STEREO CASSETTE RECORDER

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Build your own cassette recorder around a "surplus" deck and this high quality circuit. One for the experimenter.

IN THE last 20 years or so, there seems to have been few (if any) published designs for tape recorders. Some 20 to 30 years ago several tape recorder designs were published, and they were quite popular.

One probable reason for the demise of home constructed recorders is that new cassette deck mechanisms have been virtually unobtainable for many years. The few that have been available were invariably high quality and very expensive types. Together with the falling cost of ready-made cassette recorders, this has made do-it-yourself units a less attractive proposition than was once the case.

ABSORBING PROJECT

On the other hand, a cassette recorder is still a very absorbing project to tackle, and interest in this type of project would seem to be far from dead. This Stereo Cassette Recorder project was produced in response to a steady flow of readers' letters requesting a project of this type.

Although new cassette deck mechanisms are currently unobtainable, there seems to be an almost constant flow of decks onto the surplus market. Many of these cost just a few pounds each, complete with heads and motor. I have also removed a perfectly good deck from a "dumped" cassette/radio that had come to a premature end due to an electronic fault that would have been too expensive to have repaired.

It is standard advice to obtain any awkward parts before buying the rest of the components for a project. In this case it is clearly essential to obtain a suitable cassette mechanism before proceeding to buy the other parts.

Having obtained a cassette mechanism, you need to carefully assess its potential before proceeding further. A deck removed from a piece of defunct equipment should be complete with heads, motor, etc., and should be suitable for a do-it-yourself cassette recorder, *provided it is working and in reasonably good condition.*

Surplus cassette mechanisms seem to vary enormously, but in order to realistically use one of these units as the basis of a "do-it-yourself" cassette deck it is necessary to have one that is largely complete. In other words, choose a deck that is complete with a motor, record/playback and erase heads, plus all the mechanical parts.

A deck that has a mono record/playback head can be used for stereo operation if the head is replaced with a stereo type. Provided it has the standard mounting arrangement, replacing the head is not difficult, but it is likely to be much more expensive than obtaining a deck that is ready fitted with a stereo record/playback head. The erase head is the same for mono and stereo recorders, incidentally.

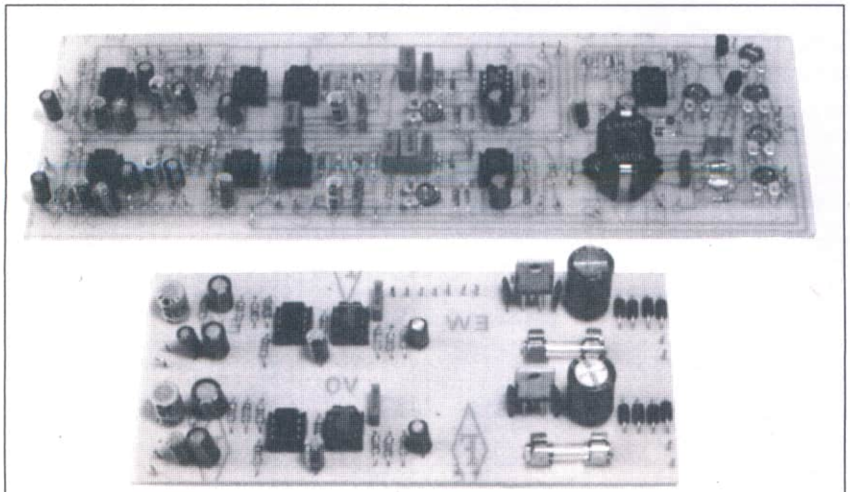
PLAY ONLY

Bear in mind that there are two types of cassette mechanism. The simpler type normally has five rather than the full set of six buttons or levers, and they are only intended for *playing* tapes, not recording them.

Some of these play-only units have the full complement of six levers or buttons, but one of them is either non-functioning, or simply duplicates the action of the "play" button. The "record-protect" mechanism at the rear of the unit will be missing. The erase head will also be missing, or a dummy type to act as a tape guide will be fitted.

It is probably not worthwhile trying to upgrade a play-only unit for operation in a recorder. A mechanism of this type can be used as the basis of a cassette player though, and should provide excellent results.

This cassette recorder project is based on two printed circuit boards, one of which carries the power supply and playback amplifier circuits. Only this board is needed if you intend to build just a cassette player.



Completed Record/Erase (top) and Playback/PSU boards.

RECORD/PLAYBACK

If you intend to build a unit capable of recording and playing back tapes, it is essential to have at least one set of switch contacts that are activated only when the mechanism is set to the "record" mode. The number of contacts fitted seems to vary substantially from one deck to another. There will usually be one or two sets of contacts that close whenever the mechanism is activated.

When using a battery powered unit these can be used to automatically switch on the motor and electronics when the deck is used. For a mains powered unit they are not too important. The motor and (possibly) the electronics are left running continuously so that the deck can provide an "instant" start-up.

There may be several contacts that are controlled by the "record" lever, and these can then provide the record/playback switching. This is unlikely though, and usually just a single set of normally open contacts are provided. These are used to control the record/playback switching either via electronic switching, or a relay.

This tape recorder circuit is intended for control via a relay if the deck lacks sufficient contacts for direct control. If the mechanism lacks a set of contacts that are only operated by the "record" lever, it can only be used in a recorder if you can find a means of adding a microswitch to control the record/playback switching. Provided the deck mechanism is otherwise complete, this should not be too difficult.

TURN OF SPEED

It seems to be the norm for the motors used in cassette mechanisms to have built in speed regulation circuits. In some cases the speed is preset at the correct figure, and you simply have to connect a suitable supply with the correct polarity. A substantial percentage of cassette deck motors seem to have two large supply tags, plus two smaller tags. The latter seem to be for use with an external speed control, and a 4k7Ω (4·7 kilohms) preset (wired as a variable resistor) connected between them usually gives the desired effect.

With some motors the speed control is optional, and the motor defaults to a suitable speed if the preset potentiometer is omitted. With motors of this type it is probably best just to leave these tags unconnected.

With other motors it is essential to add the speed control, since without it the motor runs much too fast. In fact it will probably run at something approaching twice the required speed.

The best way to set the correct speed is to record a test tone at about 1kHz using any cassette recorder that is in good working order. Play the tape back on the do-it-yourself recorder, and compare the reproduced tone with that from the original signal source. Then simply adjust the speed control so that the played-back tone is the same as the original tone.

UNKNOWN QUANTITY

This article is primarily concerned with the electronics for a cassette recorder, and details of the mechanical side of construction are not provided. It would be impractical to do so, since the cassette mechanism is something of an unknown quantity. These units vary considerably in size and shape, and in most cases it will be necessary to use a certain amount of ingenuity in order to get the mechanism securely mounted in a case and working well.

However, it is worth making one or two general points about the mechanical side of construction. The cassette mechanism is unlikely to hold the cassettes in place properly, except in the case of some up-market front loading types. You will normally have to provide side pieces to prevent the cassette from skewing round slightly when the tape heads are engaged.

Also, a sprung cover over the cassette compartment is needed. This keeps out dust when the unit is not in use, and holds the cassette down on the mechanism when it is.

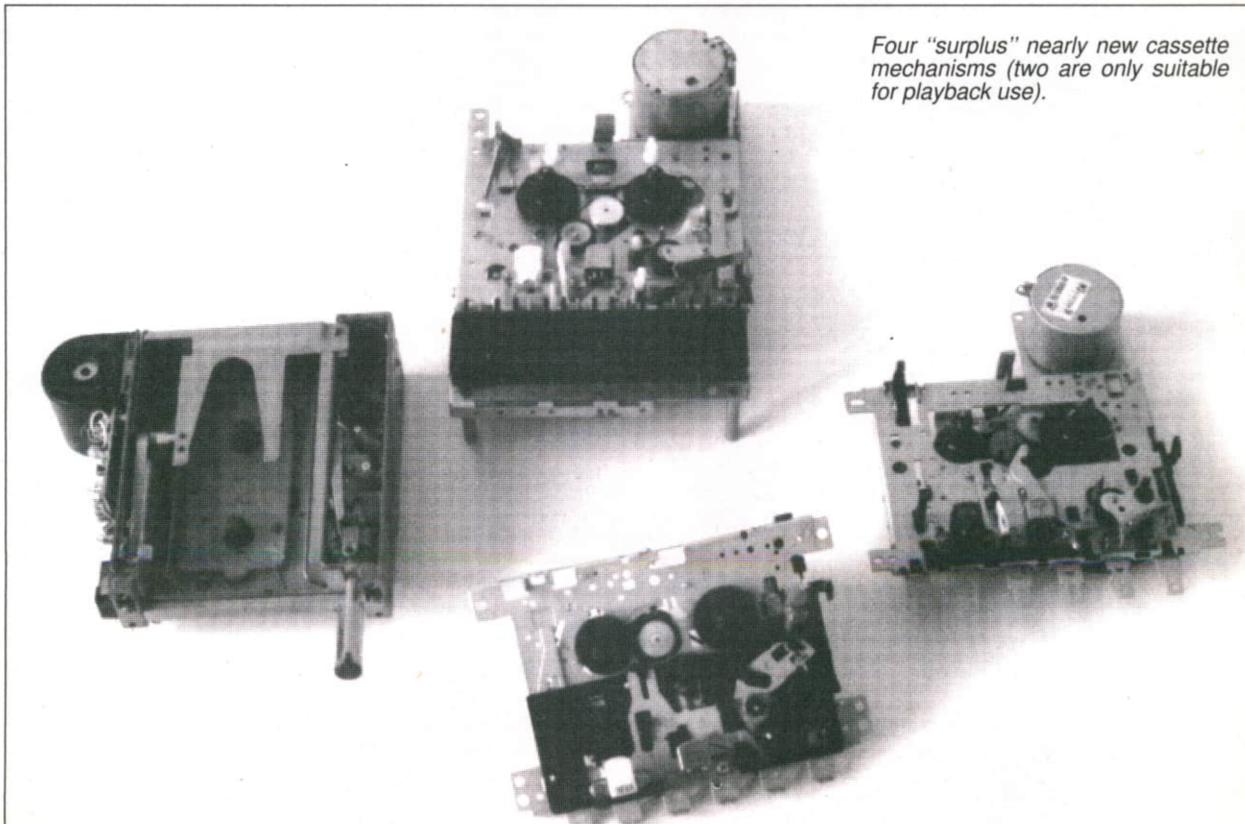
On ready-made recorders the side cheeks and lid are usually in one assembly. The cassette is inserted into the lid assembly and closing the lid then takes the cassette down into position. Life will be a lot easier if the cassette holder is included with the cassette mechanism, but it usually seems to be absent. Unless the cassette is held firmly in position during use it is likely that a lot of mangled tapes will be produced!

