MELBOURNE TECHNICAL COLLEGE

RADIO SCHOOL

CATHODE RAY OSCILLOGRAPHS

OPERATION AND PROCEDURE FOR USE

Layout and controls are very similar in all oscilloscopes, therefore, operation and procedure that you will use on oscilloscopes, here will apply generally to all.

GENERAL LAYOUT OF CIRCUIT BELOW:-

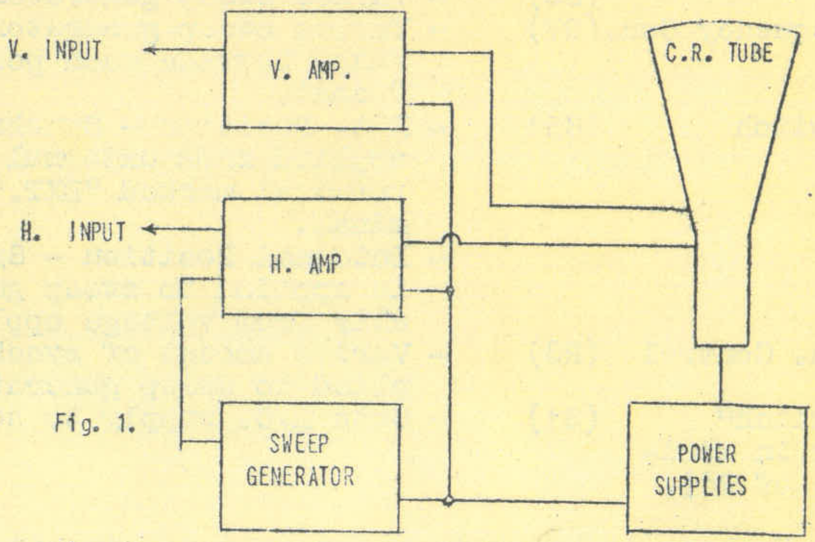


Fig. 1.

DETAILED CIRCUIT DIAGRAMS GIVEN ON FOLLOWING 4 PAGES:-

Circuit	1.	Cathode ray tube and power supply No. 1.
"	2.	V and H shifts controls, and Power supply No. 2 added.
"	3.	V and H amplifiers, and sweep generator added.
"	4.	Completed circuit with extras added.

SUMMARY OF CONTROLS:-

Although controls may be marked differently on some 'scopes they do just the same job. General ones used are tabulated below:-

Intensity Control	(R1)	- Brilliance of spot on screen.
Focus "	(R2)	- Sharpness of image.
V position "	(R3)	- Shifts image or spot vertically on screen.
H position "	(R4)	- Shifts image or spot horizontally on screen.
V Gain "	(R5)	- Varies height of image on screen.
H gain control	(R6)	- Varies width of image or line on screen.
Hor. Amp. Switch	(S2)	- Sweep position - applies sweep voltage to horizontal plates. Amp. position - feeds external voltage on H & G terminals to hor. plates.
Coarse Frequency Control	(S4)	- Varies sweep generator freq. in steps.
Fine Frequency Con.	(R7)	- Varies sweep generator freq. to fill range between each position of Coarse f cont.
Sync. Switch	(S3)	- Ext. Position - Synchronization is applied from external source between terminal marked "EXT." and a "G" terminal. - Internal Position - Synchronization is applied to sweep generator internally from voltage applied to V plates.
Synchron. Control	(R8)	- Varies amount of synchronization applied to sweep generator.
Mains Switch* (Operates in minimum pos. of R1).	(S1)	- Cuts A.C. supply to scope.

NOTE:- Numbers in brackets refer only to circuits on following pages.

PROCEDURE FOR OPERATION

1. Make all necessary connections to V and H inputs before switching on.

2. Bring all controls to "zero or off" position.

3. Adjust "H and V position" controls to about 60 so that spot will appear on screen.

4. Plug scope into mains supply.

5. Switch on scope by turning "Intensity" control clockwise until click is heard.

6. Wait 15 secs. for tubes to heat up.

7. Increase "intensity" control until spot appears on screen. If spot does not appear, adjust "V and H position" controls slightly.

NOTE:- <u>Do not focus beam on a spot.</u> Always obtain a line, by applying sweep generator to H plates as follows:-

8. Turn "HOR." switch to sweep position.

9. Increase "H gain" control to about 70.

10. Turn "Coarse Frequency" control to 60 position.

<u>FOCUSING</u>:-

11. Increase "focus" control, and at same time decrease "intensity" control until a sharp clear line is obtained.

12. Adjust "V and H position" controls until line is central on screen.

13. Adjust "H gain" control until line comes to within a ¼" of either edge of the screen.

<u>FEEDING SIGNAL TO V PLATES TO VIEW WAVE FORMS</u>:-

14. Turn "Sync." switch to internal position.

15. Increase "sync." control to 40 approximately.

16. Increase "V gain" control until image amplitude is approximately half height of the screen.

17. Swing "Coarse Frequency" control over all position until the nearest to correct number of cycles or pattern is obtained.

18. Obtain correct pattern by adjusting "fine frequency" control.

<u>PHASE OR FREQUENCY MEASUREMENTS</u> (OR ANY TEST REQUIRING SIGNAL FED INTO <u>V AND H INPUTS FROM EXTERNAL SOURCES</u>):-

Follow above procedure to 12. Then:-

19. Increase "V gain" control until desired amplitude is obtained.

20. Turn "HOR." switch to "AMP" position.

21. Adjust "H gain" control until desired amplitude is obtained.

NOTES:-

1. Do not be afraid to shift controls as:

2. Only damage that can be done to scope is to burn the flourescent screen by too bright an image or spot.

3. With phase measurements note the bottom terminal of "V and H inputs" are earthed and common.

EXPERIMENTS ON USE OF OSCILLOSCOPE

EXP. 1.

VIEWING WAVE FORMS

THEORY:-

By placing a linear sweep voltage on to the horizontal plates of a scope, and a variable amplitude voltage on the vertical plates, the shape of the variable voltage may be observed on the screen. From shape of wave amount of distortion, or harmonic content may be noticed.

AIM:-

To check:-

(a) the distortion and amplitude output of a B.F.O.

(b) the wave shape of a multi-vibrator.

METHOD:-

Make connections to scope as per diagram Fig. 1.

Using B.F.O:- Switch on scope and B.F.O. Adjust scope with B.F.O. set to 50~, and reproduce 3 cycles on the screen. With B.F.O. set to 500~, 2000, 10,000~, and again reproduce 3 cycles at each frequency.

Using M. Vibrator:- Switch on scope and M. Vibrator. Set M. Vibrator dial to 25 and adjust scope to reproduce 3 cycles on the screen. Reset M. Vibrator to 10, and 4 and again reproduce 3 cycles at each setting.

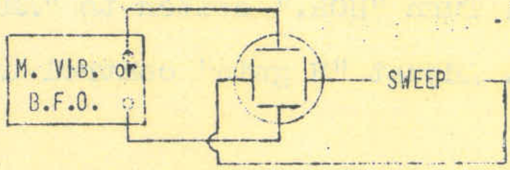


Fig. 1.

