ONGKORN UNIVERSITY
DEPARTMENT OF EDUCATIONAL TECHNIQUES (MINISTRY OF EDUCATION)
APPLIED SCIENTIFIC RESEARCH CORPORATION OF THAILAND

COOPERATIVE RESEARCH PROGRAMME NO. 4
SOLAR FLARES IN RELATION TO RADIO COMMUNICATIONS AND STUDY OF ALLIED SOLAR PHENOMENA

RESEARCH PROJECT NO. 4/2
RADIO FREQUENCY OBSERVATIONS OF SOLAR ENERGY OUTPUT AT 21-CENTIMETRE WAVELENGTH

REPORT NO. 1
DESCRIPTION AND INSTALLATION OF THE 3-METRE, 21-CENTIMETRE RADIO TELESCOPE AT ASRCT

BY
SUVIDHYA VIBULSRESTH
INSTRUMENT REPAIR AND CALIBRATION CENTRE

ASRCT, BANGKOK 1968
not for publication

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FOREWORD

As part of a cooperative research programme on solar phenomena, regular observations have been carried on since June 1967 with the 3-metre, 21-cm radio telescope. The parabolic reflector is installed on the roof of the headquarters building, Applied Scientific Research Corporation of Thailand at Bang Khen, Bangkok.

The whole system was designed and constructed under the supervision of Dr. J.G. Bolton, Division of Radiophysics, Commonwealth Scientific and Industrial Research Organization of Australia. The instrument has been made available on indefinite loan from CSIRO. It was officially transferred to ASRCT by the Australian Ambassador on 25 May 1967. The instrument will enable the Solar Physics Unit to extend the present optical observations to include radiation from the sun on the radio wavelength of 21 centimetres.

This paper describes the purpose of the observations, the radio telescope instrumentation, its operation, and maintenance requirements.

DESCRIPTION AND INSTALLATION OF THE 3-METRE, 21-CM RADIO TELESCOPE AT ASRCT

By Suvidhya Vibulsresth*

I. INTRODUCTION

This report has been prepared to give an account of the 21 cm radio telescope installed at ASRCT Headquarters, Bang Khen, Bangkok, and typical data observed. It is primarily concerned with describing the instrument and its circuitry, and providing information on its installation, operation, and maintenance.

Solar radiation in radio spectrum

The following brief account is based mainly on papers by Wild, Smerd, and Weiss (1963) and Kundu (1965).

The pioneering discovery in 1932 by Karl Jansky of radio waves from the Milky Way initiated a new science of radio astronomy. But it was not until 1942 that Hey discovered solar radio emission at metre wavelengths associated with sunspots. Nearly simultaneously, Southworth independently discovered thermal radiation from the sun at centimetre wavelengths. Similarly, Reber in 1943, looked for radio emission from the sun's corona at the longer wavelength of 1.9 metres. However, it was Appleton and Hey who established that intense radio emission occurs following solar flares. A flare is an explosion in the sun's atmosphere; it is observed as a sudden brightening in a spectral line, for example in the Hα line (6563 Å).

The early radio observations of the sun were made with simple radio telescopes which consisted of an aerial of narrow beamwidth connected to a sensitive receiver, the output of which is usually registered on a recorder. Although the simple radio telescope has very limited angular resolution, they are still widely used at a number of frequencies for the purpose of making continuous recordings of the total flux from the sun. The observations have revealed that the radio emission from the

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sun has three distinct components, namely, those originating from the quiet sun from bright regions, and from such transient disturbances as flares. The intensities of these components are shown in Figure 1 (taken from Wild et al. 1963).

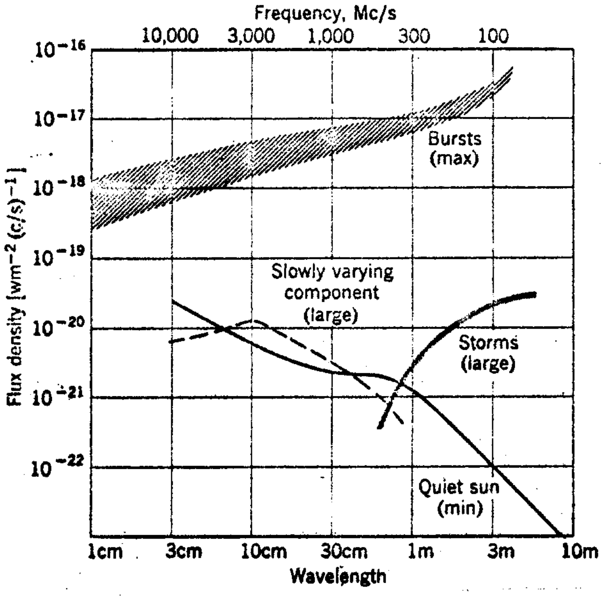


Figure 1.—The spectra of different components of solar radio emission. (From Wild et al. (1963.)

The quiet sun component is the radiation due to thermal emission in the solar atmosphere.

The component originating from bright regions is the slowly varying component and is also due to thermal emission. It originates over sunspots and plage regions.

The third component consists of the radio bursts which are generally associated with solar flares and originates from all levels of the solar atmosphere between the lower chromosphere (millimetre and centimetre wavelengths) and the outer corona to heights of several solar radii (metre and decametre wavelengths). The bursts occur on all wavelengths between 4 mm and 40 m. However, they exhibit widely different properties on different wavelengths. Usually, they are classified into various types according to their spectral and temporal characteristics.

Near the microwave limit the bursts are weak, uncomplicated, and of short duration. As the wavelength increases, the bursts become increasingly intense and complex, and sometimes last for many hours. The metre-wave bursts, particularly, are rich in variety, and sudden changes in the characteristics of the emission may occur. These contrasting features of microwave and metre-wave bursts, which are shown in Figure 2 (taken from Wild et al. 1963), can be related to the characteristics of the regions of the solar atmosphere in which they originate. The comparatively uncomplicated microwave bursts are generated around or beneath the flare region, probably at the base of the corona or the upper levels of the chromosphere. The metre-wave bursts, on the other hand, originate in the higher and rarer levels of the corona (roughly from 0.2 to 2 or more solar radii above the photosphere).

Bursts radiation is fully specified by the intensity and polarization of the radiation as a function of position, time, and frequency. Special equipment has been developed to enable it to be recorded with adequate resolution. Besides the simple radio telescope or "radiometers" which measures the intensity of the solar flux (in MKS unit, watts m^{-2} $(c/s)^{-1}$), there are spectroscopy, polarimetry, and interferometry techniques. The spectrograph consists of a tunable receiver in which a narrow reception band is swept rapidly over a broad frequency range covered by one non-selective aerial. The spectra are normally displayed on a cathode-ray tube and recorded photographically on continuously moving film, as a series of intensity modulated traces which register intensity as a brightening in the frequency-time plane. Polarimetry is the technique used to measure the state of polarization of burst radiation. Interferometry tries to measure the positions of burst radiation on the solar disk and the brightness distributions, as well as source of the bursts.

ASRCT radio telescope

The radio telescope at ASRCT is essentially a radiometer which observes the solar radio emission on the radio wavelength of 21 centimetres (1400 MHz). Its prime mission is to keep track of the disturbances in the sun's atmosphere that lead to interruption of radio communications on earth as well as the daily recording of solar flux. The initial installation was done in February 1967, and daily observation

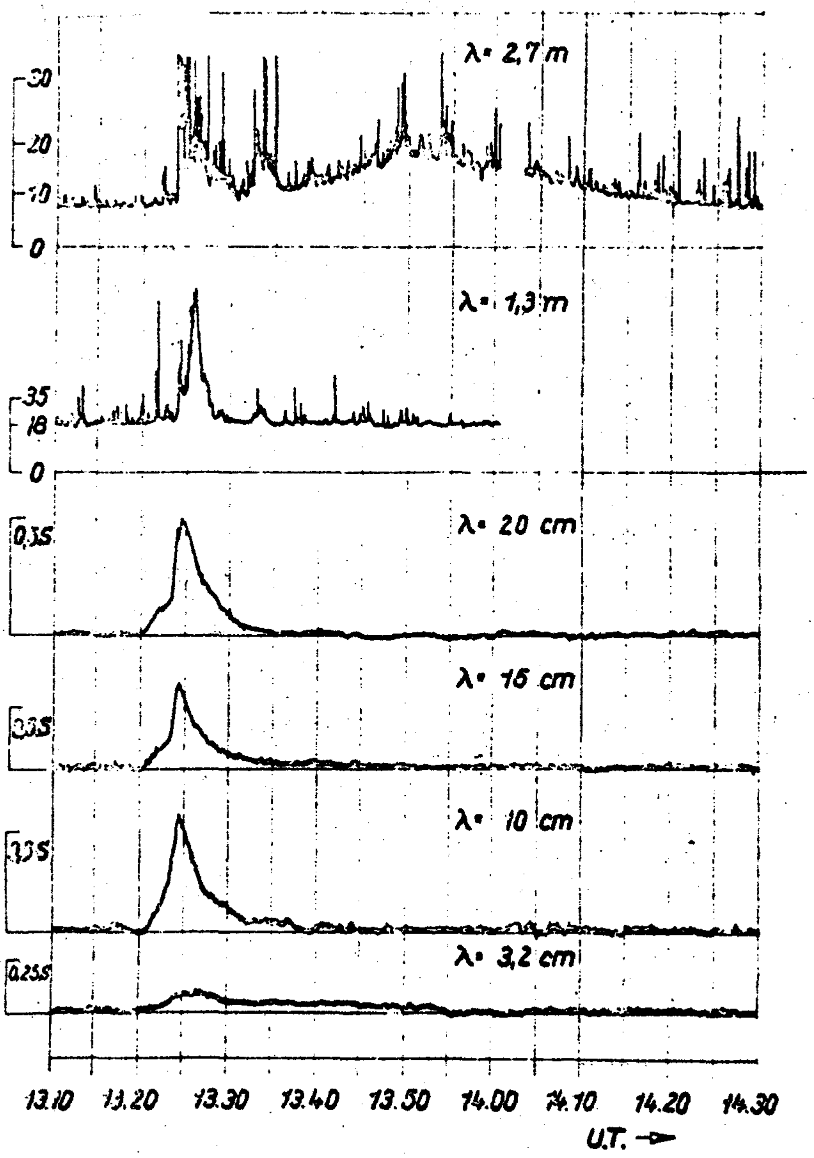


Figure 2.—Single-frequency recordings of the solar burst of 23 May 1960, illustrating the characteristic differences between metre- and microwave bursts. Recordings from 3.2–20 cm were made at Berlin-Adlershof; the flux density is given in units of the flux from the quiet Sun. Recordings at 1.3 and 2.7 m, in units of $10^{-22}Wm^{-2}(c/s)^{-1}$, were made at Potsdam-Tremsdorf (from Beobachtungsergebnisse of Heinrich-Hertz-Institut, May 1960).

(From Wild et al. 1963.)

has been carried out on a routine basis since June 1967. It was found that the polar axis did not point correctly to the north. The misalignment occurred due to the use of a compass in determining the direction when the unit was originally installed. With correct direction acquired by optical means, the deviation (six degrees) was corrected in January 1968. Since then, continuous observations have been carried out successfully.

II. DESCRIPTION OF INSTRUMENT

The information given in this section is based in part on information provided with the equipment by Dr. J.G. Bolton of the Division of Radiophysics, CSIRO, Australia.

