Microwave

หนังสืออ้างอิงสำหรับเขียนทฤษฎีและเพื่อค้นคว้าทั่วไป

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MARK II ED-SET DESCRIPTION AND ASSEMBLY INSTRUCTIONS

The previous pages illustrate the various component parts which comprise the Mark II ED-SET. As you unpack the ED-SET, compare each part with the corresponding illustration and identify it by name.

A - The Goniometer

1. Place the Goniometer Base on a flat, smooth work surface.
2. Mount the four Goniometer Arms on the center bushing of the Goniometer Base in any sequence, at approximately right angles to each other.
3. Place the Goniometer Protractor Scale on the Base bushing over the Arms, and then engage the pin protruding from the underside of the Scale in the mating hole of the Arm to your left. This fixes the Protractor Scale to 0 degrees relative to the Arm to which it is pinned.
4. Place the Goniometer Rotary Platform on the bushing, over the Protractor Scale.
5. Place the Rotary Platform Accessory Holder on the Rotary Platform engaging the pins in the mating holes.

B - The Transmitter

1. The knob on the Transmitter is a combination on-off switch and voltage control for the repeller plate of the Klystron. This is referred to as the "Repeller Tuning Knob." It is used to vary the repeller voltage to obtain maximum power output from the Klystron.

   The transmitter has been modified to incorporate an electronically tunable klystron so that repeated tuning of the klystron from one extreme to the other will not have any appreciable effect on the life of the tube.
2. The underside of the case is fitted with a standard $1/4 \times 20$ tripod thread.

C - The Receiver

1. The large knob varies the gain of the Receiver and is called the "Gain Control."

   The receiver has a jack to permit the use of an audio amplifier, or a public address system so that the received microwave signals may be heard, if so desired. The jack will also allow the use of an external meter, or oscilloscope.

   Cat. No. 2641C Amplifier is recommended for use with the receiver.

2. The small knob is a part of the crystal detector assembly and should not be used except for crystal replacement or when specifically stated in the Manual.

3. The meter on the receiver is a microammeter with full-scale deflection of 20 microamperes. All readings, unless otherwise specified will be taken on the upper or "main" scale which is calibrated from 0 to 100. To avoid burnout or other damage, keep the Receiver Gain control set so that the deflection does not exceed 100 and preferably remains in the 85 to 95 range, unless otherwise indicated in the instructions.

4. The small plastic screw on the lower face of the meter can be used, if necessary, to zero adjust the meter.

5. The underside of the case is fitted with a standard 1/4 × 20 tripod thread.

D - Recommended Setup

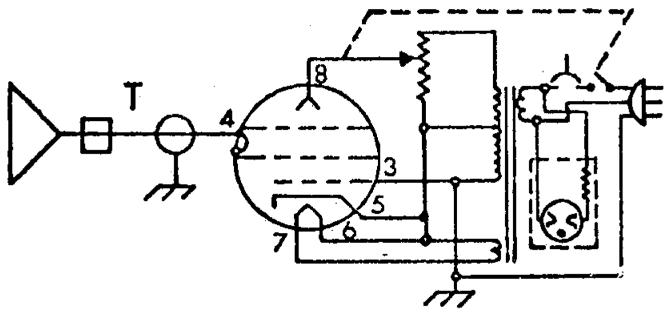
1. It will be found most convenient to place the Transmitter on the Arm to the left of the user in most experiments. This arrangement permits the Receiver to be placed on the right Arm thus providing maximum visibility of the Receiver meter. The Receiver and Transmitter are placed with the horns facing each other.

2. Place the four Arms at 90 degrees to each other, with the Transmitter and Receiver as described above. Note that each Arm is equipped with two different centimeter scales; one scale starts at zero centimeters and indicates the distance from the axis of rotation to the aperture plane of either Horn when attached to the Transmitter or Receiver. The other scale starts at 15 centimeters and indicates the distance from the axis of rotation to any accessory mounted in the Sliding Accessory Holder. A red arrow on the lower part of the Horn side of the Transmitter and Receiver, and a black arrow on the flat surface of the Sliding Accessory Holder indicate which scale is to be used.