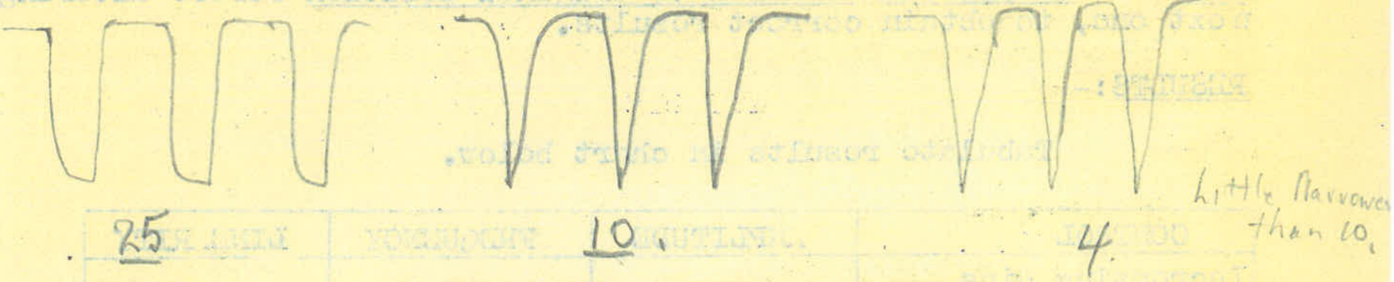
RESULTS:-

B.F.O:-

Note variation in amplitude, any distortion in wave at each frequency.

M. VIBRATOR:-

Make drawing below of wave shape at each frequency.



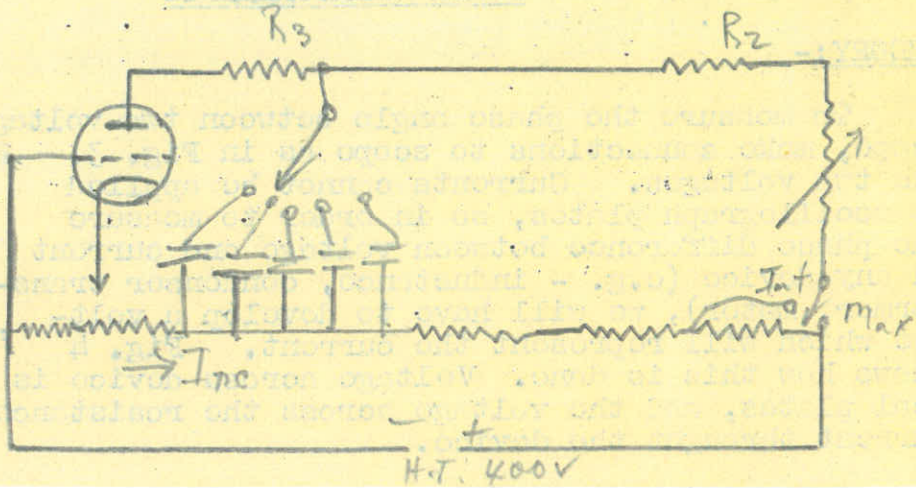
EXPERIMENT 2.

Wave shape of Thyratron Sweep Generator.

AIM:-

To view the effect on the saw tooth output of a Thyratron generator, by changing certain values of components.

CIRCUIT:-



METHOD:-

Connect generator to scope as is Fig. 2.
Switch on sweep generator and scope.
Adjust scope to reproduce 6 cycles of the saw tooth on the screen.

One by one -
Increase bias
Decrease capacity of C.1.
Decrease resistance of R.1.
Decrease H.T. supply - and

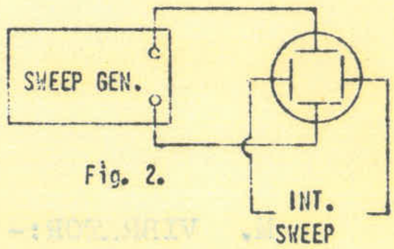


Fig. 2.

Note change in -

Amplitude,
Frequency,
Linearity.

Note:- Return each control to original position before altering next one, to obtain correct results.

RESULTS:-

Tabulate results in chart below.

CONTROL	AMPLITUDE	FREQUENCY	LINEARITY
Increasing Bias			
Decreasing C.1.			
" R.1.			
" H.T.			

With change in linearity it is only necessary to note whether wave remains linear or becomes distorted.

EXPERIMENT 3.

PHASE MEASUREMENTS

THEORY:-

To measure the phase angle between two voltages with a scope, make connections to scope as in Fig. 3. E and E_1 are the two voltages. Currents cannot be applied to oscillograph plates, so in order to measure the phase difference between voltage and current in any device (e.g. - inductance, condenser transformer, motor), we will have to develop a voltage which will represent the current. Fig. 4 shows how this is done. Voltage across device is applied to vertical plates, and the voltage across the resistance represents the current through the device.

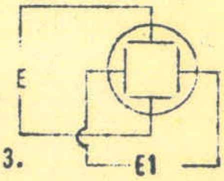
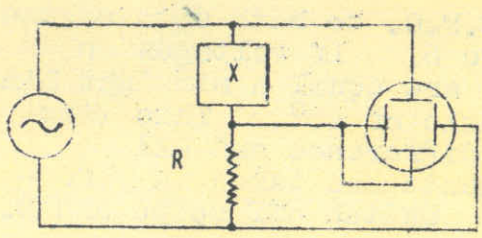


Fig. 3.



X = device producing out of phase component.

Fig. 4.

Different phase differences of voltages and/or currents give patterns on screen as shown below.

0° $0^\circ - 90^\circ$ 90° $90^\circ - 180^\circ$ 180°

Note:- The axis through an elipse must be at an angle of 45° to the horizontal plane, irrespective of the phase difference. This can be adjusted by the "V and H gain" controls.

AIM:-

1. To measure the phase difference of E and I in a condenser.

2. To note the change in phase of E and I in a load of varying ratio of X_C and R.

METHOD:-

Connect B.F.O. to both sets plates on scope as in Figure 5. If voltages on either set of plates are equal a straight line will result at an angle of 45^{o}. This line represents 0^{o} phase difference and all other phase measurements are taken in reference to that line. Switch off scope and B.F.O.

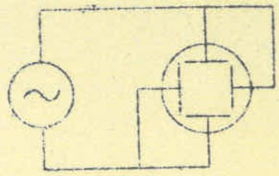


Fig. 5.

1. Now make connections to scope as in Fig. 6. Switch on scope and B.F.O. Set B.F.O. to 300~, R to 2000 Ω. Adjust scope to produce one of patterns in Fig. 6 which should be a circle.

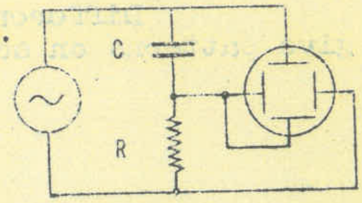


Fig. 6.

It may be an elipse in a vertical or horizontal plane. This can be adjusted to a circle by "V and H gain" control.

Change B.F.O. to 1000, 5000~, and note any change in phase difference by change in shape of pattern, if any.

2. Alter connections to scope to suit Fig. 7. With B.F.O. = 300~, R = 500Ω, adjust scope to produce an elipse at the correct angle to the horizontal plane. (This is done with "V and H gain" controls).