TAKE NOTE

One final, but important, point is that this project is not intended for beginners, unless carefully supervised. The circuits have been kept reasonably straightforward, but this is still a fairly complex piece of electronics having a mains power supply.

It is possible to get usable results without the aid of any test equipment, but in order to obtain optimum results it is necessary to have access to some audio test gear. Ideally, an audio sinewave generator and an oscilloscope should be available, together with a knowledge of how to use them.

The circuits provided here are all tried and tested, but this project is primarily aimed at those who like to experiment.



Four "surplus" nearly new cassette mechanisms (two are only suitable for playback use).

SYSTEM OPERATION

The block diagram shown in Fig. 1 helps to explain the way in which the Stereo Cassette Recorder functions. In order to keep the record/playback switching as simple as possible, separate recording and playback amplifiers are used.

When used in the "play" mode, the unit is very simple since most of the stages are switched off, or provide no useful function. The only stage that it is absolutely essential to switched off is the "erase oscillator", which, of course, would otherwise erase the tape being played!

The second function of this oscillator is to provide a high frequency bias signal to the record/playback head when recording. This is necessary to counteract the inherent non-linearity of a magnetic recording system. The exact frequency of the erase/bias signal is not that important, and most tape heads will work satisfactorily with a frequency of around 50kHz to 100kHz.

Quite a high signal level is needed in order to drive the erase head properly. Typically some 10V to 12V r.m.s. is needed at a current of about 40mA to 50mA. The basic erase oscillator is a simple Wien sinewave type which cannot provide a high enough drive voltage or current. It therefore drives the erase head via a simple complementary class-B output stage and a step-up transformer. This enables the erase head to be driven with a good quality sinewave signal at anything from about 25V to 40V peak-to-peak.

A simple two input mixer is at the heart of each recording amplifier. One input of the mixer is designed for use with a high level signal source such as an f.m. tuner. The other input is fed from a microphone via a high gain microphone preamplifier. There are separate gain controls for the line and microphone signals.

Many cassette recorder circuits have the line input provided via the microphone input and an attenuator. This is a simple method, but the noise of the microphone preamplifier gives a significantly reduced signal-to-noise ratio when using the line input.

The method used here gives much better results, because the microphone gain controls can be fully backed-off when the line input is in use. This totally eliminates the noise from the microphone preamplifier. Another advantage of this system is that it enables the microphone and line signals to be mixed at the desired levels.

The output from each mixer is fed to a low gain amplifier, and these amplifiers provide the pre-emphasis. They also drive the record/playback head.

There is a slight problem in driving the tape head in that it provides a highly inductive load. This means that a given drive voltage will provide a much higher current flow at a low frequency than at a high frequency. In order to overcome this problem it is necessary to use a constant current drive circuit.

The most simple way of achieving the desired result is to feed each channel of the tape head via a high value resistor. Provided the value of the resistor is many times higher than the high frequency impedance of the tape head, the current flow will be largely governed by the series resistors. The high value of the resistors swamps the variations in the tape head's impedance.

The erase/bias oscillator also feeds each channel of the record/playback head via a high value resistor. The resistors form simple passive mixers which combines the audio and high frequency bias signals.

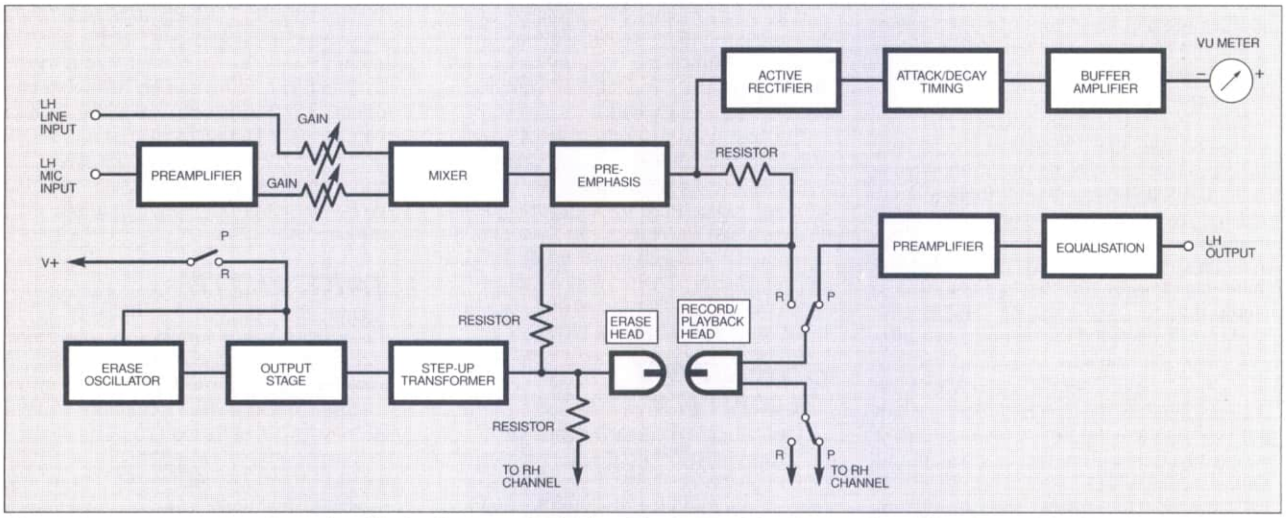


Fig. 1. Stereo Cassette Recorder block diagram. Only the left channel is shown, the right channel is identical. The erase oscillator is common to both channels.

During "playback" mode, the only stages which are used are the playback preamplifier and equalisation circuits. These are duplicated in the two stereo channels, as are most other stages.

The output level from a tape head is quite low, and is typically a little under one millivolt peak-to-peak. The preamplifier provides a voltage gain of just over 20, and the equalisation provides further voltage gain. This stage also provides a large amount of treble cut, which counteracts the treble boost (pre-emphasis) used during the recording process.

The treble boost and cut gives a flat overall frequency response, and the treble cut used during playback gives a useful reduction in the background "hiss".

Additionally, the equalisation has to compensate for the frequency response of the tape head. This gives an output that rises at 6dB per octave. In other words, a doubling of the signal frequency gives a doubling of the output level. The output level from the playback circuit is typically a little over one volt r.m.s., which should be sufficient to drive any normal hi-fi amplifier.

ERASE OSCILLATOR

Two identical signal chains are used in the two stereo channels of the recording circuit, but the erase oscillator circuitry is common to both channels. The erase oscillator serves two functions, and obviously one of these is to drive the erase head. The erase head is positioned ahead of the record/playback head, to ensure that recordings are always made onto blank tape, even when a tape is being reused.

Manual rather than automatic recording level control is used, because the manual type is simpler and generally gives much better results when recording music. The recording level meters are of the peak reading variety, and the two stereo channels are identical.

The output from the pre-emphasis amplifier is fed to a half-wave active rectifier. This feeds into a smoothing circuit which provides the standard attack and decay times of 2·5ms and one second respectively.

This relatively fast attack and slow decay enables the circuit to respond properly to brief but strong signals which can be missed by average reading meters. The meter movement is driven via a buffer amplifier which ensures that the long decay time of the smoothing circuit is not shortened by loading effects.

PLAYBACK AMPLIFIER

The circuit diagram for the Playback Amplifier appears in Fig. 2. The two stereo channels are identical, so we will only consider the left hand channel here.

Switch S1 provides the record/playback switching. This can either be switch contacts on the cassette mechanism, or relay contacts. Using a relay to provide this switching is considered in detail later.