E - The Accessories

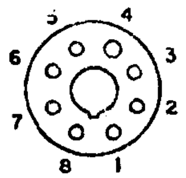
1. The Positioning Attachments can be installed as follows:
   a. Loosen the locking screw by turning the wing nut counterclockwise.
   b. Turn the large knurled knob on the Positioning Attachment until the long lead screw is approximately centered in the U-shaped frame.
   c. Place the Transmitter, Receiver, or Sliding Accessory Holder on one of The Arms in the position defined in the particular experiment.
   d. Place the Positioning Attachment on the Arm so that the part to be positioned is between the Positioning Attachment and the Goniometer axis of rotation. The large knurled knob on the Positioning Attachment is furthest from the Goniometer axis of rotation.
   e. Engage the small round foot on the end of the Positioning Attachment lead screw in the shoe of the Sliding Accessory Holder, Transmitter, or Receiver, as the case may be.
   f. Lock the Positioning Attachment to the Radially-Rotatable Arm by turning the wing nut clockwise until it is moderately tight.
   g. Turn the large knurled knob through exactly 360 degrees and you will note that the movement will be exactly 0.1 centimeter (1 millimeter), or one minor division on the Arm scale. There are 100 grooves on the knob and therefore rotating the knob one groove will move the attached part 0.1 millimeters. In this way, by counting fractions of a turn, positions on the Arm can be very accurately determined when necessary. Effects of backlash must be eliminated by taking out any existing play between parts before counting the turns of the large knurled knob.

2. The Full Reflector, the Half Reflector, the Single Slit Plate, and Double Slit Plate, and the Polarization Grid each have a small hole above their straight edge, which edge is to be placed downward in the Rotary Platform Accessory Holder and the Sliding Accessory Holder. This hole is to be centered in the "V" notch of the Accessory Holder and will ensure centering of the Accessory.