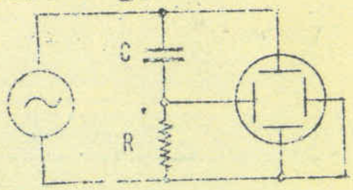


Fig. 7.

By theory notes diagram Fig. 27. calculate approximate phase difference represented by elipse on screen. Change R to 2000, 5000 readjust scope and again calculate the phase difference.

With R = 2000Ω change B.F.O. to 1000, 5000~ and again calculate phase difference as above.

RESULTS:- Tabulate results below in tables provided.

f	R	Ø

f	R	Ø

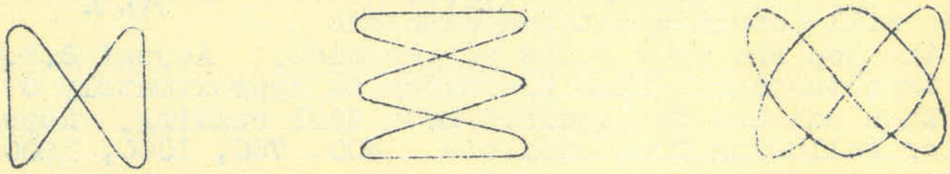
Give reasons for results of phase difference obtained in both 1 and 2 above.

EXPERIMENT 5.

FREQUENCY MEASUREMENT

THEORY:-

By applying two different frequencies to each set of deflecting plates, certain patterns known as Lissajou figures are produced. Examples below:-



From the first pattern it will be seen that there are two peaks along the top of the pattern, and one peak down the side of the pattern.

Comparing this with the fact that the frequency on the V plates equals twice the frequency of that on the H Plates, we arrive at the formula:-

$$\frac{f_1}{f_2} = \frac{\text{No. of peaks along top of pattern.}}{\text{No. of peaks down side of pattern}}$$

see Fig. 8. Comparing ratios of peaks and frequencies of the other two patterns above will prove this formula.

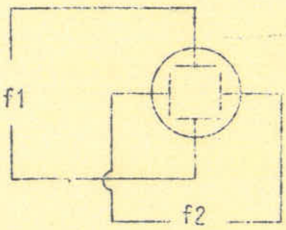


Fig. 8.

From the above working, knowing one frequency we can determine an unknown frequency from the pattern obtained on scope screen by the above formula.

AIM:-

To calibrate the dial of a B.F.O.

METHOD:-

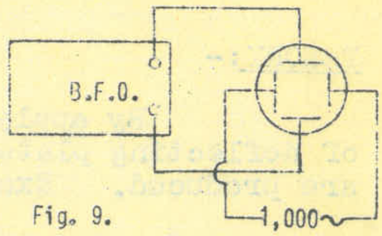


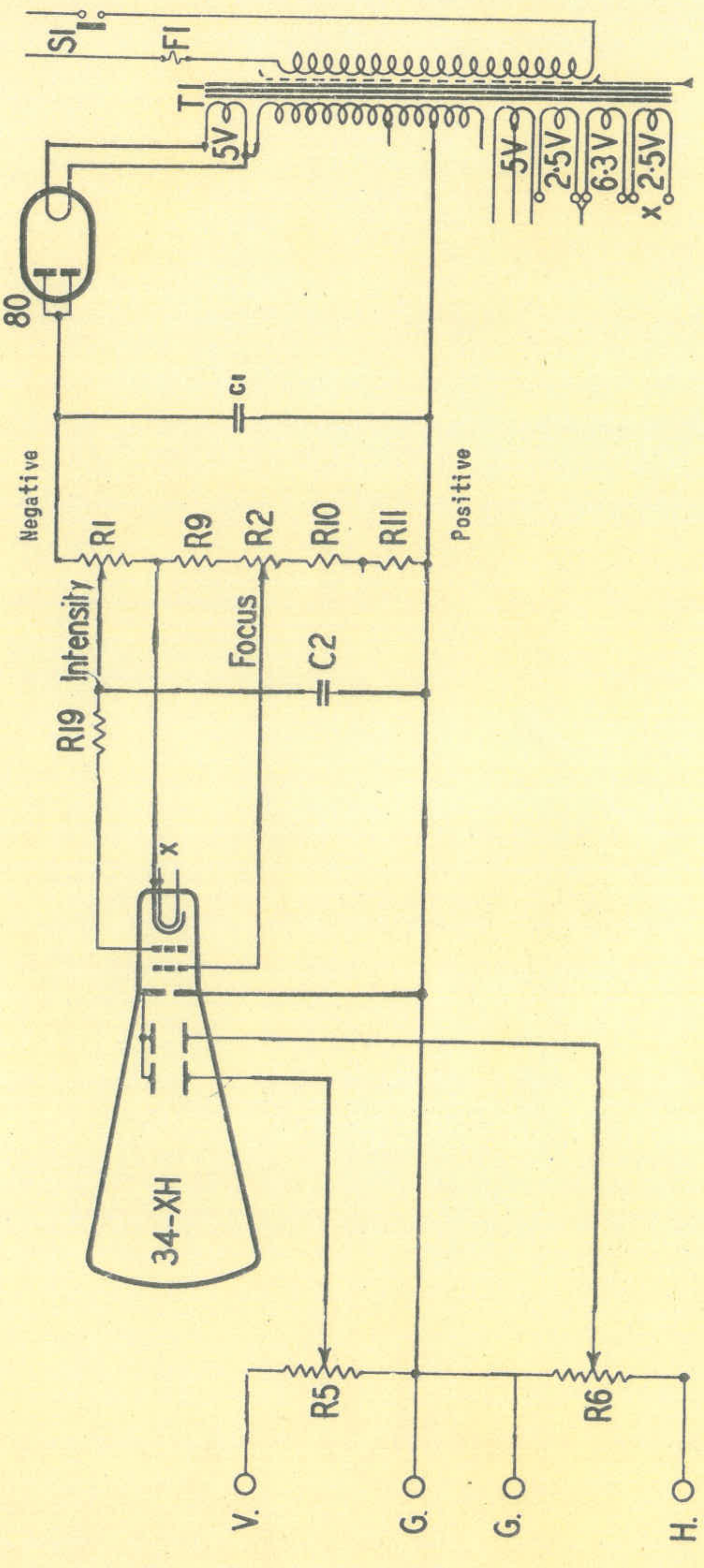
Fig. 9.

Make connections to scope as shown in Fig. 9. Switch on scope and B.F.O. By calculation from the formula when the frequency of B.F.O. = 250~, we will obtain a pattern with one peak on the top and four peaks on the side. Adjust B.F.O. until this pattern is obtained. This frequency is approximately 8 on the dial. When pattern is obtained note dial reading. Repeat same procedure for following frequencies:- 500, 750, 1000, 1500, 2500, 4000, 6000, 10000~, noting dial reading in each case.

