Australia $1.10 New Zealand $1.20 Malaysia $3.50

PRACTICAL
ELECTRONICS

11 A$1.10

SEPTEMBER 1980 55p

DISCO DESK
Part 1

SPECIAL OFFER Autoranging DMM

COMPUKIT SOUND BOARD

DISCO DESK

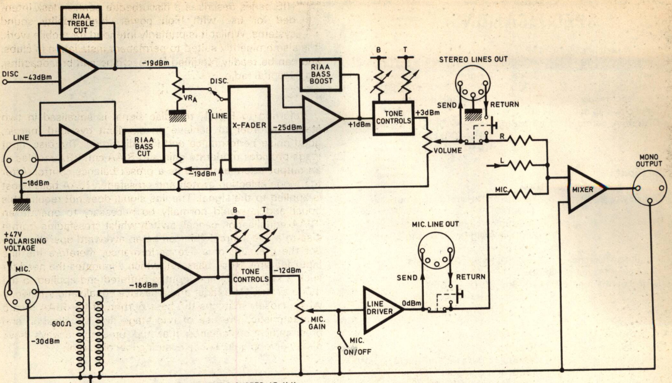
THIS series describes a discotheque control desk intended for use with high power, high fidelity sound systems. Whilst it is primarily intended for mobile work, it is also eminently suited to permanent installation in clubs, and can be readily modified for recording and broadcasting, e.g: Hospital radio.

BLOCK DIAGRAM

Referring to Fig. 1, the disc signal is equalised in two stages in order to achieve an excellent overload margin, good noise performance and low distortion. The disc input stage provides moderate gain and RIAA cut. VR_A doubles as an output attenuator and as a preset balance control. After the mode selection switch and crossfader, RIAA bass boost is applied to the signal. The line signal does not require this boost and it would normally be necessary to operate an 'RIAA equalisation cancel' switch whilst crossfading from a disc to a line source. This can be an awkward operation under the pressure of a live performance, therefore the line input features RIAA bass cut, which eliminates the need for such a switch. The line input is buffered and applied to the mode switch via a fader and a passive equalisation network, which closely matches the bass portion of the RIAA record characteristic. The use of two stage disc equalisation and preamplification ensures that the op-amps always have plenty of loop gain, hence ensuring low distortion.

Part 1

BEN DUNCAN

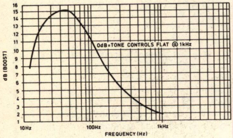


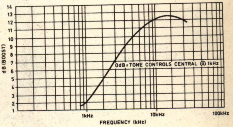
ALL LEVELS QUOTED AT 1kHz
0dBm = 776mV INTO AN UNSPECIFIED IMPEDANCE

Fig. 1. Block diagram of main circuitry

In a design of this nature, the tone control characteristics can be emphatic without embarrassing consequences. For instance, the very low hum level makes possible a bass boost characteristic which approximately compensates for typical loudspeaker deficiencies. This permits the reproduction of low bass at lifelike levels, assuming that suitable loudspeakers and low rumble turntables are available. The plentiful bass boost is also helpful when 'thin' recordings are encountered; EP singles are often lacking in the lowest bass notes. The bass boost curve rolls off sharply below the audio band in order to minimise the amplification of rumble. Further rumble filtering is provided in the preceding stage. The treble control provides moderate boost and cut over a wide band of frequencies, without excessive midrange or high treble boost. The commonly encountered 20dB boost at 18kHz is simply not required in a good sound system, and readily causes amplifier or horn overload and 'tinny' treble; deficiencies above 10kHz usually indicate worn discs or stylii, or an inadequate loudspeaker system. Most of the distortion in the disc and line channels is generated in this stage.

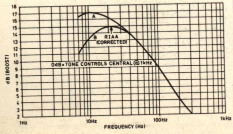
The tone control stage feeds the send-return socket via the volume control. In its normal position, the send-return switch allows the signal to pass directly to the mono output, via the mixer, and also out of the 'send' pins on the socket. Thus both mono and stereo outputs are provided simultaneously. Depressing the send-return switch forces the signal to pass via auxiliary equipment and allows the signal to return by closing the switch in series with the 'return' pins on the send-return socket. Finally, the stereo music lines are mixed down to mono, together with the microphone signal, by a unity gain mixer.