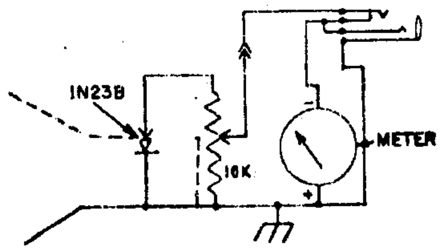


TRANSMITTER SCHEMATIC

Figure 1



SOCKET-TOP VIEW



RECEIVER SCHEMATIC

Figure 2

VOLTAGES BETWEEN	VOLTAGE AC
7 and 6	6.3
3 and 5	350
3 and 8	350 - 550

Figure 3

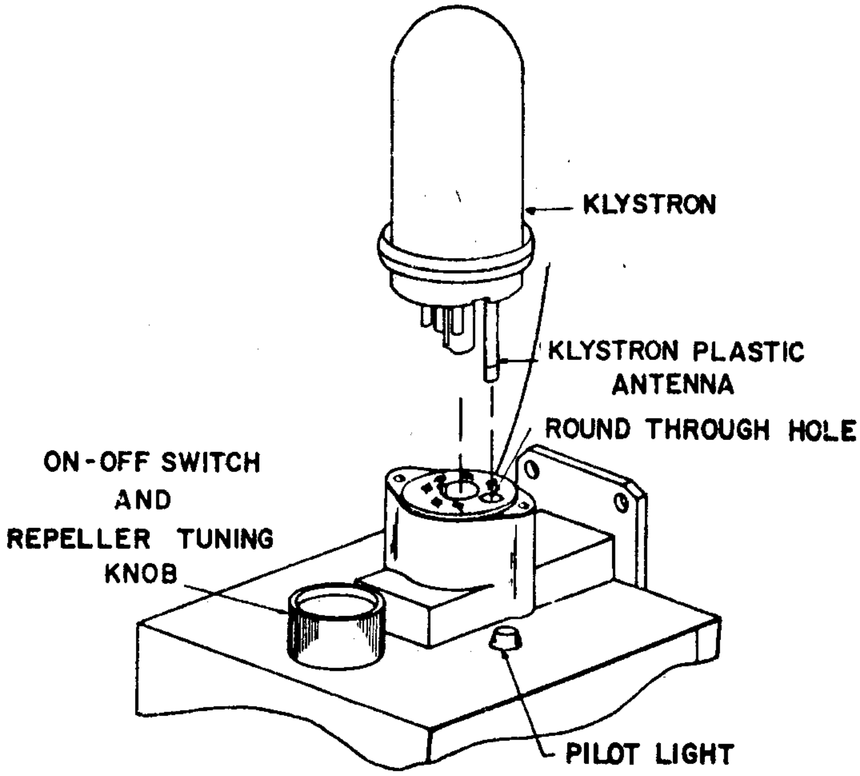
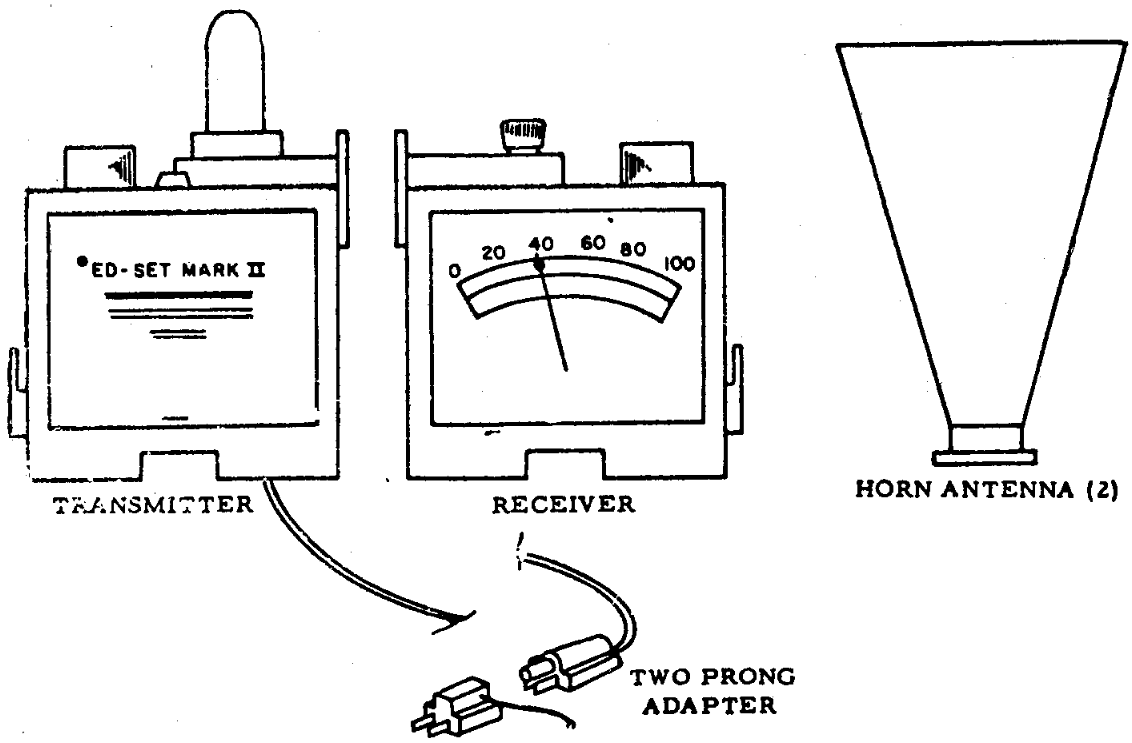
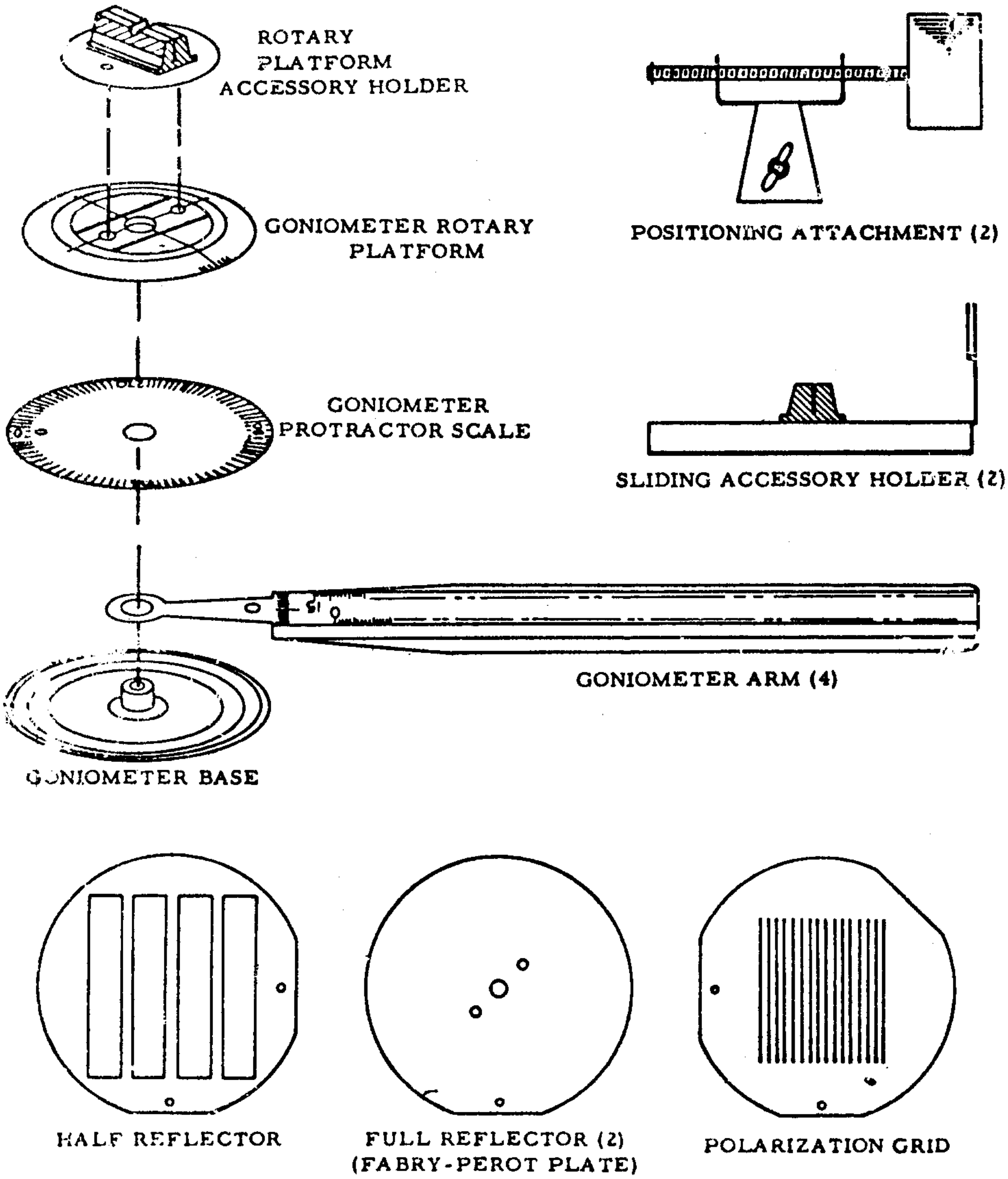
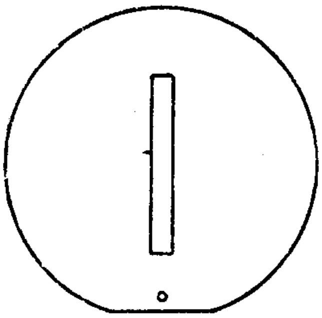

