A basic monitor for slow-scan television

Here is a new design for a monitor to display slow-scan TV pictures, of the type being transmitted by increasing numbers of radio amateurs. It uses four valves, four transistors, an IC and two SCRs, each performing the circuit functions for which they are best suited. This simplifies the unit and makes it easy to build, without sacrificing performance.

by IAN POGSON

Slow Scan TV, or SSTV for short, has become very popular in the United States and activity is beginning to quicken in this country as well. However, many Australian amateurs possibly do not realise just what a fascinating and absorbing branch of amateur radio is available to them, at quite a modest outlay in cost and equipment. Very little has been published in this country on the subject of SSTV and we propose to remedy that at least in some measure with the article to follow.

Without doubt, the best place to start in SSTV is with a monitor. Involving no more complexity than a modest CRO, a monitor can be used with the existing shack receiver, so that you can really "read the mail" of any amateur SSTV transmissions, either locally or from overseas. Equipment for the transmission of amateur SSTV signals is a little more involved and for the present at least, we will confine our efforts to describing a new monitor.

For those not yet familiar with SSTV, it is basically rather similar to conventional television except that the rate of scanning is slowed down from one picture every 1/25th of a second to approximately one every 8 seconds. This reduces the bandwidth required to transmit the signals from the usual 5MHz or so right down to a figure well within the audio spectrum. And as a result, SSTV signals can be transmitted and received using almost any of the established types of radio equipment, whether it employs AM, FM, SSB or other types of modulaton system.

Actually the SSTV "video" signal itself is not used to modulate the RF carrier directly. Because of the low scanning rate, the video is largely made up of very low-frequency components, and for these to be transmitted and received properly the transmitter and receiver would have to be fitted with much longer time constants than usual in the coupling circuits and other sections. To avoid this, the SSTV video signal is used to frequency modulate an audio subcarrier.

The subcarrier is made to vary between the limits of 1200Hz and 2300Hz. Synchronising pulses correspond with 1200Hz, black level is 1500Hz and white level is 2300Hz, with shades of grey in between black and white. Horizontal sync pulses have a duration of 5mS, with 30mS for vertical pulses.

The number of scanning lines is 120. Due to the fact that the United States uses a 60Hz standard for their supply mains while we, with Britain and many other countries have a 50Hz standard, and as the mains frequency is used as a reference for synchronising pulses, a compromise has had to be struck. The result is a 15Hz sweep rate (60/4) for the US and a 16-2/3Hz sweep rate (50/3) for Australia, etc. To tie in with the set 120 horizontal lines, the vertical rate is 8 seconds and 7.2 seconds for 60Hz and 50Hz mains frequencies respectively.

The question may well be asked as to how this works out when an amateur in Australia is in SSTV contact with an amateur in the United States. In fact the differences in sweep rates are not very great and are well within the synchronising capabilities of the equipment involved. The pictures stay in lock, but the picture size will vary slightly.

Our approach to the design of an SSTV monitor has been along lines already established overseas. However, in order to encourage newcomers into this fascinating field, we have made some effort to simplify circuitry as much as possible, together with an eye to keeping costs down.

In line with the cost angle, we have made use of an oscilloscope which was described by Jamieson Rowe in May, 1966. In fact, the unit modified (or rather largely rebuilt) is the original prototype. There may be some readers who are in the same position, with one of these units which can form the basis of an SSTV monitor. Whether or not you are in this position, or whether you are starting from the beginning as it were, we wish to emphasise that the mechanical approach we used has been dictated by circumstances and is only intended as a guide for constructors. Apart from the usual precautions with the installation of a CRO tube with respect to magnetic fields, layout does not seem to be at all cirtical.

Let us turn our attention to the circuit diagram and go through it, discussing the various circuit functions. The frequency modulated SSTV subcarrier is fed to the input. This may be from a communications receiver, tape recorder, etc. To avoid excessive input to the 741 op-amp, a pair of 1N914A diode clippers are included. The signal is amplified by the op-amp and emerges as a square wave. In series with the output is an inductor, about 200mH, shunted by .022uF which tunes it to 2300Hz. This LC combination is the "video discriminator" and is effectively a rejector circuit at 2300Hz. The FM signal passing through the discriminator is effectively changed into an AM type signal, rather like the well established "slope detection" used in AM receivers for receiving FM signals.