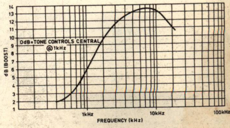




(Left) Mic bass boost curve
(Right) Disc treble boost curve

Response Curves





(Left) Disc bass boost curve
(Right) Mic treble boost curve

SPECIFICATIONS

Disc

Input impedance	47k
Sensitivity $\pm\frac{1}{2}$dB	−43dBm at 1kHz ref 0dBm out (5·5mV)
Hum	−80dB, unweighted
Noise	−70dB, unweighted, 20Hz to 20kHz
Frequency response	12Hz–25kHz at −3dB points
Input overload margin 41dB	
Distortion, harmonic at +10dBm, 30Hz—0·06%	
	1kHz—0·01%
	10kHz—0·03%

Line inputs

Input impedance	100k
Sensitivity $\pm\frac{1}{2}$dB	−18dBm at 1kHz ref. 0dBm out (100mV)
Hum	−105dB unweighted
Noise	−76dB, unweighted, 20Hz to 20kHz, 600 ohm input load
Frequency response	30Hz–50kHz at −3dB points
Input overload margin 38dB	
Distortion, harmonic at +10dBm, 30Hz—0·06%	
	1kHz—0·008%
	10kHz—0·03%

Microphone

Input impedance	600 ohms
Sensitivity	−30dBm at 1kHz ref. 0dBm out (25mV)
Hum	−93dB, unweighted
Noise	−80dB (unweighted), 20Hz–20kHz, 200 ohm input load
Frequency response	32Hz–22kHz at −3dB points
Input overload margin −40dB	
Distortion, Harmonic at +10dBm, 30Hz—0·01%	
	1kHz—0·02%
	10kHz—0·1%

General

Slew rate, all stages	⩾5·5V/µs
Distortion, any input,	⩽0·1% at 10dBm, 30Hz−18kHz
Output clip level	+20dBm

Mono and mic outputs provide 0dBm at 100 ohm source impedance and will drive 600 ohm lines at +20dBm

Stereo lines provide 0dBm at 350 ohm source impedance

Tone controls & RIAA equalisation matched to within $\frac{1}{2}$dB

0dBm = 776mV into an unspecified impedance

COMPONENTS

Card 1

Resistors

R1–4	47k
R5–8	7k5
R9–12	470R
R13–16	560R
R17–20	100k

(All $\frac{1}{2}$ watt *metal oxide*, 2%)

Potentiometers

VR1–4	22k enclosed cermet (RS components type 186–198)
VR5–8	1k dual log (Rivlin CS60 type, Maplin order code HB 00A)

Capacitors

C1–4	1µ polycarbonate
C5–8	22p ceramic
C9–12	10n polycarbonate
C13–16	6n8 polycarbonate
C17–20	680n polycarbonate
C21–24	22µ 25V PC mounting electrolytic
C25–28	470n polyester, C 280AE series
C29–32	22p ceramic
C33–36	18n polycarbonate
C37–38	100µ, 40V axial electrolytic
C39–40	100n polyester, C280AE series

Semiconductors

IC1–IC8 NE5534N or NE5534AN, 8 pin d.i.l. version

Miscellaneous

SKT1, 2—XLR 3 pin female sockets (Maplin BW90X)
SW1, 2—Miniature toggles (RS components type 316–973)
"Copper-clad single-sided epoxy-glass p.c.b. board incorporating 0·1" pitch edge connector (RS type 434–150)
8 × 8 pin d.i.l. sockets
185 × 90mm aluminium screen, 22 s.w.g.

Facilities and functions (see numbered photo)

Music

Two stereo disc inputs from internal turntables A & B **(1–2)**
A+B line and disc inputs selected by rotary switches **(A&B)**
Two stereo line inputs from female XLR's A & B **(3–4)**
Internal preset disc balance controls
Line input level controls **(5–6)**
Line input earth-isolation switches **(7–8)**
Slider crossfading between line & disc in any of 4 combinations **(9)**
Bass, treble and volume controls **(10–12)**
Music send-return socket provides stereo lines at 0dBm **(13)**
Music send-return switch activates stereo return for insertion of graphic equalisers, limiters, expanders, etc. **(14)**
Music 'cancel' switch for audience participation and emergency announcements **(15)**