KLYSTRON
KLYSTRON PLASTIC ANTENNA
ROUND THROUGH HOLE
ON-OFF SWITCH AND REPELLER TUNING KNOB
PILOT LIGHT

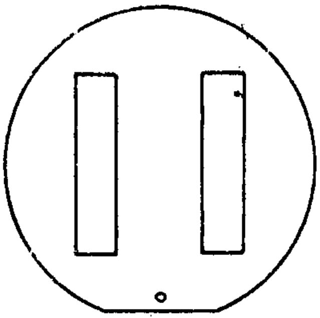
Figure 4


ED-SET MARK II
0
20
40
60
80
100
TRANSMITTER
RECEIVER
HORN ANTENNA (2)
TWO PRONG ADAPTER


ROTARY
PLATFORM
ACCESSORY HOLDER
POSITIONING ATTACHMENT (2)
GONIOMETER ROTARY
PLATFORM
GONIOMETER
PROTRACTOR SCALE
SLIDING ACCESSORY HOLDER (2)
GONIOMETER ARM (4)
GONIOMETER BASE
HALF REFLECTOR
FULL REFLECTOR (2)
(FABRY-PEROT PLATE)
POLARIZATION GRID

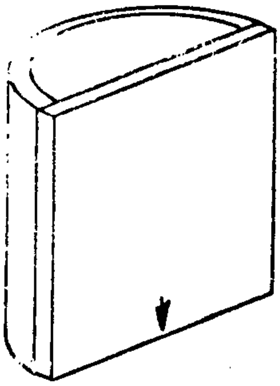


SINGLE SLIT PLATE



DOUBLE SLIT PLATE

PROBE



REFRACTION TANK

SCREW (8)

PLASTIC BAG (2)

POLYETHYLENE BEADS (2)

INITIAL TURN-ON INSTRUCTIONS

1. Assemble the equipment as described in Mark II ED-SET Description and Assembly Instructions.

2. Arrange the ED-SET as shown in Figure 5.

3. Plug the Transmitter into a 115 volt, 50-60 cycle A.C. outlet which is not subject to sudden variations in line voltage. Use the Two Prong Adapter if necessary. **CAUTION: The Transmitter can be severely damaged by connecting to an improper power source.** Set the Gain Control of the Receiver at 3 on its scale. Turn on the Transmitter by rotating the Repeller Tuning Knob in a clockwise direction. The red pilot lamp will light, indicating that power is "ON." Wait at least two minutes to permit the Klystron to warm up and stabilize.

   A circuit breaker in the primary of the transformer will open if an overload occurs. Wait several minutes for the circuit breaker to cool and then push in the red reset button on the rear of the transmitter unit. If it quickly reopens, the cause is probably a defective klystron and a replacement klystron should be tried.

4. **Very slowly** adjust the Repeller Tuning Knob to obtain maximum power on the Receiver meter. Do this very carefully and note the Repeller Tuning Knob setting for each peak reading on the Receiver meter. After each peak has been explored, return the Repeller Tuning Knob to the setting which gave the highest reading. This tuning must be done very carefully and should be rechecked for **minor** adjustment before each experiment. The ED-SET is now in operating condition.

5. During all experiments, avoid placing your hand or any other object within the field while making measurements. Failure to do so will cause inaccurate meter readings.

