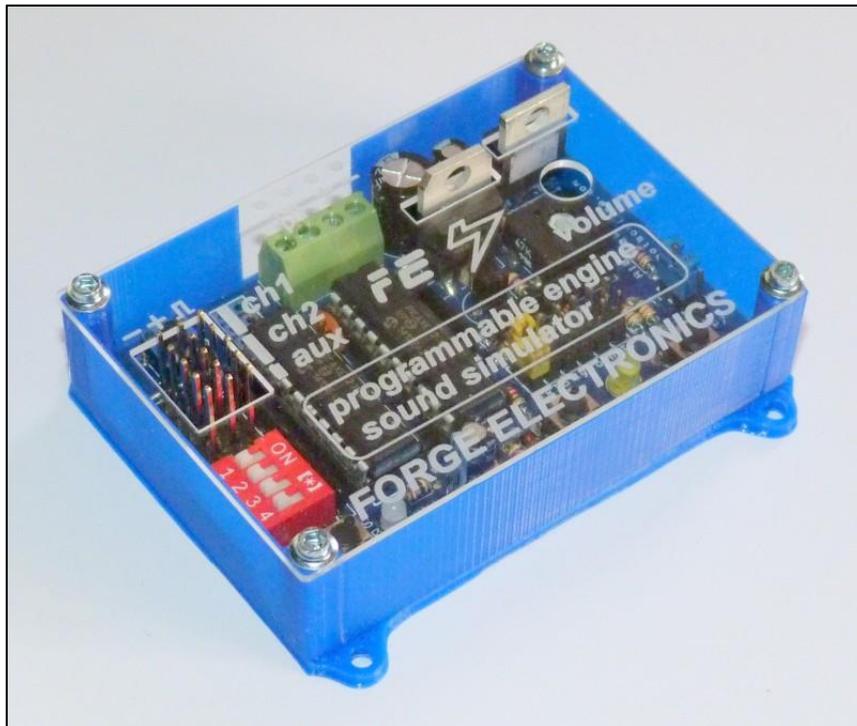




PROGRAMMABLE ENGINE SOUND UNIT MK2

This Manual is for the POTENTIOMETER CONTROL Option



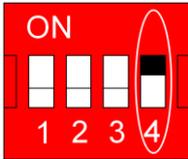
No longer marketed by Technobots, these units will remain available from Forge Electronics (the original designer/manufacturer) until current stocks of PCBs are exhausted. A new lower profile 3D printed case has been designed but the original functionality remains unchanged.

A digital synthesized sound unit with 20 petrol/diesel 'voices' - 10 factory presets plus 10 that the user can interactively adjust to better suit the type of model in which it is fitted. Speed demand input may be by the usual RC interface or by potentiometer for use in manually controlled vehicles such as the 'Toylander' electric ride-in vehicle for children.

ABOUT THIS MANUAL

The user can choose to control this unit by either a standard radio control receiver or by a throttle potentiometer and switches. Either mode of operation may be selected by a configuration option switch.

Both options have differences in behaviour dictated by the control method and require to be wired up differently. Thus it was judged that a universal manual would be confusing to use.



This is the **POTENTIOMETER CONTROL** version of the manual. Before proceeding further, check that switch 4 of the configuration option switches is set to the ON position to configure the unit for **POTENTIOMETER CONTROL**.

INTRODUCTION

This sound unit can synthesize a wide range of multi-cylinder petrol/diesel engine sounds, all the major engine operating parameters (tick over, top speed, number of cylinders, engine 'voice') being user adjustable by a simple selector link and push-button interface (see the following overview for details).

In all cases the engine sound varies smoothly and proportionally with the throttle demand.

The engine has an adjustable idling time-out (typically set by the user to around 20 seconds) after which it runs down and stops. Opening the throttle again causes the engine to re-start following a short "cranking" sound. Alternatively, the user may connect a toggle switch to start and stop the engine at will. A push-button switch may also be connected to sound a built in horn, whose pitch is adjustable.

Unusually, the sound unit also allows users to synthesize their own engine sounds, full control of the pitch and duration of all the cylinders is supported by a simple selector link and push-button interface.

The sound unit is simply controlled by connecting a potentiometer to its input. The unit provides power to the potentiometer track and responds to the voltage picked-off from the potentiometer wiper. This control potentiometer is intended to be mechanically coupled to the potentiometer controlling the motive power to the model. ***The sound unit WILL NOT accept a raw input voltage from a potentiometer which is already connected to a speed controller. Damage to one or both units is almost certain to occur!***

'Neutral' (i.e. throttle closed) is expected to be set at one end of the potentiometer, though the sound unit can cope with any neutral setting within the entire range of the potentiometer. The neutral condition is indicated by a case mounted status LED which assists in setting up the travel of potentiometer. The range and the neutral zone of the throttle response may also be set by a simple push-button procedure.

As the sound unit was originally intended for radio control installations, the unit's electronics expected to take their power from the receiver supply, so in this application the user must provide a separate source of 5v for the unit – a 4AA cell NiMh battery pack for example or a 5v voltage regulator device coupled to the main battery of the model. The loudspeaker derives its power from the model's main propulsion battery, ***but a limit of 12v applies***. Models using higher voltages for traction will often use two or more 12v batteries

in series for that purpose and so 12v could be tapped off from the lower battery in the chain, which is probably already utilised to power lights and indicators. See the installation diagrams for examples of powering the unit.

The engine sound volume is adjustable by a PCB mounted rotary potentiometer.

Connections for speaker power and the loudspeaker itself are made using screw terminal blocks.

OVERVIEW

This sound unit carries on from where the original Technobots Petrol and Diesel Sound units left off, and not so much replaces them as compliments them, although the original units only featured radio control inputs. The original sound units continue to be small, affordable, entry-level products whereas this sound unit in a slightly larger package scopes the sound range of the two earlier sound units and offers a whole host of *additional* features as follows:-

- Push button setting to match the neutral and span over the entire range of the control potentiometer travel – this function also includes the option to double the width of the neutral zone to make throttle setting less critical for the engine's auto stop facility
- Provision to connect a toggle switch for manual control of engine start/stop
- Provision to connect a push button to operate a horn - uses the engine speaker, replacing the engine sound whilst operated - sounds at maximum volume regardless of engine volume setting
- Push button adjustment (during real-time operation) of
 - Tick over
 - Top speed
 - Number of cylinders – from 2 to 6, though single cylinder operation is simulated in voice #6 (see later)
 - Engine 'voice' – 10 fixed, 10 custom (user defined) characters
 - Pitch of the horn
 - Idle timeout period (only valid for auto start/stop option) – 0 to 90 secs in 10 second increments, or continuous running
 - Voice designer mode (for custom voices only)
 - set pitch for each cylinder (128 possible values)
 - set duration for each cylinder (5 possible values)

All settings are saved into non-volatile memory and are retrieved at switch-on the next time the sound unit is powered up.