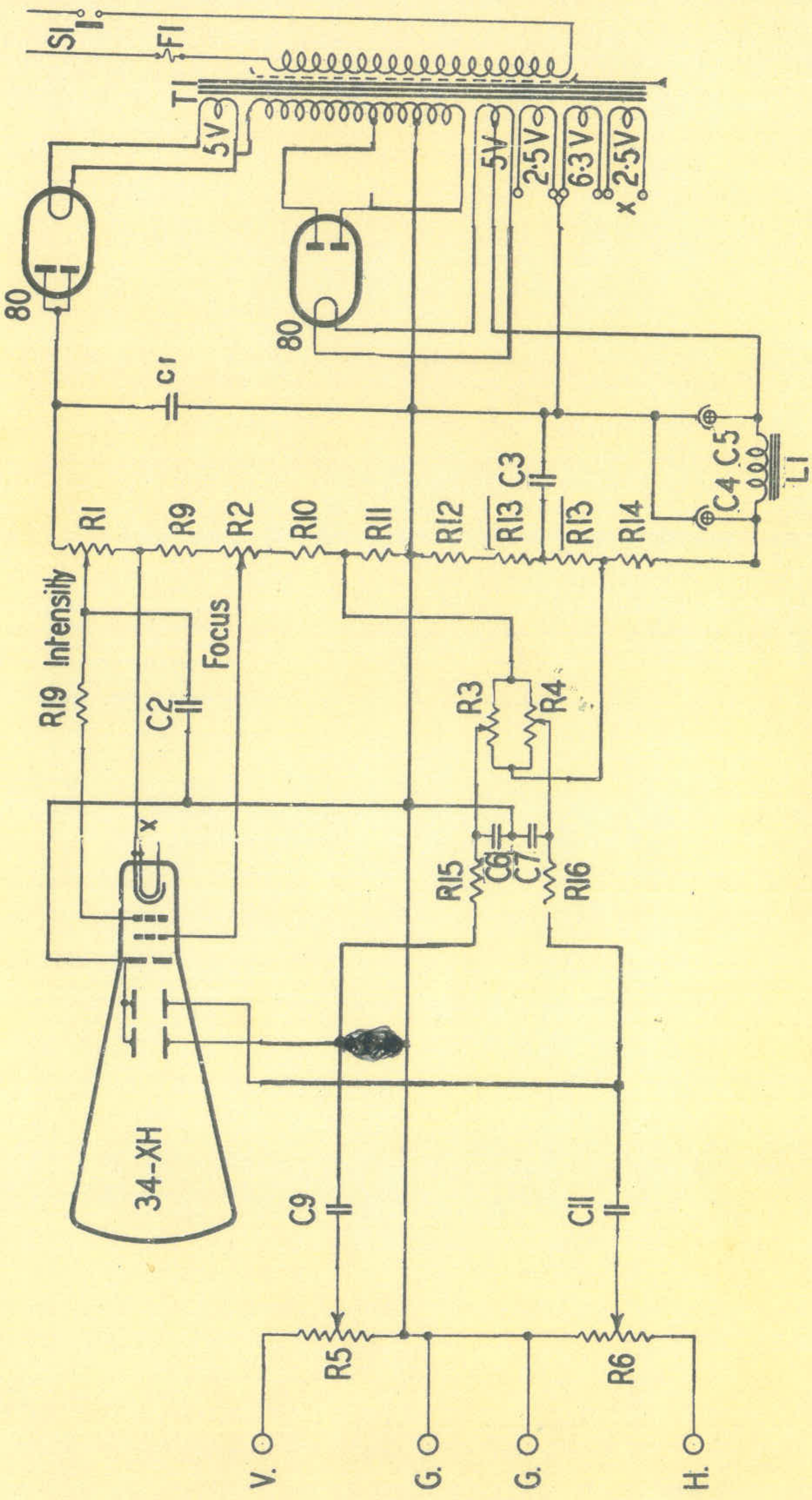
RESULTS:-

Tabulate results in the table below:-

FREQ.	RATIO V PEAKS/H PEAKS	DIAL READING	FREQ.	RATIO V PEAKS/H PEAKS	DIAL READING



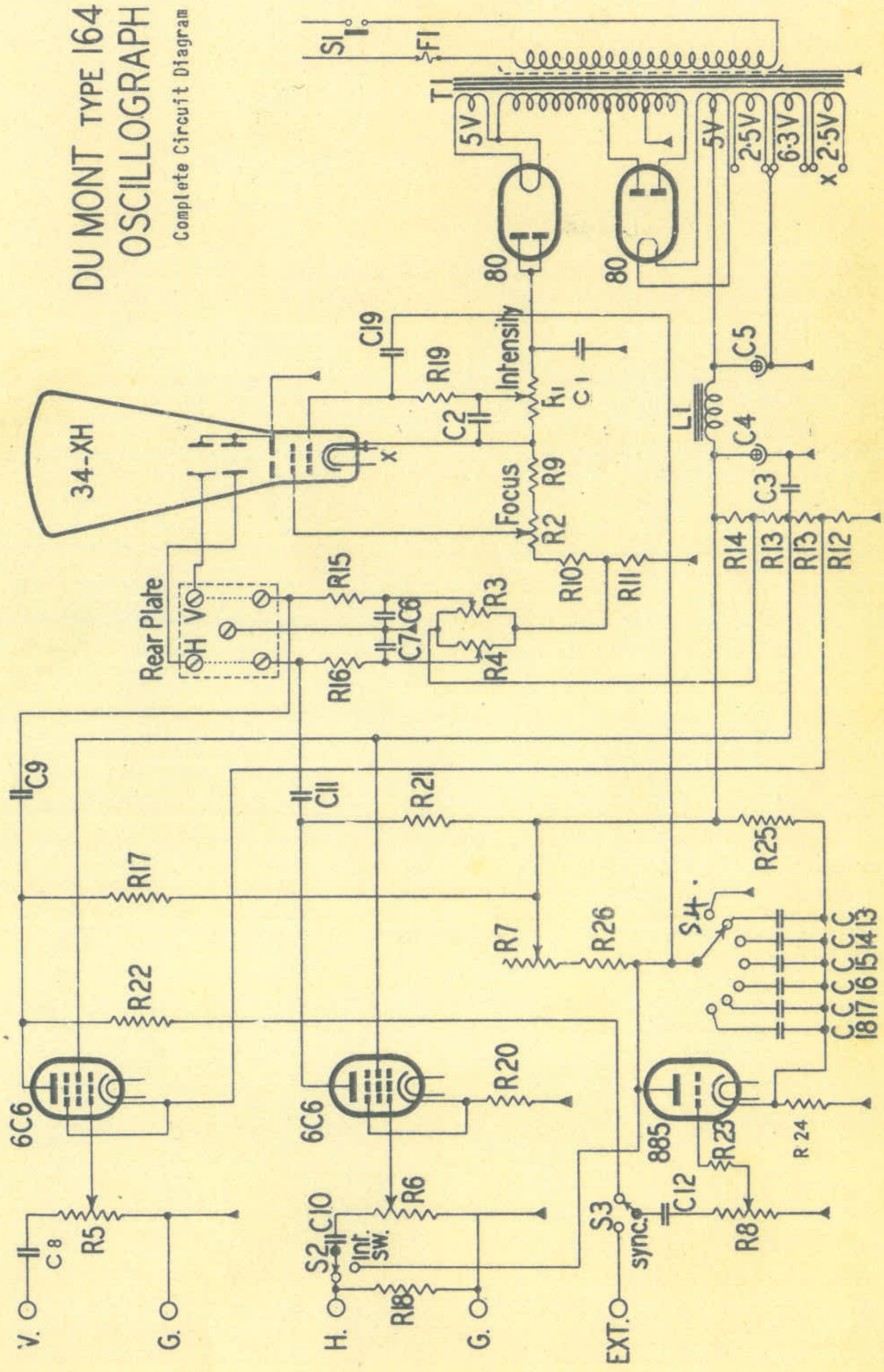
Simplified circuit diagram of cathode ray oscillograph less amplifier, time axis sweep oscillator and centering controls to show clearly that the operating voltages for the C.R. tube are obtained from a potential divider across the high voltage supply. Note that the positive is the grounded or low side.