(i) Outline

The 3-metre, 21-cm radio telescope consists of a parabolic reflector antenna, a receiving horn for 1400 MHz band incident wave, a cavity-tuned oscillator employing a triode, a pre-amplifier, a main intermediate frequency amplifier, a d.c. amplifier, and a recorder. The functioning block diagram is shown in Figure 3. Specifications of the instruments are as follows:

Power requirement	220 V 1A
Frequency of observation	1350-1450 MHz
Antenna	Parabolic reflector, 3 m diameter
Oscillator tube	Triode OD 03-10
Tuning	Cavity plate tuning and cathode tuning
Mixer diode	Crystal diode 1N21
Bandwidth of amplifier	10 MHz
Recorder	Esterline-Angus 0-1 mA fullscale

(ii) Circuit description

(1) Filament power supplies. There are altogether three units which supply: the oscillator, the preamplifier, and main i.f. amplifier (recorder amplifier tube included) racks. Each produces 6.3 volts at 3 amperes. They have silicon rectifiers and transistor control and reference elements. There is only one a.c. on/off switch and the voltage

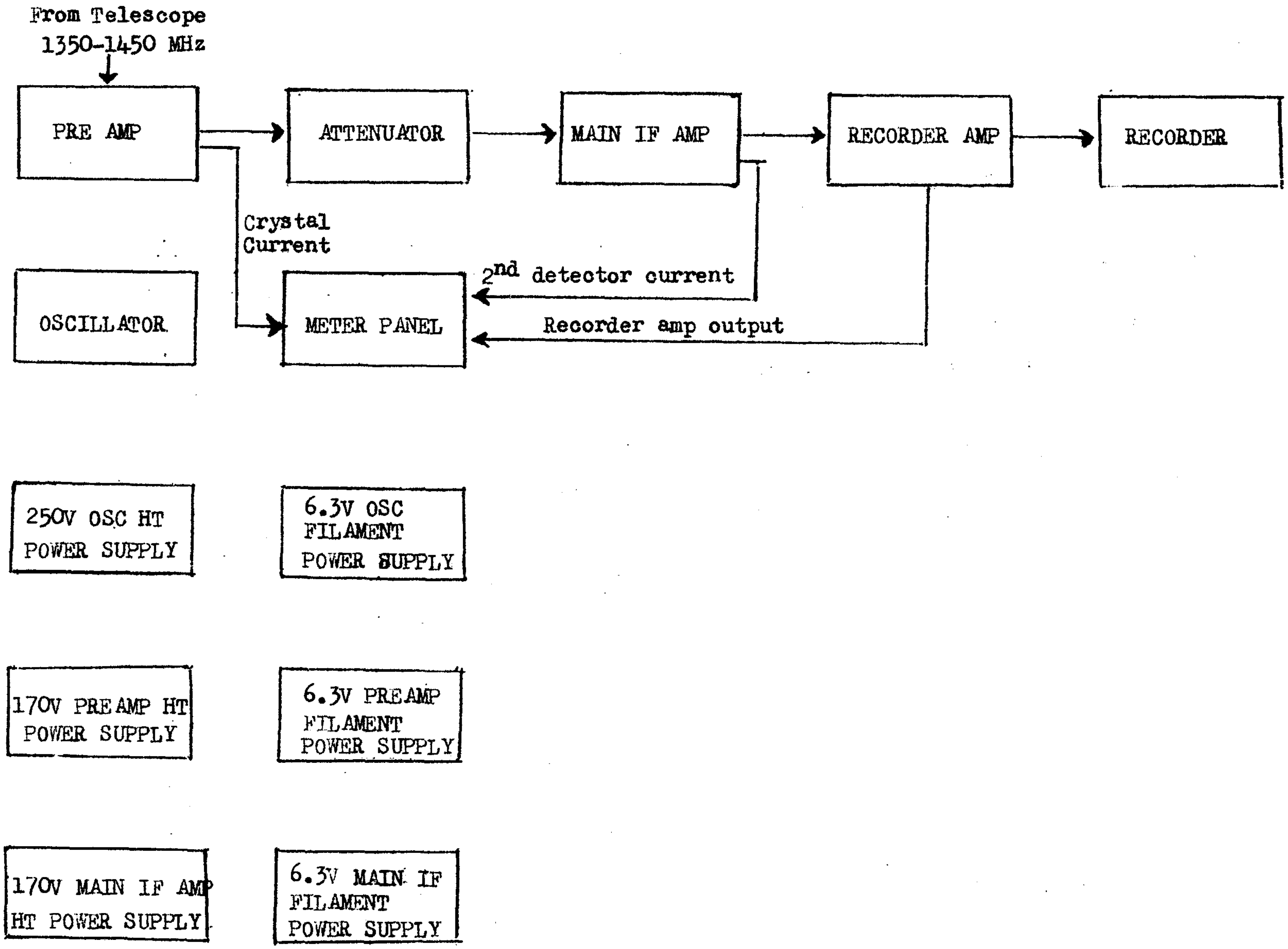


Figure 3.—Functioning block diagram of 21-cm radio telescope.

is available immediately. This will prevent switching on of the high tension power supply before the filament is on. Even if one unit fails, the remaining two are adequate to supply the receiver units. The circuit diagram is shown in Figure 4.

(2) High tension power supplies. These units are essentially the same except that one is set for 250 volts and the other two for 170 volts. They have silicon rectifiers with control, series, and gas regulating tubes (85 A2). The supplies have an a.c. on/off switch, but the output switch for the h.t. must be switched on to provide h.t. for the tubes. The supplies take about 30 seconds to warm up and regulate, and during this time one will see variations in the output voltage. The circuit diagram is shown in Figures 5 and 6.

(3) Preamplifier and mixer. The schematic diagram of the mixer is shown in Figure 7. Either a 50 ohm dummy load or the aerial should be on the mixer for it to perform. Mixer crystal 1N21 is used to convert the incoming signal to a lower frequency. The preamplifier is tuned to 10 MHz employing 437A and 417A repeater triodes as early stage amplifier, followed by three E180F broadband amplifier pentode tubes. The crystal current is connected to the meter panel. The circuit diagram is shown in Figure 8.

(4) Attenuator panel. This is a 50 ohm attenuator placed between the preamplifier and the main i.f. amplifier. It consists of one 1 dB, one 2 dB, one 3 dB, one 5 dB, one 10 dB, and two 20 dB attenuators. The circuit diagram is shown in Figure 9.

(5) Main i.f. amplifier and 2nd detector. Four E180F broadband amplifier pentode tubes are used. The detected output is called 2nd detector current and varies from 0 to 250 microamperes according to the attenuations inserted. The circuit diagram is shown in Figure 10.

(6) Recorder amplifier. This is a d.c. amplifier to run the Esterline Augus recorder which has 1 milliampere fullscale. It employs a 12AU7 tube. Circuit diagram is shown in Figure 11.

(7) Meter panel. Besides crystal current, 2nd detector current, and recorder ampere meters, there is a crystal bias switch which supplies a d.c. crystal bias when it is on. It prevents the preamplifier

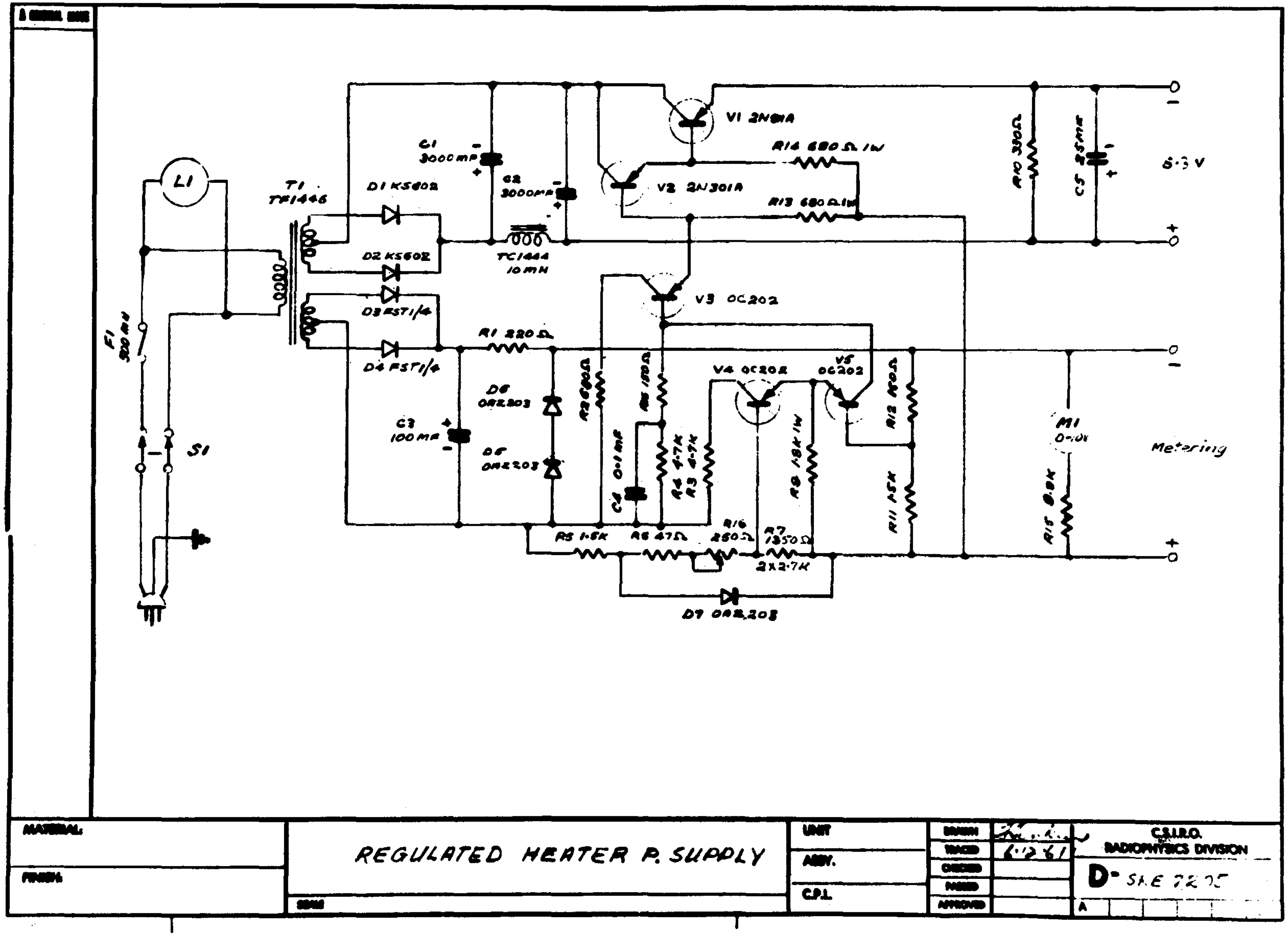


Figure 4.—Diagram of regulated heater power supply.