- Volume control – controls engine sound volume only

SPECIFICATIONS

Speed demand sensing method

User connected throttle potentiometer. Impedance not critical, typically 1K to 10K values recommended, 20K maximum. Linear track required.

Neutral (idling) signal condition

May be set by push button anywhere within the potentiometer range

Throttle span adjustment

Ensures zero and full throttle conditions can be achieved for potentiometers producing less than their full resistive range due to mounting/linkage considerations.

Receiver voltage (which powers the sound unit's electronics)

4.8V min to 6V max **DO NOT USE A "6V" LEAD ACID BATTERY – a fully charged one of these can output as much as 6.6v. Neither are four AA primary (single use) 1.5v cells suitable – brand new they typically output 6.8v rather than the expected 6v.**

Speaker impedance

8 ohm minimum (Technobots part no. 2400-015 recommended)

Speaker supply voltage

From zero to '12v'. There is a 16V rated capacitor across this input, exceed this voltage at your peril! A fully charged 12V lead acid battery will be in the region of 13.5V and hence is ok, **but 12 cells NiMH, a nominal '14.4v', will exceed 16V when fully charged and is NOT ok.**

Engine 'voices'

20 different voices (10 fixed, 10 user defined), encompassing 'petrol' and 'diesel' characters

Number of cylinders

Selectable from 2 to 6, though single cylinder operation is simulated in voice #6 (see later)

Engine stop/start

Choice of automatic or manual – automatic is determined by the throttle demand and the idling period, whereas manual responds directly to a user fitted toggle switch.

Engine idle timeout

For the case of automatic start/stop, the idling period may be set from zero to 90 seconds in ten second increments or optionally continuous running may be set.

Engine Slow Down/Stop

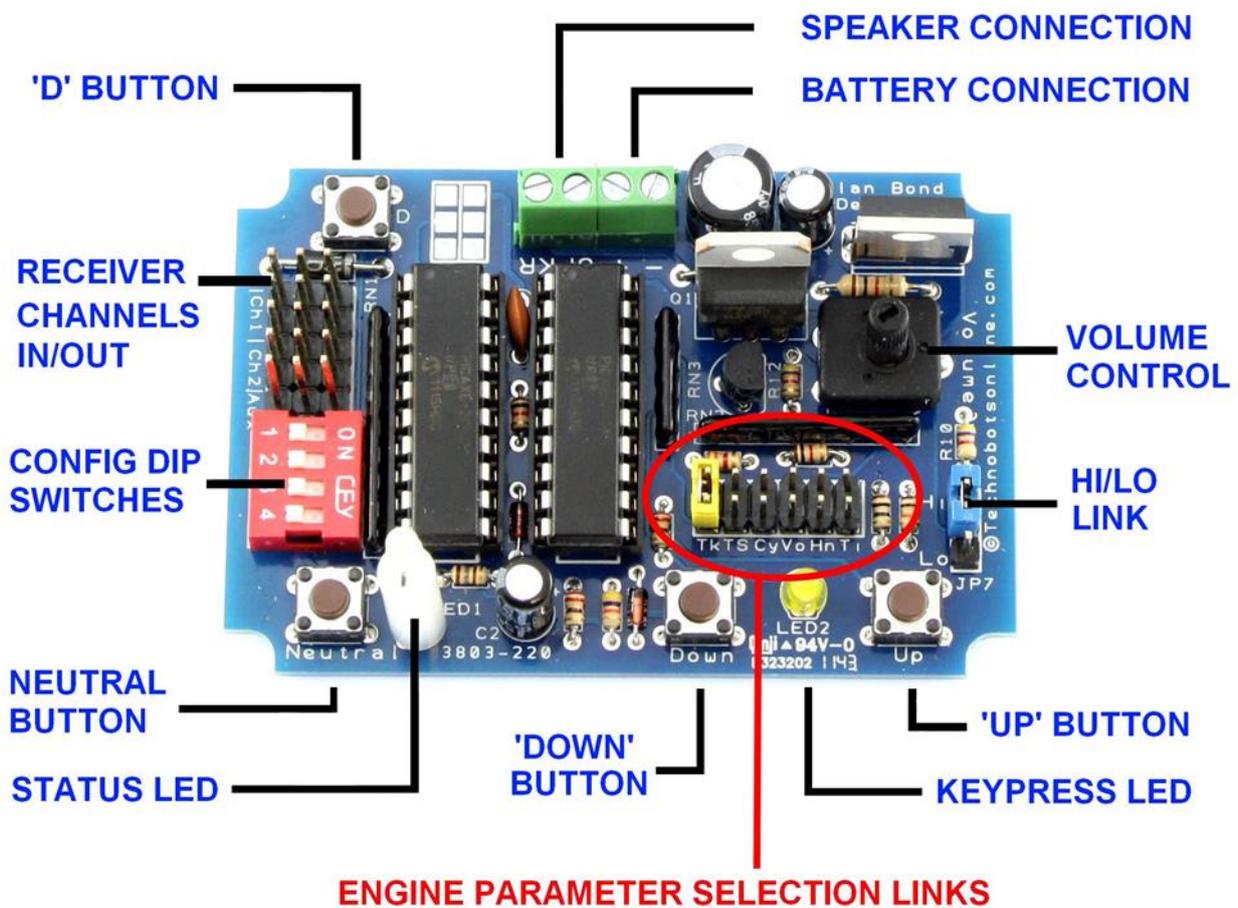
Choice of fast or slow stop to simulate engines with normal or large heavy flywheels.

INSTALLATION

What's In The Box?

On the top of the box there are four fixing screws which allow the lid to be removed from the box to reveal the sound unit inside for the purpose of making connections and setting up its parameters. When replacing the lid **do not over-tighten the fixing screws** – these are self-tapping into relatively soft plastic and you may strip the threads.

The photograph below shows the location of the connections and the principal controls.



Make connections to the sound unit (as described later), configure it and try it out with the lid removed. If for easier access the unit is removed from its box, to avoid short-circuiting the exposed PCB tracks, make sure that it is not placed on a metallic surface or a surface contaminated with metal debris.

Only fit the sound unit back into its case when it is ready to be installed in the model. Note the case is for mechanical and splash protection only, it is NOT waterproof, so its location in the model should take this into account.