6. The meter on the Receiver has been heavily damped for the purpose of reducing the effects of variation in input line voltage. It is therefore recommended that, when seeking a peak reading by moving either the Transmitter, Receiver, Rotary Platform, or the Sliding Accessory Holder, all changes in the position of these components be made **very slowly.**

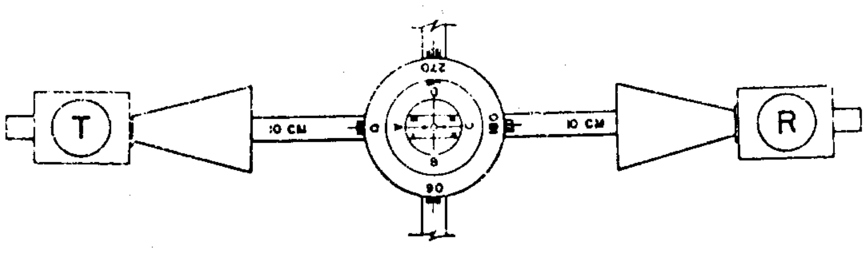


Figure 5

Experiment 1

ABSORPTION, MEASUREMENT OF

1. Place the ED-SET in operating condition. Remove the Rotary Platform Accessory Holder.
2. Arrange the ED-SET as shown in Figure 6.
3. Adjust the Gain Control of the Receiver to obtain a reading of 100. Place on the Rotary Platform an absorber such as a text book, with the cover which faces the Receiver on line AC, with the plane of the absorber vertical to the direction of transmission. Record the Receiver reading.
4. Measure the reflection from the absorber by rotating the Receiver to the 90 degree position. Record the Receiver reading. The original power level minus the total of the attenuated and reflected power is the absorbed power.
5. Try various other absorbers such as wood, plaster board, cellulose sponge, and glass plate.

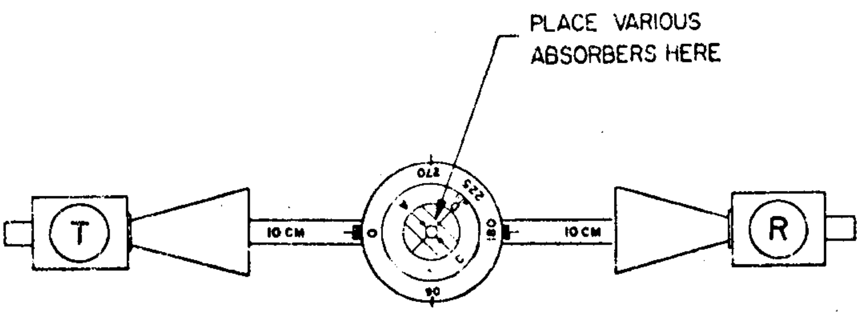


Figure 6

Experiment 2

POLARIZATION, MEASUREMENT OF

1. Place the ED-SET in operating condition.
2. Arrange the ED-SET as shown in Figure 7.
3. Place the Polarization Grid in the Rotary Platform Accessory Holder with the grids in a horizontal position and note the Receiver reading.

4. Repeat step 3 except rotate the Polarization Grid so that the grids are 45 degrees from the horizontal by placing appropriate straight edge of the Polarization Grid in the Rotary Platform Accessory Holder. Note the Receiver reading.

5. Repeat step 3 except with the grids in a vertical position. Note the Receiver reading.

6. The ED-SET 3 centimeter microwaves are vertically polarized, similar to polarized light. You will note that the transmission decreases as rotation of the Polarization Grid increases form horizontal to vertical.

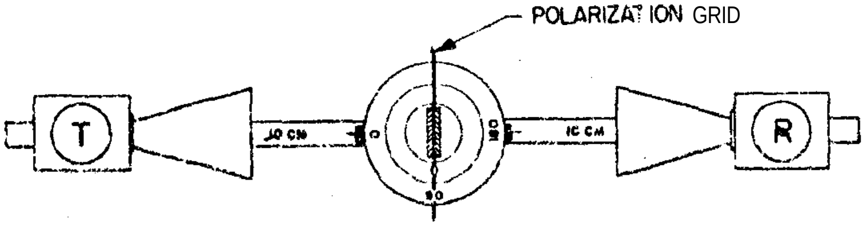


Figure 7

Experiment 3

LAW OF REFLECTION, VERIFICATION OF

1. Place the ED-SET in operating condition

2. Arrange the ED-SET as shown in Figure 8.

3. Slowly rotate the Rotary Platform until a peak reading is obtained on the Receiver. Is the angle of incidence equal to the angle of reflection as stated in the Law of Reflection? Repeat the experiment using different angles.