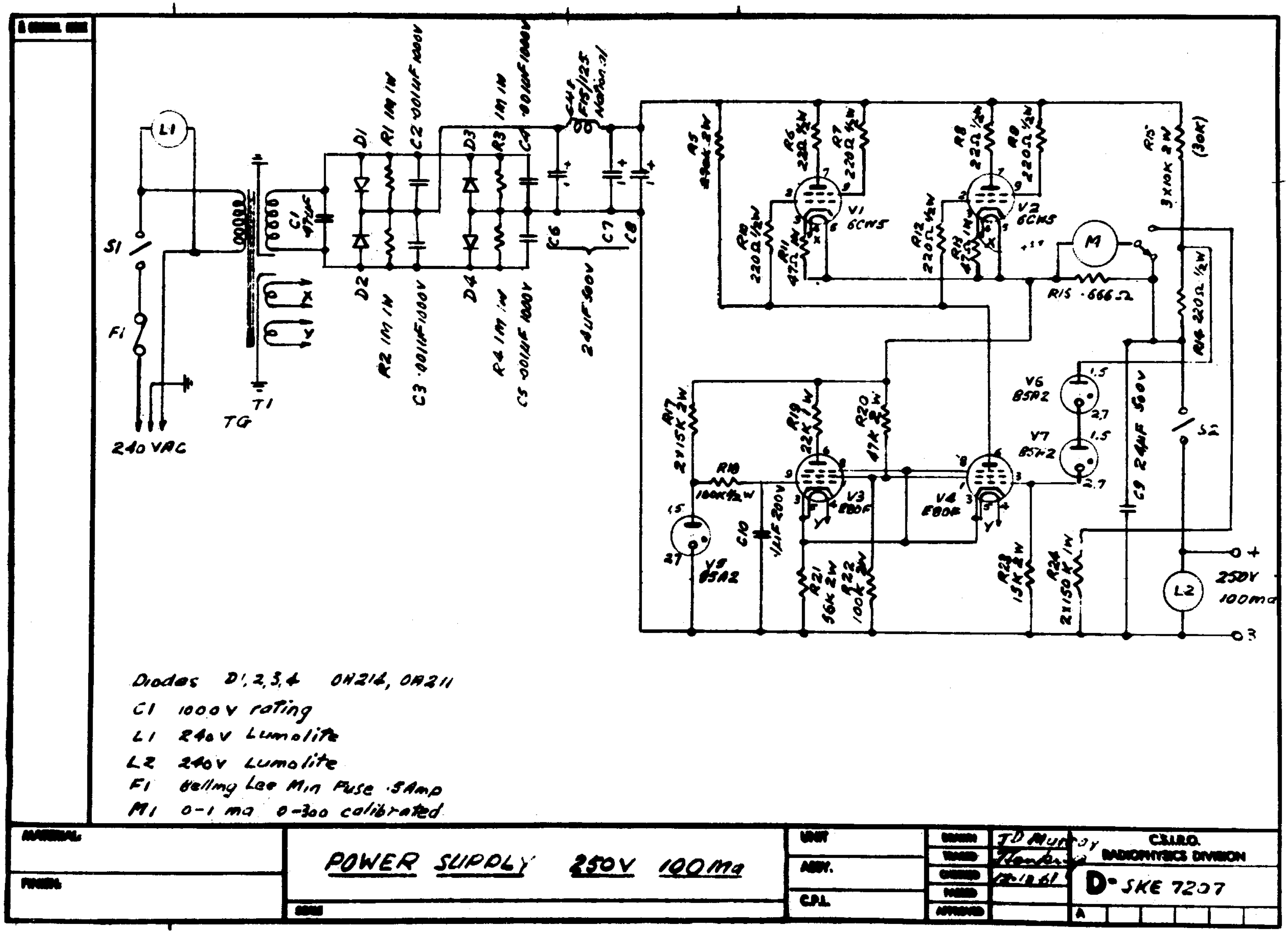


Figure 5.—Diagram of power supply, 250V 100mA.

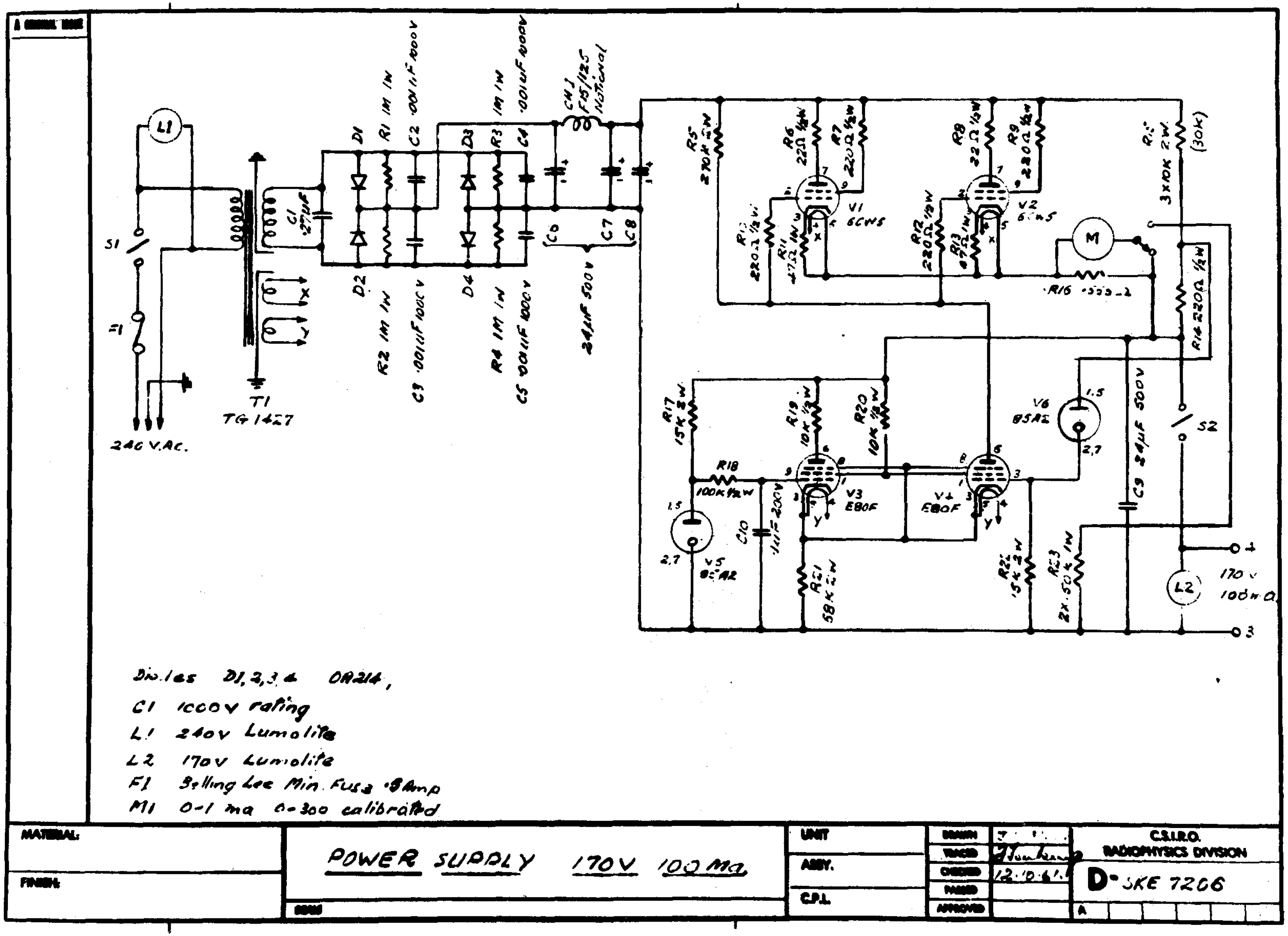


Figure 6.—Diagram of power supply, 170V 100 mA.

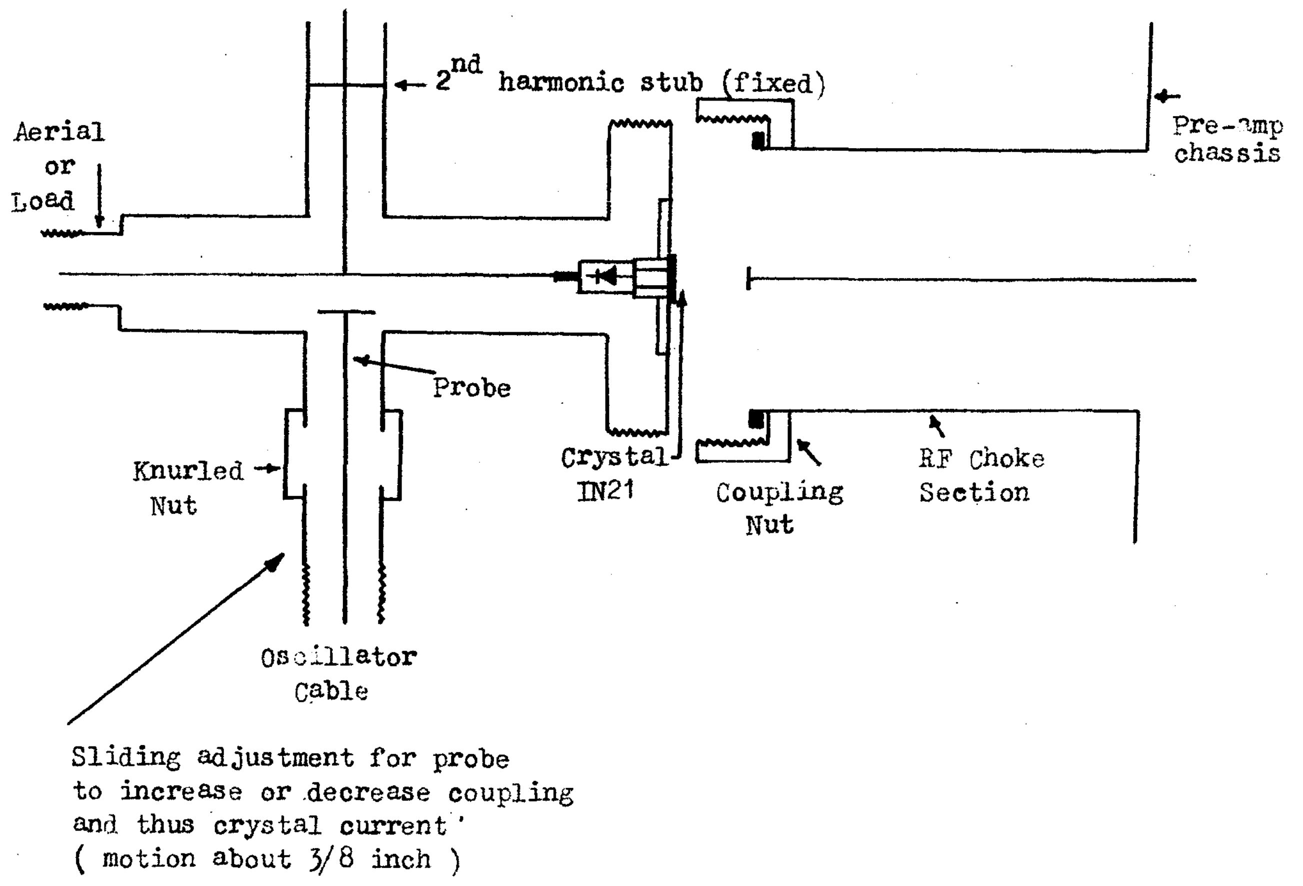


Figure 7.—Schematic diagram of Xtal mixer.