For the case to offer a low profile, slots have been made in the lid to clear the metal tabs of the two tall power devices – ***these tabs are live (though at safe voltages) and must not be allowed to be shorted together or contact any other electrical connections***

Key to above photograph

- **Speaker connection** – 8 ohm minimum
- **Battery connection** – '12v' maximum (see specifications)
- **Volume control** – adjusts the volume of the engine sound, but the horn always sounds at maximum volume regardless of this setting, note that minimum volume does not yield silence (by design)
- **Hi/Lo link** – used to best match the mechanical range of the volume control to the user's battery voltage
- **'Up' button** – increases the value of the selected engine parameter
- **Keypress LED** – acknowledges pressing of 'Up' or 'Down' buttons – also on permanently to indicate sound unit is in voice designer mode, in which case it briefly extinguishes to acknowledge a button press
- **'Down' button** – decreases the value of the selected engine parameter
- **Status LED**
 - Solid red – engine stopped in neutral
 - Blinking red at engine revolution rate – engine is running in neutral
 - Blinking green at engine revolution rate – engine is running
 - Solid green – engine is running at full speed
 - Flashing orange – error condition
- **Neutral button** – press at any time to set neutral, press at switch-on to set neutral, throttle span and neutral zone
- **Configuration DIP switches** – set engine start auto/manual and rc/potentiometer input options
- **Input channels** - Ch1 accepts input from a throttle potentiometer. Ch2 accepts input from a toggle switch for manual start/stop of the engine. Aux channel accepts input from a push button switch to sound the horn
- **'D' button** – in normal running this is the 'Data' button and via audible 'beeps' allows the user to verify settings of cylinder count, 'voice' and idle time-out values. In voice designer mode, this is the 'Duration' button and in conjunction with the 'Up' and 'Down' buttons allows the user to adjust the duration of the exhaust pulses from each cylinder. Additionally, at power-up only, this button sets either fast or slow engine run-down/stop (toggle action)
- **Engine parameter selection links** – move the yellow jumper link to the following positions, marked on the PCB, in order to adjust the appropriate parameter by means of the 'Up' and 'Down' buttons
 - Tk – tick over speed of the engine
 - TS - top speed of the engine
 - Cy - number of cylinders in the engine
 - Vo – 'voice' of the engine
 - Hn – pitch of the horn
 - Ti – time period of engine idle before auto-stop

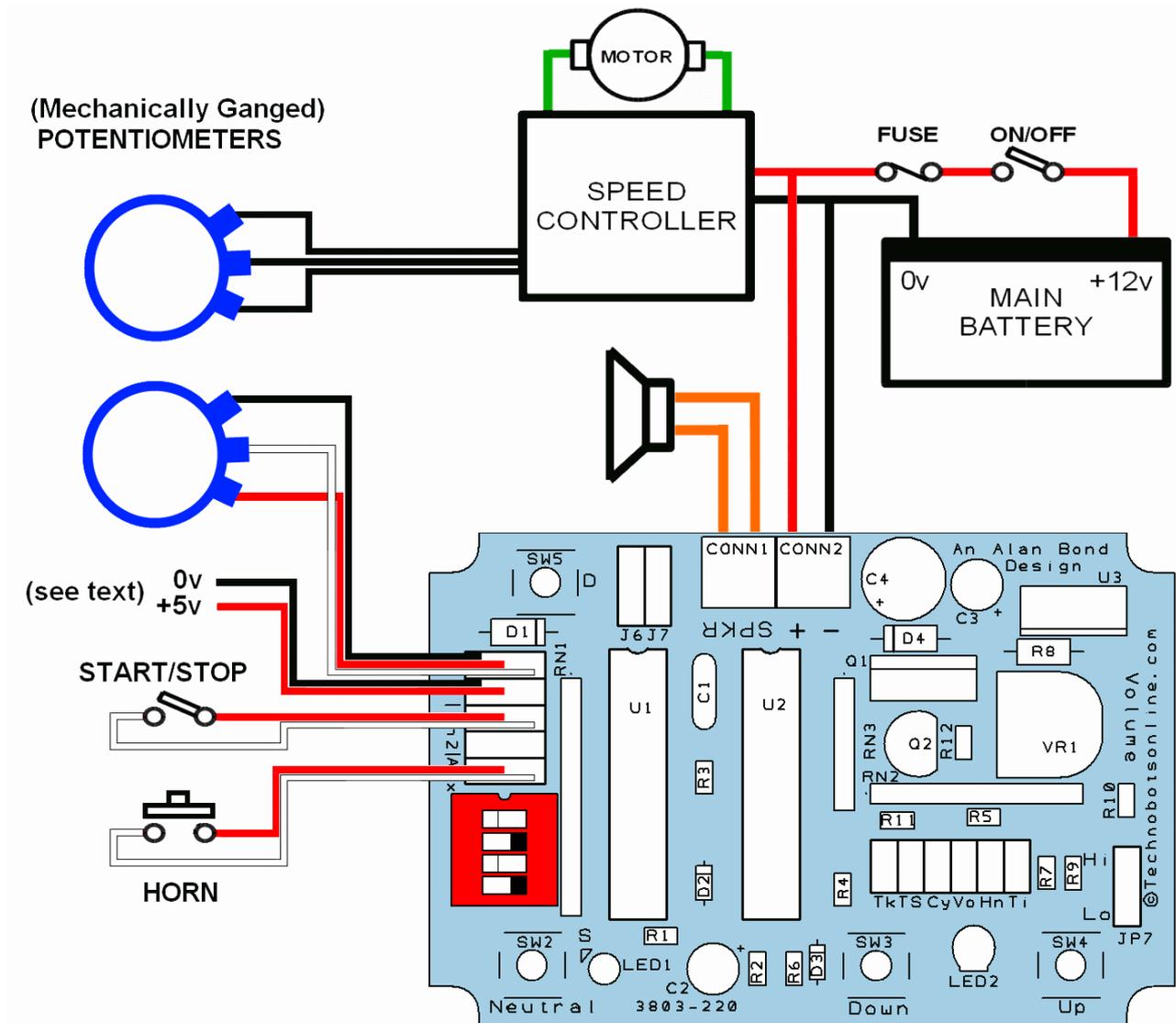
Connecting It Up

Leads

This sound unit was originally designed for installation in RC (radio controlled) models and therefore the signal inputs use standard pattern RC connectors. Only much later on was I persuaded to adapt it for potentiometer control for use in Toylanders, so as a result the connectors are less than ideal for this application. Thus the user is supplied with a 3 way male/male Futaba RC lead for the potentiometer and two 2 way JST leads for the start/stop and horn switches. The 3 way lead will need one plug cutting off and the leads extending to reach the potentiometer location. Similarly the JST leads also require extending.