This AM signal passes through a level or "contrast" control and is then amplified by TR1. The ouput at the collector is stepped up in voltage by the transformer, where it is detected in the bridge consisting of four silicon diodes. The video voltage from the detector is then fed directly between the cathode and grid of the cathode ray tube, where the beam is modulated to give shades of grey between black and white levels.

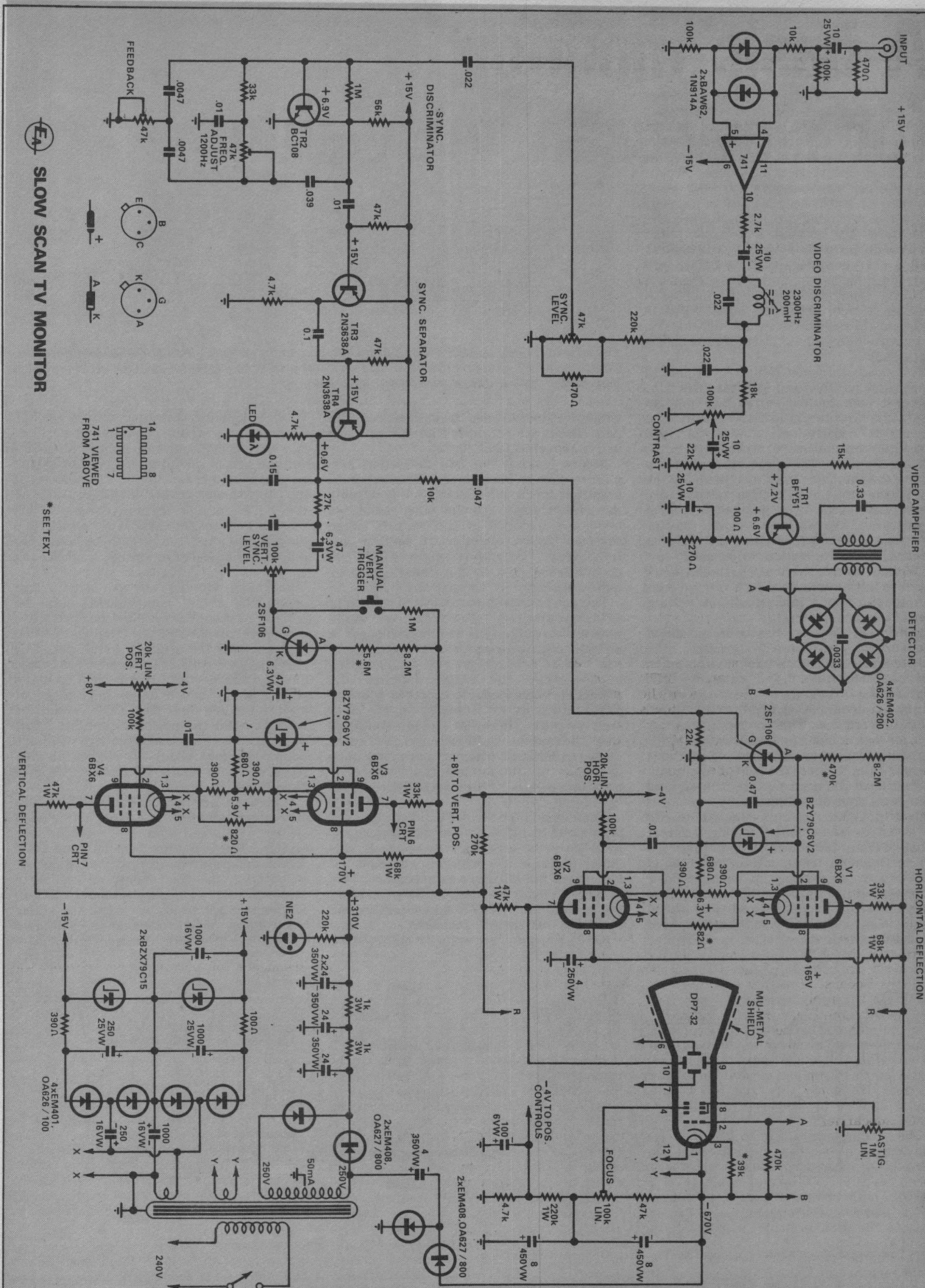
Returning now to the output of the video discriminator, a split is taken via a sync level control, to the sync discriminator. The level available from the video discriminator is quite high, much too high for our purpose and so the need for the 220k series resistor and the 470 ohm resistor shunting the 47k potentiometer.