Microphone

Capacitor microphone input (Readily modified for moving coil microphones) from female XLR **(16)**
Bass and treble controls specially contoured for vocal applications **(17–18)**
Microphone gain control and on-off switch **(19–20)**
XLR send-return socket providing (mono) microphone output at 0dBm for routing to vocals amplifier **(21)**
Microphone send-return switch activates return for insertion of graphic equaliser, special effects, etc **(22)**

Output

XLR mono output from stereo lines and microphone line via a unity gain mixer. This output can be exclusively microphone *or* music if required, by depressing appropriate send-return switch. Also XLR stereo music output. **(23)**

Auxiliary

Output and PFL monitoring, the latter switchable to all music inputs **(24–25)**
Monitor level control **(26)**
4 watts into 4 ohms monitor amplifier, for phones or monitor speaker, with short circuit and thermal protection **(27)**
A & B cueing indicators (yellow panel l.e.d.s) illuminate when disc modulation begins or line input exceeds an equivalent threshold **(28–29)**
Left and Right peak indicators (Red panel l.e.d.s) are set to illuminate at the nominal r.m.s. input level of the systems power **(30–31)**, e.g: 500mV, whilst VU meters provide the desk 0dB reference across the stereo lines **(32–33)**
Autofader on-off switch and locking panel-presets for depth, rate and sensitivity adjustments **(34–37)**
Remote push button turntable start switches and turntable lamp switches. Jack socket sound-to-light modulator output **(38–42)**
High reliability remote power supply with comprehensive protection.

MICROPHONE CHANNEL

The microphone input is designed for the Calrec CM654 capacitor microphone but input stage modifications are given to cover the majority of moving coil and capacitor microphones, including those which are balanced or phantom powered. A good vocals microphone is essential for discotheque applications, where 'close miking' is the rule. All cardiod microphones provide strongly accentuated low bass under these conditions. Windshields help, but microphones intended for vocal applications often incorporate compensation for 'close miking'. This virtually eliminates 'pop' and other explosive breath sounds and minimises the input transformer's overload margin requirements. A discotheque microphone may also be required to handle SPLs in excess of 100dB if the operator shouts; capacitor microphones are particularly suited to handling high SPLs with low distortion. .

Most of the distortion in the microphone channel is generated by the input transformer, but it is predominantly 2nd harmonic and quite inaudible under normal conditions. The input stage has unity gain in order to avoid overloading the tone control stage, bearing in mind the high outputs produced by close miking. The tone controls have been contoured as far as possible to suit vocals requirements, ie: for frequencies between 100Hz and 10kHz. The fundamentals of male and female speech lie around 130Hz and 200Hz respectively. These low frequencies provide the voice with body and character whilst the harmonics, particularly those around 1kHz–3kHz are essential for intelligibility.

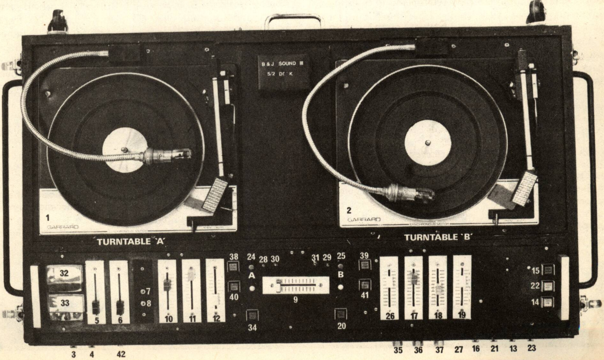
With this in mind, the treble boost curve has been contoured to give relatively large amounts of boost around these latter frequencies, thus allowing vocals to 'cut through' if desired. It is difficult using the Baxandall network to bring the maximum boost up to the fundamental frequencies of the human voice. Maximum boost occurs, therefore around 50Hz but in practice the characteristic is satisfactory provided a vocally compensated microphone is used.

The microphone signal passes to a line driver, capable of providing some +20dBm into a 600 ohm load, via a gain control and the on-off switch. The microphone send-return switch is wired in the same manner as that previously described, and finally the microphone line feeds the mono mixer.

