# AN IMAGE ORTHICON CAMERA

P. Hayes

## PART 1

This article describes the design and construction of a $4\frac{1}{2}$ inch Image Orthicon camera channel, the basic requirement being sensitivity together with good definition and operational stability. I do not expect anyone will wish to build a "carbon copy" but the design is presented here in the belief that the reader will find some part interesting. I have attempted to make the design simple to operate and free from external connections, only requiring power and a picture monitor connection. Some knowledge of the I.O. is useful in obtaining the best results;

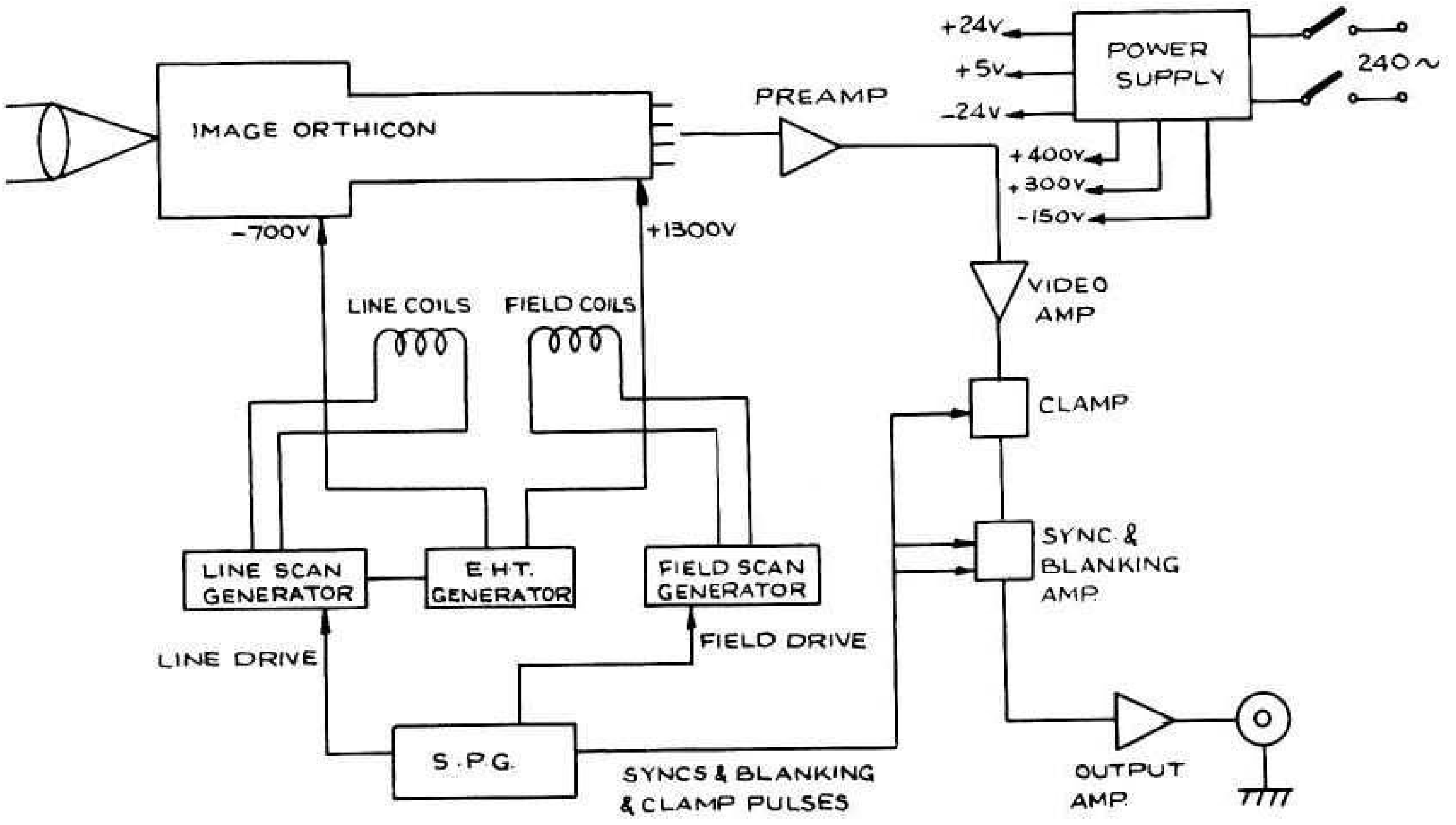


FIG 2. OVERALL BLOCK DIAGRAM

Fig. 1 illustrates the internal construction of the tube, and tube controls. A full description would occupy an issue of C Q - T V by itself!

Fig. 2 shows the block diagram of the complete channel and is more or less self explanatory. Fig. 3 is the block diagram of the S.P.G. The S.P.G. is simply constructed out of four SN7490 integrated circuits, as shown in Fig. 4. A twice line frequency oscillator is fed into a ÷2 and a ÷625 thus producing interlaced line and field rate signals. These are used to generate syncs, blanking and clamping pulses. By disabling the divide chain (removing +5v), and feeding in external line and field drive pulses to points A and B on Fig. 4, the camera can be run from an external S.P.G. With careful adjustment of pulse timing, the channel can be made sync at a remote mixing point. The transistors are mainly cheap PNP components salvaged from ex-computer boards. Any RF transistor will do: slight adjustment of the bias potential divider in each of the White monostable multivibrators may be necessary in some cases.

Fig. 4 also shows the target bias and blanking generator. Essentially this consists of a mixed blanking amplifier, and a clipper arranged to limit the positive peak to a maximum of 5 volts, controlled by the dc bias on Q15. The back to back Zener diodes across the output clip the negative excursion to -8.2v and limit the maximum positive excursion to 5.1v in the event of component failure in the clipper. The I.O. can be damaged by excessive target voltage. A delay line is used to generate the front porch period and the clamp pulses; monostables would be equally suitable, but would need to be high speed types or an IC such as SN74121. Note that the output pulses are not at the standard level.