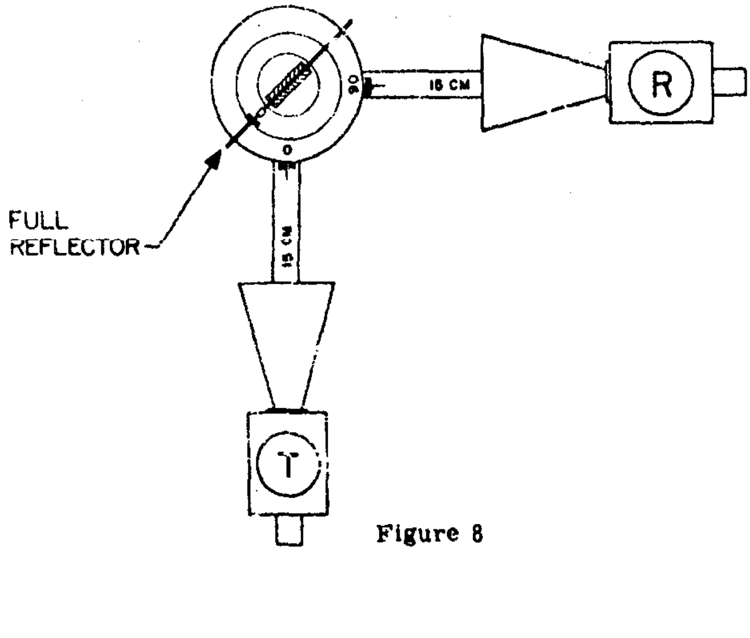


Figure 8

Experiment 4

STANDING WAVES, MEASUREMENT OF

1. Place the ED-SET in operating condition.

2. Arrange the ED-SET as shown in Figure 9.

3. This arrangement will create a standing-wave pattern between the Transmitter and the Full Reflector. A portion of the wave pattern is picked up by the Probe Plate and reflected to the Receiver.

4. As the Full Reflector is moved by the Positioning Attachment, the maxima and minima can be observed on the Receiver. At the first maximum, adjust the Gain Control to obtain a maximum reading. Record the reading and the position on the 180 degree Arm.

5. Using the Positioning Attachment, move the Full Reflector away from the axis and record the Receiver reading at each position one millimeter (one full turn of the knob of the Positioning Attachment) away from the previous position. Repeat until 20 readings and positions have been recorded.

6. Sufficient data is now available to plot a graph of the standing wave in terms of Reflector position and Receiver readings.

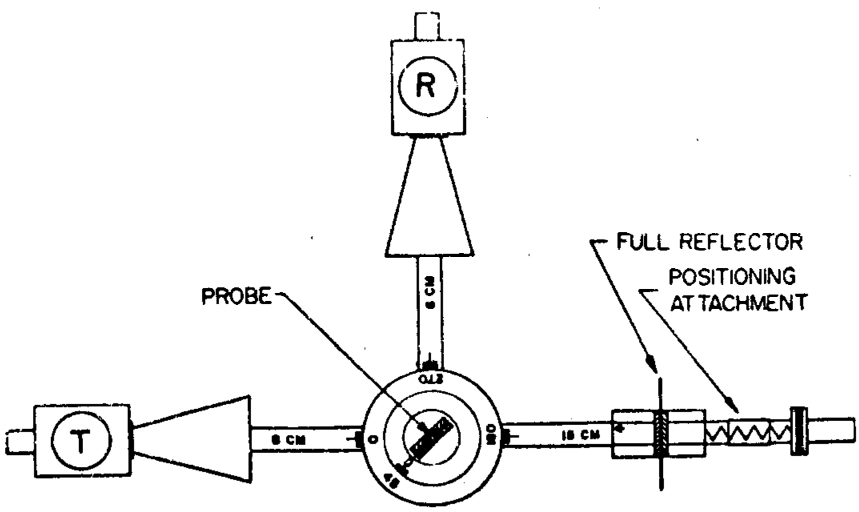


Figure 9

Experiment 5

MICHELSON'S INTERFEROMETER, USE OF IN MEASURING WAVELENGTH

1. Place the ED-SET in operating condition.

2. Arrange the ED-SET as shown in Figure 10.

3. Optimize the setup for sharpest nulls by removing the Full Reflectors from the two Sliding Accessory Holders and slightly changing the positions of the Transmitter and Receiver from their 10-centimeter marks until a maximum reading is obtained. Replace the two Full Reflectors and position the 270 degree Full Reflector for a minimum reading on the meter. Sharpen this null by adjusting the 180 degree Full Reflector. Adjusting the 270 degree Full Reflector will now give deep nulls.

4. The free-space wavelength can now be calculated by measuring the distance traveled by the 270 degree Full Reflector between nulls. This distance is equal to one-half wavelength in free-space. Where λ = free-space wavelength in centimeters, then $\lambda/2$ = distance between nulls in centimeters.

5. With the ED-SET arranged for a null reading as in Step 4, the Index of Refraction of low loss materials (a) in thin sheet form can be measured by placing the sheet in a vertical position between the 270 degree Full Reflector and the Half Reflector. Subject to minor error caused by multiple reflections within the sample, the Index of Refraction can be calculated using the formula:

$$n = 1 + \frac{\Delta}{d}$$

where

n = index of refraction

Δ = Full Reflector movement in centimeters required to restore the original null obtained prior to insertion of material being measured.

d = thickness of sample in centimeters.