ANCILLARY FUNCTIONS

The auxiliary functions are shown in Fig. 2. The autofader drives an f.e.t. which shunts the music lines; attenuator VR_A controls the fade depth. VR_C and VR_B adjust the sensitivity (i.e. microphone level required to trigger) and the fade-up rate of the circuit respectively. S_A disconnects the f.e.t. when the autofader is not required. A four way switch selects the right hand disc and line inputs for PFL (pre-fader listen) monitoring. In turn, a two way switch selects either PFL or output monitoring. A 4 watt amplifier is provided to drive either headphones or a monitor loudspeaker.

The cue l.e.d.s allow discs to be lined up rapidly and without the use of headphones. VR_D is set to discriminate between rumble and music modulations on typical discs. The VU meter driver preset is normally set such that 776mV on the stereo lines gives an 0 VU reading, though this is not conventional practice in broadcast sound equipment. The peak indicator switches on its associated l.e.d. for a few hundred milliseconds whenever a signal peak exceeds the nominal input sensitivity of the power amplifiers, eg: 500mV



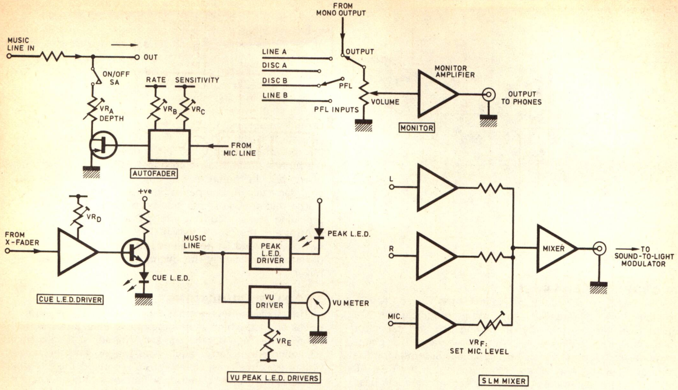


Fig. 2. Block diagram of auxiliary functions

(−3½Bm). In this way, they warn that the power amplifiers are being driven close to clipping.

The 'sound-to-light mixer' provides a +10dBm output for lighting effects. The microphone level in the mix is adjusted to match the level of the music signals under normal 'miking' conditions by means of preset VR_F.

CONSTRUCTION

Apart from the monitor amplifier, all the circuitry is contained on four pluggable cards; this greatly simplifies construction and debugging. Fig. 3 will be found helpful as construction progresses, as it shows how the circuitry on each card is interconnected. The power supply, whilst sophisticated, is simple to construct and is unlikely to require debugging. For this reason it will be presented later. For initial tests, ±15V and +12V supplies are required. To test individual cards, very little current is required (<100mA) and batteries are quite adequate if a good bench power supply is not available.

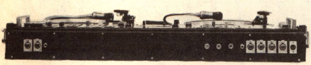
All the audio circuitry is built around the Signetics NE5534 op amp. This was introduced to Britain some 18 months ago and is truly described as 'high performance' in that it is the first op amp to approach the performance of the best discrete circuits. As a result, it has found wide acceptance in professional audio equipment. It has pin compatibility with the 741C and features internal compensation for gains in excess of 10dB. However, the addition of a small compensation capacitor ensures stability without compromising performance in the audio band. The low noise version, designated 'NE5534AN' is expensive but may be used to advantage in the disc input stage if desired.

The NE5534N, like the 741 is a hardy bi-polar device and does not require special handling precautions. However, it is not as cheap as the 741 and when the cards are initially tested it is wise to substitute the latter.

CARD 1

This card contains the disc and line input stages. With reference to Fig. 4, R1 provides the input bias current for IC1 and also the standard load for a magnetic cartridge. At high frequencies, the gain of IC1 falls to unity, therefore external compensation (C5) is required. R5 and R9 provide a gain of 24dB and together with C9 also furnish RIAA treble cut. However, in the series feedback configuration used here, the gain of IC1 cannot fall below unity. Thus R13 and C13 are required to maintain treble cut at high frequencies. The electrolytic capacitor C21 has significant reactance above 1kHz and therefore C17 is added to ensure good treble response. Wherever possible throughout the audio circuitry non-electrolytic coupling capacitors have been specified for this reason. VR1 doubles as a preset balance control and output attenuator as previously described.