IC1 is a very low noise, almost distortion free, operational amplifier (op.amp) which is specifically designed for use in low-noise audio preamplifiers. It is used here as a straightforward non-inverting mode amplifier having an input impedance of about 5kΩ (five kilohms) or so and an open loop voltage gain of about 22 times.

The output of IC1 is direct coupled to the input of IC2, which is another very low noise, low distortion, op.amp. This circuit is also used in the non-inverting mode.

Resistors R6 and R7 set the voltage gain at about 1000 times, but this is significantly reduced at all but the lowest frequencies by the inclusion of equalisation components capacitor C6 and resistor R9. These reduce the voltage gain to about 30 times at high frequencies.

In theory, the equalisation must provide a 6dB per octave roll-off across the whole audio spectrum to compensate for the 6dB per octave rise in output level from the tape head. Further treble cut is needed in order to counteract the pre-emphasis used during the recording process.

Things are very different in practice due to the inefficiency of the tape head at higher frequencies. In fact the output from a typical tape head starts to fall away at middle audio frequencies. Consequently, the equalisation must only be maintained over the lower and middle audio range.

There is no standard replay characteristic, since the required frequency response for the playback amplifier has to take into account the frequency response of the tape head used, and the desired bandwidth of the system. Good results should be obtained with the specified values for C6 and R9, but it will probably be possible to obtain a flatter response by "tweaking" these values slightly.

With a high quality tape head, it should be possible to obtain something approaching the full 20kHz audio bandwidth. It is not a good idea to try to force the full 20kHz bandwidth from a tape head of lesser quality. This may actually be possible, but only at the expense of a poor signal-to-noise ratio.

In order to keep the circuit relatively simple and straightforward, the unit does not incorporate any form of noise reduction circuitry. Due to the increased quality provided by modern tape heads, tapes, and electronics, this is a less serious omission than it would have been a few years ago. Even without resorting to noise reduction it is possible to obtain a signal-to-noise ratio of about 60dB to 70dB, which is adequate for most purposes.

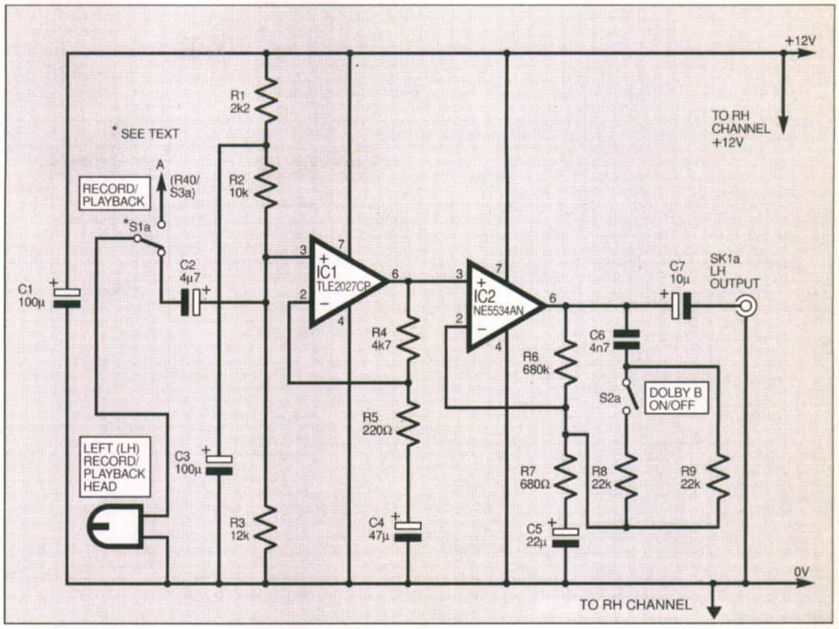


Fig. 2. Circuit diagram for the Playback Amplifier of the Stereo Cassette Recorder.

Switch S2 should be closed when playing Dolby-B encoded tapes. This increases the high frequency roll-off slightly, which avoids the excessive treble which will otherwise be obtained.

If the ultimate in performance is not required, an NE5534A op.amp can be used for IC1 (and IC3), and a bifet device such as an LF351N or TL071CP can be used for IC2 (and IC4). This provides a useful reduction in cost with only a marginally higher noise level.

Using inexpensive devices such as the µA741C, LF351N, etc. for IC1 (and IC3) is not to be recommended. Devices such as these will provide a significantly higher noise level than the TLE2027CP or NE5534AN.

ERASE OSCILLATOR

The circuit diagram for the Erase/Bias Oscillator appears in Fig. 3. IC5 is used in a conventional Wien oscillator circuit. The operating frequency is governed by the values of capacitors C17 and C18, and resistors R21 and R23. The specified values give an output frequency of around 70kHz to 80kHz.

Preset VR1 is adjusted to provide an output signal of the required amplitude, with diodes D1 and D2 providing a certain amount of gain stabilisation. Transistors TR1 and TR2 form the complementary class-B output stage.

In order to obtain a high enough drive voltage for the erase head, a step-up transformer (T1) must be used. Resistor R25 limits the drive current to T1, which otherwise tends to produce a slightly excessive output level.

Capacitor C20 brings the tape head and secondary of T1 to resonance at the appropriate frequency, and this greatly improves the quality of the sinewave output signal. It might be necessary to alter the value of C20 to optimise results with some erase heads, but a value of 10nF (nanofarads) gave good results with several different erase heads.

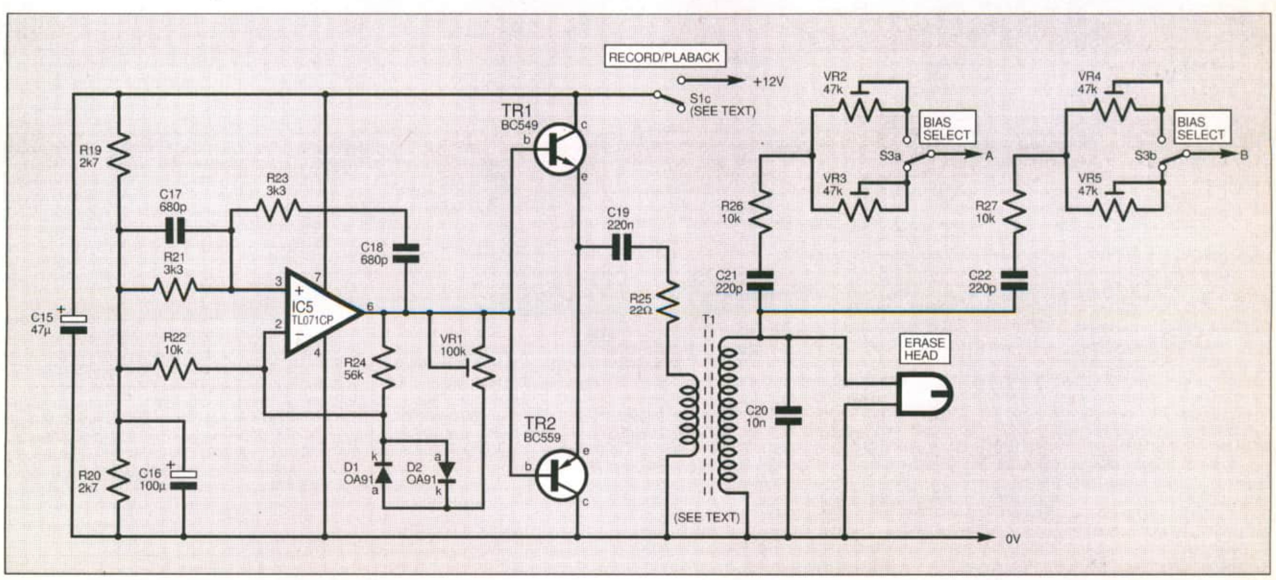


Fig. 3. Circuit diagram for the Erase/Bias Oscillator stage. This circuit serves both channels.

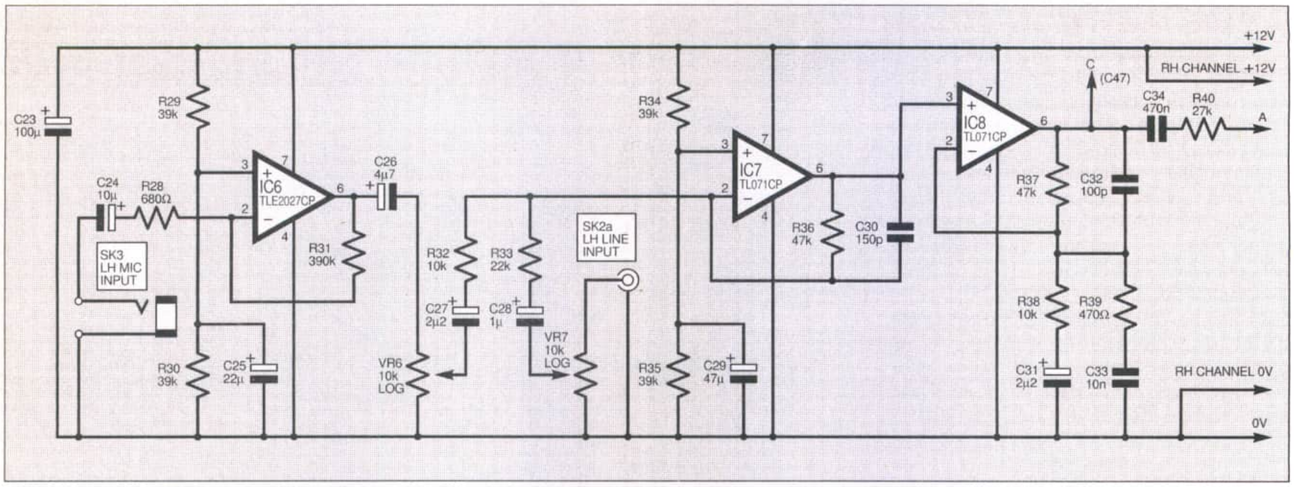


Fig. 4. Left-hand channel circuit diagram for the Record Amplifier. The right channel is identical.