Simplified circuit diagram of cathode ray oscillograph less amplifiers and time axis sweep oscillator., to show clearly the beam centering controls.

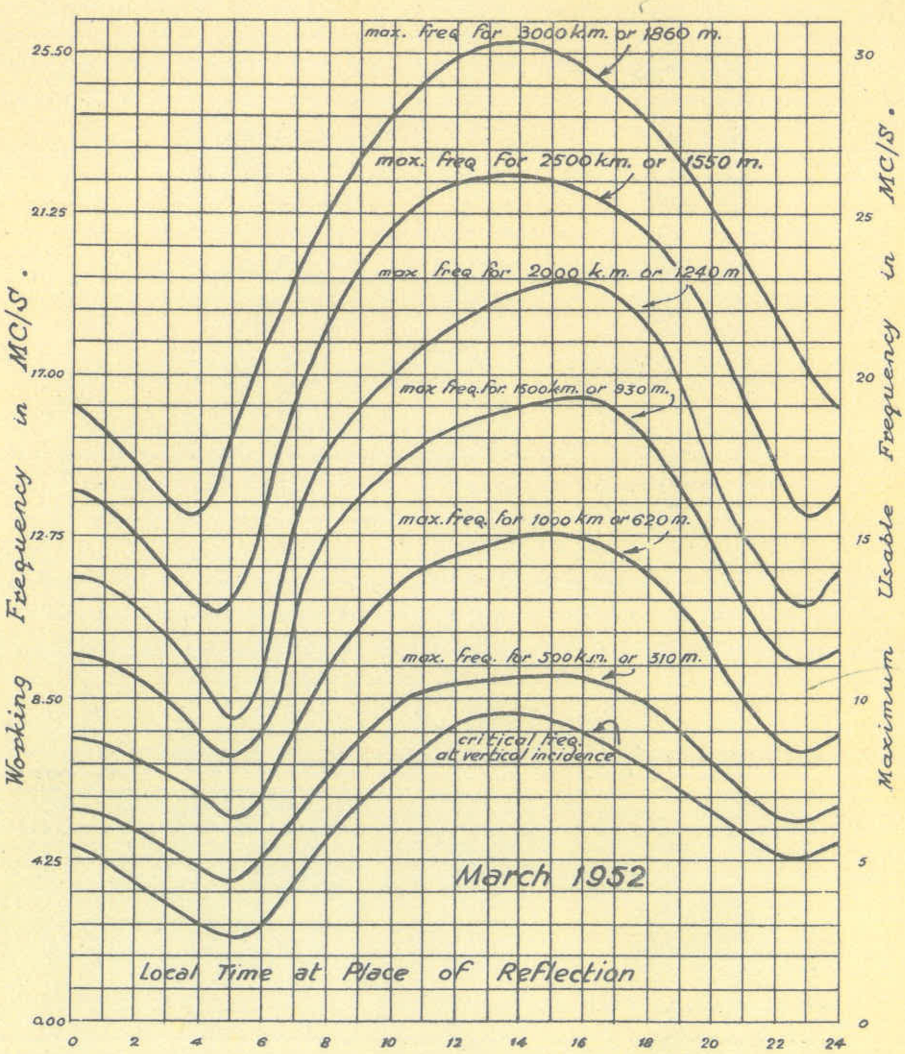
DU MONT TYPE 164 OSCILLOGRAPH

Complete Circuit Diagram



Ionospere + Radio Transmission

MELBOURNE TECHNICAL COLLEGE



USE OF THE CHART

1. First choose the chart predicted for the given year and month - say, March 1952.
2. Choose the graph line corresponding to the measured distance between the transmitter and receiver - say Melbourne and Perth - 1700 miles - Top graph.
3. Choose the time of transmission at Melbourne. Calculate the time in Perth. Take the mean of the two times. Melbourne - 0700 Hours. Perth - 0500 Hours mean time, where reflection will take place - 0600 Hours.
4. Run a line up the 6a.m. line till it strikes the 1860 mile graph, and read the maximum usable frequency - 21 megacycles on the right scale.
5. Choose a frequency 15% less than this as given on the left scale to guard against Ionosphere variations - 17 megacycles.

If a lower frequency is chosen, down to 50%, the signal may still arrive at its destination, but it will be greatly weakened. It will peak at Adelaide and then die away rapidly. If a higher frequency than the maximum is used it will pass through the ionized layers and will not be reflected.

. . . .

The 1860 mile graph shows that at 4a.m. mean time the working frequency to use for Perth is its lowest being 13mcs., while at midday it is its highest being 25mcs. If a 25mcs. frequency was used at 4a.m. the signals would be lost through the layer. If the 13mcs. was used at midday the signals strike the earth about 800 miles away from Melbourne as indicated by reading the 930 and 620 mile graphs. The clearest picture is given by taking the graphs and their calculated best working frequencies and noting the values for dawn (6a.m.) and midday.

DISTANCE	0600 Hours Mcs.	0600 Hours Meters	1200 Hours Mcs.	1200 Hours Meters
Local	(below) 3	100 (above)	6	50
310 Miles	4	75	8.5	35
620 "	5.5	55	12.5	23
930 "	7	40	16	19
1240 "	8	38	19	16
1550 "	12.5	24	22	13.5
1860 "	18	16.5	26	11

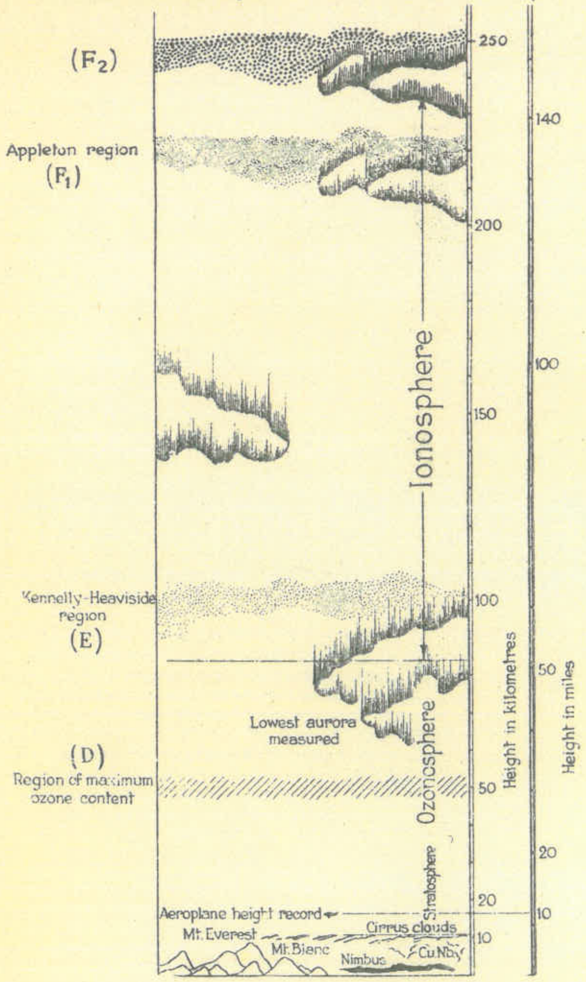


Fig. 1 - Elevation showing the ionized E, F_1 and the F_2 ionized layers together with scales and reference heights.