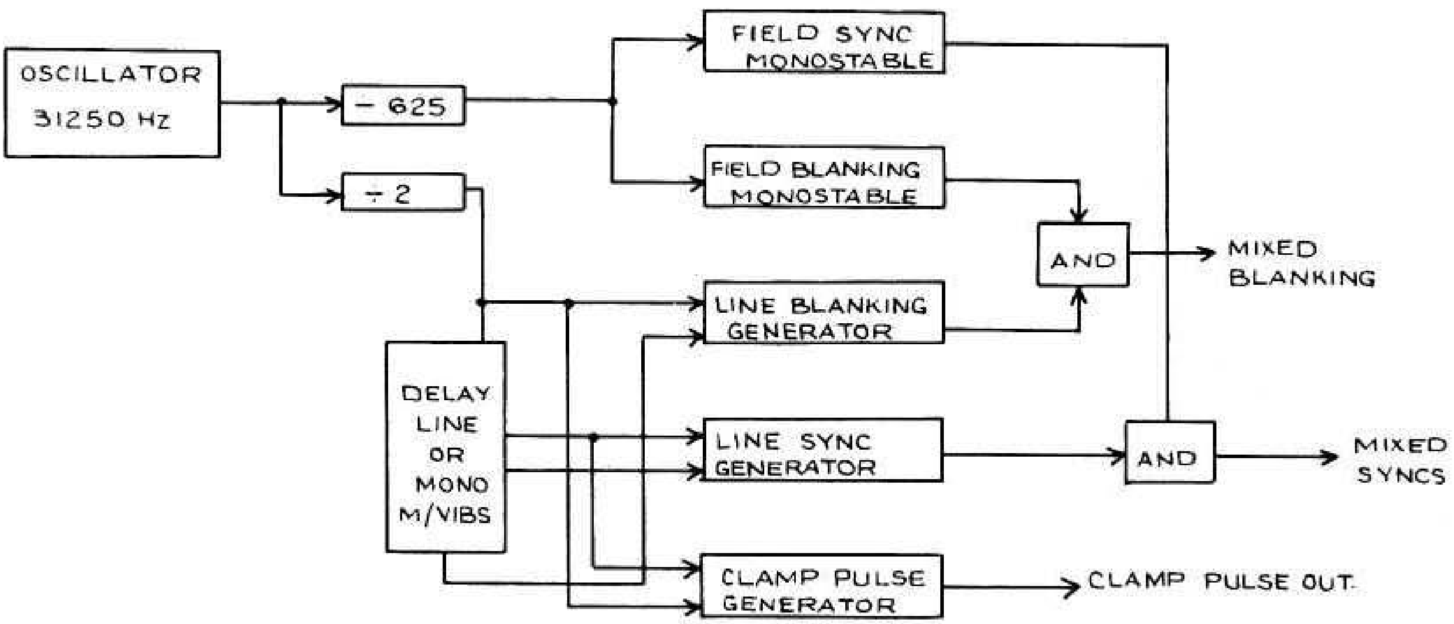


FIG.3 S.P.G. BLOCK DIAGRAM

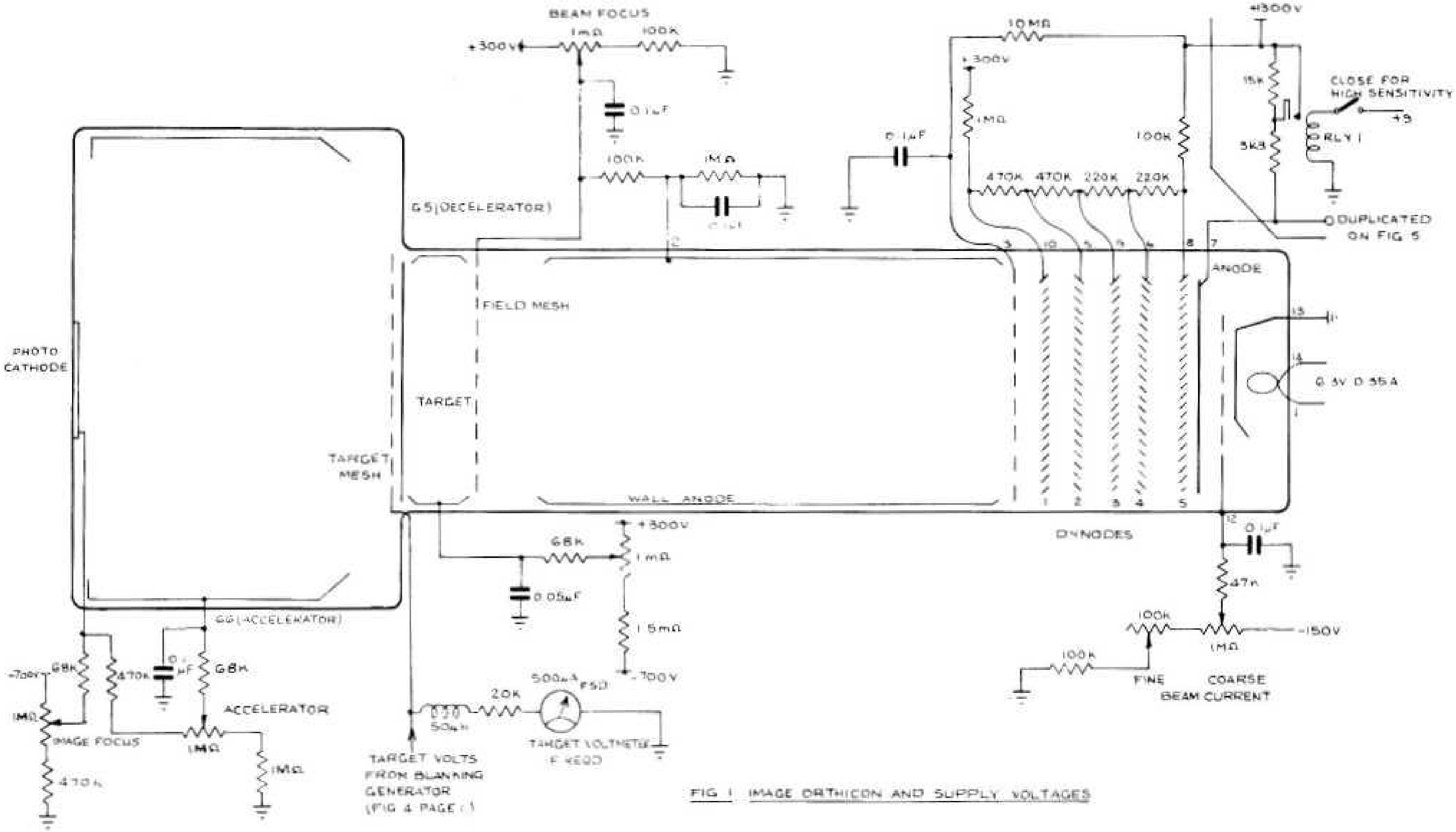


FIG 1 IMAGE ORTHICON AND SUPPLY VOLTAGES

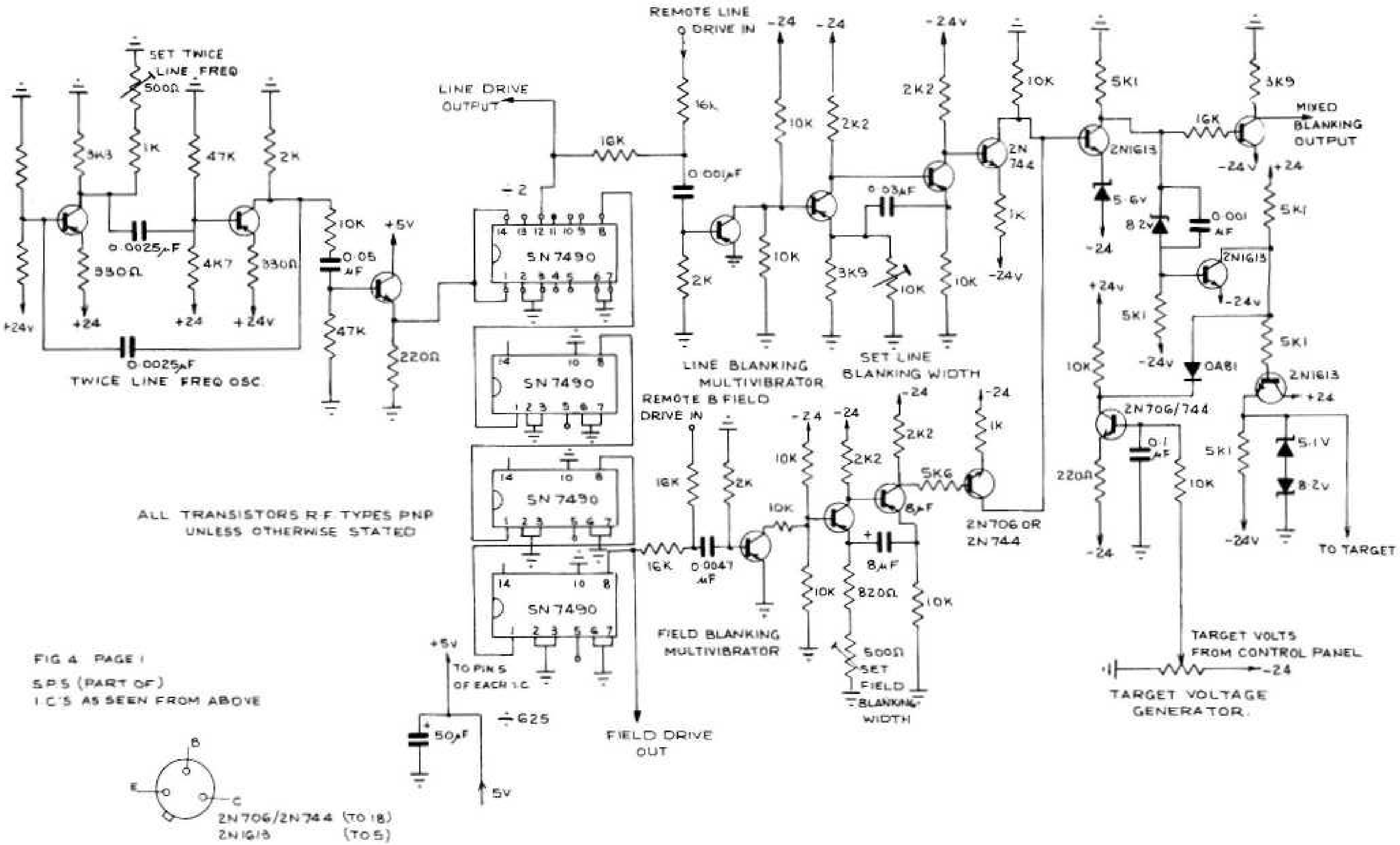


FIG 4 PAGE 1
S.P.5 (PART OF)
I.C'S AS SEEN FROM ABOVE

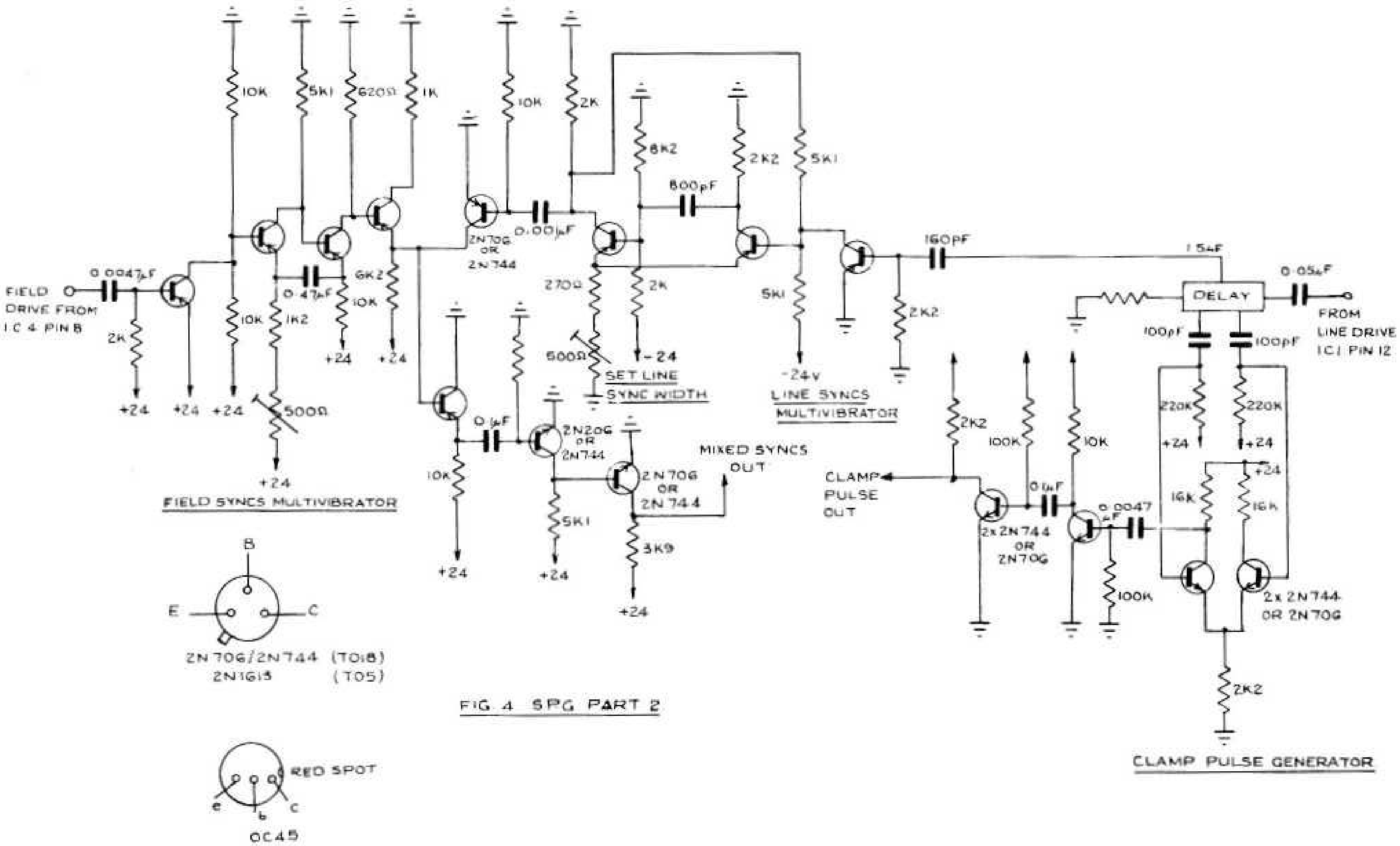


FIG 4 SPG PART 2

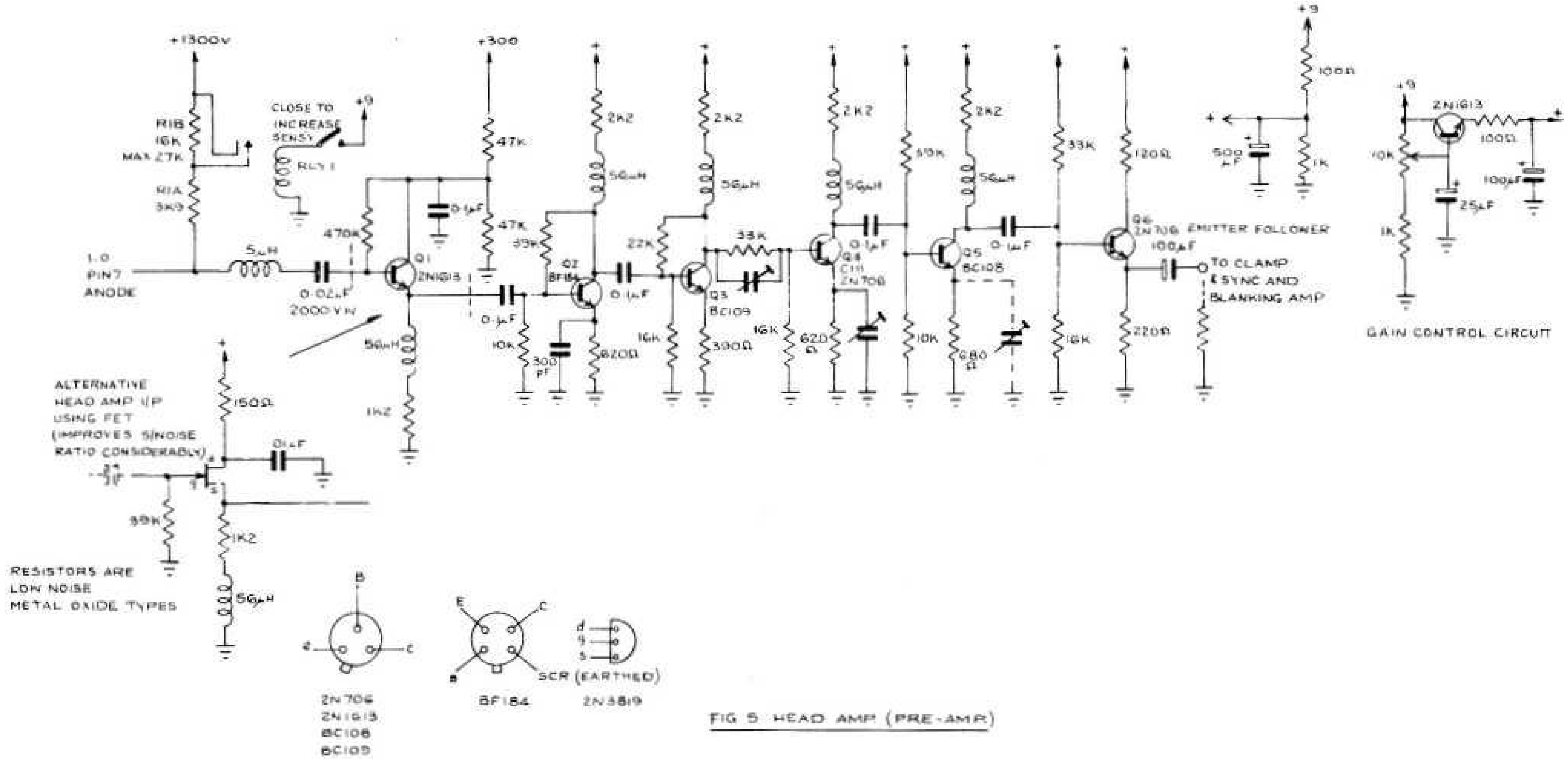


FIG 5 HEAD AMP (PRE-AMP)

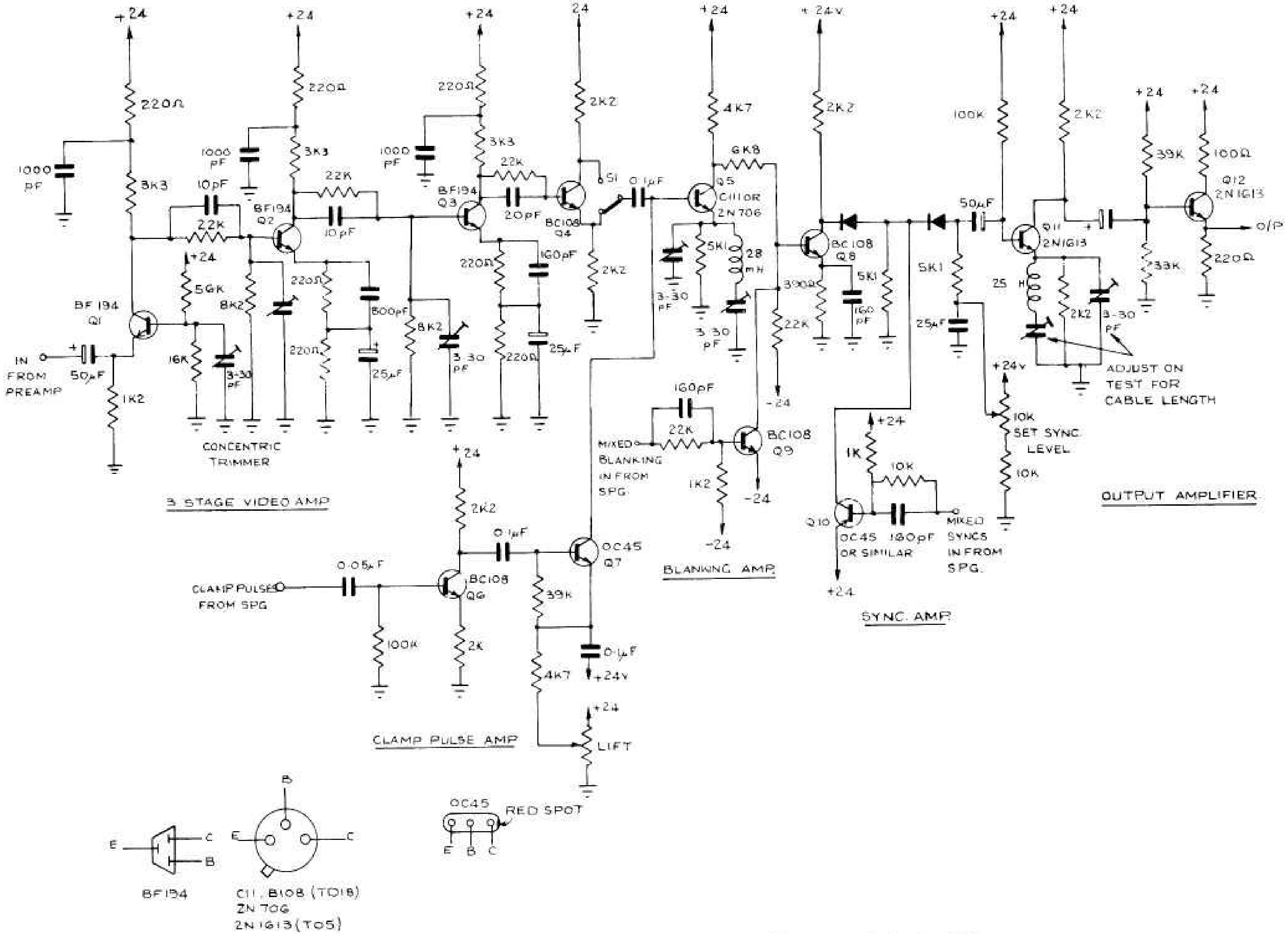


FIG 6 CLAMPING SYNC & BLANKING AMPLIFIER

Fig. 5 shows the video amplifier. The output of the I.O. is developed across RIa. For use in low light conditions a further fixed resistor, RIb, is switched in by a reed relay, Rly1. This provides a higher output voltage at the cost of definition. This loss of definition can be compensated for to a certain extent provided a low noise head-amplifier is used. If RIa + RIb were in circuit all the time, the tube output would severely overload the head amp under normal conditions. Q1 is connected as an emitter follower to present the tube with a high impedance load, L1 separates the tube output capacitance from the head amp input capacitance. Q2 -5 amplify the signal up to about 0.5v p-p, and apply hf correction