Wiring Diagram

The diagram below shows a typical configuration. The push button switch may be omitted if the horn function is not required. Similarly, the toggle switch may be omitted if the user prefers automatic rather than manual start/stop of the engine. **Configuration Options DIP switch #4 must be set to the ON position.** DIP switch #2 can be set to ON or OFF to select either manual or automatic start/stop of the engine. The horn function is permanently enabled and so does not require configuration.



Configuration DIP Switch Settings

	OFF	ON
#1	X	X
#2	auto	manual
#3	X	X
#4	r/c	pot

If the throttle sense is found to be reversed (i.e. the full speed sound occurs with the throttle closed and vice-versa) then simply swap the red and black wires on the throttle potentiometer or invoke the neutral/span setting procedure at power-up with the throttle in the desired tickover position.

Provision of +5v Supply

In RC (radio control) systems, for which the sound unit was originally intended, this supply usually comes from a nominal 5V BEC (battery eliminator circuit) which is already in place to supply the receiver and servos.

Thus for non-RC equipped systems the user must provide this supply themselves, for which there are three options:-

- A separate '5v' battery pack
- A commercial BEC
- A home-made 5v voltage regulator



A battery pack can be made up using 4 AA cells in a suitable holder – preferably a type that is both enclosed and switched, such as Technobots part 1063-063 (shown here).

Only re-chargeable NiMh batteries yielding a nominal 4.8v (1.2v per cell) may be used.

Primary (single use) cells yielding a nominal 6v (1.5v per cell) when fresh can give up to 6.8v so must NOT be used. Note also that a nominal '6v' lead acid battery when fully charged can output as much as 6.6v so must NOT be used either.

A typical commercial 5v BEC is shown here, which can drop the typical 12v speaker supply down to the requisite 5v, thus avoiding the logistics of accommodating and charging an extra set of batteries with the benefit that the main power switch will also switch off the 5v output from this unit. It also benefits from being supplied with a standard RC lead/plug which is directly compatible with the sound unit.

The unit shown is Technobots part 1062-017





The final option is to make your own 5v regulated supply using a three terminal voltage regulator such as the L7805 - Technobots #2230-110. Depending on the main battery supply voltage you may need to use a heatsink. *This option is only suitable for those able to design and construct such circuitry themselves.*

Notes On Wiring

The speaker battery supply and speaker wires must be connected to the sound unit prior to the box being refitted. A slot in the case side allows the wires to exit.

The control potentiometer, push button and toggle switch leads may be connected through the aperture in the top of the box, taking care to observe the polarity marking on the label – this means the black lead to the edge of the box and the white (or sometimes orange) lead to the centre of the box.

The screw terminal connectors (rated 10A) for the battery and speaker will accept wires whose conductor size is up to 1mm². As the currents involved are quite modest it is not necessary to use thick cable such as that used for the motor(s) in your model. 16/0.2mm equipment wire (rated 3A) is suggested.

Speaker Installation

Inevitably the size and construction of the model may preclude the recommended speaker being used and if in addition its installation is less than ideal, then both the volume and quality of the sound will be compromised.

Connect the sound unit up to a loose speaker on the bench and prepare to be disappointed! The sound quality needs to be judged with the speaker properly mounted in the model.

Speakers are ideally mounted on a baffle – this is usually a piece of wood whose width is about twice the diameter of the cone with a hole in it about the size of the cone (determined by the speaker mounting arrangement). The purpose of the baffle is to prevent the anti-phase sound waves from the rear of the cone 'leaking' round to cancel out the sound waves from the front. The higher the frequency the more sound tends to travel in straight lines and is therefore less able to 'leak' round to the other side of the cone. Thus it's the bass response that is lacking from an unmounted speaker. Hi-fi speaker cabinets are generally sealed to achieve this. The hull of a boat makes an excellent substitute if the speaker can be mounted beneath the cabin using the entire deck as a baffle and the sound can escape through open portholes, windows, doors or ventilation grilles.

If you make the sound sealing box too small, the speaker will struggle to compress the air in it (the cone displacement will be making a large percentage volumetric change) and the volume and sound quality will suffer.

If in any doubt as to the sound unit's capabilities, kidnap a compact music-centre loudspeaker, connect it up and hear the result. Anything sounding less rewarding than this represents the magnitude of your personal battle to defy the laws of acoustics!

To appreciate the importance of the all the above and the dividends repaid by a bit of effort, the following testimonial, for the original Technobots (Petrol) sound unit is published below (by courtesy of Peter Bone)

Just thought I'd let you know that I got the sound unit installed and up and running for the Southend Model Power Boat club Annual Festival this weekend. Our guest judge was Andy Coulson of the Southwater Dabblers Club and he judged my boat 'Best in Show'! I'm sure the sound unit tipped the balance and helped me win.

The sound unit is terrific and attracted a lot of attention and several people asked me where it came from.

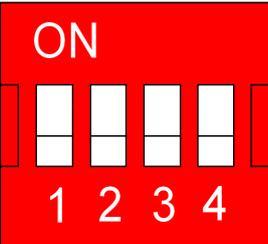
As you quite rightly said, the really difficult bit is mounting the speaker and getting the sound out. The model is Andy Griggs' 1/12th scale Cygnus 33 the one with the 'bulbous' bow. After quite a lot of experimentation I've mounted the speaker on a relatively small wooden baffle low down in the bow, facing upwards at an angle towards the underside of the wheelhouse floor. I put a cardboard tube (from a reel of tape) over the speaker, then I found that an empty container of Cadbury's cocoa powder just happened to be a nice sliding fit inside the cardboard tube, by sliding the cocoa container in and out (and shortening it) with the open end facing the speaker and the closed end upwards, I found I could 'tune' the note. The cocoa container is a cardboard tube with a metal bottom and the thin metal bottom needed a bit of 'damping' which I did with a disc of self adhesive felt, then I drilled a hole in the bottom of the container and fitted a piece of plastic tube about 15mm dia, this terminated just under the wheelhouse. I finally drilled a few holes in the wheelhouse floor in places where they were not visible from the inside as the wheelhouse is nicely fitted out and I didn't want to spoil the look from the inside.

CONFIGURATION

This section expands the information about the DIP switch settings given in the installation instructions above, and also introduces the battery voltage setting (Hi/Lo) link.

DIP Switch Settings

The following three options which relate to configuration of the radio control input channel(s) are located on the red 4 way DIP switch (DIP=Dual In-line Plastic). The switch positions for the various options are illustrated below.