The only exceptions were a couple of old heads from mono cassette decks. These seem to have a higher impedance than modern erase heads. Apart from tuning problems, they also seem to require a higher drive voltage than this circuit can provide. If the cassette mechanism is fitted with a head of this type it is probably better to replace the erase head with a modern type rather than try to modify the driver circuit to suit the old head.

Capacitor C21, resistor R26 and either preset VR2 or VR3 couple the bias signal to the left hand section of the record/playback head. Capacitor C22, resistor R27, together with presets VR4 and VR5, provide the same function in the right hand channel.

The point of using two preset resistors plus selection switch S3 is that it enables two bias levels to be used, so that the deck can be used with two different types of tape. These will usually be normal ferric tapes and chromium dioxide tapes. The latter require a higher bias level. Although the bias signal is fed to the tape head via fairly high resistances, the bias level is quite high. In fact the bias level is about ten times higher than the audio signal.

RECORD AMPLIFIER

Refer to Fig. 4 for the Record Amplifier circuit diagram. Again the two channels are identical, and only the left hand channel will be described. IC6 is a low noise and low distortion op.amp which is used as the basis of the microphone preamplifier. It is used in a simple inverting mode circuit. The circuit is designed for use with a *low* impedance microphone, such as a dynamic or electret type which does not have a built-in step-up transformer.

Like a tape head, the output level from a microphone is likely to be less than one millivolt peak-to-peak. Op.amp IC6 must therefore provide a substantial amount of voltage amplification. Resistor R28 and R31 set the input impedance of the circuit at 680 ohms, and the closed loop voltage gain at a little under 600 times.

The mixer stage has IC7 in a conventional summing mode circuit. Potentiometers VR6 and VR7 are respectively the microphone and line level controls. IC7 boosts the microphone signal by a factor of just under five times. There is a voltage gain of a little over two times from the line input to the output of IC7.

Less than one volt peak-to-peak is needed at the line input in order to fully drive the unit. Capacitor C30 provides a small amount of high frequency roll-off which helps to avoid problems with any high frequency input signals reacting with the bias signal to produce heterodyne tones.

The output of IC7 is direct coupled to the input of the pre-emphasis amplifier. This is based on IC8, which is used in the non-inverting mode. Its basic voltage gain is set at about six times by resistors R37 and R38, but resistor R39 and capacitor C33 produce a substantial amount of boost at high audio frequencies. In fact it provides almost 20dB of boost at the highest audio frequencies. Capacitor C32 and resistor R39 tame the response of the amplifier at frequencies above the upper limit of the audio range.

Capacitor C34 couples the output of IC8 to the tape head via series resistor R40. As explained previously, this resistor is needed in order to provide a constant current drive to the tape head.

This resistor obviously introduces large losses, but the tape head needs a typical drive current of only about 40 microamps or so. Even with the losses through R40, less than 2V r.m.s. at the output of IC8 is sufficient to drive the tape head properly.

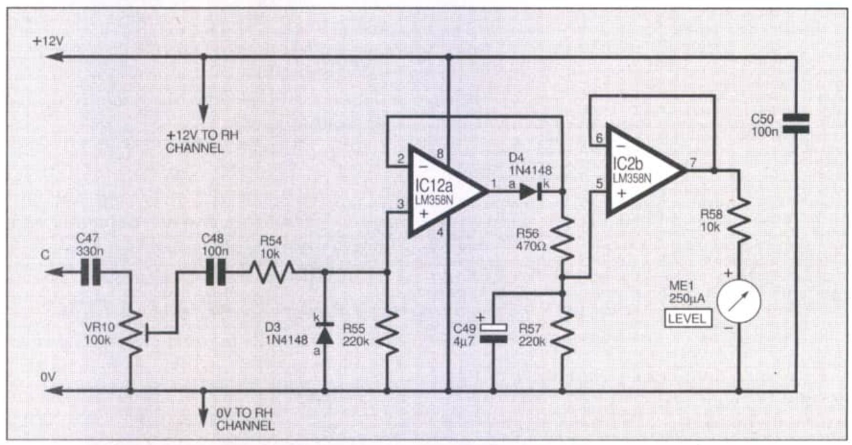


Fig. 5. Recording Level left channel circuit diagram. Right channel is repeated.

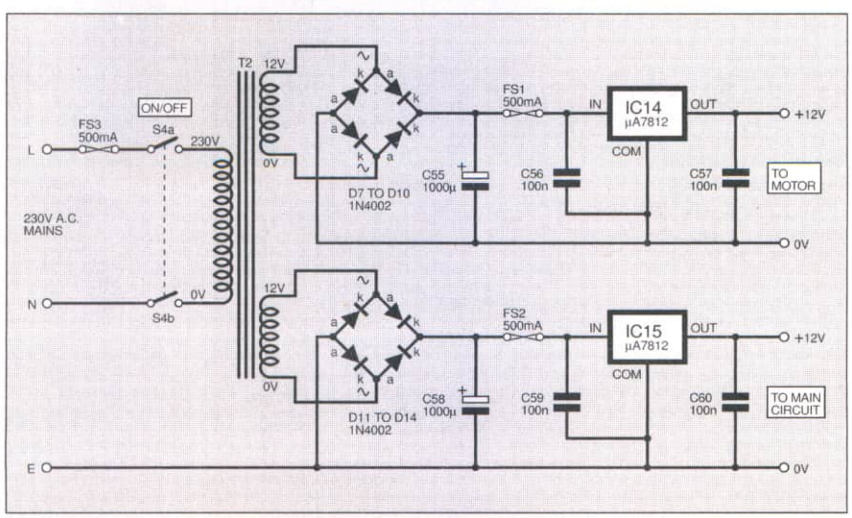


Fig. 6. Circuit diagram for the twin regulated power supply.

LEVEL METERS

The circuit diagram for the recording level meters is shown in Fig. 5. Once again the two stereo channels are identical, and only the left hand channel will be described.

Preset VR10 is a variable input attenuator that enables the sensitivity of the circuit to be set at a suitable level. The output from VR10 is coupled to a conventional half-wave active rectifier based on IC12a. The LM358N used for IC12 permits operation from a single 12V supply, but this circuit will not work properly with most other dual op.amps (LM1458C, LF353N, etc.).

Capacitor C49 is the smoothing component. Resistors R56 and R57 respectively set the attack and decay times at approximately the required figures of 2·5ms and one second. IC12b acts as a buffer stage between the smoothing circuit and the meter circuit.

The meter circuit should have a full scale sensitivity of about 2·5V. If the meter used has a full scale sensitivity of other than 250µA it will be necessary to alter the value of resistor R58 to suit.

POWER SUPPLY

The circuit diagram for a mains power supply unit for the electronics and motor is provided in Fig. 6. It is not essential to have largely separate supplies for the motor and the electronics, but this method virtually guarantees that there are no problems with electrical noise from the motor finding its way into the audio signal paths.

Mains transformer T2 has twin secondary windings which drive two identical regulated supplies; one for the electronics and one for the cassette deck's motor.

Full-wave bridge rectification is used, with smoothing provided by C55 and C58. Electronic smoothing and regulation is provided by two 12 volt monolithic voltage regulators (IC14 and IC15). The foldback current limiting of the regulators provides protection against short circuits on the outputs, and further protection is provided by fuses FS1 and FS2.

The maximum output current from each supply is about 250mA or so. The current consumption of the electronics is no more than about 100mA, but if a relay is used to provide the record/playback switching, this can virtually double.

The current consumption of a 12V cassette deck motor is usually about 100mA in normal use. Some motors might require a somewhat higher current though, particularly those that have solenoids for automatic loading and ejecting of tapes, or other up-market features.

If the cassette mechanism has a 6V motor, it is probably best to power the main supply from a 12V 500mA mains transformer (or a component having two 6V 500mA secondaries wired in series), and to omit all the components for the motor's supply circuit. The motor would then have to be powered from an entirely separate 6V supply.