using standard high-peaking techniques. The signal is fed to the clamping and sync mixing amplifier. Before clamping the signal is raised to about 5v p-p by QI-3 on Fig. 6. Q4 is unity gain phase splitter, S1 selects the required polarity, giving positive or negative pictures. The signal is coupled to Q5 via a 0.1uf capacitor. Clampin occurs at the base of Q5. The clamp pulses from the S.P.G. board are raised to 24v p-p by Q6 which is driven hard on by the clamp pulses. Q7 is also driven hard on during the clamping time and this results in the base of Q5 being returned to the emitter voltage of Q7, which is itself set by the "lift" control. Syncs and blanking are added in the following two stages, and the composite output amplifier by Q11. The hf response is trimmed up in this stage, and matched to the output cable by emitter follower, Q12.

To be continued in the next issue of C Q - T V.

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## PART 2

Fig. 7 shows the field scan generator. A surprising amount of scanning power is required by an image-orthicon; approaching the amount required by a 12" to 14" CRT. Referring to Fig. 7, Q1 is a unijunction sawtooth oscillator. Differentiated field drive is fed to B1 and triggers the discharge of the 2uf capacitor, C1. C1 then charges up through Q7, the rate of charging being controlled by the voltage on the base of Q7. Emitter follwer Q2 isolates Q1 from the amplifier stages, Q3-4. Q5 is the output stage, and a measure of the output waveform is obtained across the emitter resistor. This is amplified by Q6 and used to control Q7, the charging circuit for C1. The amount of "bootstrapping" thus obtained is set by the 200 Ω control in the emitter of Q5, and adjusts the scan linearity. The height control in the emitter of Q2 also affects linearity so this latter control should be adjusted first. Some variation in scan size with heating of the scan coils does occur; This could be reduced by placing a thermistor in parallel with the coils. The maximum output that can be obtained from this circuit is over twice that required to fully scan the target, but requires a well stabilised power supply. Experiments are being undertaken to reduce this requirement, mainly centering around feeding back dc voltage proportional to scan output to the height control in such a way as to stabilize scan amplitude.