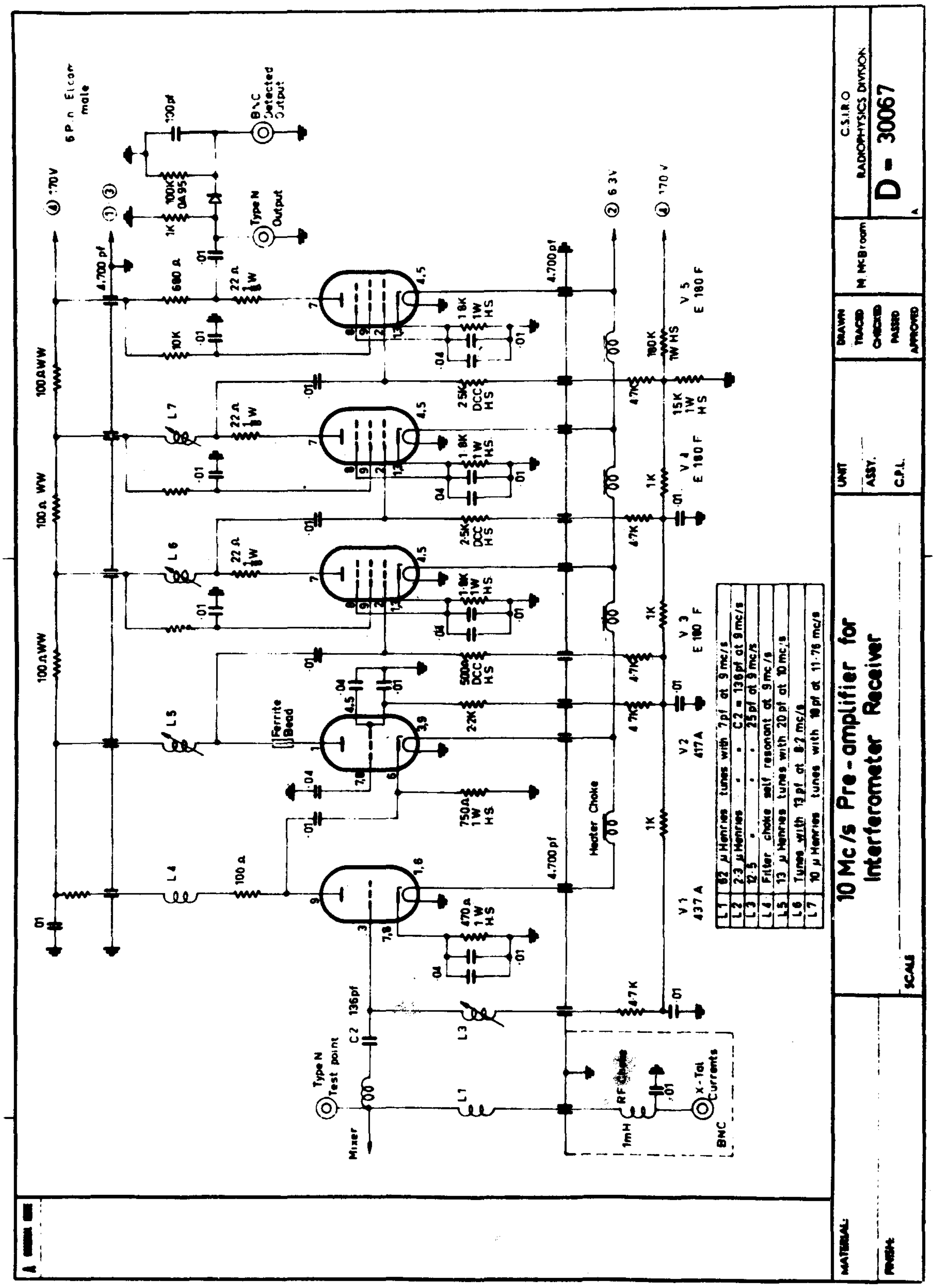


Figure 8.—Diagram of 10 Mc/s preamplifier for interferometer receiver.

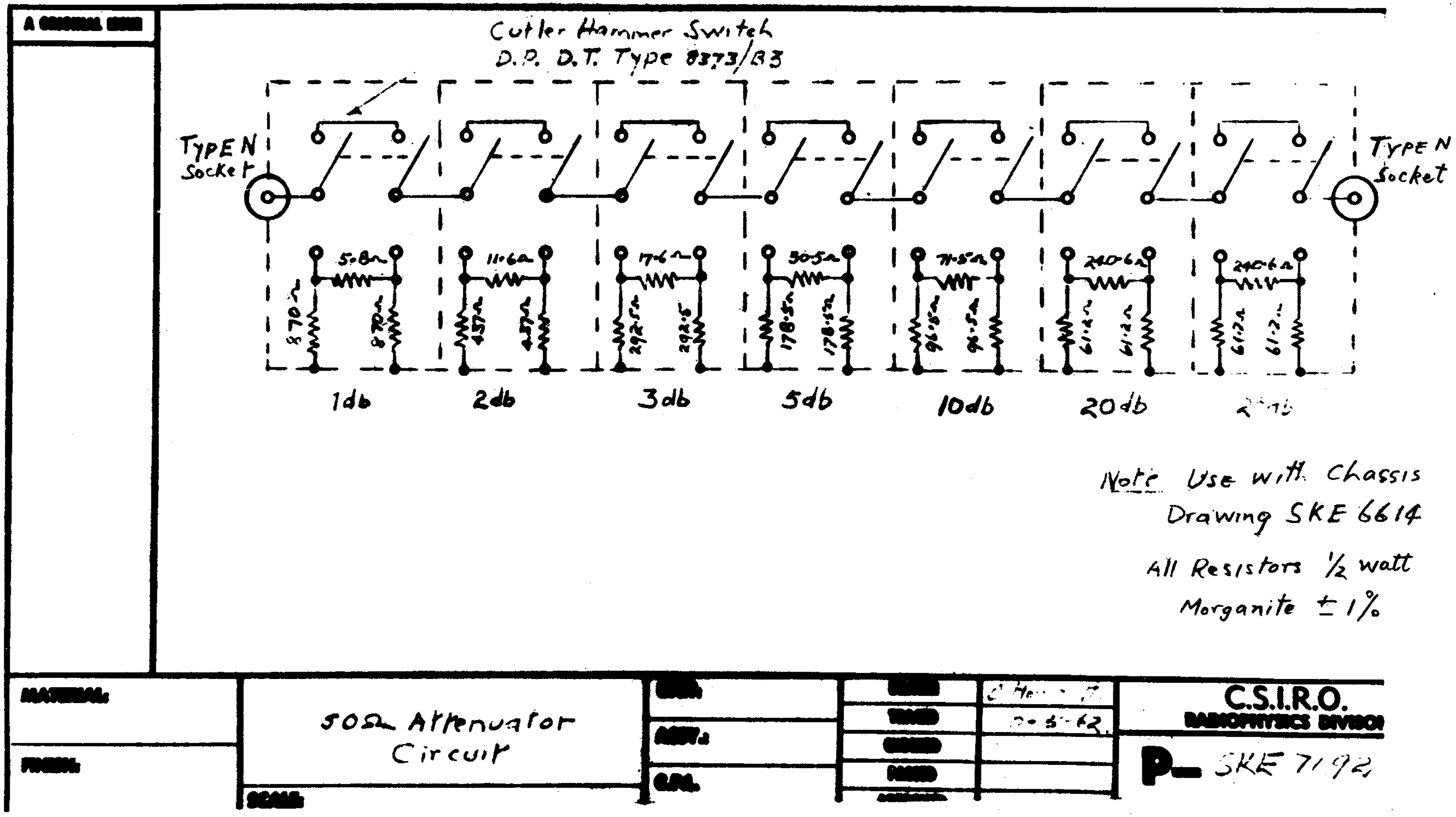
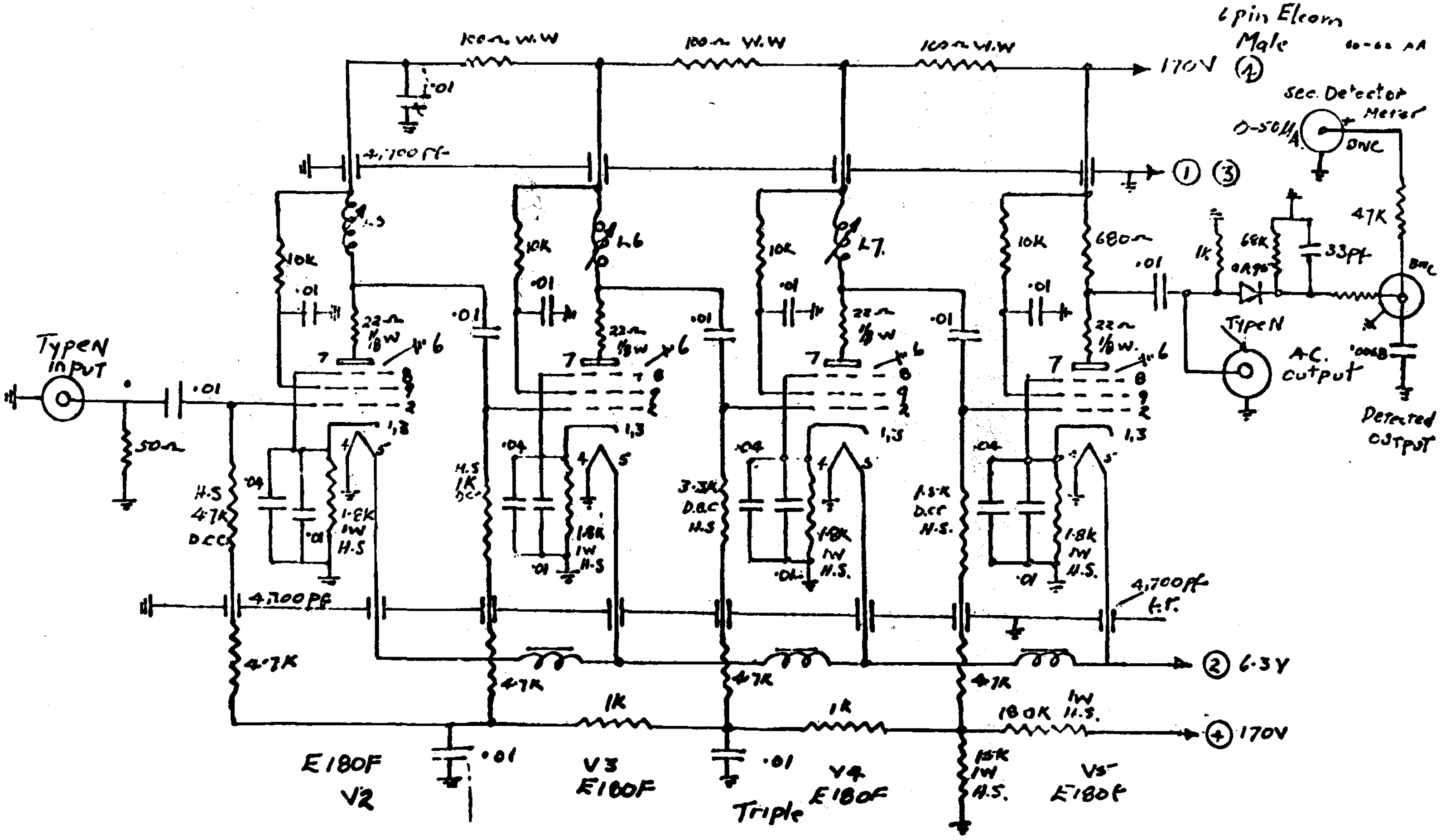


Figure 9.—Diagram of 50Ω attenuator circuit.