The sync discriminator is, in effect, a frequency conscious amplifier, using a twin-T network and peaked to the sync frequency of 1200Hz. This circuit was selected in preference to an LC circuit similar to the video discriminator because a fairly high Q circuit is required and readily available coils did not come up to this requirement.

Following the sync discriminator is a two-stage sync separator using TR3 and TR4. In the collector of TR4 is a light emitting diode, which blinks on every sync pulse and is very useful for adjustment purposes. Sync pulses appear across the 0.15uF capacitor and are fed via a 10k isolating resistor to the gate of the SCR in the horizontal deflection circuit.

The 30ms-long vertical sync pulses are a little tricky to separate out cleanly, but by using the two-stage sync separator, an

Above is a picture of our SSTV monitor and the full circuit details are shown on the opposite page.


SLOW SCAN TV MONITOR
INPUT
VIDEO DISCRIMINATOR
VIDEO AMPLIFIER
DETECTOR
HORIZONTAL DEFLECTION
VERTICAL DEFLECTION
SYNC. DISCRIMINATOR
SYNC. SEPARATOR
FEEDBACK
FREQ. ADJUST 1200Hz
SYNC. LEVEL
CONTRAST
MANUAL VERT. TRIGGER
VERT. SYNC. LEVEL
20k LIN. VERT. POS.
20k LIN. HOR. POS.
+8V TO VERT. POS.
-4V TO POS. CONTROLS
FOCUS
ASTIG. 1M LIN.
MU-METAL SHIELD
DP7-32
741 VIEWED FROM ABOVE
*SEE TEXT
240V

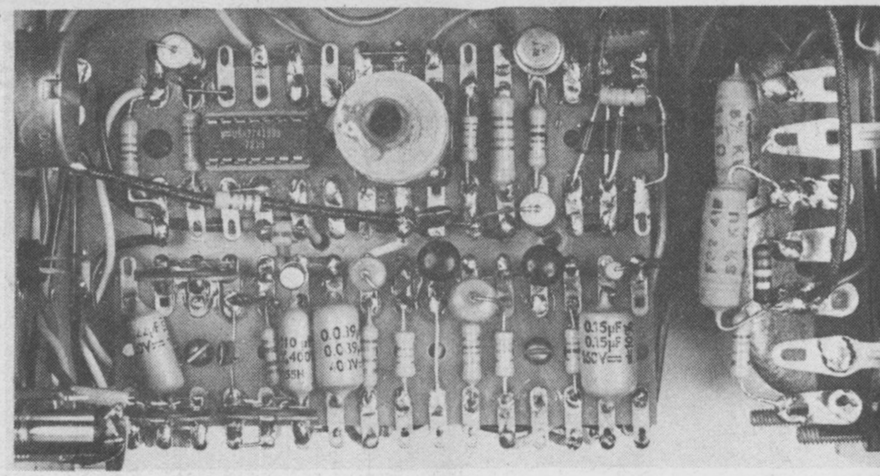
integrator consisting of the 27k resistor and 1uF capacitor, together with a vertical sync level control, very successful vertical synchronising has been achieved. The vertical sync pulses are fed into the gate of the SCR of the vertical deflection circuit.

As the vertical sweep rate is very slow, between 7.2 and 8 seconds, it often happens that when receiving a transmitted picture, you have just missed a vertical pulse. This would normally mean that you have to wait a very considerable time before you start to get the next picture. To avoid this, it is fairly standard practice to include a manual vertical triggering button. This is simply a 1M resistor from the high tension in series with a "make" press button on the front panel.

The sawtooth generators are perhaps of more than just passing interest. The simplicity is such that it is difficult to imagine anything simpler. Fundamentally, the generator consists of a resistor and capacitor time constant, with an SCR to initiate flyback. The sawtooth appearing across the capacitor is DC connected to the grid of the relevant deflection valve. There are only two extra components additional to those already mentioned. A 22k resistor from the gate of the horizontal SCR to ground is added to ensure a reasonably low impedance so that there is less likelihood of spurious triggering, while 6.2V zener diodes are used to limit the maximum voltage across each capacitor.