Alternatively, IC14 can be replaced with a 7808 regulator, which will provide an output of 8V to the motor. This is somewhat higher than the rated voltage of the motor, but the built-in speed regulators of 6V decks seem well able to cope with

COMPONENTS

See SHOP TALK Page

Resistors

R1, R10	2k2 (2 off)
R2, R11, R22, R26, R27, R32, R38, R45, R51, R54, R58, R59, R63	10k (13 off)
R3, R12	12k (2 off)
R4, R13	4k7 (2 off)
R5, R14	220Ω (2 off)
R6, R15	680k (2 off)
R7, R16, R28, R41	680Ω (4 off)
R8, R9, R17, R18, R33, R46	22k (6 off)
R19, R20	2k7 (2 off)
R21, R23	3k3 (2 off)
R24	56k
R25	22Ω
R29, R30, R34, R35, R42, R43, R47, R48	39k (8 off)
R31, R44	390k (2 off)
R36, R37, R49, R50	47k (4 off)
R39, R52, R56, R61	470Ω (4 off)
R40, R53	27k (2 off)
R55, R57, R60, R62	220k (4 off)

All 0·25W 5% carbon film, or better

Potentiometers

VR1, VR10, VR11	100k min. preset, horiz. (3 off)
VR2 to VR5	47k min. preset, horiz. (4 off)
VR6 to VR9	10k rotary carbon log. (4 off)

Capacitors

C1, C3, C8, C10, C16, C23, C35	100µ radial elect., 16V (7 off)
C2, C9, C26, C38, C49, C53	4µ7 radial elect., 50V (6 off)
C4, C11, C15, C29, C41	47µ radial elect., 25V (5 off)
C5, C12, C25, C37	22µ radial elect., 25V (4 off)
C6, C13	4n7 polyester (2 off)
C7, C14, C24, C36	10µ radial elect., 25V (4 off)
C17, C18	680p polystyrene (2 off)
C19	220n polyester
C20, C33, C45	10n polyester (3 off)
C21, C22	220p polystyrene (2 off)
C27, C31, C39, C43	2µ2 radial elect., 50V (4 off)
C28, C40	1µ radial elect., 50V (2 off)
C30, C42	150p polystyrene (2 off)
C32, C44	100p polystyrene (2 off)
C34, C46	470n polyester (2 off)
C47, C51	330n polyester (2 off)
C48, C52	100n polyester (2 off)
C50, C54, C56, C57, C59, C60	100n ceramic (6 off)
C55, C58	1000µ radial elect., 25V (2 off)

Semiconductors

D1, D2	OA91 germanium signal diode (2 off)
D3 to D6	1N4148 silicon signal diode (4 off)
D7 to D14	1N4002 100V 1A rectifier diode (8 off)
IC1, IC3, IC6, IC9	TLE2027CP low noise op.amp (4 off)
IC2, IC4	NE5534AN low noise op.amp (2 off)
IC5, IC7, IC8, IC10, IC11	TL071CP bifet op.amp (5 off)
IC12, IC13	LM358N dual op.amp (2 off)
IC14, IC15	µA7812 12V 1A positive regulator (2 off)
TR1	BC549 *npn* transistor
TR2	BC559 *pnp* transistor

Miscellaneous

FS1, FS2	20mm 500mA quickblow fuse (2 off)
FS3	20mm 500mA anti-surge fuse
T1	record head transformer (see text and below)
T2	mains transformer, twin 12V 500mA secondaries
ME1, ME2	Twin 250µA VU meter (see text)
S1	d.p.d.t. min. toggle switch (see text)
S2	d.p.s.t. min. toggle switch
S3	d.p.d.t. min. toggle switch
S4	d.p.s.t. rotary mains switch
SK1, SK2	twin phono socket (2 off – see text)
SK3, SK4	3·5mm jack sockets (2 off – see text)

Printed circuit boards, available from the *EPE PCB Service*, codes 128 (Playback/PSU), 129 (Record); cassette mechanism with heads (see text); knob (5 off); case (see text); 20mm fuse-clip, p.c.b. mounting (2 off); 20mm fuseholder, panel mounting; 8-pin d.i.l. socket (13 off); multi-strand connecting wire; screened lead; mains lead and plug; solder, etc.

Materials for transformer T1: LA4345 pot core assembly, bobbin, fixing clips (2 off), 24 s.w.g. enamelled copper wire.

Note that the record/playback switching will probably require an additional 1N4148 diode, plus a 12V relay having a coil resistance of at least 185 ohms and with a minimum of three changeover contacts (see text).

Approx Cost Guidance Only **£68** **excl. cassette unit and case**

the extra voltage. There should be no problems with excessive current consumption, since 6V decks seem to consume only about 100mA to 200mA.

RECORD/PLAY SWITCHING

In the likely event that the cassette mechanism cannot provide sufficient contacts for the record/playback switching, a single set of normally open contacts on the deck are used to provide this switching via a relay. The relay coil is connected between the 0V and main 12V supply via the microswitch, and the relay will therefore be activated when the deck is set to the "record" mode (Fig. 7). A 1N4148 diode connected across the relay coil suppresses the high reverse voltage generated when the relay is switched off.

The relay must provide a minimum of three changeover contacts. RLA1 to RLA3 respectively replace switches S1c, S1a, and S1b. The relay coil should have a voltage rating of 12V and a resistance of

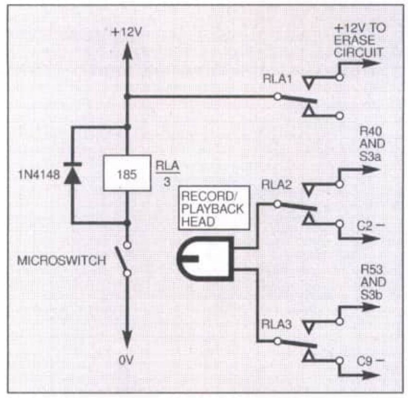


Fig. 7. Using a relay to provide the record/playback switching.

about 185 ohms or more. However, 12V relays having three or four sets of changeover contacts are relatively rare these days, but suitable "Continental" style relays can still be obtained new, and are frequently available on the surplus market.

Alternatively, two relays having coil resistances of about 300 ohms or more and two sets of changeover contacts will provide four sets of changeover contacts. The two relay coils should be wired in parallel. Two 6V relays having coil resistances of about 80 ohms or more and their coils wired in series represent another way of providing sufficient contacts. Unless a suitable relay can be found on the surplus market, the twin relay approach might actually be cheaper.

The record/replay switching shown in Fig. 7 represents a minimalist approach to the problem. In practice it might be better to include additional switching, such as removing power to the record circuits except when recording. This eliminates the possibility of breakthrough from the recording circuits to the playback amplifier.

A slight problem with this extra switching is that it makes it necessary to record onto a tape in order to set the recording level controls. A bypass switch would