	OFF	ON
		
1 [unused]		
2 ENGINE	auto	manual
3 [unused]		
4 INPUT	radio control	potentiometer

ENGINE

- **Auto Start/Stop** - the engine starts automatically when the throttle is opened. The engine stops automatically after a period of idling in the neutral condition (indicated by the status LED inside the case showing red). The user may set the idling period prior to the engine stopping in the range 0 to 90 seconds in 10 second increments. A further option is to have the engine running continuously.
- **Manual Start/Stop** – the engine starts or stops in direct response to the signal received on the Ch2 input connector. Simply opening the throttle will not start the engine (though the boat/vehicle will move accordingly) and likewise the idling time-out value set by the user is ignored if this option is selected.

INPUT

- **Radio Control** – the inputs are configured to accept signals from a standard radio control receiver in the 1mSec to 2mSec range
- **Potentiometer** – the inputs are configured to accept a potentiometer and toggle/push-button switches

DIP Switch #4 is checked at power-up and the unit then assumes the control method set by the switch position. Subsequent operation of DIP Switch #4 will not change the mode of operation, the unit producing an error buzz until the switch is returned to the position it occupied at power-up.

Battery Voltage

The remaining option is in an isolated location and its header is served by a blue jumper link (J7) whose options are marked 'Hi' and 'Lo'. This option best matches the (mechanical) range of the volume control to the loudspeaker voltage supply. For example, in the case of 6V and 12V systems, if only half volume can be achieved or full volume occurs at half rotation of the volume control then the jumper link needs to be altered to best match your battery voltage. The 'Lo' setting is optimised for 6V and 7.2V batteries and the 'Hi' for 12V batteries. The setting for intermediate battery voltage conditions is best determined by experiment.

OPERATION

Guided Tour

The sound unit may be operated immediately after installation and the information below is for the user to effect a quick guided tour of the capability of the sound unit. It is assumed that all the configuration links have been set to match the connected input channels and the main battery voltage as per the previous installation instructions. Thus, depending on the scope of the installation, not all functions described in the tour will be available to all users. It is also assumed that the user has familiarised themselves with the location of the various selection links and push buttons.

With the model on a stand to allow the propeller(s), wheels or tracks to run free, first zero the throttle potentiometer and power the model. The status LED should light up a solid red, signifying the throttle channel is in the 'neutral' condition and the engine should be silent.

However, if your closed throttle does not match the factory default neutral then at this point the status LED may be extinguished, or in the case of the auto start option or the start/stop function assigned to a toggle switch, the engine may have already started up on its own and the status LED be pulsing green at the engine revolution rate.

If so, press the neutral button and the status LED will go red, indicating the new neutral point has been set. If the engine was already running, the sound unit will settle to a slow idle and the status LED will be pulsing red at the tick over rate. If the engine was stopped the status LED will be showing a solid red. The neutral point is saved to memory and will match that of the throttle control the next time they are used.

If the sound unit is already running, then after approximately 20 seconds (factory default setting) of idling in neutral it will slow down and stop. Alternatively operate the toggle switch to stop the engine.

Depending on your installation, the engine may now be started in two possible ways:-

- opening the throttle
- operating the toggle switch

The speaker should issue a short cranking sound and the 'engine' should start and smoothly run up to full speed as the throttle is progressively opened, the status LED now showing green and pulsing increasingly faster with engine speed. At full excursion of the throttle potentiometer the LED should go solid green, signifying the engine is in receipt of the maximum possible speed demand. With the factory default 'span' setting this may occur slightly prior to full excursion, or maybe not at all. Setting the full dynamic range of the sound unit to match the 'span' of your control potentiometer is covered in the next part of this manual and need not be done for the purposes of the 'tour'.

With the throttle closed the engine should return to idling speed and the status LED should be pulsing red. The engine may now be switched off by operating the toggle switch, or waiting for (the factory default of) 20 seconds – or as appropriate to your configuration. The status LED will show solid red when the engine stops.

At some convenient point, the volume control can now be checked to operate. Note that (by design) the lowest volume setting does not yield complete silence, but is plenty quiet enough for the workshop or small exhibitions etc. Assuming a suitable loudspeaker and a decent acoustic installation, running on 12V at maximum volume the sound unit will be clearly heard right across a large pond or in a large noisy exhibition. Note the installation section gives information about best matching the range of the volume control to your battery voltage.

Now for the fun! Start the engine and let it idle. Place the yellow jumper link in the 'Tk' position and then set the tick over speed to your personal preference by use of the 'Up' and 'Down' buttons. A short stab of the appropriate button will effect a small change in tick over speed. The adjacent yellow LED will light for the duration of the press to provide visual confirmation of the press. Holding the button pressed will cause the speed to gradually ramp up or down and the button can be released at the desired setting.

At the extremes of the setting range a short high-pitched beep will be heard signifying that no further adjustment is possible. This scheme is used throughout the sound unit to indicate the limits of adjustment have been reached.

Now advance the throttle to full speed, move the yellow jumper link to **'TS'** and use the 'Up' and 'Down' buttons in the same manner as before to set the desired top speed.

At a fairly low throttle setting (suggested condition to best hear the variations) move the yellow jumper link to the **'Cy'** position and use the 'Up' and 'Down' buttons to adjust the cylinder count to personal taste. Unlike the previous use of the 'Up' and 'Down' buttons, holding a button pressed does not cause repeated adjustment, the buttons must be released to take effect. This makes for a far more positive selection 'feel'.

Depending on the number of cylinders chosen, the tick over and top speed may now benefit from being re-adjusted to suit the character of the engine afforded by its new cylinder count.

With a 4 cylinder engine set to a fairly low speed (suggested condition to best hear the variations) move the yellow jumper link to the **'Vo'** position and use the 'Up' and 'Down' buttons to cycle through the different engine characters available. The same positive selection style applies to operation of the buttons. The first ten 'voices' are factory presets and are fixed for all time, whereas the following ten voices (initially supplied with the corresponding factory presets installed in all of them, as a departure point for experimentation) are able to be adjusted by the user and their settings saved in memory for future use. A short "deedle-dee" sound warns the user that a custom voice capable of user adjustment has been selected. Development of custom engine sounds is covered in 'voice designer' section.

Moving the yellow jumper link to the 'horn' position allows the user to alter the pitch of the horn from a deep bass fog-horn to a high pitched air-horn sound, by use of the 'Up' and 'Down' buttons. The horn increments or decrements in pitch for each press of the 'Up' or 'Down' buttons and sounds at the current volume level setting.

Note the horn sound can be previewed this way even if the horn option has not been selected in the user configuration of the sound unit, though the volume control would need to be increased to its maximum setting to properly judge the final effect.

If configured, operating the horn switch will now sound the horn at full volume, regardless of the volume control setting. This is in view of the importance of the horn as a collision warning device.