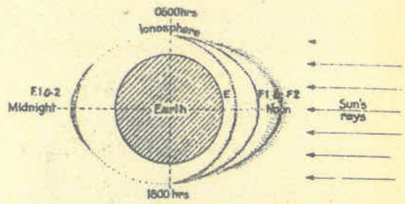


Fig. 2 - Changes in the ionized layers in terms of time of day.

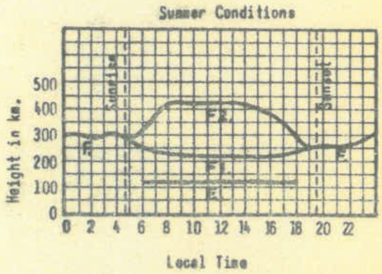


Fig. 3 - Hourly ionized layer changes for summer conditions.

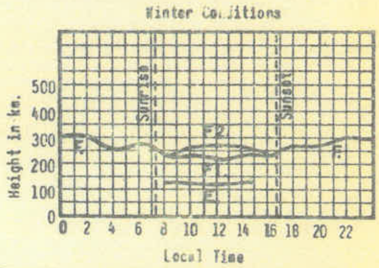


Fig. 4 - Hourly ionized layer changes for winter conditions. F_1 and F_2 practically merge into one.

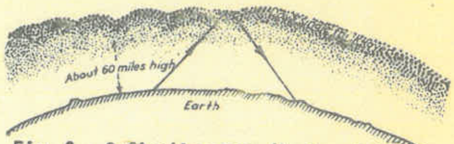


Fig. 6 - Reflection from the Heaviside layer. (Day).

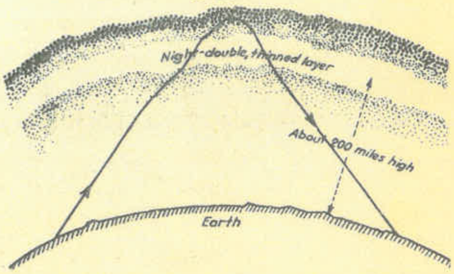


Fig. 7 - Reflection from the Appleton or F layer at night. This can be two thin layers almost touching. (Note the long skip distance.)

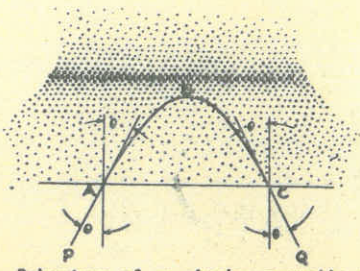


Fig. 5 - Behaviour of an electro magnetic ray or radio wave when entering an ionized layer of gas such as would be encountered when a wave is transmitted from the earth and travels upwards into the Heaviside or Appleton layers. The greater the ionization the more the ray bends. It may even be reversed in direction.

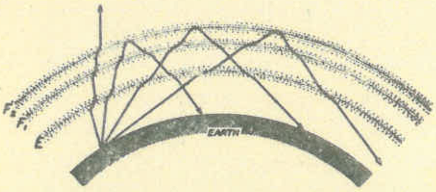


Fig. 8 - Bending of waves as they strike the various layers including the most heavily ionized one F_2.

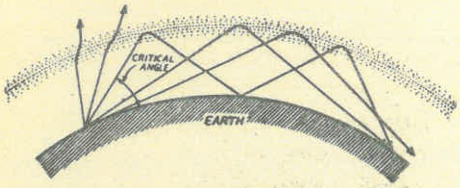


Fig. 10 - Effect of increasing frequency of transmission. As the frequency is raised a critical frequency is reached beyond which the waves are lost due to passing through the layer.

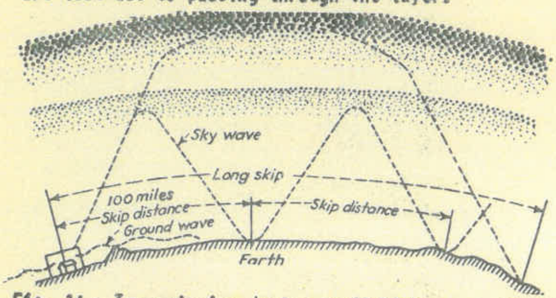


Fig. 14 - Transmission during daylight hours. The E layer returns its signal to ground quickly and long distance transmission is accomplished by the higher F_1 and F_2 layer. Fig. 11 & 14 are not drawn to the same scale.

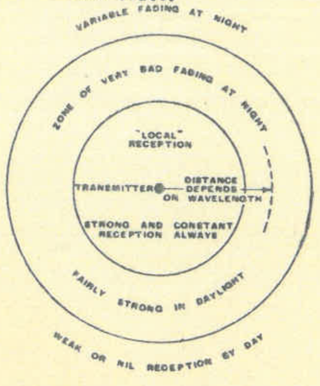


Fig. 15 - Typical interference plan showing the zones for good and bad reception for broadcast or medium frequencies.

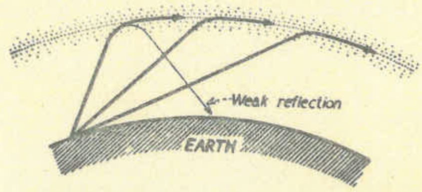


Fig. 9 - Effect of relatively long waves on striking an ionized layer. The wave is absorbed in the layer and only a fraction returned to earth. The amount returned cannot help transmission.

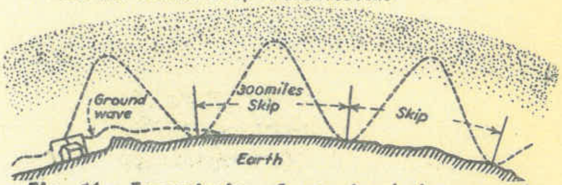


Fig. 11 - Transmission of ground and sky waves at night from the single F layer. The skip distance is great and the ground wave traverses a considerable distance so that at the first return point of the sky waves, two waves are received.

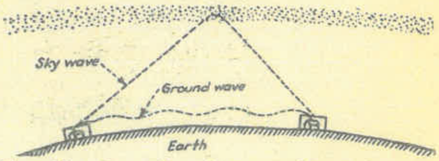


Fig. 12 - Reception for ground and sky waves.

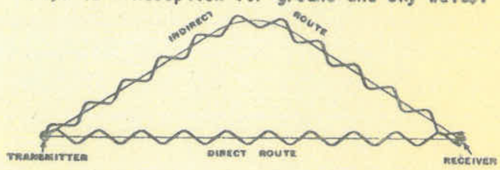


Fig. 13 - Reason for fading. The direct and indirect waves may reach the receiver out of phase.