The foregoing describes both horizontal and vertical generators in principle. The horizontal circuit has an 8.2M resistor and a 470k in series with a 0.47uF capacitor. The 470k resistor may have to be modified during adjustment but more will be said about that later on. The vertical circuit has an 8.2M and a 5.6M in series with a 47uF tantalum capacitor. Instead of the 22k resistor from the gate of the SCR to ground, the in-circuit resistance of the 100k vertical sync level control is substituted.

Each deflection circuit consists of two 6BX6 valves in a "long-tail pair." Direct coupling from the valve plates permits the use of amplified trace positioning. This is achieved by an adjustable voltage via a potentiometer to the undriven grid of each pair. The grid is bypassed for signal frequencies with a .01uF capacitor. Gain of the stage and so sweep size, is controlled



The strip at the top contains the IC amplifier, discriminator coil, video amplifier and detector. The strip below contains the sync discriminator and sync separator circuits. At the right is part of the power transformer and supply wiring.

with a resistor between the cathodes of each pair. These are set during adjustment and will be covered later in detail.

Before leaving the two deflection amplifiers, it may be seen that the horizontal amplifier has a 4uF electrolytic bypassing the screen grids. On the other hand, no bypass is included in the vertical stage screens. To be effective at such a low frequency, the capacitance would be prohibitively large. Happily the stage works quite satisfactorily without any bypass.

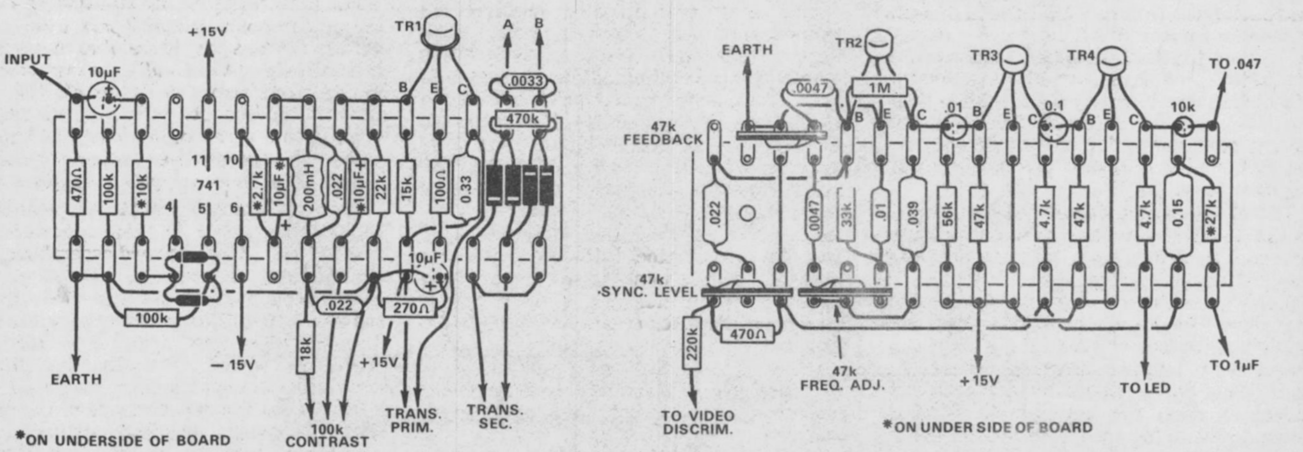
The power supply system is of necessity rather complex. However, we have managed to simplify it as much as possible and only one transformer is involved. There are two 6.3V windings, one for the CRT heater while the other supplies the deflection valve heaters, together with the plus and minus 15V supplies for the solid state circuits. These use voltage doubling, with the output stabilised by 15V zener diodes. Additional filtering was found to be necessary on the positive rail and this is provided with a 1000uF electrolytic across the output.

High tension for the deflection amplifiers is obtained by full wave rectification from a 250-0-250 volts secondary winding. It was found that a considerable amount of filtering of the HT line was necessary. This is achieved with a two-stage filter, making use of four 24uF 350VW capacitors in one can, with two 1k 3W resistors.