If the sound unit has been configured for auto stop/start then the period of idling before the engine stops can be set by moving the yellow jumper link to the **'Ti'** position. The 'Up' and 'Down' switches adjust the idling period in approximately 10 second increments between 0 and 90 seconds. This link setting is ignored of course if the sound unit has been configured for manual start/stop of the engine. As the effect of this adjustment won't be apparent for some period of time, the sound unit will issue a number of medium pitched beeps to indicate the setting now selected. Each beep represents 10 seconds of idling time (the resolution of adjustment). Silence of course represents zero seconds. At what would be the 100 second option position, the sound unit issues 10 beeps but continuous engine running is now selected – i.e. the engine will only stop when the power to the sound unit is removed.

A fourth pushbutton marked **'D'** will later be used in the Voice Designer mode, but during normal operation it doubles up as a **Data** button. If in doubt as to the selected 'voice', number of cylinders or timeout values, pressing the **'D'** button with the yellow jumper link in

the corresponding position will cause the sound unit to emit a series of medium pitched 'beeps' related to the setting of the chosen parameter. These are distinctly different from the higher pitched 'beeps' indicating the extremes of adjustment. In the case of the user adjustable voices, the beeps are preceded by the "deedle-dee" sound as in the normal voice selection. Pressing the 'D' button with the jumper link in tick over, top speed or horn positions will cause a low pitched buzz, indicating that an inappropriate data request has been made.

That concludes the quick guided tour of the sound unit.

The Neutral/Span/Neutral Zone Setting Button

This button accesses two distinct procedures. The first procedure is really a configuration issue and sets up the neutral and then the span parameters to match those of the control potentiometer being used with the model and the width of the neutral zone to best suit the user. This procedure is only available at power-up time, and should not need to be repeated unless a different control potentiometer is subsequently fitted or its linkage is changed.

The second procedure may be accessed at any time whilst the sound unit is operating and sets up the neutral alone. This action does not affect the 'span' or neutral zone of the sound unit, and so it should only be used to correct minor deviations from neutral (i.e. 'drift').

The sound unit assumes a full range of control potentiometer movement, occurs but mounting/linkage considerations may preclude this, in which case without a span adjustment the user could not achieve the full speed range that the sound unit is capable of. Thus some adjustment of span to match the user's control potentiometer installation is desirable.

- ***Neutral , Span & Neutral Zone***

IMPORTANT – this configuration routine can only be entered at power-up. Prior to switching on the sound unit, the throttle potentiometer should be set to its desired (physical) neutral position. Press and hold the 'Neutral' push-button **prior** to powering up the sound unit.

After the sound unit is powered up, continue holding the button until the status LED shows solid red, to signify the successful setting of neutral. When, and only when, the status LED is red, release the push button and proceed to set up the span.

Having released the button, the status LED will now slowly flash red, inviting you to advance to the full throttle position. Once the throttle control has exceeded 50% of the larger of the two potential spans (if the neutral setting is asymmetric) the status LED will now rapidly flicker red and when the user has completed moving the throttle to its maximum excursion, the neutral button should be pressed a second time. The gain of the sound unit's throttle channel is now set such that full engine speed matches full movement of the control potentiometer. Unless the 50% condition (slow flash) is exceeded the sound unit will remain in this condition indefinitely. Similarly the sound unit will remain locked into the rapid flicker phase until the neutral button is pressed a second time.

The status LED will now go green, alternating between slow and rapid flickering every few seconds. This will continue indefinitely until the neutral button is pressed. For the factory default neutral zone setting, press the neutral button during the slow flicker phase, or to double its width press the button during the rapid flicker phase.

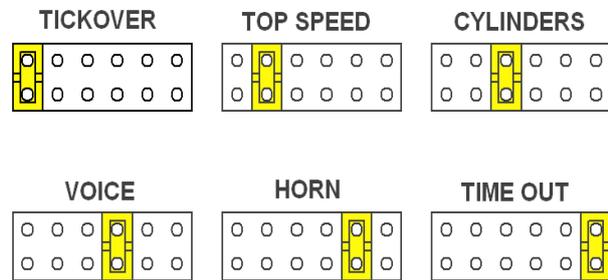
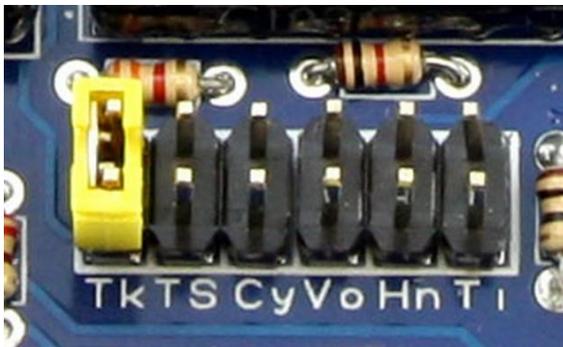
The throttle must be then be returned back to the neutral position to exit this configuration routine.

- **Neutral**

Apart from the opportunity to set neutral at system start-up, the ‘Neutral’ button may be pressed *at any other time* to set the sound unit's neutral point to match the current throttle position. Assuming the closed throttle currently yields a fast idle with the status LED pulsing green, then upon pressing the neutral button the status LED will show pulsing red and the engine will settle to the true tick over speed.

Sound Adjustments

These are effected by moving the yellow jumper link to the appropriate position on the header block and using the ‘Up’ and ‘Down’ buttons to adjust the selected parameter. Changes are effective immediately, their values being saved in memory for subsequent use.



The link positions are labelled on the silk-screen of the PCB but for clarity are also shown in the accompanying diagram.

To protect users from themselves, tick over, top speed, number of cylinders and voice can only be adjusted whilst the engine is actually running (it is all too easy to completely muddle your settings without the audio feedback of what the engine is doing!) Thus, attempting to set these parameters whilst the engine is stopped will result in the speaker emitting a low pitched buzz, warning that an inappropriate operation is being attempted. The horn and idle timeout may be adjusted at any time. Users will note some text is repeated in the following sections – this is to allow each topic to be read in isolation from the others, but there are in fact a few subtle differences so please read each section thoroughly to become aware of them.

- **Tick over**

Position the throttle at neutral position, ensuring that the status LED is pulsing red. Fit the yellow jumper link in the appropriate position on the header block. Pressing the up button will increase the tick over speed and pressing the down button will decrease it. At the extremes of the adjustment range a short 'beep' will be heard, signifying that no further adjustment is possible. When a button is pressed, the adjacent yellow LED will light confirming that the press has been accepted.

Because the buttons are only scanned once per full cycle of the engine, when a multi-cylinder engine is ticking over very slowly, it is possible that a very short jab of the button may be missed.