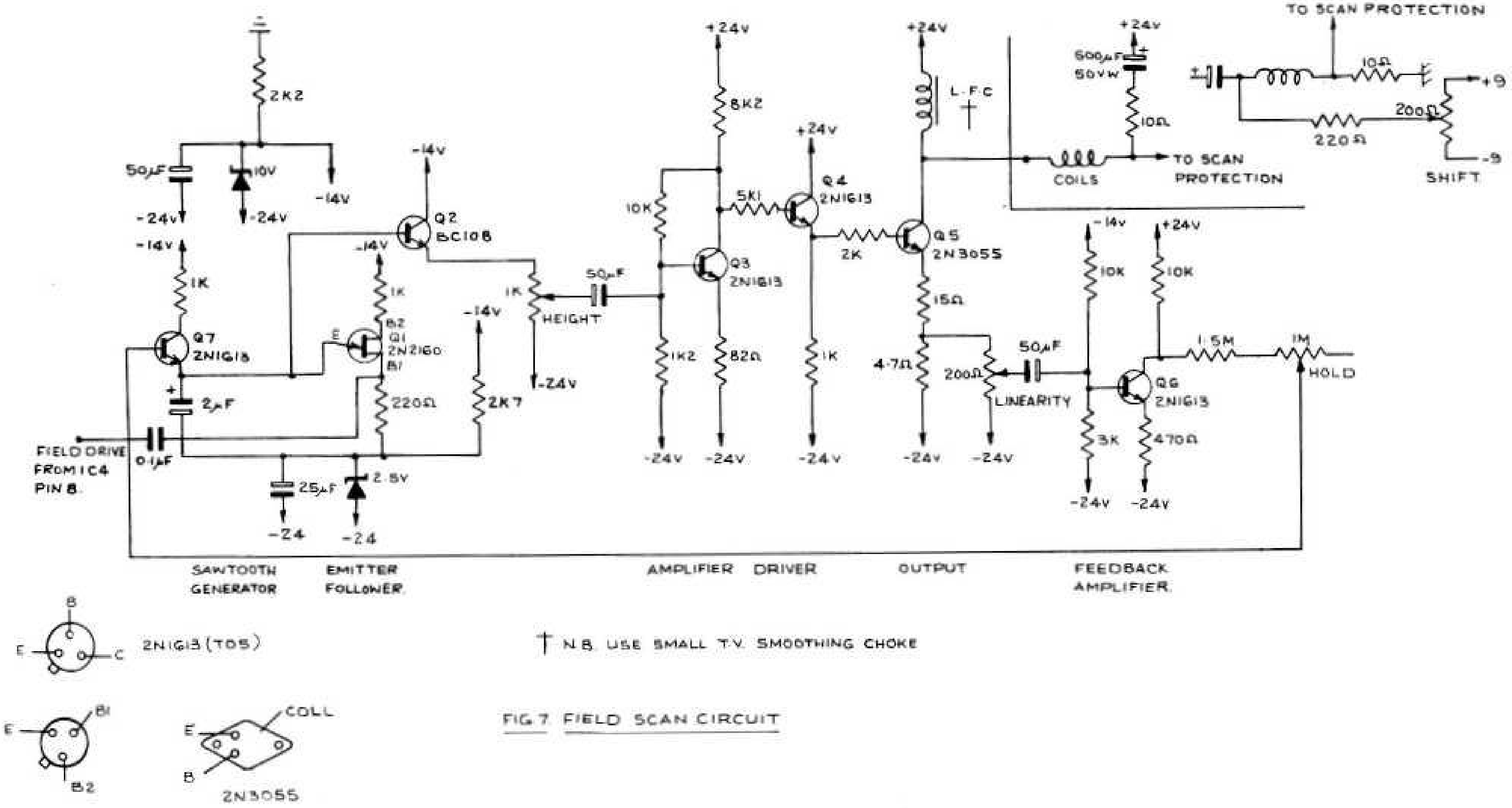
This field scan circuit gives enough power to drive the scan coil of a 5 inch view finder. The feed taken from the collector of the 2N3055 output transistor to the I.O. coils should be taken through the viewfinder scan coil then through a 500uf 500vw capacitor to earth. Across the viewfinder coil wire a 22 ohm 1 watt resistor in series with a 25 ohm variable to act as a height control. Varying this control has less than 5% effect on the I.O. scan power. Shift volts are applied to the "cold" end of the I.O. coils.

The line scan circuit produces many problems. Various circuits were tried with little success, and many burnt out ransistors! Thyristors were also tried, also unsuccessfully. Finally I decided to use valves in the output and driver stages. The circuit is that used in the Marconi cameras, with modifications to the early stages to use transistors, and is shown in Fig. 8. Q1 and 2 serve to clean up the line drive input, and Q3-4 amplify it up to about 45v p-p. The amount fed to V1 is set by the line drive control. Feedback from line output transformer is not essential, but linearity is improved by its inclusion. It is possible to replace the efficiency diode by 6 IN4007 silicon power diodes. 1 M5 resistors should be placed in parallel with each to balance the load evenly betweenthem. Most line output transformers will work to some extent and will match into most IO coils. A guide to the construction of scanning coils is given later.

The IO tube requires EHT supplies of +1500v for the dynode chain, and -700v for the image section. A small amount of line scan output is fed to V5, and the EHT is developed across the ringing coil in its anode.

Severe damage can occur to the IO tube if either or both scans should fail. Some form of protection must therefore be included preferably of a "fail safe" nature. Fig. 9 shows a suitable circuit. Q1-2 form a schmitt trigger producing no output unless the input rises above a certain threshold level, set by the sensitivity control. Q3-4 is identical, and the combined output is rectified by D3. The dc voltage is amplified by Q5, and used to hold off the third schmitt trigger made up of Q6-7. Relay RLY2 in the collector of Q7 is thus energised only when both scans are present. Failure of most components, the relay, or the power supply to the protection circuit will stop the IO tube operating thus giving a measure of "fail safe".

Fig. 10 gives the circuit of the 300v power supply, and the focus current stabiliser. The HT supply does not require stabilisation as the line scan amplifier is relatively unaffected by HT supply variations, and the focus supply has to be current stabilised. The IO tube requires an axial magnetic field strength of 120 gauss for the image section and 70 gauss for the scanning section ($4\frac{1}{2}$" tube). With the standard focus coils used by camera manufacturers and available to amateurs, a focus current of125ma is required. This current must be stabilised or beam and image focus will vary considerably as the focus coil warms up. It is not good enough to stabilise the voltage across the coil as the current will fall when the coil heats up and its resistance rises. In fig 10, the current is stabilised by measuring the voltage across a resistor in series with the coil, and arranging for this to be kept constant. The voltage across the resistor (100Ω) should be 12.5v for the correct focus current to be flowing, and a proportion