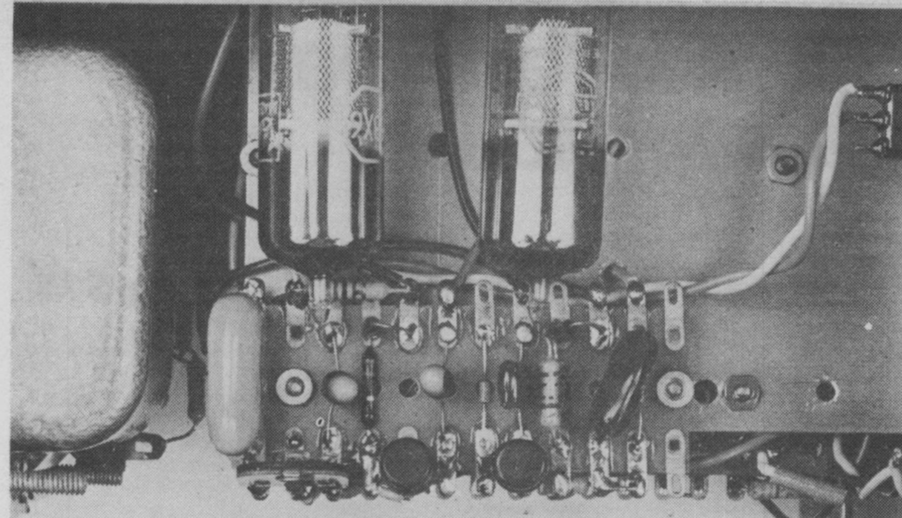
EHT of nearly 700 volts is obtained by voltage doubling from one side of the HT winding. The output capacitor consists of two 8uF 450VW units in series. The DC voltage across each unit is established by connecting their junction to the junction of the 100k focusing pot and the 220k resistor of the EHT voltage divider chain. A 39k resistor between the cathode of the CRT and the EHT rail sets the brightness level, and may need adjustment during final setting up.

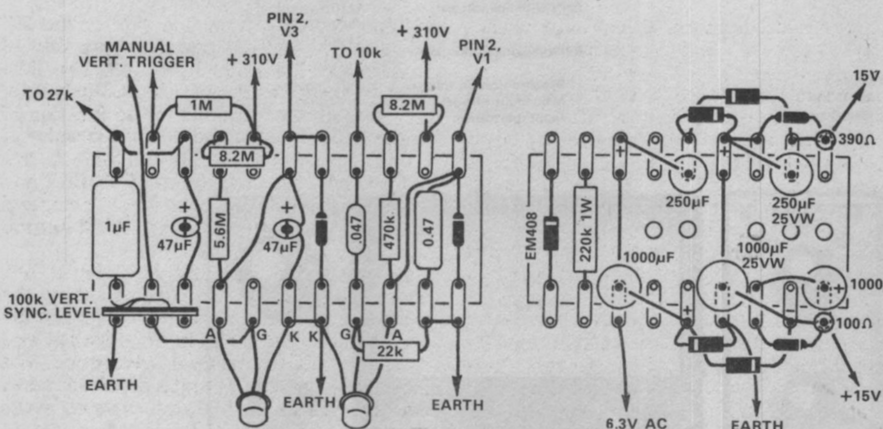
So much for the circuit. Now a few comments about components may be helpful. As mentioned earlier, our prototype is a much rebuilt 1966 3in Oscilloscope and as such, uses the original metalwork. The only change of note, is that a new front panel overlay was needed. If you wish to make your unit up as we have, then a set of metalwork for the 1966 CRO would be suitable, with the need for the new panel overlay. More than likely readers will have their own ideas about this and a suitable panel could be made up from a piece of aluminium.

Resistors and potentiometers should present no problems. The capacitors should all be available, with one possible exception. The can type housing four 24uF 350VW units may be difficult to obtain but substitutes in the form of separate capacitors should be easy enough to obtain. The capacitors which we used are either electrolytics or polycarbonates, with two exceptions. They are the two 47uF, 6.3VW



At the left is the wiring diagram for the board with the IC, discriminator, video amplifier and detector. At the right is the wiring diagram for the sync discriminator and sync separator circuits. Care should be taken wiring the detector as high voltage appears here.





The picture at the top shows a close-up of the vertical and horizontal sweep generators, with the inverted vertical amplifier valves. Below are wiring diagrams for the two sweep generators and the low voltage power supplies.

tantalums. Diodes should present no problems. Either the types specified or their equivalents may be used. The only possible exception is the LED. This may be any small ruby coloured unit, with a bezel for mounting it on the front panel. A wide variety of suitable LEDs are currently available.