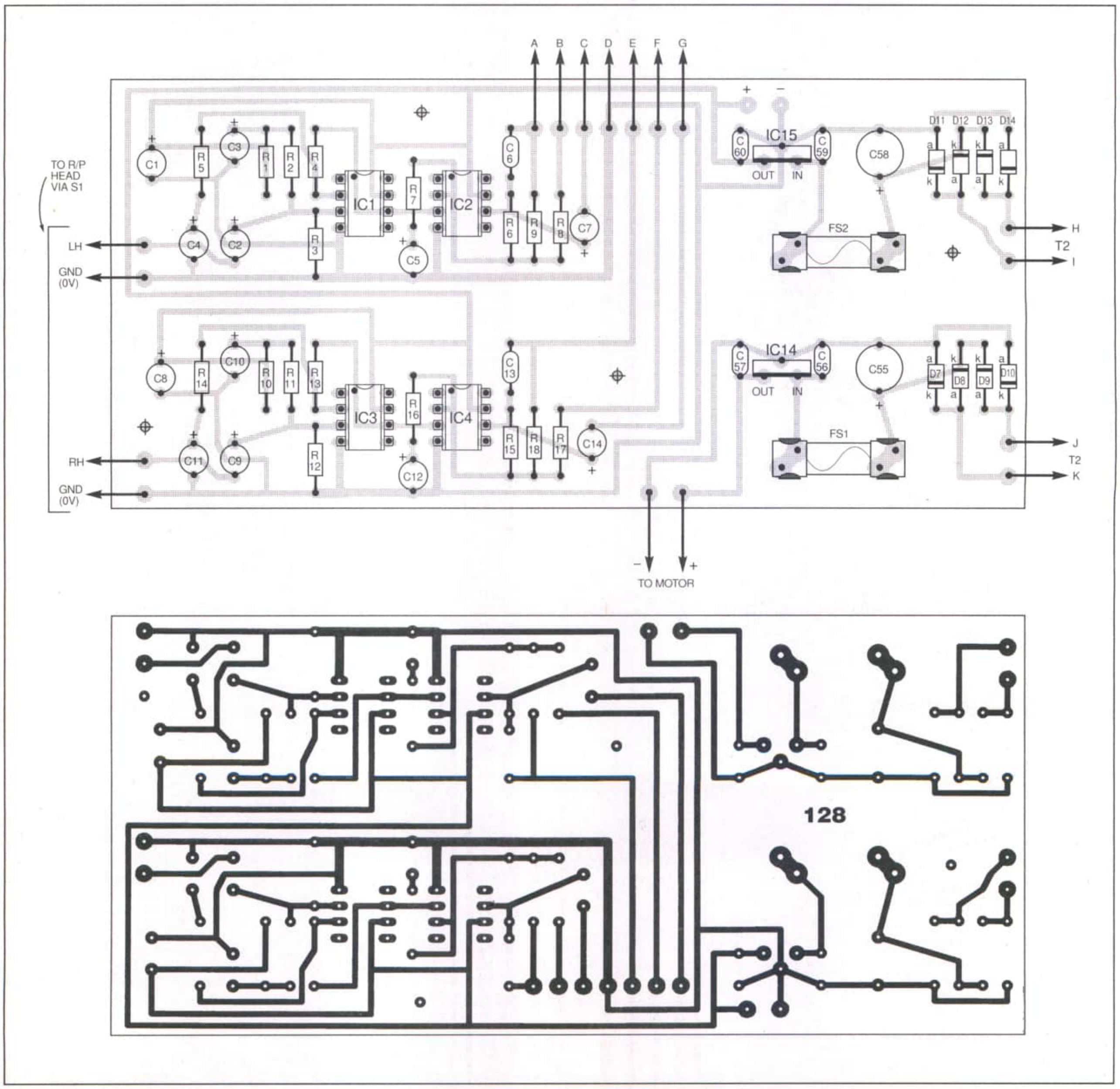


Fig. 8. Playback/Power Supply printed circuit board component layout and full size copper foil master.

enable the recording level to be set prior to actually recording anything. Also, many cassette mechanisms have a "pause" button. Selecting "play/record" and then "pause" enables the recording level to be set. The "pause" button is then pressed again in order to start recording.

CASE SELECTION

As already pointed out, the mechanical side of construction must be varied to suit the particular cassette mechanism used. The case must be quite large in order to accommodate all the components, with a minimum width of about 300 millimetres being required.

As the unit is *mains* powered the case should be of all-metal construction and be "earthed" to the mains Earth lead. The lid of the case must be a screw fitting type, and not a clip-on type which would permit easy access to the dangerous mains wiring.

Most modern relays have no provision for chassis mounting, which makes it potentially difficult to mount the record/playback relay. It should possible to reliably mount a cased relay on the base panel of the case using a high quality adhesive, such as an epoxy type or a "Superglue".

PLAYBACK BOARD

The component layout and actual size foil track pattern for the Playback and Power Supplies board (p.c.b.) are shown in Fig. 8. This board is available from the *EPE PCB Service*, code 128.

None of the integrated circuits used in this project are static-sensitive, but it is still advisable to fit all the d.i.l. (dual-in-line) types in holders. Fit single-sided terminal pins at the points where the connections to the controls, sockets, etc. will eventually be made.

IC14 and IC15 are mounted on the board vertically. IC15 should be fitted with a small heatsink if the current consumption of the electronics and relay is more than about 150mA. It is unlikely that IC14 will require a heatsink unless it is an 8V regulator used to power a 6V motor. It would then be best to play safe and fit it with a small heatsink. For either regulator any small bolt-on heatsink for TO220 devices should be more than adequate. In fact, a small "U" shaped piece of 18 s.w.g. aluminium should suffice.

Fuses FS1 and FS2 are normal 20mm "quick-blow" types, mounted on the board via a pair of fuse-clips. Be careful to fit capacitors C55, C58, and the eight rectifier diodes (D7 to D14) with the correct polarity. Errors here could result in costly damage, and could be dangerous.

Capacitors C6 and C13 must be printed circuit mounting types having 0·3 inch (7·5mm) lead spacing if they are to fit easily onto the board. Capacitors C56, C57, C59 and C60 must be disc ceramic types, or some other form of miniature ceramic capacitor. The electrolytics must all be reasonably small radial (vertical mounting) types if they are to fit neatly into place.

WIRING

The wiring associated with the playback and power supply board is shown in Fig. 9, which should be used in conjunction with Fig. 8. A solder tag fitted on one of transformer T2's mounting bolts provides a reliable means of connecting the mains Earth lead to the case. It is advisable to take a lead from this solder tag to the chassis of the cassette mechanism, to make absolutely certain that it is reliably earthed.

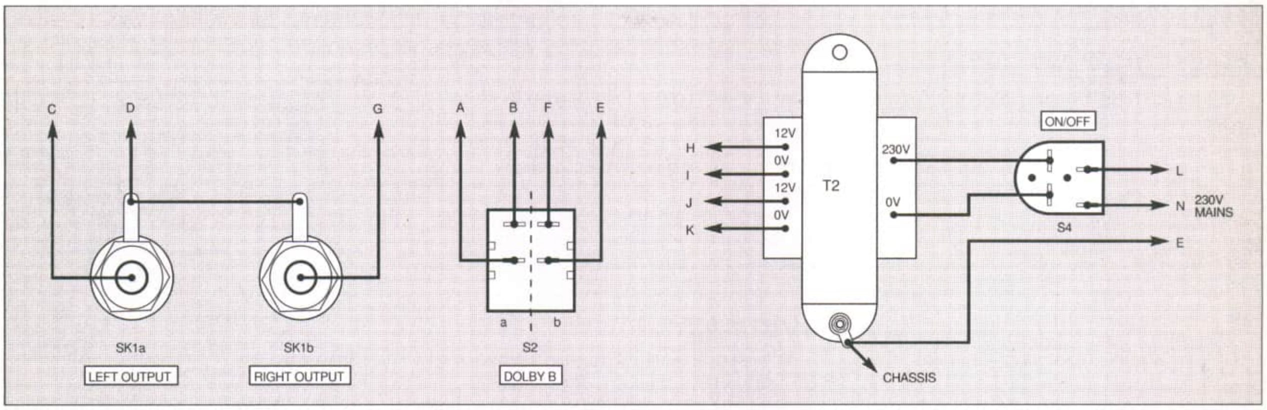


Fig. 9. Wiring details for the playback/power supply off-board components. Leads designated with letters A to K join up with identical points on the p.c.b. in Fig. 8.

It should be possible to customise a ready-made case to suit practically any cassette mechanism, but it is probably best to settle for a relatively simple case. It will almost certainly be necessary to undertake a fair amount of cutting and filing in order to fit the cassette mechanism into the case. This is likely to be easier with a simple aluminium case than a fancy aluminium and steel type.

Timber end pieces (cheeks), etc. can be used to give a more hi-fi style appearance if desired. Ideally the case would be custom made to fit everything, but this is only a practical proposition for those who possess the requisite skills and have access to suitable tools.

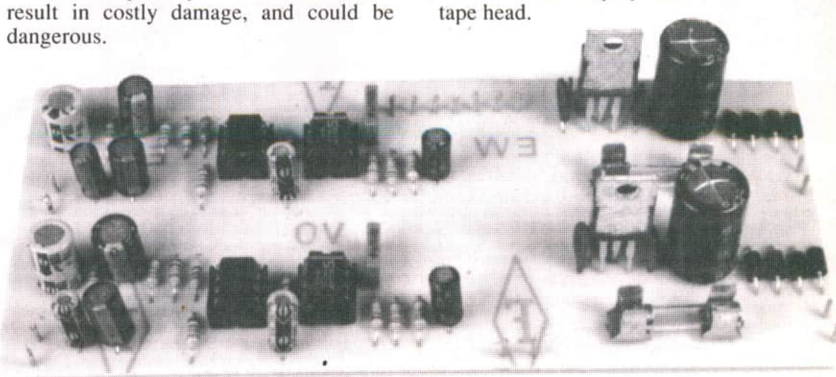
It is normal for a cassette mechanism to be mounted in the case via some form of flexible mounting to prevent the mechanism from spreading noisy vibrations through the case. For a home-constructed recorder it should be possible to improvise a suitable mounting based on some rubber grommets and washers. Without some form of vibration absorbing mounting there will almost certainly be a high level of mechanical noise from the unit.

CASE LAYOUT

The general layout of the unit is not too critical in most respects, but it is advisable to keep transformer T2 and the mains wiring as far away as possible from the tape heads and the input wiring to the recording and playback amplifiers.

Socket SK1 is shown as a twin phono socket in Fig. 10, but it can be a 5-way DIN type, or any audio connector that fits in well with your audio gear. As the output signal is at a fairly high level and a low impedance it is not essential to use screened leads to make the connections to this socket.

The wiring to switch S2 does not have to be screened, but this wiring must be reasonably short. The gain of the playback amplifier is very high at low frequencies, making it susceptible to stray pick up of mains "hum". It is therefore essential that all the input wiring is properly screened, including the wiring from the record/playback switch to the tape head.



Layout of components on the completed Playback Amplifier and Power Supply board. Only this p.c.b. is needed for the Playback only version.

RECORD/ERASE BOARD

The component layout and actual size foil track master for the record amplifier/erase oscillator board appears in Fig. 10. This board is available from the *EPE PCB Service*, code 129.

Construction of this board follows along much the same lines as construction of the playback board. However, there are a few additional points to note.

The seven preset potentiometers must be miniature horizontal mounting types (open or closed construction) if they are to fit onto the board properly. Do not overlook the three short link-wires.