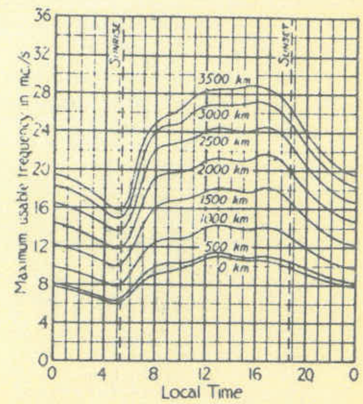


Fig. 16 - Frequency chart for choosing best frequency to communicate between any two points for any given hour of the day. Note: (New charts are required month by month and year by year.)

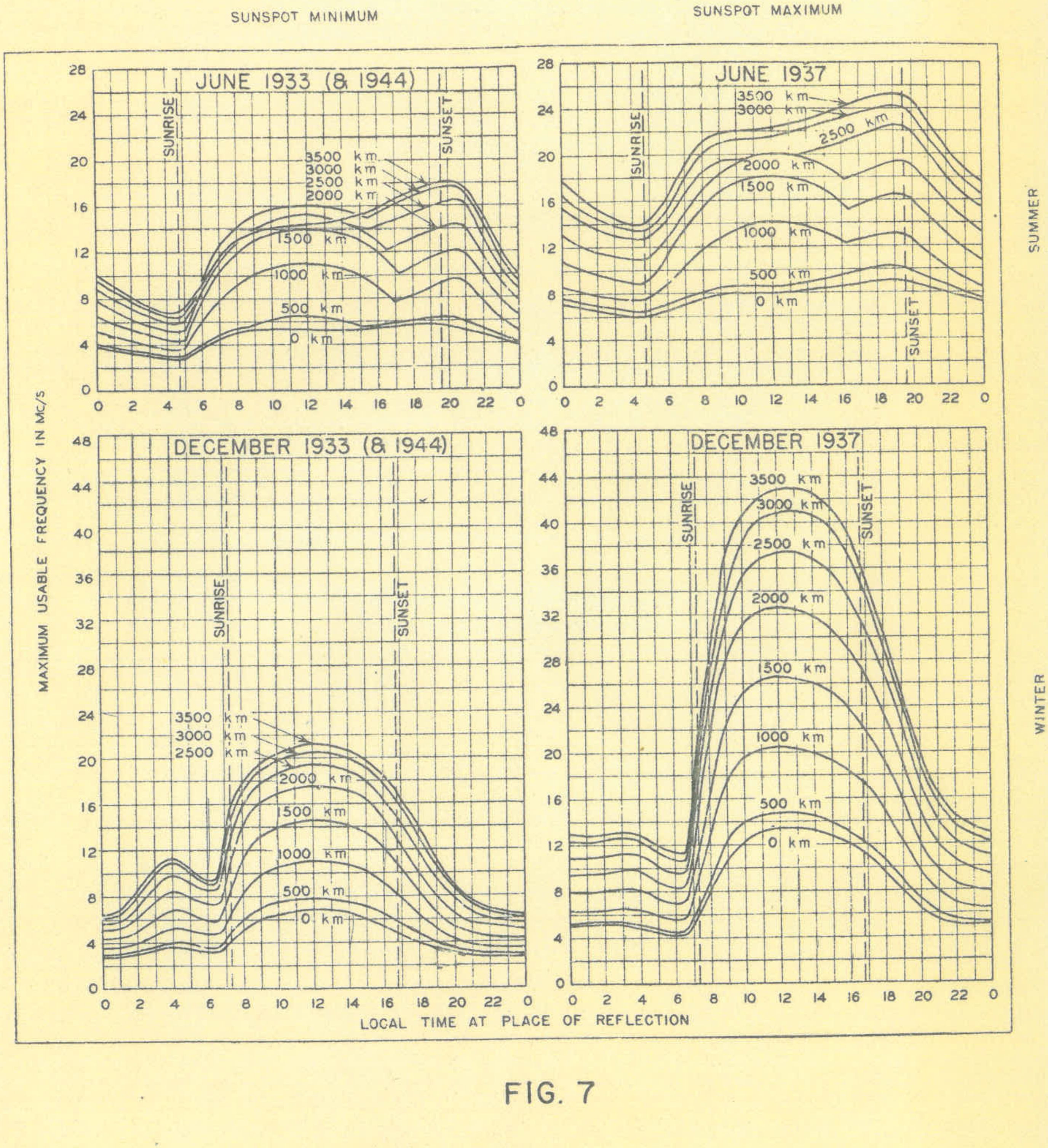

SUNSPOT MINIMUM
SUNSPOT MAXIMUM
JUNE 1933 (& 1944)
JUNE 1937
DECEMBER 1933 (& 1944)
DECEMBER 1937
SUNRISE
SUNSET
3500 km
3000 km
2500 km
2000 km
1500 km
1000 km
500 km
0 km
MAXIMUM USABLE FREQUENCY IN MC/S
LOCAL TIME AT PLACE OF REFLECTION
SUMMER
WINTER