L5	13 μhenries Tunes with 20pf @ 10 Mc/s.
L6	Tunes with 13 pf @ 8.2 Mc/s
L7	10 μhenries Tunes with 18 p.f @ 11.76 Mc/s.

Figure 10.—Diagram of 10 Mc/s post i.f., bandwidth 10 Mc/s.

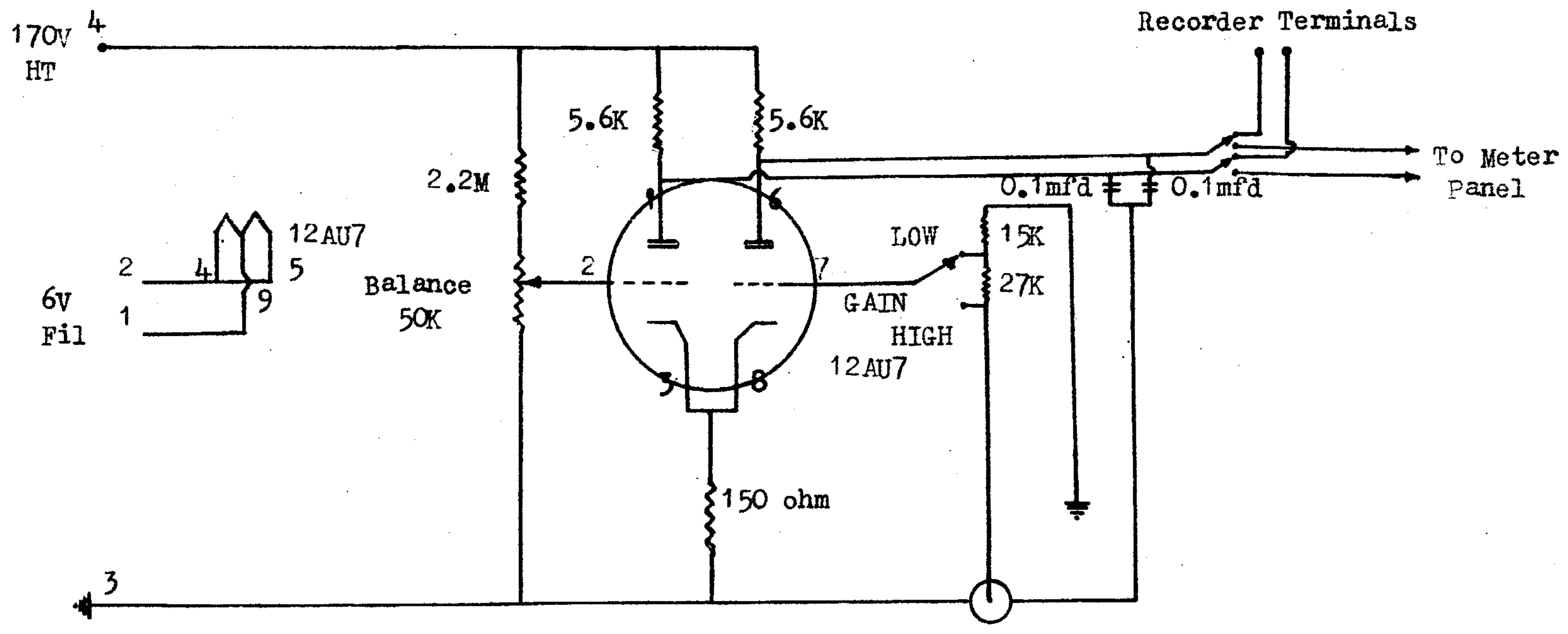


Figure 11.—Schematic diagram of d.c. amplifier.

oscillating if there is no crystal current provided by the oscillator. The bias should be on if for any reason the oscillator is turned off or for the one minute warm up when the receiver is switched on and before the oscillator produces output. The schematic diagram is shown in Figure 12.

(8) Oscillator. The oscillator tube is a 0D 03-10 with cavity plate tuning and cavity cathode tuning. The feedback screw at the back acts as the exciter for the oscillation. The plate tuning dial is about 3 MHz per turn, and the range of the oscillator is from 1350 to 1450 MHz.

(iii) Operating procedure

The chart recorder has two interchangeable gears with speeds of 3 inches per hour and 6 inches per hour. A further speed change to provide higher resolution can be made manually by moving a control lever on the side of the chart drive. This gives a 60-time increase in speed, changing hourly rates to rates per minute. Use the gear for 3 inches per hour with chart No. 4309C because the marking on the chart is the same. The following are the operating procedures in routine work.

(1) Before switching on the a.c. master switch, care should be taken of the following:

(1.1) See that the switches of 6.3-volt filament supplies for oscillator, preamplifier, and main i.f. amplifier panels which are at the bottom of the rack, are all in the on position (pointing downward). If they are not in this position, switch them on.

(1.2) The h.t. power supplies for oscillator, preamplifier, and main i.f. amplifier panels have two switches, the a.c. switch and the output switch. The a.c. switch should be in the on position, while the output switch should be in the off position (pointing upward).

(1.3) Crystal bias switch should be in the on position.

(1.4) Coaxial input from antenna should be on the mixer.

(2) After checking the above conditions, then turn on a.c. master switch, which is at the middle of the rack, wait for three minutes, then

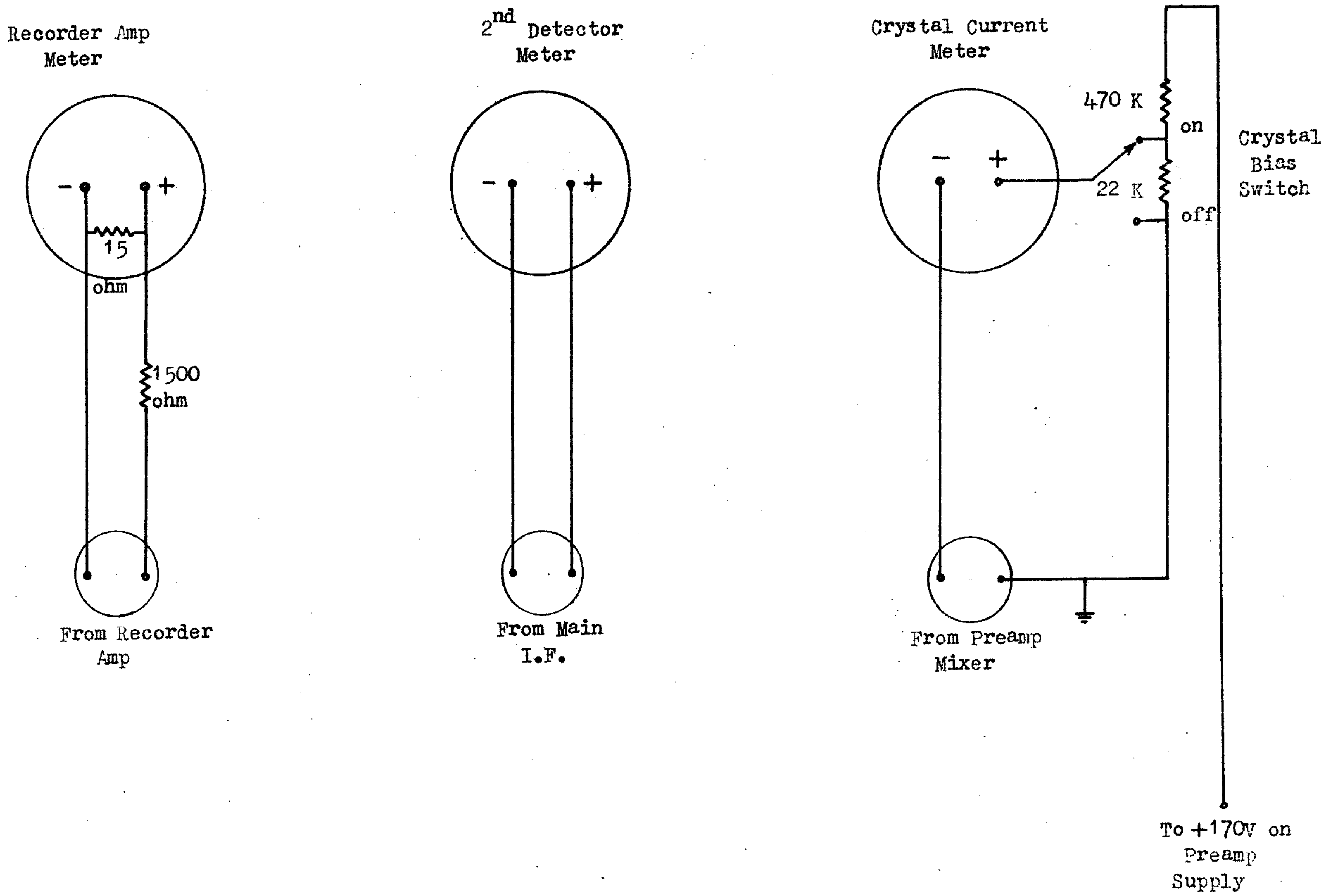


Figure 12.—Schematic diagram of meter panel.

turn h.t. power supplies switches for oscillator, preamplifier, and main i.f. amplifier to the on position.

(3) Wait another two or three minutes for equipment to warm up, then turn the crystal bias switch to the off position. Gently push the mixer probe in. If crystal current shows, then set to 0.5 mA or less and turn the plate tuning and/or feedback adjustment at the back for maximum output, then set the probe to 0.5 mA. Repeat again after half an hour if necessary.

(4) Set 2nd detector current to about 125 mA when the antenna is pointing towards sky, by increasing or decreasing the attenuators. Nominal value is 24 dB.

(5) Gain switch on d.c. amplifier panel should be in the high gain position.

(6) Switch the meter-off-recorder switch to meter position.

(7) Switch on the motor drive unit of the recorder. Adjust mechanical zero by running the chart with fast speed until the needle points the same time as the actual time, then move the lever back to slow speed.

(8) Turn meter-off-recorder switch to recorder position, then adjust the balance control pot to get about 1.0 division reading when the antenna points to the sky.

(9) Go up to the roof. Turn the antenna dish towards the sun and lock the clutch with two red handles. Change the screw for declination if necessary, then unlock the clutch and set to the position a little faster than the sun. Switch on the motor drive switch. The motor will not turn until the switch in the receiver room is turned on.

(10) Return to the receiver room and note the reading on the chart of the recorder. When it reaches maximum point, switch on the motor drive unit for antenna.

(11) Write down the time and date, attenuation, crystal current, 2nd detector current, balance control, plate tunning, cathode tuning, and recorder chart readings as well as the condition of input to the receiver and the antenna position. Typical daily log is given in

Tables 1 and 2.

(12) At intervals, dummy load should be on the mixer instead of antenna coaxial input for calibration purpose. But before each time of changing the input, the crystal bias should be switched to the on position, and switch back to off position after changing.

(13) Set the antenna to point at zenith every evening after the striker strikes the microswitch for the consistency of the cold sky value.

(iv) Maintenance

The maintenance of the receiver is quite easy. The frequency of the oscillator, the filament power supply output, and the h.t. power supply output should be checked regularly once a month. The amplifier tubes should be checked every six months, and weak ones replaced if necessary.