The two SCRs which we used are made by ITT but any low power SCR should be quite suitable; the circuit is quite undemanding. Similarly the 741 IC comes in various makes and packages. The one we used is in a 14-pin dual-in-line package but no trouble should be experienced in adapting almost any mechanical arrangement. The transistors, of which there are only four, are all readily available. However, if substitution of the BFY51 video amplifier is considered, care should be taken to make sure that the substitute will do the job.

The 6BX6 valves should still be readily available but if you have some other types on hand, then they may be used provided they will do the job. The pentode section of a 6BL8 is quite satisfactory and we imagine that other types such as 6AU6, 6AM6, etc would be satisfactory. The CRT is special in that it has a long persistence phosphor. We understand that Elcoma have stocks sufficient to meet the anticipated demand. When ordering the tube, a mu-metal shield type No 55530 may be ordered at the same time. The orange perspex filter which we fitted, although not essential, does seem to help to give a better picture. Pieces of suitable material should be available from suppliers who have prepared kits for digital projects, such as our digital frequency meter.

The 200mH adjustable inductor used for the video discriminator has been made available by Transcap Pty Ltd. Stocks should be available through your local supplier but if any difficulty is experienced, stocks should be available from Watkin Wynne Pty Ltd, 32 Falcon Street Crows Nest, NSW, 2065.

The small transformer feeding the detector is actually a miniature 240/12.6V heater transformer. We used a Ferguson type PF2851 but any small transformer with about the same turns ratio should be satisfactory. The mains transformer is not quite so easy as this particular type is no longer in production. As the demand for the transformer for this project is likely to be rather limited (we could be wrong!) we hesitated to suggest that manufacturers make up further stocks. However, the type of reader who is likely to make up one of these slow scan monitors is also likely to have a transformer of similar specs in his junk box. It may be necessary to add a shorting strap to reduce the stray field. In any case, we feel that we can leave this problem for each individual to solve in his own way.

Another small point on the same less optimistic note relates to miniature tag board, which we have used on this unit and many others in the past. We are advised that this material is going off the market. However, a new product has already appeared which should be quite a satisfactory substitute. Instead of a strip with lugs eyeleted each side it is a printed board of about the same total width, and provides copper pads in lieu of the lugs. In short, this item should substitute quite well for the former product.

From the constructional point of view, we will assume that readers will be following the method which we used. Any deviations can safely be left to the individual to sort out for himself. We will also assume that you have a suitable set of metalwork.

A good place to start is with the sub-assemblies. There are five main boards, each with components mounted on miniature tag board and we have given wiring diagrams to make the job somewhat easier than if you had to work it all out for yourself.

One board includes the signal input, IC op amp, video discriminator, video amplifier and detector. The detector transformer is mounted separately. It is straightforward except for the IC and the 200mH coil. We used a socket for the IC and we snipped off all the unused lugs. With the socket correctly located on the board, we drilled five small holes corresponding to pin positions 4, 5, 6, 10 and 11. The socket is located in these holes and the lugs are connected to the tagstrip as indicated, by means of thin tinned copper wire. Before mounting the 200mH coil, carefully cut off the extreme end at the moulded shoulder. Cut off all four corner lugs and bend the remaining two active lugs out at right angles for soldering to the appropriate lugs on the board.

The board containing the sync discriminator and sync separator presents no problems. The trimpots are mounted vertically and it may be seen that in common with the other boards, some resistors and capacitors are also mounted vertically to save space. For the same reason some items are mounted underneath the board.

The board containing the two sawtooth generators and the board carrying most of the small components for the two deflection amplifiers are quite straightforward. The last board, which mainly includes components for the two 15 volt supplies is rather crowded and needs some care in fitting the electrolytics. Two pairs of lugs at one end carry a 220k 1W resistor and an 800 PIV diode. These belong to the CRT EHT circuit.

The pictures show the location of all the major components and apart from a few details readers should be able to assemble the unit without difficulty. In our case, the power transformer is stood off the back skirt of the chassis with four spacers. A small panel of aluminium is fixed to one side of the transformer to accommodate a couple of tagstrips for power supply wiring.