FIG. 7

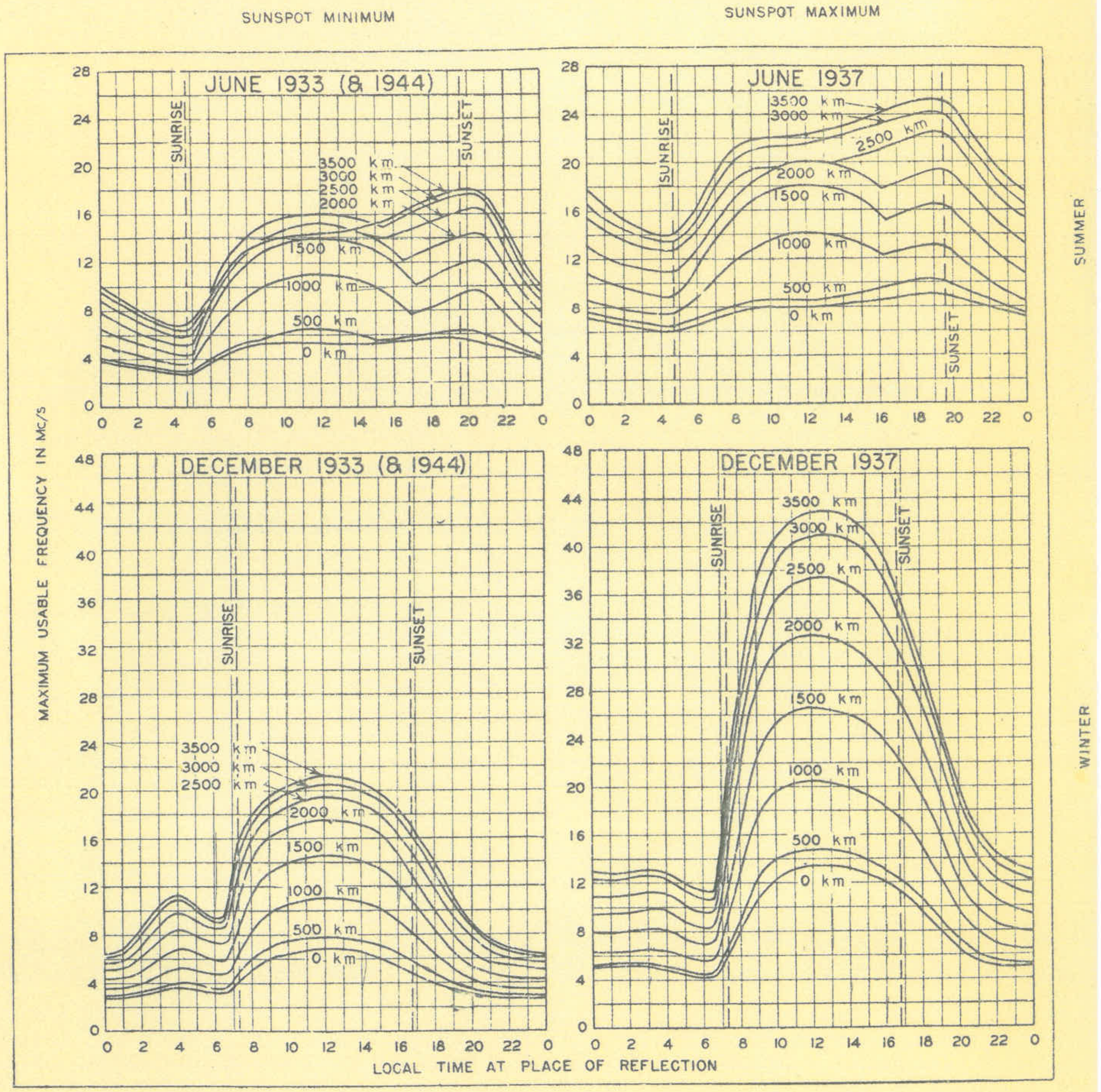

SUNSPOT MINIMUM
SUNSPOT MAXIMUM
JUNE 1933 (& 1944)
JUNE 1937
DECEMBER 1933 (& 1944)
DECEMBER 1937
SUNRISE
SUNSET
3500 km
3000 km
2500 km
2000 km
1500 km
1000 km
500 km
0 km
SUMMER
WINTER
MAXIMUM USABLE FREQUENCY IN Mc/s
LOCAL TIME AT PLACE OF REFLECTION

FIG. 7

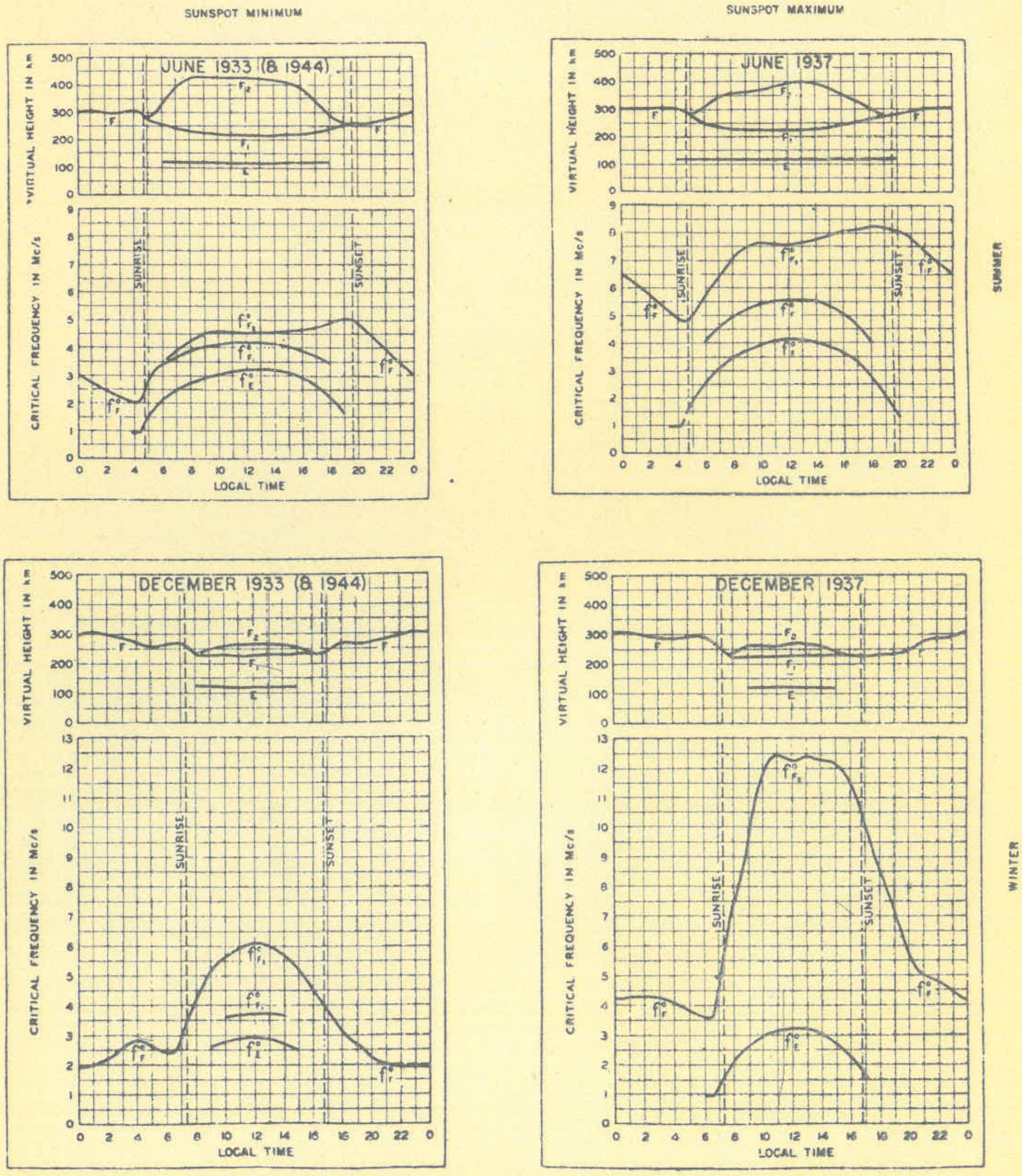

SUNSPOT MINIMUM
SUNSPOT MAXIMUM
JUNE 1933 (& 1944)
JUNE 1937
DECEMBER 1933 (& 1944)
DECEMBER 1937
VIRTUAL HEIGHT IN km
CRITICAL FREQUENCY IN Mc/s
LOCAL TIME
SUNRISE
SUNSET
SUMMER
WINTER

Fig. 6.

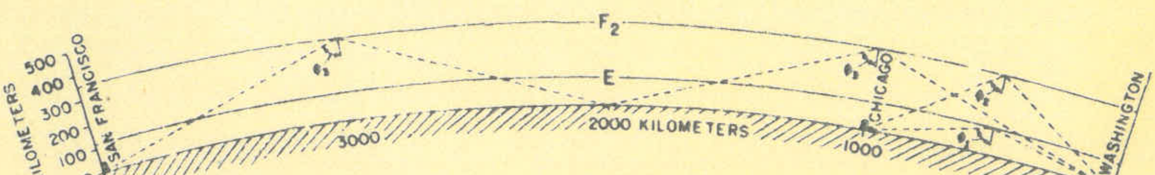

F_2
E
KILOMETERS
SAN FRANCISCO
CHICAGO
WASHINGTON
2000 KILOMETERS
3000
1000
4000
0
Earth

FIG. 8