beam at high power in bulb mode, and the wide beam at medium power in advanced mode, then that is how the unit will power up after a disconnection of power for a fraction of a second, or for many months. Effectively, powering up a unit in programmed mode is rather a non-event.

Programming modes into a B17
Remember that a B17 only requires programming very occasionally, when the user wishes to

alter one or both of the power modes programmed into the unit.
To set the power modes to be used in programed mode, the B17 should be started up in traditional mode, and the user should be familiar with how to set power modes in traditional mode. If the jumper is subsequently replaced while a beam is operating (high, medium or low power), then the future power **mode** *for that beam* is programmed into the unit, depending on the power **level** the beam is operating at.

If a beam is operating at **high** power (in either bulb, simple or advanced mode), **bulb** mode is programmed.
If a beam is operating at **medium** power (simple or advanced mode), **simple** mode is programmed.
If a beam is operating at **low** power (advanced mode), then **advanced** mode is programmed.
If the jumper is replaced whilst the lamp is powering up (both beams flashing), then both beams are programmed to **simple** mode. This is the **factory reset** operation, and may be useful for people simply wishing to get a simple setup with little effort.

After connection of a battery with the B17 jumper removed, each beam only responds to the **first** time the jumper is replaced while that beam is operating, and ignores any jumper replacement while the beam is off. This means that if a lamp is started up in traditional mode, then the jumper is replaced while the wide beam is running and the spot beam is off, the only the wide beam power-mode will be programmed by that jumper replacement. Without further disconnecting the battery, if the jumper is removed, both beams are set running and the jumper is replaced, then only the spot beam power-mode will be programmed by the second jumper replacement, since the wide beam had already been programmed by the first jumper replacement.
If only the operation of a single beam is desired to be reprogrammed, simply make sure that the other beam is not running at the point the jumper is replaced.
If a unit is powered up with the jumper removed, and the jumper is not replaced until after the power is removed, the programmed modes will be unaltered.

The user should be aware that there is a short delay between replacing the jumper and the circuit programming a new mode, so the user should wait for ~4 seconds after replacing the jumper before removing it or disconnecting the battery. Additionally, programming sets the power-mode that ***will*** be used for beams when the unit is next powered up in programmed mode. Until the power is removed and then reapplied, it will continue to operate in traditional mode, with the power-modes selected when it was powered up.

To get both beams programmed to advanced mode, it will be necessary to power the unit up twice with the jumper removed, and each time one beam should be set to advanced mode (its switch closed during battery reconnection). It should then be set to low power, with the other beam off, the jumper replaced, and left for a few seconds. The jumper and power can then be removed, and the procedure repeated for the other beam.
It is possible to program any other power-mode combination with only a single power-up in traditional mode. Simply make sure that the relevant beams are running in appropriate power modes, set the beams to the appropriate power levels (high power if you wish program bulb mode, medium to program simple, low to program advanced), replace the jumper, wait for ~4 seconds, then remove and reconnect the battery.

General Usage
In practice, it is expected that advanced mode is most likely to be used when battery economy is of greatest importance, such as when expedition caving, or in a low-battery situation, though it can also be useful to have a low power mode available when not moving, such as when camping or sitting waiting for other cavers to arrive (or clear the next section of rope). Additionally, given the extreme intensity of the Luxeon LEDs, if frequently sitting around *with* other cavers, it is considerate not to be running the wide-angle beam at medium or high power to help avoid temporary black spots in the eyes of companions.

Some cavers may find the low setting of the wide beam adequate for 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 (roughly 7x24h of constant use) might be obtained from a 4.5V MN1203 battery. Alternatively, if forced to cave with a nearly-dead battery and no spare, another option is to set the *spot* beam to advanced mode, and use it on the low setting. While the close-up lighting would not be bright, the weak spot beam can still light up relatively distant features, enabling progress even over uneven terrain.
It may be noticed that when low power is selected, the LED will flicker a little for the first few seconds, and then stabilise. This is entirely normal, and nothing to worry about.

In traditional mode, at high and medium power levels, if the controller detects that it is not able to supply sufficient power to the LED, it will warn the user of this by a short flickering. During this flicker, the LED is mainly on, but with brief periods off, and so does not constitute a hazard if actively caving when the flicker starts. Each LED will flicker a maximum of three times per battery, after which time it is assumed that the user is aware of the low-power situation.
If in medium power mode, the beam will maintain whatever power level it can after flickering, giving plenty of time with a gradually dimming beam before battery change is required. If in high-power mode, the beam will switch to medium power after flickering. After three low-power-flicker events, selecting high power will cause the circuit to give whatever output it can manage.

In programmed mode, if the battery becomes depleted to the point where it cannot sustain the beam at the desired power level, the beam will simply be run at whatever level the battery can sustain, and slowly decline in brightness.

Battery life
The approximate nominal capacities of various batteries are given below

NiMH AA	1800-2400mAh
Alkaline AA	~2700mAh
Headlite (NiCd, high capacity)	3000mAh
NiMH 7/5 AF cells	3500mAh
NiMH '18670' cells	4500mAh
4.5V alkaline 'flat pack' (Duracell MN1203 or equivalent)	5500-6100mAh

One beam at high power gives roughly 3 hours per Amp-hour
One beam at medium power gives roughly 8 hours per Amp-hour
One beam at low power gives roughly 30 hours per Amp-hour

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 (~2.5-3 hours high power per nominal battery amp-hour) should be obtainable.
Once a rechargeable battery is exhausted to the point where noticeable dimming (or the flicker warning in traditional mode) 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 ef-

fect is often not very severe.

Experimental example (one beam operating):
Using 3x2000mAh freshly charged NiMH cells, (in traditional mode), high power lasted for 4h38m, and medium power for a further 0h54m, Then, with the lamp still running on the medium setting, the power had declined to half medium-power level (twice low-power level) after a futher hour.
In this case, if the beam had been started on medium power, it would probably have lasted for 14-15 hours before starting to decline. Assuming the cells actually did have 2000mAh capacity, the warning on high power happened at about 80% of capacity, and the medium power warning after another 5%
It can be seen that even with rechargeable cells, which tend to have a steep drop-off of voltage when nearing exhaustion, there was a very gentle decline of output as the batteries emptied.
Real-life example:
With a prototype lamp, 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 - a spot beam running at well under medium power is still more than adequate for safe caving.

The power controller has a very low power consumption in 'sleep' mode (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 B17 should be limited to no more than ~5 Volts, which usually means a 3-cell alkaline, NiCd or NiMH battery. Use of 4x NiMH cells would be possible, but would give no extra life compared to 3 cells, and would simply waste heat in the circuitry.
Use of an FX5 battery would risk serious damage and should not be considered.
The control circuits are protected against reverse voltages that can occur due to incorrect installation into a headset, or from misconnection of a battery.

Care of your unit.
Whilst the circuitry is potted in resin, has so far proved immune to water problems, and is likely to temporarily fail safe even if water did somehow penetrate the resin, it is still advised to avoid getting water in the headset, primarily because of the potential effect on the reflector silvering.
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. 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.

Finally, despite the effort put into making the B17 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.

Contact: cavelights@bisun.co.uk