The experience of the reporter showed that the power supplies are quite stable. Only one silicon rectifying diode BYZ 13 has been found defective throughout the operation of more than one year. Tubes were replaced from time to time including the amplifier tubes. Feed-through capacitor at the head of the oscillator cavity should be checked periodically. Malfunction of it may cause serious interferences as shown in Figure 13. Crystal diode 1N21 will last long unless mixer probe is carelessly pushed too deep and causes excessive current to flow through the diode.

III. INSTALLATION

The installation of the antenna mount requires three persons to perform. Having acquired the polar axis on the place where it is to be mounted, the installation should proceed as follows.

The baseframe has a 6" x 4" R.S.J. forming the south pillar and two 3" x 3" angles forming the north pillar. It has a triangular base with nine holes for securing bolts in it. The bolts are provided as are nine LOXINS for securing it to the concrete roof. This frame should go flat on the roof - say not closer than 2 m from the edge and in a

TABLE 1

DAILY LOG OF THE 21-CM RADIO TELESCOPE RECEIVER AT ASRCT

(before realignment of polar axis)

Date and time	Attenuation (dB)	Xtal current (mA)	2nd det. current (μA)	Input	Output (div.)	Balance control	Plate tuning	Cathode tuning	Antenna position	Remark
23.viii.67										
0127	22	.50	147.5	SUN	3.07	6.38	82.1	69.0	1/6	
0220	22	.49	147.0	SUN	3.01	6.38	82.1	69.0	3/8	
0413	22	.49	146.0	SUN	2.97	6.38	82.1	69.0	2/6	1 FLARE 0514
0638	22	.49	146.0	SUN	3.01	6.38	82.1	69.0	2/5	
0815	22	.49	149.0	SUN	3.10	6.38	82.1	69.0	2/4	
20.ix.67										
0132	22	.50	134.5	SUN	3.69	6.71	81.0	90.0	1/8	
0340	22	.50	139.0	SUN	4.00	6.71	81.0	90.0	1/8	
0452	22	.50	138.0	SUN	3.95	6.71	81.0	90.0	3/10	
0806	22	.50	139.5	SUN	4.00	6.71	81.0	90.0	1/6	
30.x.67										
0135	22	.50	130.0	DUMMY	1.53	6.47	82.0	64.0	-	
0203	22	.50	123.0	SKY	1.04	6.47	82.0	64.0	ZENITH	
0325	22	.50	141.0	SUN	2.27	6.47	82.0	64.0	1/13	
0448	22	.49	138.5	SUN	2.12	6.47	82.0	64.0	3/15	
0538	22	.49	141.0	SUN	2.20	6.47	82.0	64.0	1/12	
0749	22	.50	130.0	SUN	1.52	6.47	82.0	64.0	2/12	
0905	22	.50	124.0	SKY	1.12	6.47	82.0	64.0	WEST	
0930	22	.50	130.5	DUMMY	1.55	6.47	82.0	64.0	-	

TABLE 2

DAILY LOG OF THE 21-CM RADIO TELESCOPE RECEIVER AT ASRCT

(after realignment of polar axis)

Date and time	Attenuation (dB)	Xtal current (mA)	2nd det. current (µA)	Input	Output (div.)	Balance control	Plate tuning	Cathode tuning	Antenna position	Remarks
5.ii.68										
0200	24	.50	121.0	SKY	0.60	6.23	93.4	95.2	ZENITH	
0245	24	.50	143.5	SUN	2.04	6.23	93.4	95.2	1/13	
0500	24	.46	143.0	SUN	2.10	6.23	93.4	95.2	1/13	1 FLARE 0818
0905	24	.44	120.5	SKY	0.60	6.23	93.4	95.2	ZENITH	
0918	24	.50	126.5	DUMMY	0.95	6.23	93.4	95.2	-	
20.iii.68										
0140	24	.50	125.0	DUMMY	0.90	6.27	90.0	95.2	-	SPRING EQUINOX DECLINATION AT MIDDLE POSITION
0235	24	.50	133.5	SUN	1.49	6.27	90.0	95.2	2/9	
0452	24	.51	133.5	SUN	1.50	6.27	90.0	95.2	2/9	
0725	24	.51	132.5	SUN	1.44	6.27	90.0	95.2	2/9	
0850	24	.49	117.5	SKY	0.47	6.27	90.0	95.2	-	
0916	24	.50	124.5	DUMMY	0.90	6.27	90.0	95.2	-	
10.vi.68										
0200	24	.50	128.5	DUMMY	1.50	6.23	87.5	73.2		
0205	24	.50	136.5	SUN	1.90	6.23	87.5	73.2	3/3	
0507	24	.50	136.5	SUN	1.90	6.23	87.5	73.2	3/3	
0558	24	.50	128.0	DUMMY	1.40	6.23	87.5	73.2	-	
0934	24	.50	123.0	SKY	1.00	6.23	87.5	73.2	-	

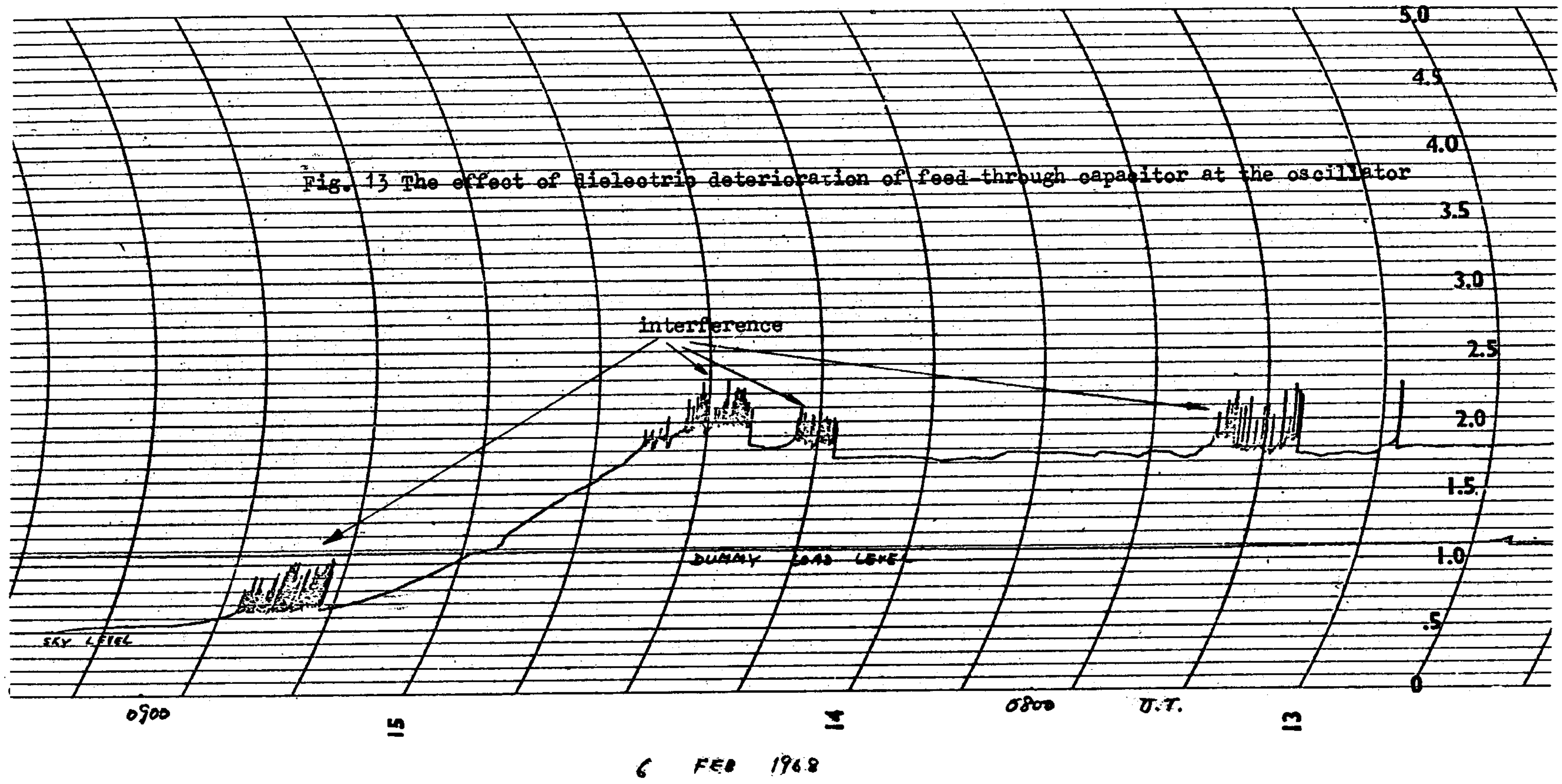


Figure 13.—The effect of dielectric deterioration of feed through capacitor at the oscillator.

favourable position for the smallest cable run to the preamplifier. Having secured the base, the next step is to put the drive chain together round the base of the south column. Then the polar declination axes can be secured to the top of the base mount (4 bolts) through the plummer blocks. The large sprocket should be placed nearest to the south pillar. The chain can then be slipped over the large sprocket. Next, attach the gear drive to its mounting frame and the whole assembly to the base frame with the drive chain slipped over small sprocket. With some downward pressure on the gear drive, in order to get good tension on the chain, lock the 4 securing bolts for the drive unit to the base frame. The clutch (two red handles) will maintain the R.A. axis in any position. Set this so that the declination axis is horizontal.

Next, place the dish vertically against the south pillar - with a block of wood under the lower edge so that the dish mount holes line up with the declination bearings and stub shafts. A washer, an end plate and two bolts at each end of the declination shaft complete this assembly. Then turn the dish vertical securing it in position with two bolts through the declination scale plates. The three holes in the dish mount form a vernier with those in the declination plates. Then attach the counterweights with the large steel blocks pointing away from the base frame. The whole thing will be then pretty well balanced and can be handled safely by one man.

Slide the two horn support tubes over two of the stubs on opposite sides of the dish edge. Four screws and nuts will complete the job, then attach the horn to these support tubes. For guys in the other direction, strong nylon fishing line should be run from the loops in the horn bracket to the other two stubs. The r.f. cable can then be connected, tapes along one of the support tubes, round the back of the dish, and down to the receiver.

The limit microswitch attaches to the small bracket near the top of the north pillar and the microswitch striker to the declination tube. The HA scale attaches to the back of the north pillar at the top and the pointer to the HA axis at the north end.

With a suitable plug on the power lead it should be ready to go. Starting HA can be set by unlocking the clutch (anticlockwise) manually turning the dish and locking the clutch. The siderial drive is started by the switch on the inner side (i.e. facing the south) of the electrical box. If it does not turn in the right direction, remove the cover and reconnect the yellow lead to the MF condenser to the opposite side.

A white target is provided in the center of the dish for using the shadow of the feed horn for alignment of the declination scale.

The coverage of observing time can be increased or decreased with the relocation of the counterweights. The counterweights can even be removed if two men are to change position in HA or declination instead of one. The motor is quite adequate to drive it without counterweights.

The installation of the antenna mount is completed. Now run the r.f. cable from the horn to the mixer probe and proceed as prescribed in the operating procedures. As the receiver is installed in the second floor of the building, the r.f. cable runs from the horn to the preamplifier is quite short, the preamplifier therefore is put in the same rack as other panels.