Note: (a) Polyethylene, polystyrene, paraffin wax, teflon.

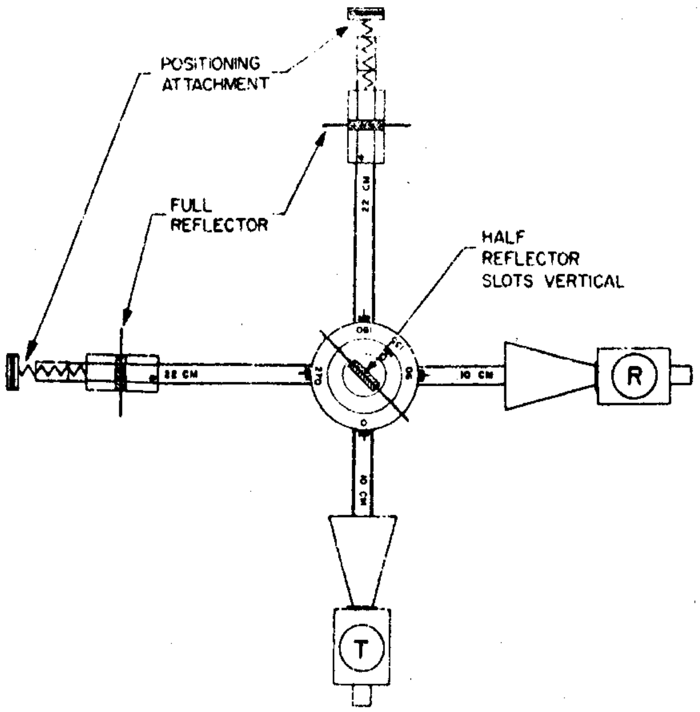


Figure 10

Experiment 6

THIN FILM, MEASUREMENT OF

1. Place the ED-SET in operating condition.
2. Arrange the ED-SET as shown in Figure 11.
3. Using the Positioning Attachment, move the Full Reflector away from the axis to produce sharp nulls and peaks in the Receiver readings. By noting the distance between the Full Reflector and the Half Reflector at null points, it will be observed that nulls occur when the distance between the Full Reflector and the Half Reflector are multiples of one half wavelength (approximately 1.5 centimeters). Similarly, peaks occur when separation distances are multiples of one-quarter wavelength.
4. This is analogous to optical thin-film interference effects which produce dark and light bands in the reflected light of a single color. In this case the spacing between the Half Reflector and the Full Reflector is comparable to the thickness of the thin film.

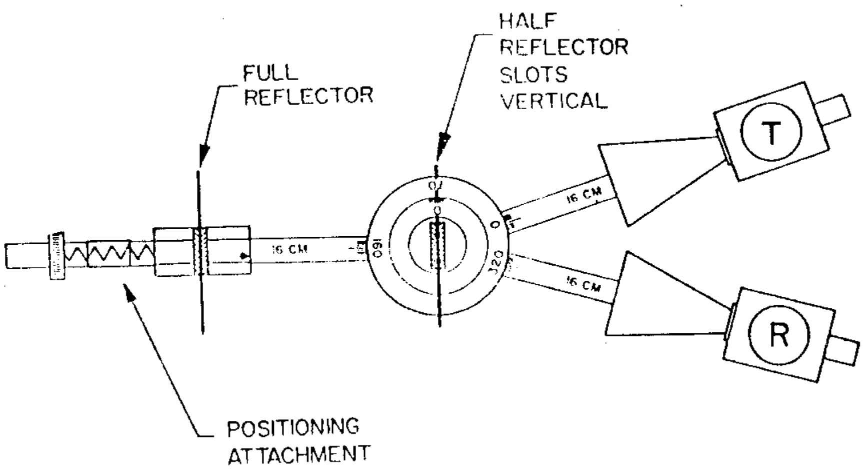


Figure 11

Experiment 7

THIN FILM INTERFERENCE, AS APPLIED TO COATED OPTICS

1. Place the ED-SET in operating condition.

2. Arrange the ED-SET as shown in Figure 12.

3. Using the Positioning Attachment, withdraw the Polarization Grid from the axis until a minimum reading is obtained on the Receiver. Note the Receiver reading and the position of the Polarization Grid on the Arm. We have measured the intensity of a wave which has been reflected by a medium which both transmits and reflects, and to which a means of reducing the reflectivity of the medium has been interposed between the Transmitter and the medium.

4. Remove the Half Reflector and note the Receiver reading. We have measured the intensity of a wave which has been reflected by a medium which both transmits and reflects.