A vertical panel, about 11cm long and 8cm wide, is fixed below the main chassis and on it are mounted three board assemblies. The one including the input to detector circuits is mounted nearest the underside of the chassis, with the board containing the sync discriminator and sync separator immediately below. The board with the sawtooth generators is mounted immediately on the opposite side of the panel. With the boards in these positions, it is possible to get to all the adjustments without hindrance.

The board with the deflection circuit components is mounted atop the chassis.

SSTV MONITOR

The horizontal deflection valves are those above the chassis and the vertical deflection valves are mounted upside down on the other side of the chassis. The detector transformer is above the chassis between the horizontal valves and the front panel. Focusing and astigmatism potentiometers are mounted on a bracket above and at the rear of the chassis and the horizontal and vertical shift controls are immediately below and mounted on the back skirt of the chassis.

The power supply board is mounted immediately behind the CRT socket and the board is stood off the chassis by a cm or so to clear any components mounted under the board. This also applies to all the other boards. If you are not using a can type multiple electrolytic assembly, then some ingenuity may be needed to fit the substitutes in the space available.

Apart from the tube face, with its hood and filter, the only other items on the front panel are the input socket, trigger and mains switch, LED and mains indicator lamps and contrast control. The panel is held in place by the trigger switch and contrast control.

Having built the SSTV Monitor, the next task is to put it into operation. Some suggestions as to how to go about this are added. Although it is not necessary in most cases, we stress that the 700 volts of EHT and the 300 volts HT line can be dangerous, particularly as the source impedance is quite low in each case. Apart from the more obvious danger points, the detector components which at first sight seem innocent enough, are in the EHT circuit and a bite from this is not recommended.

Before switching on foı the first time, it is always wise to make a thorough check of wiring to make sure that there are no errors or omissions. Having done this, a helpful

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LIST OF PARTS

1 Case, 12.7cm wide x 19cm high x 21.6cm deep, with front panel and chassis
1 Carrying handle
4 Rubber feet
1 Set of brackets, including tube hood and support ring
1 Perspex orange filter
1 Power transformer, 240V primary, 250V- 0-250V secondary at 50mA, 6.3V at 1A, 6.3V at 3A, low radiation type (see text)
1 Miniature detector transformer, 240V primary, 12.6V at 150mA (PF2851 or similar)
1 200mH variable inductor (Transcap)
1 Coaxial input socket
1 CRT socket
4 9-pin miniature valve sockets
1 Miniature toggle switch, SPDT
1 Miniature press-on switch, SPDT
1 Knob
1 NE-2 neon bulb, in pilot bezel
1 Rubber grommet, ⅜in
1 Rubber grommet, ¾in
2 7-lug tagstrips
1 3-lug tagstrip
2 Miniature tag boards with 16 prs tags
1 Miniature tag board with 15 prs tags
1 Miniature tag board with 12 prs tags
1 Miniature tag board with 9 prs tags
2 Diodes, BAW62, 1N914A
4 Diodes, EM401, OA626 / 100
4 Diodes, EM402, OA626 / 200
4 Diodes, EM408, OA627 / 800
2 Zener diodes, BZY79 6V2
2 Zener diodes, BZX79 C15
2 SCR, 2SF106 or similar
1 LED (see text)
1 IC, 741
1 Transistor, BFY51
1 Transistor, BC108
2 Transistors, 2N3638A
1 Neon indicator, NE-2
4 Valves, 6BX6
1 CRT, DP7-32, with mu-metal shield type 55530

CAPACITORS

1 .0033uF 100V polycarbonate
2 .0047uF 100V polycarbonate
5 .01uF 100V polycarbonate
3 .022uF 100V polycarbonate
1 .039uF 100V polycarbonate
1 0.15uF 50V polycarbonate
1 0.33uF 50V polycarbonate
1 0.47uF 50V polycarbonate
1 1uF 50V polycarbonate
1 4uF 250VW electrolytic
1 4uF 350VW electrolytic
2 8uF 450VW electrolytics
4 10uF 25VW electrolytics
4 24uF 350VW electrolytics (in one can)
2 47uF 6.3VW tantalums
1 100uF 6VW electrolytic
1 250uF 16VW electrolytic
1 250uF 25VW electrolytic
2 1000uF 16VW electrolytics
1 1000uF 25VW electrolytic

RESISTORS (½W unless stated otherwise)