You may also press and hold a button, whereupon the tick over will gradually ramp up or down throughout its entire range. You will get a good indication of the tick over speed this way, but it may speed up slightly and thus sound fractionally different when the button is released as there is now less processing for the microcontroller chip to perform.

So, in summary, press and hold until the approximate tick over speed is achieved and then finalise it by short presses to single-step the adjustment.

- **Top Speed**

Position the throttle at full travel. Fit the yellow jumper link in the appropriate position on the header block. Pressing the up button will increase the top speed and pressing the down button will decrease it. At the extremes of the adjustment range a short 'beep' will be heard, signifying that no further adjustment is possible. When a button is pressed, the adjacent yellow LED will light confirming that the press has been accepted.

You may also press and hold a button, whereupon the top speed will gradually ramp up or down throughout its entire range. You will get a good indication of the top speed this way, but it may speed up slightly and sound fractionally different when the button is released as there is now less processing for the microcontroller chip to perform.

So, in summary, press and hold until the approximate top speed is achieved and then finalise it by short presses to single-step the adjustment.

- **Number of cylinders**

Be sure to move the throttle up and down during this procedure to best appreciate the overall effect of this adjustment. Fit the yellow jumper link in the appropriate position on the header block. Pressing the up button will increase the number of cylinders and pressing the down button will decrease it. At the extremes of the adjustment range a short 'beep' will be heard, signifying that no further adjustment is possible. When a button is pressed, the adjacent yellow LED will light confirming that the press has been accepted.

The press and hold function is not appropriate for this adjustment. Holding the button down will actually stop the engine sound altogether. The cylinder count is only altered when the button is released. Waiting for the button to be released has the effect of 'debouncing' the switch contacts so accidental skipping of a setting is avoided and the user experiences a very positive selection 'feel'.

Note that in the factory preset 'voices', some cylinders have a zero length exhaust pulse – this gap in the rhythm usually produces a very satisfying 'throbbing' sound, so for example in voice #1, this gap is introduced in cylinder 5, so there are 4 exhaust pulses but for reporting purposes the engine considers itself to be a 5 cylinder engine. A single exhaust pulse on its own does not sound very convincing, but in voice #6, only cylinders 1 & 2 are used, the remaining cylinders staying quiet – thus in 5 or 6 cylinder mode the two 'blats' close together followed by a long gap

**do* sound very much like a single cylinder engine. So although the sound unit only nominally supports 2 to 6 cylinder operation, a single cylinder sound can be simulated.*

- **Engine 'Voice'**

Be sure to adjust the throttle up and down and/or adjust the number of cylinders during this procedure to best appreciate the overall effect of this adjustment. Fit the yellow jumper link in the appropriate position on the header block. Pressing the up or down buttons will step through the different 'voices' available. At the extremes of the adjustment range a short 'beep' will be heard, signifying that no further adjustment is possible. When a button is pressed, the adjacent yellow LED will light confirming that the press has been accepted. To identify the 'custom' voices, capable of being adjusted by the user, a short 'deedle-dee' sound is played prior to a custom voice being asserted.

The press and hold function is not appropriate for this adjustment. Holding the button down will actually stop the engine sound altogether. The 'voice' is only altered when the button is released. Waiting for the button to be released has the effect of 'debouncing' the switch contacts so accidental skipping of a setting is avoided and the user experiences a very positive selection 'feel'.

- **Horn**

This may be adjusted at any time whether the engine is running or not. However, it cannot be adjusted whilst the horn is being asserted from the user's horn switch. If the engine is running, it replaces the engine sound each time an adjustment button is pressed. Users may prefer to stop the engine before commencing adjustment – but this is not essential. Fit the yellow jumper link in the appropriate position on the header block. Pressing the up button will increase the pitch of the horn and pressing the down button will decrease it. At the extremes of the adjustment range a short 'beep' will be heard, signifying that no further adjustment is possible. When a button is pressed, the adjacent yellow LED will light confirming that the press has been accepted.

The horn will sound for the duration of the button press and the pitch heard is saved when the button is released. Waiting for the button to be released has the effect of 'debouncing' the switch contacts so accidental skipping of a setting is avoided and the user experiences a very positive selection 'feel'.

- **Idle Time-out**

This may be adjusted at any time whether the engine is running or not. Fit the yellow jumper link in the appropriate position on the header block. Pressing the up button will increase the timeout value by approximately 10 seconds and pressing the down button will decrease it by the same amount. To indicate the setting achieved, a succession of medium pitched 'beeps' will sound – each 'beep' indicating a unit of approximately 10 seconds [e.g. 2 beeps=20 seconds, 3 beeps=30 seconds]. No beep=0 seconds delay of course. At what would be the 100 second option (10 'beeps') the engine enters a continuous running mode and will only stop when power is removed. At the extremes of the adjustment range a higher pitched 'beep' will be heard, signifying that no further adjustment is possible. When a button is pressed, the adjacent yellow LED will light confirming that the press has been accepted.

The press and hold function is not appropriate for this adjustment. Holding the button down will actually stop the engine sound altogether (if running). The timeout value is only altered when the button is released. Waiting for the button to be released has the effect of 'debouncing' the switch contacts so accidental skipping of a setting is avoided and the user experiences a very positive selection 'feel'.

Note the time-out periods are approximate – don't expect stop-watch precision here! There is no direct means of measuring time in the microcontroller chip, so engine revolutions are counted instead, appropriate compensation being applied at the different tick over speeds. But this means that different durations of the cylinder sounds in the various 'voices' can cause a small variation in the time-out value as indeed can a fractionally offset throttle as the idling speed can have some variation in the neutral zone, particularly if the larger of the two neutral zone options has been selected.

- **Volume Control**

If only partial volume can be achieved or full volume occurs at partial rotation of the volume control then the separate blue link on the 3 pin header JP7 whose insertion positions are marked 'Lo' and 'Hi' needs to be altered to best match your battery voltage. The 'Lo' setting is optimised for 6V and 7.2V batteries and the 'Hi' for 12V batteries. The setting for intermediate battery voltages is best determined by experiment.

Engine Slow Down/Stop

Two different rates of engine slow down/stop are available to simulate engines with large heavy flywheels (typically marine) or standard flywheels (typically road vehicles). To change between these variants hold the 'D' button pressed at power-up. Either a short or long 'beep' will be heard signifying the slow down rate now selected. Repeat the above process to swap back.

AUDIBLE WARNING SIGNALS

These provide feedback to the user in the categories of voice design, warnings, setting confirmation, and error conditions. For consistency, each category has a distinctive sound associated with it.

- **Voice Design**

Characterised by a short tune

- **Warnings**

Characterised by a single high-pitched 'beep'. This occurs during normal operation when pressing the 'Up' or 'Down' keys and indicates that the attempted adjustment has reached the limit of its range.