The first test was a failure. The crystal current did not show up. Having ascertained that the filament and h.t. power supplies were all right, the cavity was examined, and it was found out that the adjustable plunger of the cathode tuning came out of the cavity. After fixing this, and with a little adjustment of the feedback screw, the crystal current registered. Running the receiver with sky, sun, and dummy load input for a while gave indication that the receiver worked satisfactorily. However, the apparent solar flux as registered on the chart paper had a tendency to decrease very rapidly. This could mean either the polar axis of the antenna mount does not point to the true north, or the amplification of the amplifier is not stable. The tubes are found to be all right. Besides, the shadow on the white plate at the middle of the antenna dish changes position as time passes by. This indicates that the polar axis of the mount is not in correct direction. The deviation resulted from the use of compass in determining the direction at the time of installation. As the result, the operator must go up to change the declination several times a day.

The acquisition of the polar axis was delayed for several months until the four inch telescope arrived in November 1967. On three successive clear sky nights in November, polar axis was then determined using this telescope. It was found that the existing direction deviates from the true north by six degrees. Discussion then, were made among persons concerned to work out the most feasible means to put the antenna in the correct direction. Finally, a solution was reached whereby a U-type baseframe six inches high would be built by the workshop according to the drawing drawn by the reporter. The holes in the lower frame were drilled to fit into the existing screws on the cement roof, but the upper frame had holes drilled to fit the mount of the antenna to the polar axis. The U-type frame was ready on 18 January 1968. The alteration was done on the next day. The actual position of the baseframe is shown in Figure 14. The observation on the following days showed the smooth curve running on the chart paper all day. The condition of apparent solar flux before and after re-alignment is shown in Figures 15 and 16. Some results of the observation are also included.

IV. CONCLUSION

The installation of the 3-metre radio telescope observing the sun at 21 centimetre wavelength was successfully done with the realignment of the polar-axis of the antenna mount in January 1968. The position of the declination plate which lies horizontal to the ground plane (second hole of the three holes in the dish mount aligns with the ninth hole of the seventeen holes in the declination scale plates) on the vernal equinox day (20 March 1968) proves that the existing polar axis is in the right direction. The smooth apparent solar flux on the chart from morning to evening on the day of undisturbed sun also suggests that the polar axis is in the right position. The observation has been established on a regular basis excluding Saturdays and Sundays. The results of the observation have been compared with some prominent observatories in this area. Comparative data are listed in Table 3.

V. ACKNOWLEDGEMENTS

The reporter wishes to express his profound thanks to Dr. J.G. Bolton for the kind advice in the installation of the instrument. The

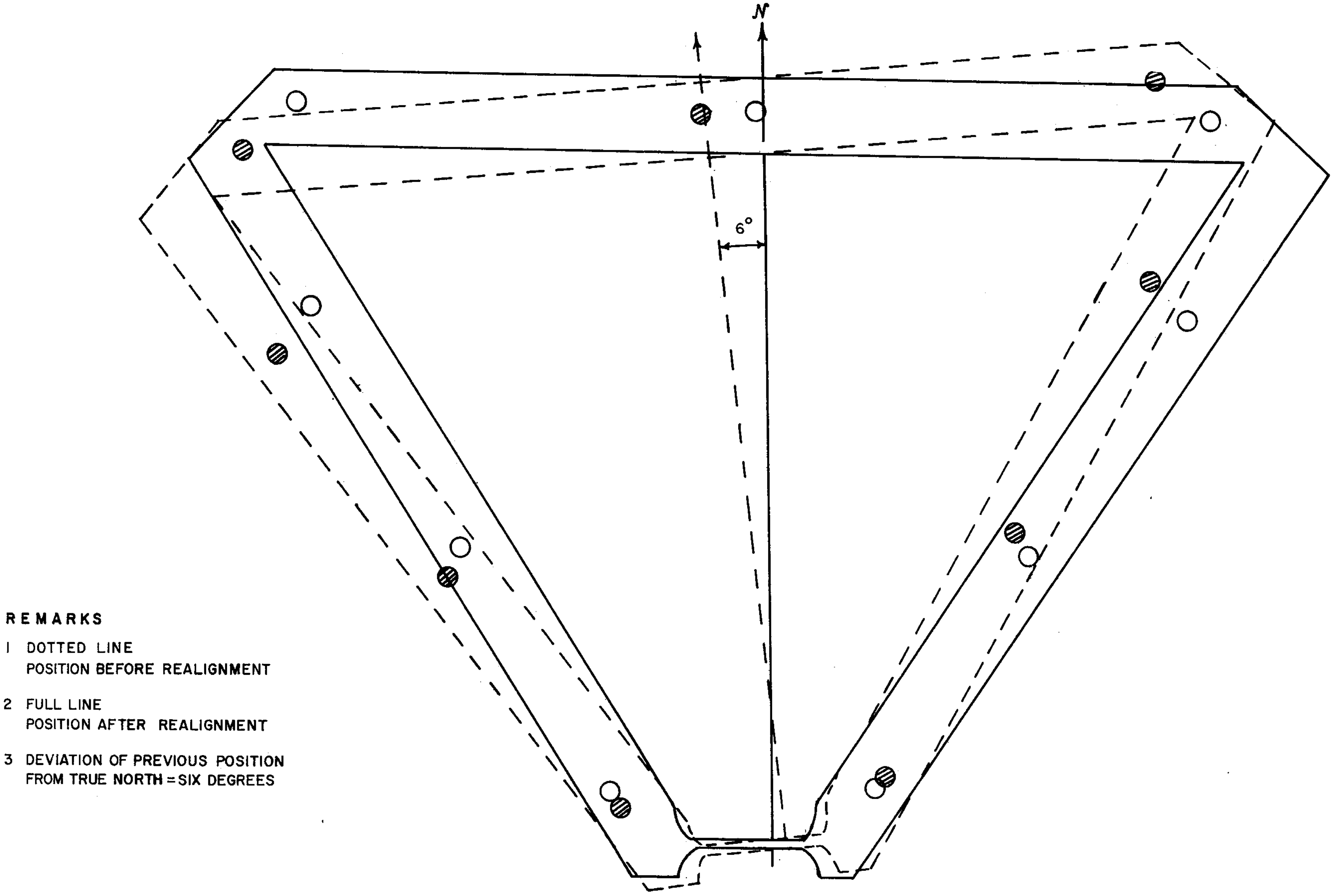


Figure 14.—Positions of base-frame before and after realignment.

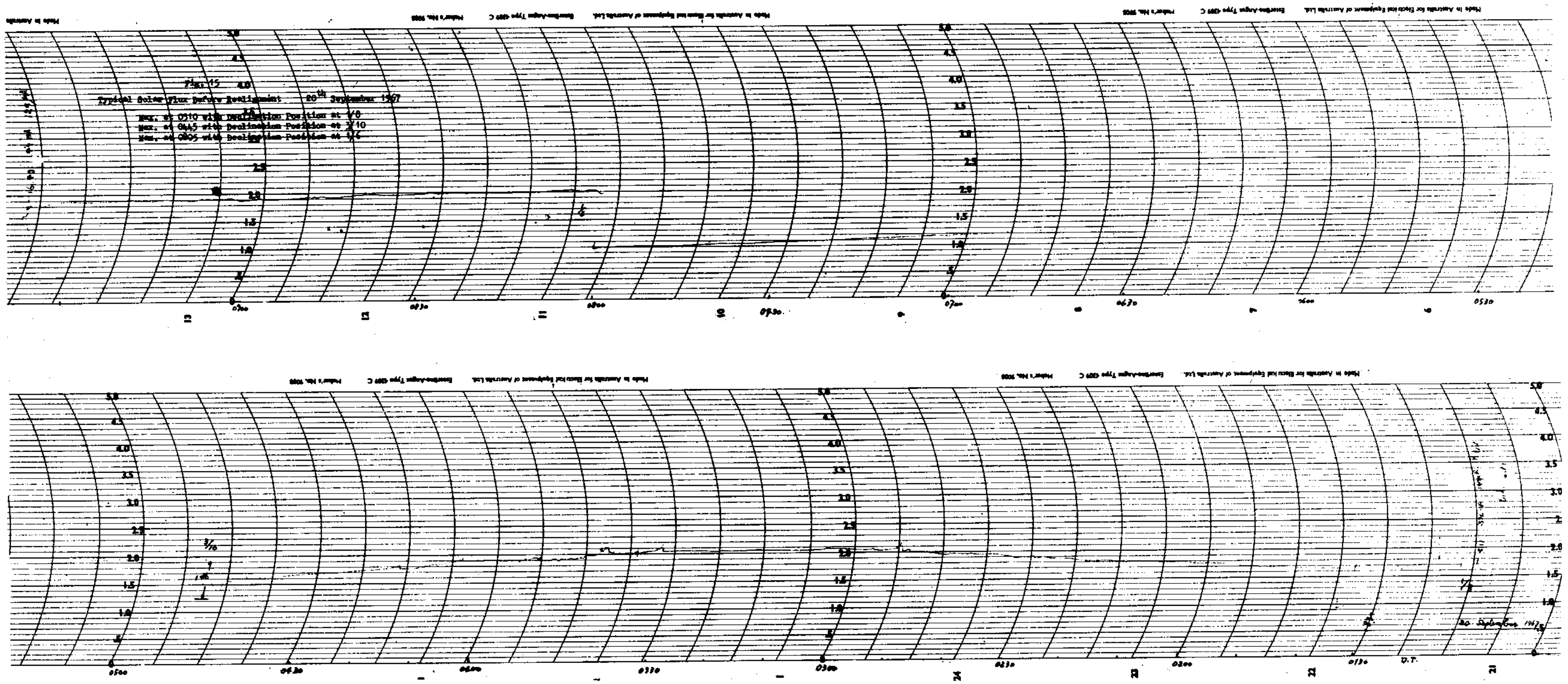


Figure 15.—Typical solar flux before realignment, 20 September 1967.
Max. at 0310 with declination position at 1/8
Max. at 0445 with declination position at 3/10
Max. at 0805 with declination position at 1/6

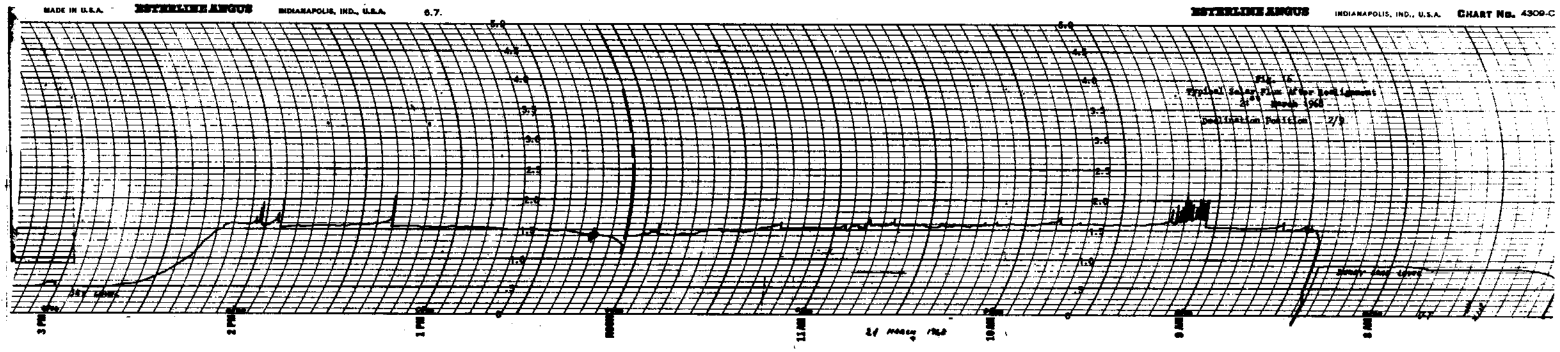


Figure 16.—Typical solar flux after realignment, 21 March 1968, declination position 2/9.