† N.B. USE SMALL T.V. SMOOTHING CHOKE

FIG 7. FIELD SCAN CIRCUIT

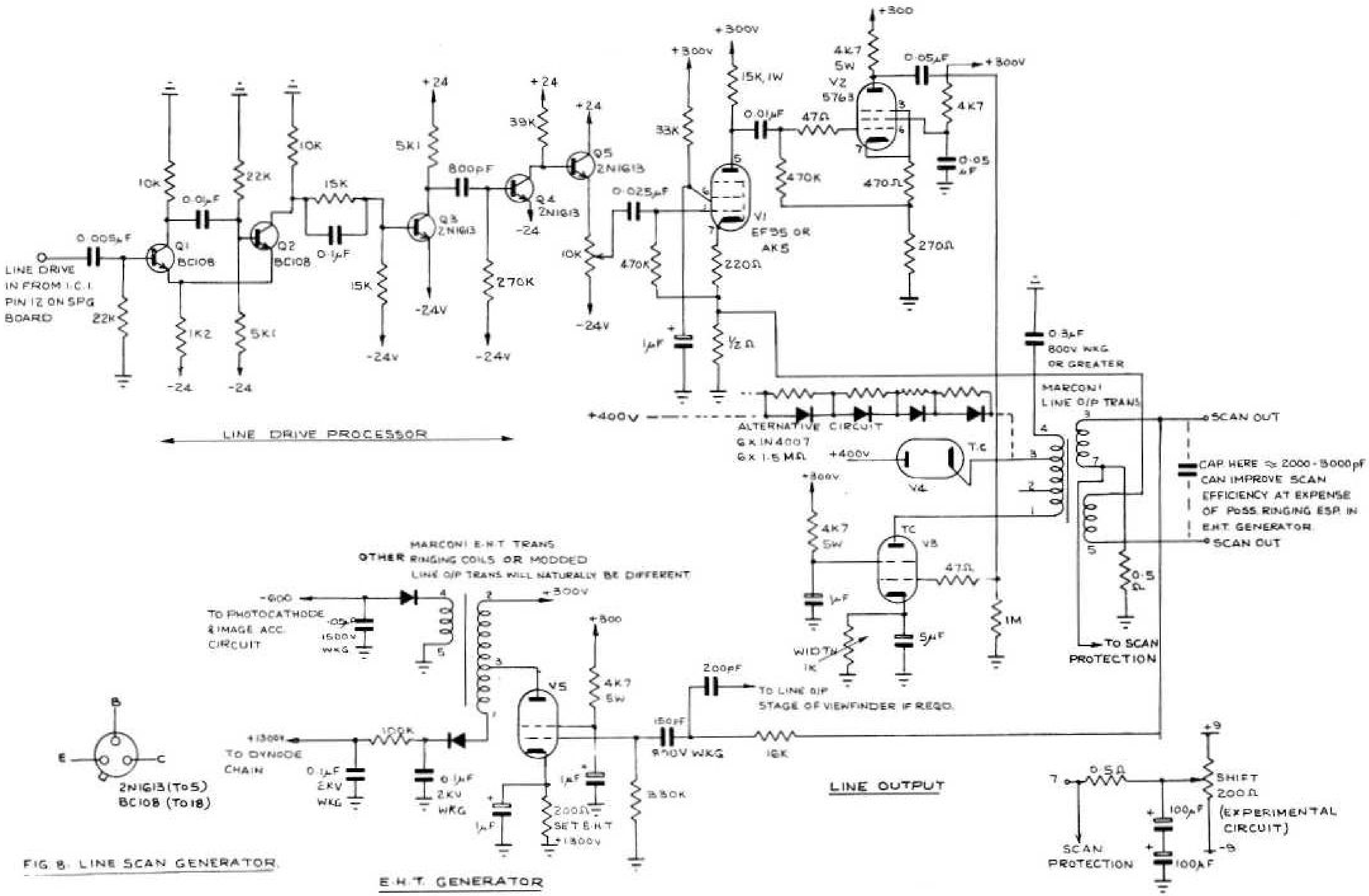



FIG. 8. LINE SCAN GENERATOR.

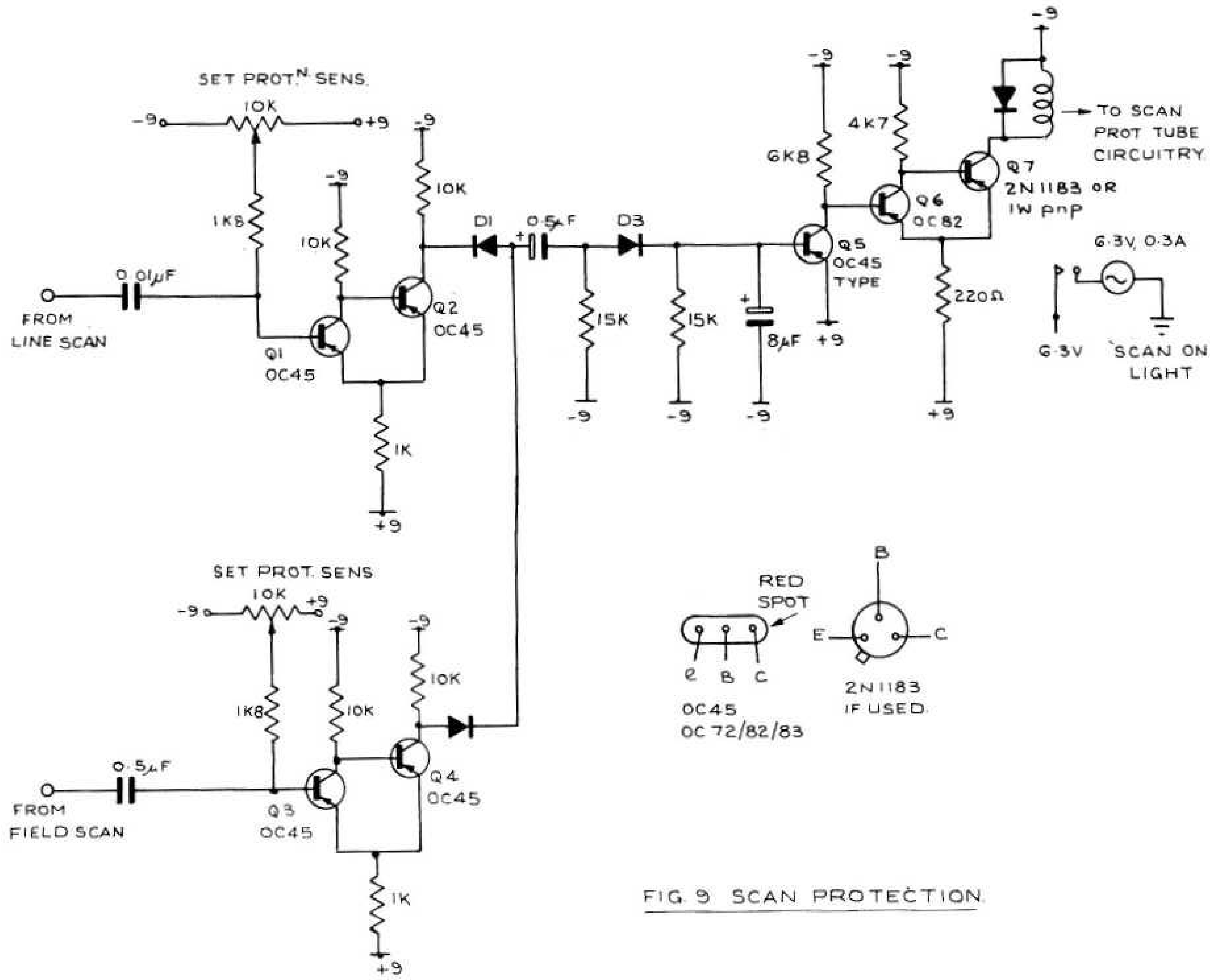



FIG. 9 SCAN PROTECTION.