- **Setting Confirmation**

Characterised by a medium-pitched 'beep' or succession of 'beeps'.

- Idle timeout - the effect of adjusting all the other parameters can be heard immediately, whereas this setting could take up to 90 seconds to make itself known. Thus, each time the idle timeout is adjusted (in 10 second increments) a

succession of 'beeps' indicates the value just set. Obviously at the extremes of the range the high pitched warning 'beep' will be heard instead

- Number of cylinders – pressing the 'D' button will cause a succession of 'beeps' corresponding to the current cylinder setting
- Voice - pressing the 'D' button will cause a succession of 'beeps' corresponding to the current voice setting

• **Error Conditions**

Characterised by a low 'buzz'. This indicates that the attempted adjustment is inappropriate in the current situation and lasts for the duration of the button press or DIP switch change. They result in the following situations:-

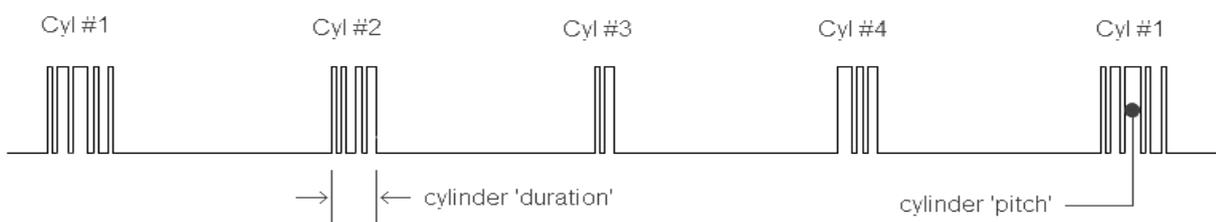
- Attempting to adjust tick over, top speed, number of cylinders or voice whilst the engine is in the stopped condition. It is all too easy to completely muddle your settings without the audio feedback of what the engine is doing!
- Attempting to enter the voice designer mode to modify a factory preset 'voice'
- Attempting to adjust the pitch or duration of a cylinder beyond the range of the current engine setting (eg adjusting cylinder 5 on a 4 cylinder engine)
- Attempting to request the setting status of tick over, topspeed or horn
- Attempting to change the input control method (radio control or potentiometer) at any time other than power-up

VOICE DESIGNER MODE

This mode allows the user to develop their own custom engine sounds for 'voices' 11 to 20 inclusive. All settings are saved in the sound unit's EEPROM (non volatile memory) for subsequent recall the next time the sound unit is powered up.

First, a description of how the sound is produced, such that the user may better appreciate what they are adjusting!

The engine sound synthesis is based on emitting a short pulse of 'white noise' for each cylinder in turn, this representing the pulses of exhaust gas from each cylinder emerging from the exhaust pipe. Each cylinder pulse lasts for a preset 'duration' and the nature of the burst of transitions within that pulse determines the 'pitch' of the 'white noise'. The pitches and durations for each cylinder are stored in the 'voice' constants in the program. When, in the example below, the sequence of 4 different exhaust gas pulses is repeated it gives rise to a rhythmic beat. The (equal length) silent periods between pulses are increased or decreased in unison to vary the apparent speed of the engine.



Note that strictly speaking 'white noise' is random and neither does it possess 'pitch', but to simulate 'white noise' the microcontroller chip in fact produces a pseudo random data stream which by definition is repeatable so each cylinder sounds the same each time it fires. The clock rate of the pseudo random data stream can also be varied which gives tones ranging from a growl to a hiss. For ease of explanation this has been referred to as its 'pitch'.

Thus, in designing a 'voice' the user simply assigns a pitch and duration to each cylinder. As supplied, the custom 'voices' initially match the factory preset ones, thereby providing a good departure point for experimentation.

The Voice Designer mode can only be entered at power-up by holding BOTH the 'Up' and 'Down' buttons pressed. The buttons should both be pressed *before* power is applied. A short tune will play to indicate the mode has been entered successfully and the yellow keypress LED will be permanently lit throughout the duration of this mode to serve as a reminder to the user. The LED will extinguish for the duration of a button press to acknowledge its operation. Attempting to enter this mode when one of the ten factory preset voices is selected will result in a low-pitched error buzz for as long as the keys remain pressed.

The group of six headers associated with the single yellow jumper link now relate to cylinders 1 to 6 and the 'Up' and 'Down' buttons now increase or decrease the pitch of the sound for the selected cylinder. Each cylinder will accept 128 different pitch values. As before, a single high pitched beep signifies the limits of adjustment have been reached. Similarly, a low pitched buzz signifies an inappropriate adjustment is being attempted (such as adjusting cylinder 5 on a four cylinder engine). The higher pitches tend to give the sharp clatter of tappets and the lower pitches give more 'body' to the sound. A successful voice usually contains a range of pitches and durations to give the engine its characteristic 'beat'.

If the 'D' button is pressed and held then the 'Up' and 'Down' buttons now adjust the duration of the exhaust pulse from the selected cylinder. Each cylinder will accept 5 different duration values. As before, a single high pitched beep signifies the limits of adjustment have been reached. Similarly, a low pitched buzz signifies an inappropriate adjustment is being attempted (such as adjusting cylinder 5 on a four cylinder engine). The lowest duration is zero and setting one of the cylinders to this value will usually produce a very satisfying 'throbbing' sound. It then becomes a moot point as to how many cylinders the engine is operating on, but the cylinder setting confirmatory beep (only available in normal mode) will report any zero duration cylinders as being present.

As the group of six headers no longer control the normal functions (ie tick over, top speed etc) these parameters should be set – particularly the number of cylinders – prior to entering this mode. However, the throttle channel does remain active so may be swept up and down during the course of 'voice' design to judge the overall effect.

To facilitate skipping through 128 pitch values, a held key is acted upon each full cylinder cycle of the engine, so increase the engine speed to facilitate more rapid progress. A six cylinder engine at top speed takes around 20 seconds to cover the range whereas a two cylinder engine takes around 6 seconds.

The changes can be quite subtle so a short jab of the 'Up' or 'Down' key which increments or decrements the pitch by one sound unit should be thoroughly explored. To prevent a slow finger response causing the pitch to skip a value or two the engine should be running at a slow tick over when fine-tuning the sound.

A good sound is a *combination* of various pitches and durations across ALL of the cylinders, so slavishly adjusting one cylinder is unlikely to yield a result in itself.

Note that not all combinations of pitch and duration make for entirely sensible sounds but there is insufficient program space in the microcontroller chip for additional code to preclude inappropriate sounds.

To exit the voice designer mode the 5V receiver power must be switched off.