Diodes D1 and D2 are germanium and are more vulnerable to heat damage than silicon types such as the 1N4148; extra care needs to be taken when soldering them into place. It should not be necessary to use a heatshunt, but do not apply the bit to each soldered joint for any longer than is really necessary.

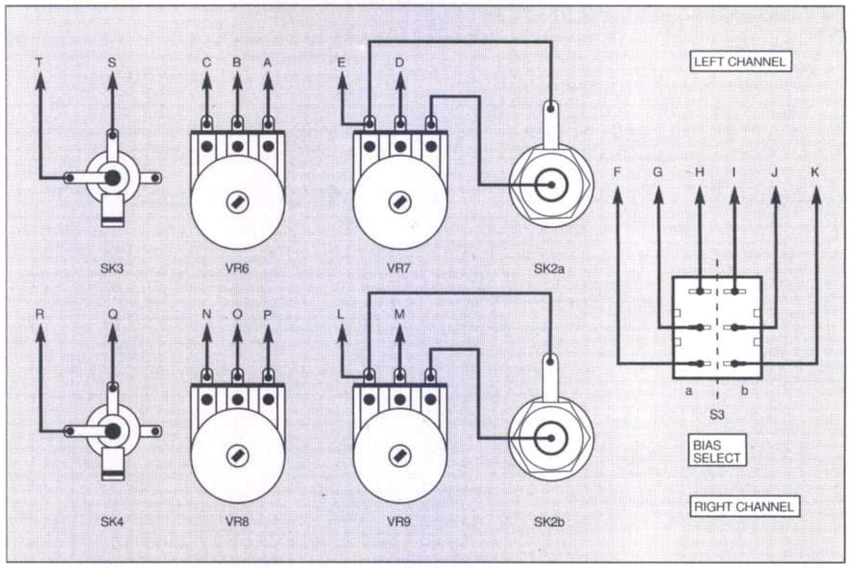


Fig. 11. Off-board wiring details for the Record/Erase components. Leads designated with letters A to T join up with identical points on the p.c.b. in Fig. 10.

OSCILLATOR COIL

Suitable transformers and coils for use in tape erase oscillators do not seem to be available any more. Transformer T1 must therefore be home constructed, and it is based on an LA4345 ferrite pot core assembly. In addition to the two-section pot core, a bobbin and two fixing clips are required. Some 24s.w.g. (0·056mm diameter) enamelled copper wire is also needed.

There is a pair of printed circuit mounting pins at each end of the bobbin. One pair is used for the primary winding, and the other for the secondary. The bobbin is symmetrical, and the phasing of the windings is unimportant. Therefore, it does not matter which pair is used for the primary and which is used for the secondary, or which pin in each pair is used for the start of the winding. The only important point is that each winding must *start* and finish at the same *pair* of pins.

Starting with the primary, use the blade of a penknife or a small file to remove a small amount of insulation from one end of the wire. Then "tin" the bare end of the wire with solder, and do the same to the top of each pin on the bobbin. Solder the end of the wire to the top of one pin, and then wind 10 turns of wire neatly and tightly around the bobbin using a single layer of closely spaced turns.

To complete the primary winding, cut the wire to length, remove a small amount of insulation from the end of the wire, "tin" it with solder, and then solder it to the top of the second pin on the primary side of the bobbin. Use a small blob of paint on the bobbin, near the appropriate pair of pins, to indicate which two pins connect to the primary winding.

The secondary winding is produced in a similar fashion, but it has 55 turns of wire. This must be wound in several layers, but it is not essential to make a particularly neat job of this. On the other hand, if the winding is too rough it is likely that it will be too large, making it impossible to fit the bobbin into the pot core.

Once the bobbin is installed inside the two halves of the pot core, use the two metal clips to clamp the two sections of the core together. The pot cores are made from a brittle ferrite material, so treat them with due care. Dropping them or even squeezing them too hard when fitting the clips can result in serious damage to the cores.

The completed transformer is mounted on the board and then soldered in place, making quite sure that it is fitted on the board the right way round.

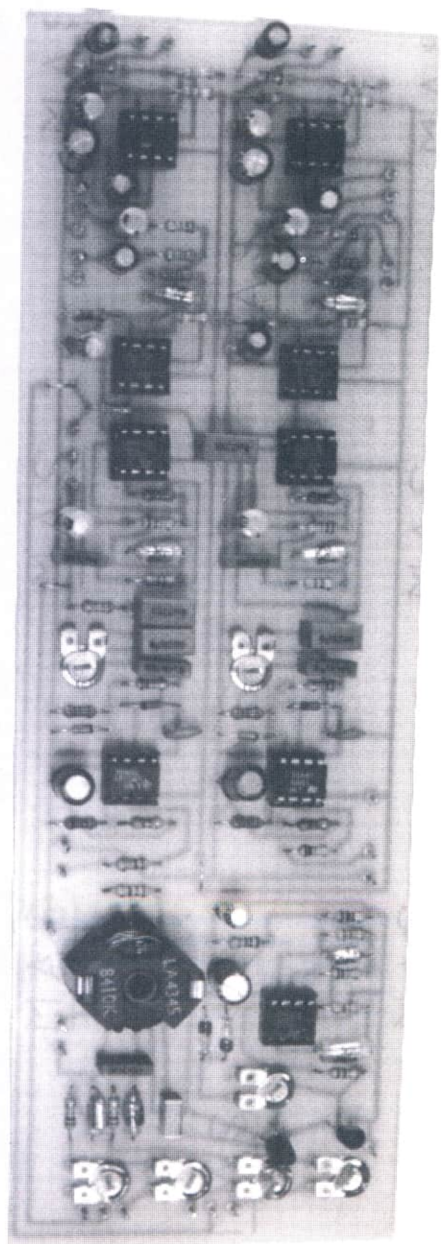
WIRING

Wiring associated with the Playback and Erase Oscillator board is shown in Fig. 11. A twin phono socket is used at the line inputs, but again, this can be replaced with a DIN type or any audio socket that fits in well with your audio equipment. The wiring to socket SK2, switch S3, and the four potentiometers does not have to be screened provided it is all kept reasonably short.

On the prototype, ordinary rotary potentiometers are used for the recording level controls. Many constructors will probably prefer to use slider types, which make it easier to adjust the left and right hand channels in unison. Do not overlook the possibility of using dual concentric rotary potentiometers, which also make it easy to adjust the two stereo channels in unison, and do not have any awkward mounting requirements.

Sockets SK3 and SK4 are 3·5mm jack types, which match the plugs fitted to most low impedance dynamic microphones. The higher quality dynamic microphones and electret types are often fitted with standard (0·25inch) jack plugs. Obviously SK3 and SK4 should be changed to standard jack sockets where appropriate. Screened leads *must* be used to connect them to the printed circuit board.

The VU meters can be standard 60mm by 40mm types, but these are relatively expensive. Panel meters of this type have the required full scale sensitivity of 250μA, but seem to have a built-in series resistor. This requires resistors R58 and R63 to be reduced to from 10kΩ to 3k3Ω. The relatively inexpensive Maplin "Dual VU Meter" is used on the prototype, and this has been found to give good results despite its low cost.



The finished Record/Erase p.c.b.