TABLE 3

OUTSTANDING EVENTS RECORDED ON 1400 MHz RADIO TELESCOPE AT ASRCT OBSERVING STATION, BANG KHEN, BANGKOK

Date	Approximate time of start (U.T.)	Approximate time of max. (U.T.)	Duration (minutes)	Type	Max. flux density ($10^{-22}Wm^{-2}(c/s)^{-1}$) (div.)	Phenomena observed elsewhere					
						Source	Start	Max.	Duration	Type	Density
16.vi.67	0417	0417	6	S	7.0	NAG 2000	0411	0412.5	4	S	2
26.vii.67	0639	0639	7	F	1.2	NAG 1000	0640	0640.4	3	S	13
26.vii.67	0658	0700	30	F	1.5	TOK 17000	0652	0657.8	20	S	30
						1 FLARE	0654				
31.vii.67	0812	0815	5	C	7.4	2B FLARE	0812				
1.viii.67	0250	0252	2	S	13.8	NAG 3750	0250	0253	65	S	12
2.viii.67	0505	0505.5	5	S	2.2	NAG 9400	0505	0505.5	2	S	115
						NAG 3750	0504	0505.5	3	S	40
						NAG 2000	0505	0505.5	3	S	20
						NAG 1000	0504.5	0505.7	9	S	17
						TOK 17000	0505.4	0505.5	0.6	S	37
3.viii.67	0433	0433	2	S	0.6	NAG 9400	0432	0432.9	2	S	10
						NAG 3750	0432	0433	4	S	11
						NAG 2000	0432.5	0433	3.5	S	11
						NAG 1000	0432.5	0433	2	S	5
3.viii.67	0437	0437	3	C	1.0	NAG 9400	0437	0437.3	6	C	28
						NAG 3750	0436.5	0437.3	9	C	25
						NAG 2000	0437	0437.4	8	C	20
						NAG 1000	0437	0437.3	3	S	9
4.viii.67	0145 ?	0145.5 ?	3	C	5.0	NAG 9400	0135	0137.4	17	C	35
						NAG 3750	0135	0137.4	15	C	35
						NAG 2000	0135.5	0137.6	8	C	75
						NAG 1000	0135	0137.3	8	C	26
7.viii.67	0400	0400	7	C	1.8	NAG 9400	0400	0420	35	S	5
						NAG 3750	0400	0407	115	C	13
						NAG 2000	0400	0407	115	C	9
						NAG 1000	0400	0404	18	C	340
15.viii.67	0226	0330	106	F	1.5	NAG 9400	0250	0410	180	S	6
						NAG 3750	0210	0400	190	S	6
						NAG 2000	0220	0355	170	S	3
16.viii.67	0507	0509	6	C	-	NAG 9400	0507	0509	8	C	11
						NAG 3750	0507	0508.9	8	C	15
						NAG 2000	0507	0511.4	7	C	9
						NAG 1000	0507	0512	8	C	35

TABLE 3 (continued)

Date	Approximate time of start (U.T.)	Approximate time of max. (U.T.)	Duration (minutes)	Type	Max. flux density ($10^{-22}Wm^{-2}(c/s)^{-1}$) (div.)	Phenomena observed elsewhere					
						Source	Start	Max.	Duration	Type	Density
17.viii.67	0651	0651	2	C	1.3	1 FLARE	0648				
17.viii.67	0836	0836.5	1	S	0.6	1 FLARE	0836				
18.viii.67	0224	0231	19	C	3.5	1 FLARE	0224				
						NAG 2000	0223	0223.3	13	C	120
						TOK 17000	0229	0230.7	10	C	82
18.viii.67	0645.5	0645.5	1	S	1.0	NAG 9400	0649	0650.1	3	S	22
						NAG 3750	0649	0650.1	3	S	21
						NAG 2000	0649.8	0650.1	1	S	4
21.viii.67	0442	0442.5	7	S	1.0	NAG 3750	0441.8	0442.2	1	S	3
						NAG 2000	0441.8	0442.2	7	S	16
						NAG 1000	0441.5	0442.3	8	S	11
22.viii.67	0156	0201.5	25	C	2.3	NAG 9400	0155	0157	35	C	8
						NAG 3750	0155.5	0157.5	45	C	18
						NAG 2000	0155.5	0157.5	25	C	15
						NAG 1000	0155	0157.5	40	C	8
						TOK 408	0155.9	0156.4	3	C	-
23.viii.67	0514	0516	9	C	6.0	1 FLARE	0514				
						NAG 9400	0514	0516.2	12	C	55
									15	p.i.	7
						NAG 3750	0514	0516.6	12	C	95
									20	p.i.	4
						NAG 2000	0514	0516.6	12	S	40
									10	p.i.	3
						NAG 1000	0514	?	9	S ?	> 19
									10	p.i.	2
						TOK 612	0514	0515.6	3	C	-
						TOK 408	0515.5	0516	1	C	-
29.viii.67	0220	0220.5	2	S	1.3	1 FLARE	0220				
						NAG 9400	0218	0218.4	2	S	11
									30	p.i.	2
						NAG 3750	0213	0218.4	7	S	13
									35	p.i.	4
						NAG 2000	0213	0218.6	15	S	5
						NAG 1000	0218	0218.4	2	S	8
30.viii.67	0500	0511.5	26	S	0.9	NAG 9400	0500	0502.8	30	C	10
						NAG 3750	0500	0502.8	30	C	10
						NAG 2000	0500	0500.5	10	C	7
						NAG 1000	0500	0500.5	1	S	3

TABLE 3 (continued)

Date	Approximate time of start (U.T.)	Approximate time of max. (U.T.)	Duration (minutes)	Type	Max. flux density $(10^{-22} Wm^{-2}(c/s)^{-1})$ (div.)	Phenomena observed elsewhere					
						Source	Start	Max.	Duration	Type	Density
14.ix.67	0745	0807	31	S	0.6	1B FLARE	0745				
18.ix.67	0138.5	0138.5	4	S	5.8	NAG 9400	0138	0139.4	4	S	15
						NAG 3750	0138	0139.6	3	S	11
									40	p.i.	2
						NAG 2000	0138	0139.4	3	C	125
									25	p.i.	2
						NAG 1000	0138	0139.3	4	S	9
21.ix.67	0324	0329	8	C	0.9	NAG 9400	0324	0331.0	30	S	10
						NAG 3750	0324	0329.3	30	C	11
						NAG 2000	0320	0329	30	C	12
						NAG 1000	0327	0330	6	C	3
						1 FLARE	0327				
26.ix.67	0718	0722	5	S	3.6	1B FLARE	0715				
27.ix.67	0317	0317	2	S	4.5	NAG 3750	0314	0314.7	2	S	3
						NAG 2000	0314	0314.7	2	S	3
						NAG 1000	0314	0315	2	S	2
26.x.67	0204	0205	2	C	3.0	NAG 3750	0204	0205.4	4	S	6
						NAG 2000	0204	0205.5	4	S	9
						NAG 1000	0204	0205.6	4	C	20
						TOK 612	0205	0205.2	1	C	95
						HIR 500	0204.5	0205.2	1.5	C	100
26.x.67	0610	0624	17	C	1.7	1 FLARE	0610				
						TOK 612	0609.2	0609.8	1.1	C	770
						TOK 227.5	0609.8	0613.0	4.4	C	650
						HIR 500	0609.0	0609.6	2.0	C	410
						HIR 200	0610.0	0610.0	2.0	C	300
						HIR 200	0613.0	0613.5	2.0	C	360
						HIR 200	0617.0	0618.8	> 93.0	C	35
27.x.67	0218	0221	4	S	2.7	NAG 9400	0217	0218.8	5	S	24
						NAG 3750	0217	0218.8	4	S	25
						NAG 2000	0216	0218.3	5	S	15
						NAG 1000	0216	0219	4	S	3
30.x.67	0158 ?	0304.5	75	F	6.0	2 FLARE	29/2350				
						NAG 9400	0047	0113.5	190	S	315
						NAG 3750	0046	0115	190	S	540
						NAG 2000	?	0116	>180	S	540
						NAG 1000	0045	0116	125	S	220

TABLE 3 (continued)

Date	Approximate time of start (U.T.)	Approximate time of max. (U.T.)	Duration (minutes)	Type	Max. flux density (10^{-22}Wm^{-2}(c/s)$^{-1}$) (div.)	Phenomena observed elsewhere					
						Source	Start	Max.	Duration	Type	Density
30.x.67	0158 ?	0304.5	75	F	6.0	TOK 227.5	0046	0100	>40	C	120
						TOK 17000	0103	0113	27	S	75
						HIR 500	0046	0058.5	65	C	100
						HIR 200	0044	0118.3	66	C	75
2.xi.67	0418	0418	1	C	1.9	NAG 9400	0422	0423.5	4	S	7
									25	p.i.	2
						NAG 3750	0419	0423.0	12	C	15
						NAG 2000	0420	0423.0	6	C	5
						NAG 1000	0420	0423.5	14	C	14
3.xi.67	0320	0325	6	S	0.5	NAG 9400	0320	0324	11	S	4
						NAG 3750	0320	0323	8	S	5
						NAG 2000	0321	0322.8	5	S	5
						NAG 1000	0318	0324.2	7	C	21
6.xi.67	0226	0231	11	S	0.4	NAG 9400	0219	0221	5	S	7
						NAG 3750	0219	0220.8	9	S	40
									10	p.i.	2
						NAG 2000	0219	0221.2	12	S	21
									80	p.i.	2
17.xi.67	0237	0240	10	C	0.8	HIR 200	0232.3	0233.8	3	C	95
27.xi.67	0316	0318	4	C	6.1	NAG 1000	0315.5	0317.5	4.5	C	15
						2 FLARE	0305				
24.i.68	0424	0424	1	C	-	1 FLARE	0423				
29.i.68	0807	0807	8	C	5.0	1 FLARE	0807				
2.ii.68	0255	0259	8	S	9.2	FLS 1420	0255	-	8	S	138
5.ii.68	0821	0821	3	C	6.8	1 FLARE	0818				
14.ii.68	0409	0409	13	C	1.2	FLS 1420	0416	-	4	C	120
21.ii.68	0710	?	20	C	13.0	1 FLARE	0710				
27.ii.68	0210	0210.5	2	S	1.0	FLS 720	0211	-	1	S	135
4.iii.68	0658	0704	8	C	2.7	1 FLARE	0659				
28.iii.68	0325	0333	15	C	27.9	2B FLARE	0320				
						FLS 1420	0321	-	12	C	272
4.iv.68	0255	0301	17	C	1.0	FLS 1420	0257	-	14	C	105
5.iv.68	0312	0326	16	F	0.8	FLS 1420	0311	-	11	F	106

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