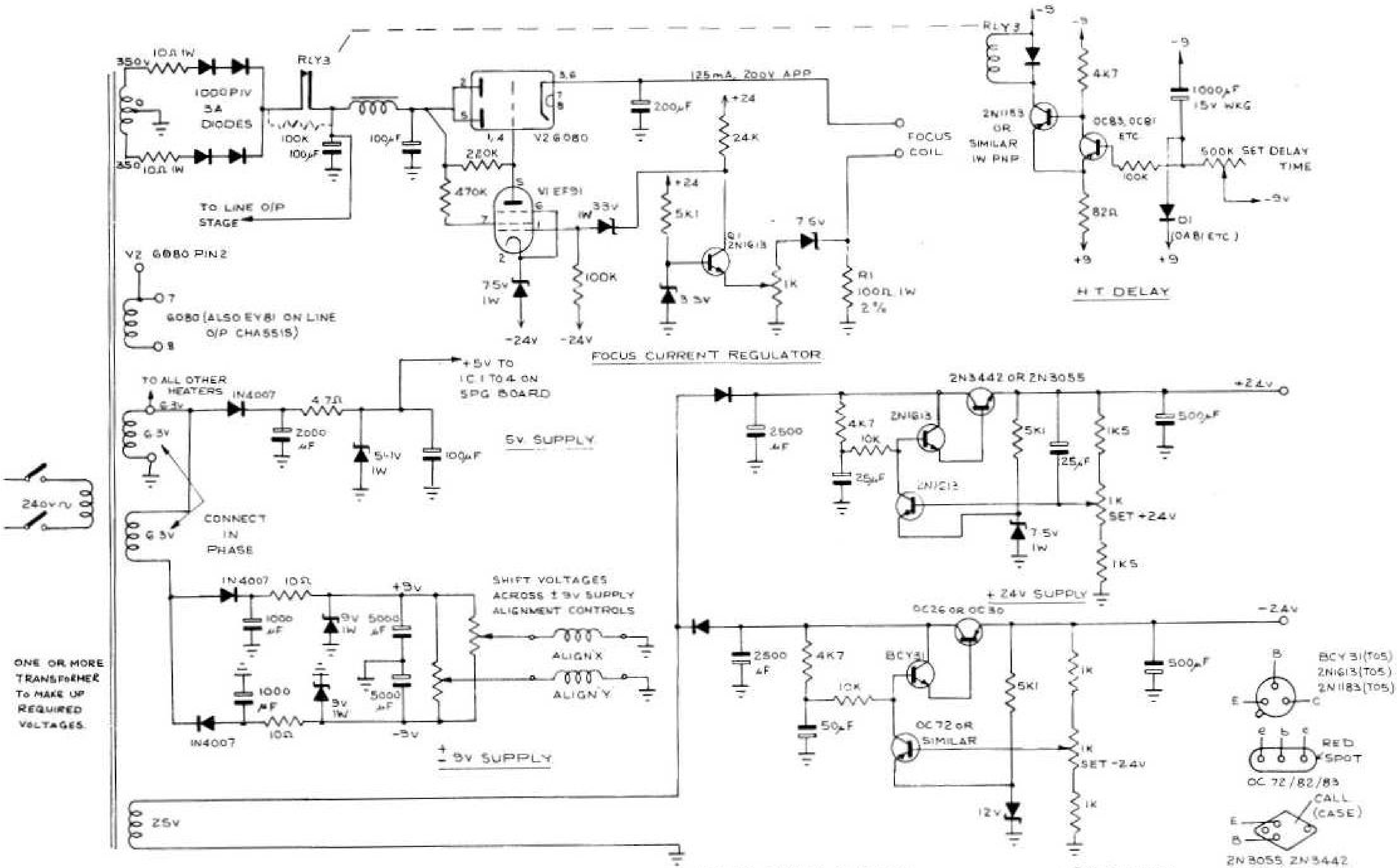



FIG 10. POWER SUPPLY

is tapped off and fed to the emitter of Q1. The base of Q1 is fixed at 3.3v by a Zener diode. Thus any difference between the base and emitter will cause Q1 to conduct (assuming the base is more positive). The amplified error is fed to V1, and after further amplification, used to control V2, the series stabiliser. A 6080, with both triode sections connected in parallel, can handle 125ma. By varying the amount tapped off the 100 Ω the focus current can be set. The two Zener diodes in the signal path serve to step down the standing dc voltage without losing"signal" level.

Also included in Fig. 10 is a simple stabilised -150v supply for the beam current circuit. An HT delay circuit is also included; this consists of a schmitt trigger driven from a capacitor charging through a resistor. When the voltage reaches the triggering point of the schmitt trigger, Q1 ceases to conduct, Q2 conducts and the relay contacts close. Should a supply failure occur, the voltages on the +9 and -9 lines fall to zero, and a very low resistance appears between the lines (the two 200 alignment pots are across the lines). Therefore the cathode of D10 is effectively connected to the negative terminal of the timing capacitor, and, as the anode is already connected to the positive terminal, the capacitor is rapidly discharged. This protects the high voltage circuits from sudden surges.

The low voltage power supply is very conventional, the only unusual feature is the half wave voltage doubling rectifier. If a centre tapped 50v transformer were available, a full wave circuit could be used. Three transistors are used to amplify the difference between a reference voltage and a proportion of the output voltage.

The camera can be constructed in a number of different ways. However, a number of points should be borne in mind. For example, place the power transformer as far away from the tube as possible to reduce hum pickup. Decide on the method of optical focussing to be used; commercial scanning yokes will almost certainly have some method of moving the carriage on some form of runner. If a home-made yoke is used it may be easier to effect focus by adjusting the lens itself (it should be noted that ordinary photographic 35mm lenses will give perfectly adequate results although lenses computed for television work will naturally give better results). Other points worthy of note include keeping the line scan chassis well away from the signal chassis and ensure that the camera is solidly constructed. I built the frame out of 1ins aluminium alloy "angle" mounted on a baseplate made of $\frac{1}{8}$ ins. alloy, and I have had no trouble mechanically. The head-amp (emitter follower) and pre-amp were built in small diecast boxes mounted in a large box, together with the tube base components. Care should be taken to avoid earth loops, as in any low level amplifier. Failure to do so can result in ringing and even oscillation. Other precautions are mainly common sense, and will be obvious to anyone capable of constructing an Image Orthicon camera.

For the benefit of anyone who may be using an IO for the first time I shall give a "run down" on how best to obtain a picture. Before installing the tube check that the voltages on the tube base are about those indicated on the circuit diagram. Also check the voltages going into the five pin image section connector, especially the target voltage. Placing a screwdriver on the base of Q1 in the head amp should produce heavy patterning on the monitor screen. Ensure the scans are present and the scan protection relay is energised. Adjust the scan amplitude for maximum scans, and adjust the alignment and shift controls to mid range. If all is well, switch off, place the tube in the camera, and switch on. After the HT has come on, adjust the lift control until a "grey" level appears, and advance the gain to mid range. Turn up the beam current (coarse, if fitted) until some evidence of beam is seen. By adjusting Beam, Image and Dynode (ortho or persuader) Focus, and optical focus, a reasonably good picture should be obtained. Alingment controls are adjusted as in a vidicon, i.e. for minimum movement of picture at centre of frame when adjusting beam focus. Alignment control settings have a considerable effect on shading as well as resolution, patterning etc. The accelerator and decelerator controls are adjusted for best picutre geometry, in particular straightness of horizontal and vertical lines, and shading signals. Scans are set as in a vidicon. i.e. just avoiding corner cutting: after setting the scans the two scan protection sensitivity controls are set so that any appreciable reduction in amplitude of either scan will cause the relay to trip out. Several settings of the Beam Focus control will produce beam focus (unlike a vidicon where only one "node" occurs); a node near mid-range should prove satisfactory. Image Focus can also give more than one node; provided the picture is satisfactory use the node nearest the high potential end as this will give the maximum accelerating potential and therefore the maximum (noise free) image gain. I found that correct setting up gave very little shading, si I decided not to include shading correctors. Exposure is adjusted to give maximum output consistent with minimum "throw off" i.e. black "halos" around highlights. Wnen the tube is correctly exposed the beam current is reduced to the point at which beam limiting occurs and then advanced a very little. Excessive use of beam will result in a poor signal to noise ratio as unused beam finding its way into the dynode chain, and thus into the signal system, appears as noise.