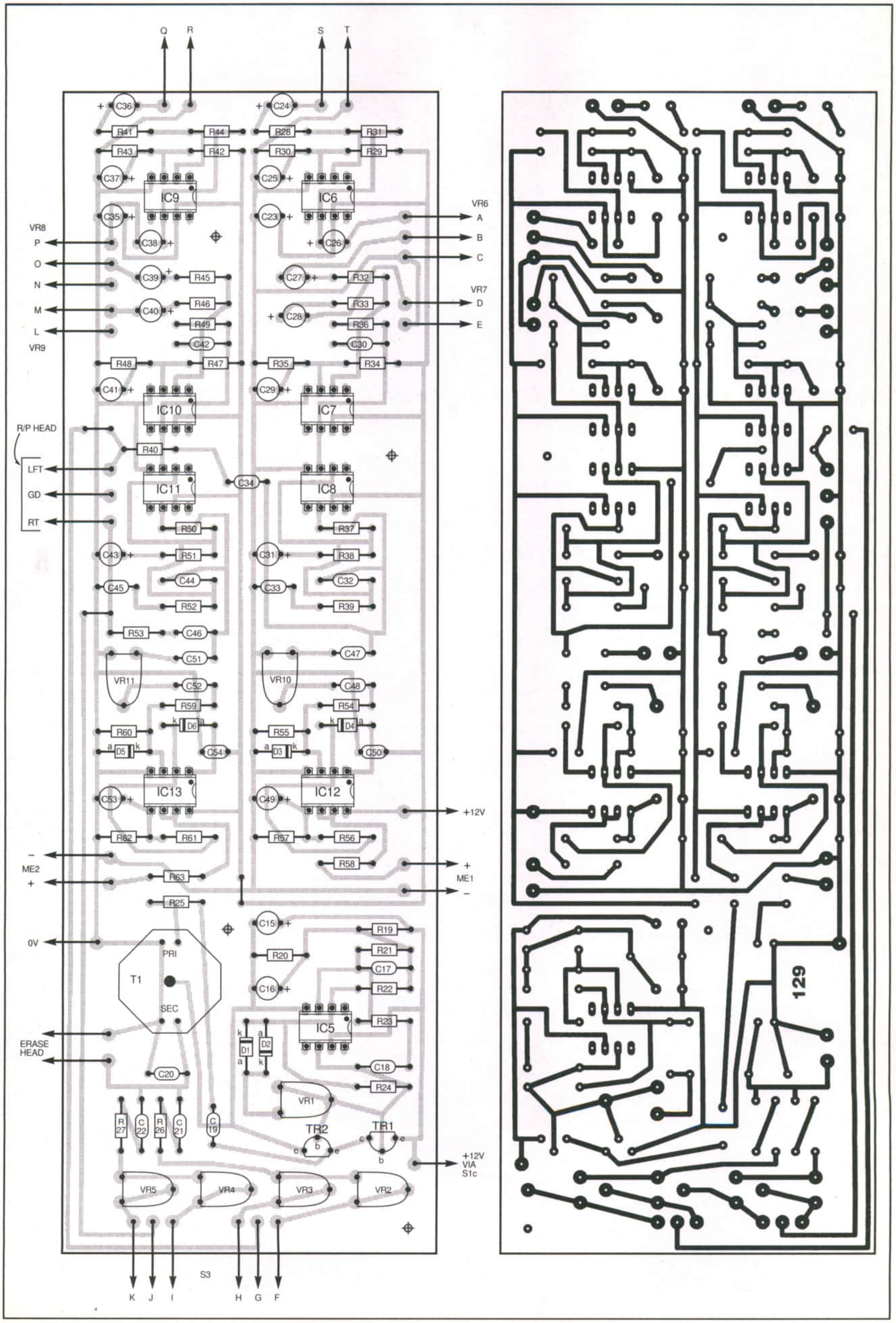
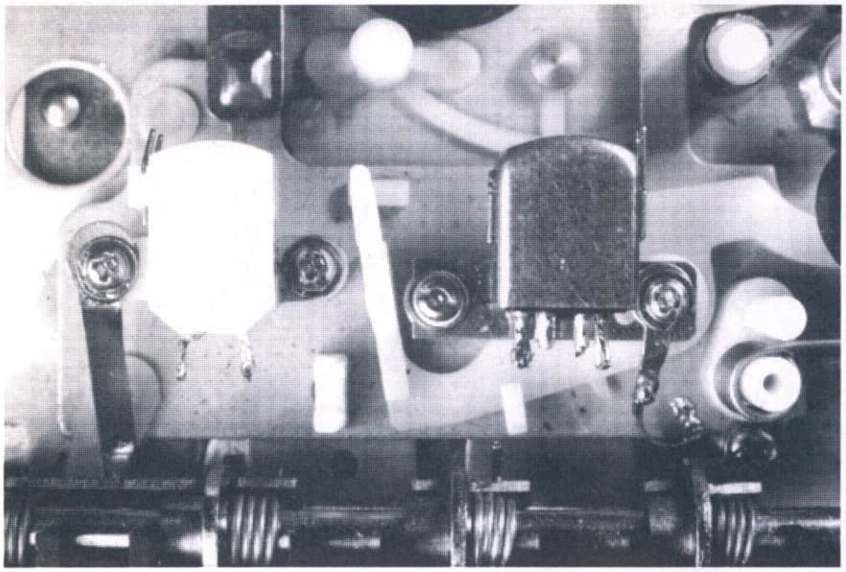


Fig. 10. Record/Erase printed circuit board component layout and full size copper foil master.



The replay head is on the right. The mounting screw on the left provides the azimuth adjustment.

AZIMUTH ADJUSTMENT

It is advisable to initially check the unit in the playback mode using a test recording of some music made using another recorder, and not using your favourite pre-recorded cassette. Then, if the record/playback switching is not working properly, you will not accidentally erase anything important!

The unit should provide a strong output signal of reasonable quality if the playback mode is working properly. However, the signal may be lacking in treble due to an error in the azimuth adjustment of the record/playback head.

For the head to scan the tape tracks properly it is essential for it to be at the correct height. If it is slightly too high or too low, part of each track will be missed, and a lack of treble response will result.

Tape heads are normally mounted by two screws, and the azimuth setting is normally controlled by the left-hand screw when looking onto the rear of the head. To set the azimuth correctly, play a pre-recorded tape through the unit, and then set the azimuth adjustment screw for maximum treble response.

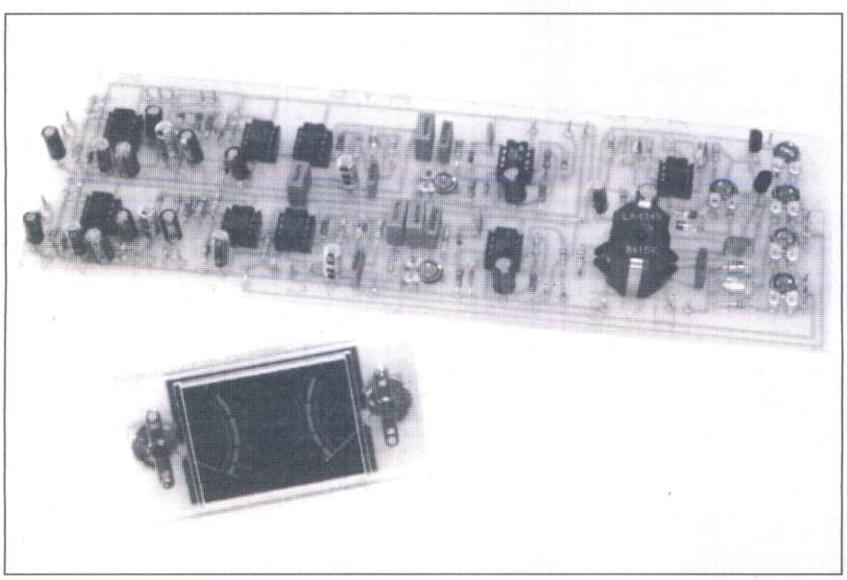
OUTPUT LEVEL

In order to get good results when recording it is necessary to set a suitable output level from the erase oscillator, and then set appropriate bias levels. If an oscilloscope is available, use it to monitor the signal across capacitor C20. With preset VR1 set close to maximum resistance (set well in a counter-clockwise direction) a strong sinewave signal at a little over 40V peak-to-peak should be produced.

By advancing VR1 in a clockwise direction it should be possible to reduce the amplitude of the output signal, and the quality of the waveform should also improve. Good results should be obtained with the signal level at around 30V to 35V peak-to-peak.

Finding a suitable setting for VR1 becomes a matter of trial and error if access to an oscilloscope is not possible. Setting VR1 well in a clockwise direction gives an improved waveshape, but if it is adjusted too far the oscillations will not be strong enough, or may even cease altogether. It is a matter of finding the most clockwise setting that gives an adequate degree of erasure.

Completed Record/Erase board together with "stereo" VU meter.



BIAS LEVEL

With the bias level presets adjusted to a roughly central setting, the recording section of the circuit should work quite well. Finding the optimum settings without the aid of any test equipment is just a matter of making some test recordings at various bias levels, and using subjective assessment to determine the bias level that gives the best overall frequency response.

If suitable test gear is available, make some frequency response tests at a recording level of about −20dB to determine the bias settings that give the flattest overall frequency responses. The easiest way to do this is to record a square wave signal at a frequency of around 50Hz to 100Hz. The best bias settings are the ones which give a squarewave output signal that is free from any major overshoot, or other serious irregularities.

Of course, the high frequency limit of the system will produce some rounding of the waveform, and the low frequency limitations will produce the usual sloping horizontals on the waveform. Chromium dioxide tapes need a higher bias level (the presets set further in a counter-clockwise direction) than normal ferric types.

Using an excessive recording level produces very soft clipping on the played-back signal. Consequently, there is no rigidly defined maximum recording level. Even if some audio test gear is available, it is probably best to use subjective assessment and some test recordings to determine the best settings for the recording meter sensitivity controls (VR10 and VR11). The sensitivity should be set quite high if low distortion is deemed to be of paramount importance. Set the sensitivity lower (set VR10 and VR11 further in a clockwise direction) if a better signal-to-noise ratio but higher maximum distortion are preferred.

RESULTS

The results obtained from these circuits depend to a significant extent on the particular cassette mechanism and heads used. The quality of the tapes used is also a significant factor. Some cassette mechanisms give much lower "wow and flutter" levels than others, and some tape heads seem to give more treble and less noise than others.

The prototype equipment has been tried with half a dozen cassette mechanisms (two of which are playback-only), and all gave respectable results. Using good quality tape and heads plus one of the better cassette mechanisms it is possible to obtain some quite impressive results, even though the unit lacks any form of noise reduction circuitry. A signal-to-noise ratio of over 60dB can be achieved.

However, be prepared to spend some time experimenting with different bias levels, etc. Some "tweaking" of the playback equalisation values might also be worthwhile for perfectionists. □