IC5 provides unity gain and C33 with the crossfinder provides bass cut which closely complements the RIAA bass boost characteristic. For optimum screening and RF1 suppression all the disc inputs have independent 0V connections and are quasi-balanced. This procedure is not so important at line input levels, and the 0V connection for each stereo line input is commoned at the XLR input connector in any case. Panel mounted earth isolation switches are provided on these inputs to facilitate the control of hum loops. The supply rails adjacent to *each* op amp are



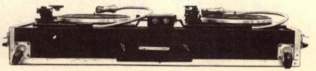
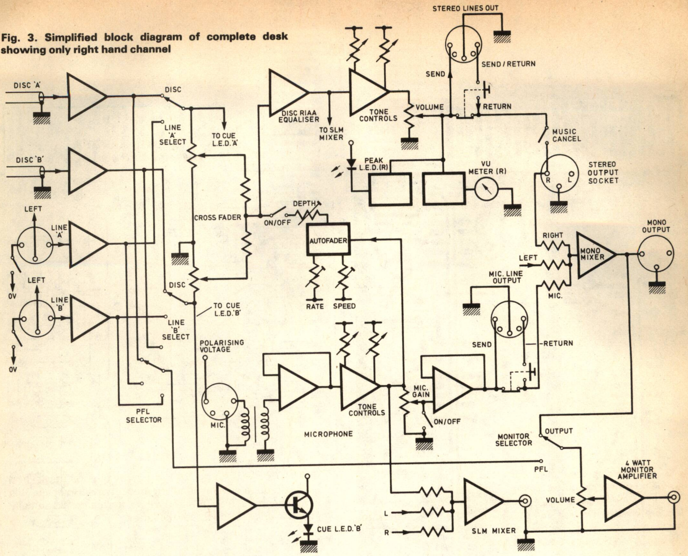
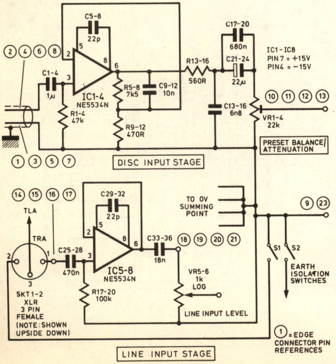
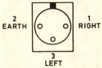


Fig. 3. Simplified block diagram of complete desk showing only right hand channel







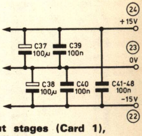


Fig. 4. Disc and line input stages (Card 1), socket detail and line decoupling

CARD 1

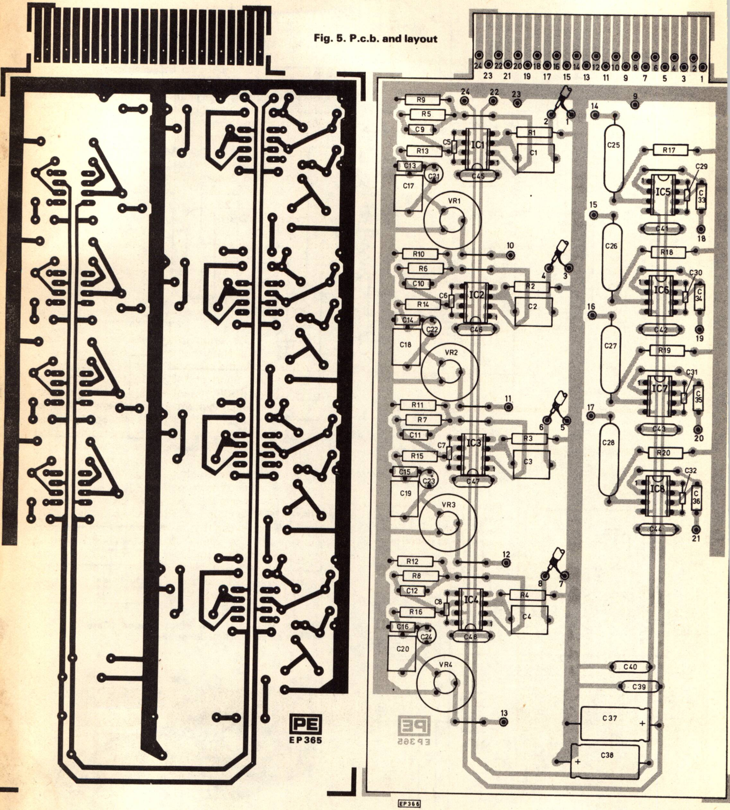


Fig. 5. P.c.b. and layout

Card 1 Edge Wiring

There are two line and disc (T and D) inputs, named A + B, and each has a left (L) and a right channel (R).