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## PART 3

CONSTRUCTION OF SCANNING AND FOCUS COILS   SEE FIG. 11

This is not an operation to be undertaken lightly. Professionally constructed coils cost several hundred pounds, so there is obviously a fair bit of work involved. However the principals are the same as for any other type of scan coil, e.g. vidicon. If an I.O. is available, construction can be made a lot easier. Firstly make a tube or former 3.2 ins. in diameter and about 13 ins. long out of stiff cardboard hardened with laquer or plenty of varnish to give it strength. The coils are made by winding wire on a frame or block of wood 10 ins. x 5 ins, each winding producing one coil; two coils are required for line and two for frame. The line coils are made of about 24swg enamelled copper wire, using about 60 - 70 turns for each coil, and the frame coils use about 30swg; about 120-130 turns should do. When they are ready the line coils are put on the former opposite each other as accurately as possible. Wind several turns of waxed paper or insulating tape over the coils, then place the frame coils on the former at right angles to the line coils, and wind some more paper or tape over them. The accuracy with which the coils are placed on the former has a very great effect on the geometry of the reproduced picture. The coils should be fitted to within ½ ins of one end of the former. The alignment coils are made up in an identical manner, wound out of 24swg wire, on a frame or block of wood about 2 ins x 5 ins. Four coils are required, mounted in the same way as the scan coils, but at the other end of a former. Another cardboard tube is now made up of sufficient inside diameter to slip smoothly over the coils, and about 10 ins. long. Two cardboard discs are now made up , 7 ins. in diameter, with a hole cut out in the centre of sufficient diameter to be a tight fit with the unused former, and they are glued to either end of the former. This forms the frame on which is wound the bulk of the focus coil. A field strength of 70 gauss is required; if the former is nearly filled with 32-34swg wire, sufficient field strength should be obtained. Another former 4.6 ins. in diameter and 6.5 ins long with cheeks 7 ins. in diameter is made up in a similar manner to the focus coil, and filled with 32 or 34swg wire. A faceplate coil is also required; this is wound on another former ¾ ins long and with cheeks of the same size as the focus coil except that the central hole is 1.8 ins. in diameter, i.e. only a little larger than the photocathode. An arrangement to fix this facecoil in place after the tube is installed is made of clips which can conveniently carry the focus current. On the inside of the image section coil former are fitted five strips of metal, e.g. phosphor-bronze spring contacts from a vhf turret-tuner. These springs are to connect with the contacts around the tube neck, and lead-out wires are soldered to them; the contacts are as follows: (looking at the tube from the base end and the keyway facing down, reading clockwise (1); field mesh
(2); photocathode
(3); G6 accelerator
(4); G5 decelerator
(5); Target

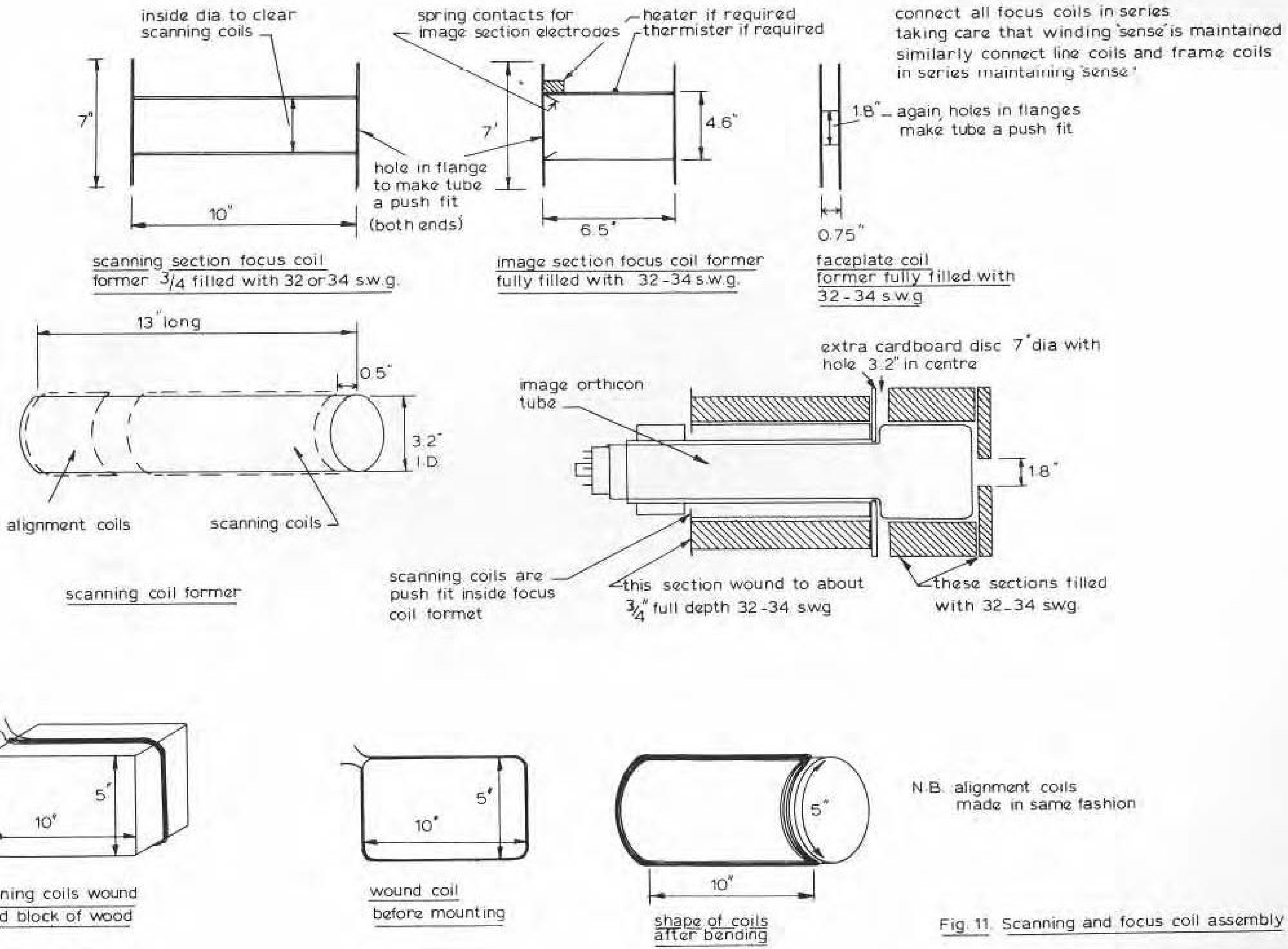


Fig. 11. Scanning and focus coil assembly

If a tube isto hand the positioning of the contacts is simple, if no tube is available fitting the contacts and final assembly will have to wait. To complete assembly, glue the two larger focus coils together with a cardboard disc 7ins. in diameter, and with a central hole 3.3ins in diameter. This allows the tube to go in as far as the image section, but prevents the scanning coils running too far up and hitting the glass of the tube. Finally, ensure the coils are connected in phase. If possible wind a single length of wire or copper tape on top of the scan coils, and on a former before the coils are mounted in the first place, a reduction of stray pickup, especially line scan ringing, will occur (the screen is earthed). Some commercial coils incorporate a target heater, and if desired to include one, proceed as follows. A heating element such as sold by Woolworths etc. using about 6ft, but best determined by experiment. The chosen length is wound on the image section focus former before winding the coil. The heater must be wound on the end with the image section connectoors, and take care to insulate it thermally as well as electrically from the focus coil. A thermistor is sometimes included as well; this can be put 2-3ins. away from the heater on the same former.

It is important to make various formers strong, as they will carry a fair amount of wire and will carry the tube. If it is possible to make the formers out of aluminium or copper a much stronger assembly will result. The focus coils are connected in series; it is unlikely that a focus current of 125mA will give the correct field strength, but ifthe current is adjusted until three beam focus nodes are obtained (using the component values shown in the focus circuit in Fig. 1) the current will be about right. The current also has a marked effect on the scan size and with the correct current the line scan circuit is capable of about 5-10% overscan at maximum output.