1 82 ohms	2 33k 1W
2 100 ohms	1 33k
1 270 ohms	1 39k
5 390 ohms	3 47k
2 470 ohms	2 47k 1W
2 680 ohms	1 56k
1 820 ohms	2 68k 1W
2 1k 3W	4 100k
1 2.7k	2 220k
3 4.7k	1 220k 1W
2 10k	1 270k
1 15k	2 470k
1 18k	2 1M
2 22k	1 5.6M
1 27k	2 8.2M

2 20k linear potentiometers
3 47k linear trimpots
2 100k linear potentiometers
1 100k linear trimpot
1 1M linear potentiometer

MISCELLANEOUS
Hookup wire, solder, solder lugs, 3-core flex and plug, cable clamp, screws, nuts.

45MHz. There are five knobs for range selection, tuning, attenuator, attenuator multiplier and the modulation selector which is combined with the power switch.

RF output is via a BNC socket on the front panel. On the back panel a socket is provided for external modulation input or access to the internal modulation signal of 400Hz. Also on the back panel is the three-pin mains cord socket and fuse.

Surprisingly, the unit uses valves. The RF oscillator uses a twin triode while the modulator-buffer and phase-shift modulation oscillator share a triode-pentode. Silicon diodes are used for the rectifier. Inside the unit, we found the construction rugged. High quality components are used throughout. The oscillator is well shielded inside a totally enclosed tinned metal box and the attenuator is similarly well shielded.

Our only complaint with the construction was that the upside-down mounted oscillator valve was not fitted with a clip to secure it into the socket. This was probably an error in assembly of the sample unit, as the socket had provision for a clip.

Specifications are as follows: Frequency range, 140kHz to 40MHz; 30 pc amplitude modulation at 400Hz; external modulation frequency range, 20Hz to 15kHz; Maximum RF output, 0.2V plus or minus 3dB; RF output impedance, 75 ohms; Dial Accuracy, plus or minus 1 pc except for band 430 to 530kHz, plus or minus 0.1 pc; Signal radiation, less than 5 microvolts.

Set up on the bench, the unit performs well. We would have preferred a larger

tuning knob to give a better "feel". Still, as it is, the dial drive is satisfactory although it is a little on the tight side presumably as a result of precautions to eliminate blacklash. Dial accuracy is very good and well within the tolerances listed.

We had no precise means of measuring the leakage signal radiation from the oscillator but listening tests seem to indicate that the maximum of 5uV is a credible figure. Stability is reasonable for an instrument of this sort.

We can sum up the instrument by stating that it is well made and is well suited for production line, service or hobbyist use. Once again the unit has an Italian manual and was supplied to us without the correct three-pin plug on the mains cord. Presumably this will be attended to on the instruments as presented for sale.

Price of the MU 472 Power Output Meter is $182.00 duty paid while the OM 866 Modulated Oscillator is $132.82. Both prices include sales tax. Further information regarding the TES range of equipment can be obtained from the Australian disbributors Jacoby, Mitchell Limited, 215 North Rocks Road, North Rocks, NSW 2151. (L.D.S.)

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move is to set all adjustment points to a position which will help the adjustment procedure. The vertical position, horizontal position, focus and astigmatism controls are set to mid-position. The sync level, contrast and vertical sync level controls are all set right off. Set the frequency adjust pot to a value of 27k and the feedback pot to 15k. The slug in the video discriminator coil may be set so that the slug is fully inside the coil, with the respective ends about flush.

For adjustment purposes, the use of a CRO, an audio generator and possibly a VTVM will be assumed. After switching on, a routine check of voltages may be made. Make sure however, that there is not a well focused bright spot on the CRT screen, which may lead to phosphor burning. With voltages checked and if the aforementioned spot has not yet appeared, rotate the horizontal and vertical positon controls untl the spot is found. A rough adjustment of the focus and astig controls may be made and then the spot should be shifted just off the screen for the time being at the bottom right.

Connect the CRO (or VTVM) to the junction of the 2.7k resistor and the 10uF electrolytic at the op-amp output, and connect the audio generator to the input socket. Feed in any frequency between 1200Hz and 2300Hz. Limiting should occur with less than 100mV input and the saturated output will be about 30V peak-to-peak.

To adjust the video discriminator coil, connect the CRO to the junction of the coil and 18k resistor. Set the audio generator to 2300Hz and output level to 100mV. Adjust

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