For turntable "A", the inputs are D_{RA} + D_{LA}

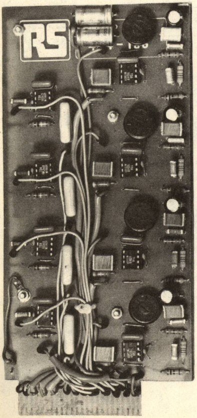
For turntable "B", the inputs are D_{RB} + D_{LB}

For line input "A", the inputs are T_{RA} + T_{LA}

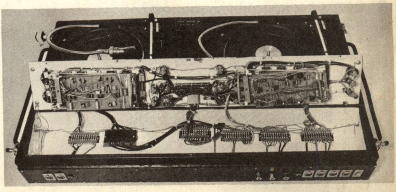
For line input "B", the inputs are T_{RB} + T_{LB}

Disc input earth connections are designated OV together with the appropriate code.

Pin No.	Connection	
1	OV, D_{RA}	Disc inputs from magnetic cartridge
2	Live, D_{RA}	
3	OV, D_{LA}	
4	Live, D_{LA}	
5	OV, D_{RB}	
6	Live, D_{RB}	
7	OV, D_{LB}	
8	Live, D_{LB}	
9	OV Summing point	
10	D_{RA}	Disc outputs to mode switches
11	D_{LA}	
12	D_{RB}	
13	D_{LB}	
14	T_{RA}	Line inputs. (OV via S1/S2 to pin 9)
15	T_{LA}	
16	T_{RB}	
17	T_{LB}	
18	T_{RA}	Line input amplifier outputs to mode switches
19	T_{LA}	
20	T_{RB}	
21	T_{LB}	
22	−ve, 15V	To power supply busbars
23	OV	
24	+ve, 15V	



Showing a completed Card 1 and below a desk with the board assembly lid pulled back



decoupled at high frequencies for stability (C41 etc) and additional capacitors (C37–40) are provided to attenuate common mode RF1 and to decouple the supply rails at audio frequencies.

CARD 1 LAYOUT

The physical layout of Card 1 is shown in Fig. 5. The copper clad board specified in the components list must be cut to size. Note that the card aperture is not symmetrical and marking out and cutting should be done from the *copper side* of the board if the aperture position is to correspond to Fig. 4. Accurate cutting is facilitated by using a jigsaw fitted with a very fine blade, together with an $\frac{1}{8}$in strip of straight aluminium as a guide along the inside of the cutting line.

The 24 edge connector strips should be covered with enamel paint to protect it during etching; paint is more consistent than etch resistant ink over such large areas. The p.c.b. pins are wired direct to the edge connector pins by 7/0.2 cable, except for pins 1–8 which require screened cable, and pins 9 and 23, which should be brought to the edge connector with 16/0.2 cable to ensure a low impedance connection. Because the edge connector pins are cramped, all the leadout wires should be sleeved. Apart from allowing a high component density, 'hard wiring' in this fashion permits control over stray capacitance which cannot be achieved first go with 24 parallel p.c.b. tracks!

When the board is completed, scrape away excess flux, using methylated spirits as a solvent, together with a stiff brush where necessary.

Check carefully for errors, then load the 8 sockets, preferably with 741s. Note that the op amps belonging to the line inputs face in the opposite direction to those handling the disc inputs. Short all the inputs to OV and apply ±12V or ±15V via 100R current limiting resistors in each supply rail. If the supply current exceeds 30mA (741s) or 70mA (NE5534s), disconnect the supply and look for errors. If all is well, load the card with NE5534s and reconnect the supply. Then check the offset voltages at pin 6 on the i.c.s; note that a carelessly placed probe may prove fatal to the devices here. If the offset voltage is greatly in excess of 300mV, disconnect and check again for errors, or for floating inputs. Finally, reconnect the supply and check the polarity of the offset at pin 6 on I.Cs 1–4. Then reorientate C21–24 if necessary. The screen can then be added (Fig. 5) and Card 1 is now completed. The same constructional and setting up procedure applies to the remainder of the cards; remember to allow for notably lower power consumption however on Card 2, and to short all inputs to the OV rail.

Next Month—more circuits.