5. Rotate the 0 degree Arm counterclockwise until the 180 degree marking is opposite the Transmitter. Remove the Positioning Attachment from the 0 degree Arm without disturbing the position of the Polarization Grid. Place the Receiver on the 0 degree Arm with its Horn lightly touching the Polarization Grid. Note the Receiver reading. We have measured the intensity of a wave which has passed through a medium which both transmits and reflects.

6. Place the Half Reflector with its Slots in a Horizontal Position in the Rotary Platform Accessory Holder, and D scale of which should be on 90 degrees. Note the Receiver reading. We have measured the intensity of a wave which has passed through a medium which both transmits and reflects, and to which a means of reducing the reflectivity of the medium has been interposed between the transmitter and the medium.

7. We have created in microwave frequencies and analogy to the principle employed in optics of increasing the transmission efficienty of a lens by coating it with the proper thin flim to reduce its reflectivity.

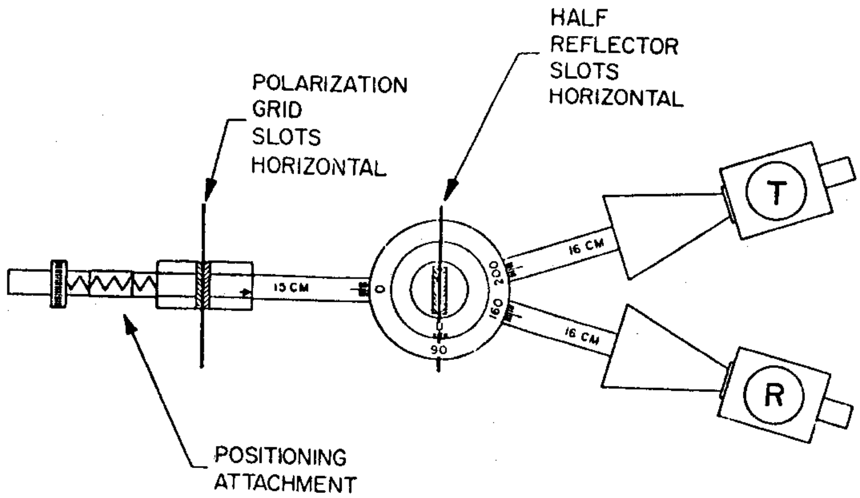


Figure 12

Experiment 8

SINGLE SLIT DIFFRACTION, USE OF IN VERIFYING THEORY OF SPHERICAL WAVELETS

1. Place the ED-SET in operating condition.

2. Arrange the ED-SET as shown in Figure 13.

3. Rotate the Receiver about the axis of rotation ±90 degrees from the 180 degree position. Record the Receiver reading every 5 degrees (37 readings). Plot this data on polar or rectangular coordinate paper. This will show the aximuth pattern obtained from the Single Slit Plate.

4. It will be noted that the radiation pattern of the Single Slit Plate confirms the Theory of Spherical Wavelets.

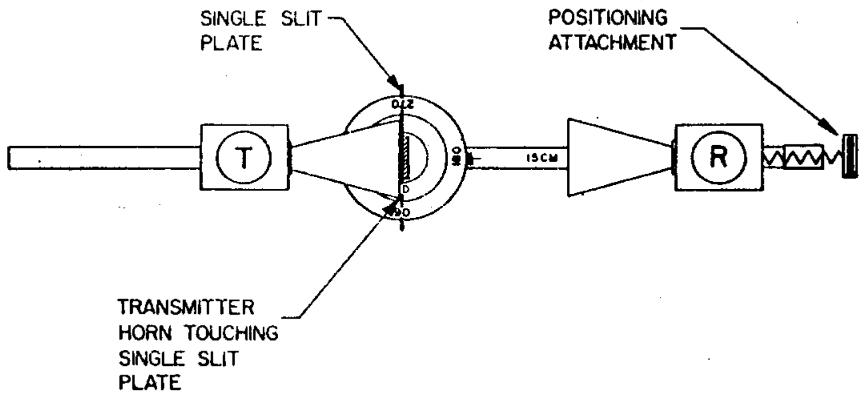


Figure 13

Experiment 9

DOUBLE SLIT INTERFERENCE, PLOTTING PATTERNS OF

1. Place the ED-SET in operating condition.

2. Arrange the ED-SET as shown in Figure 14.

3. Follow the procedure described in Experiment 8. Plot the data obtained on polar or rectangular coordinate paper. Distinct maxima and minima will be observed on each side of the central position, resulting from the cancellation and reinforcement at points where the spherical waves being transmitted from each of the two slits intersect.

4. Measure in centimeters the spacing between centerlines of the slits and the aperture of each slit. Calculate the theoretical position of the maxima and minima and compare with the observed results.

5. Move the Receiver to a somewhat greater distance from the Double-Slit Plate and repeat Steps 3 and 4.

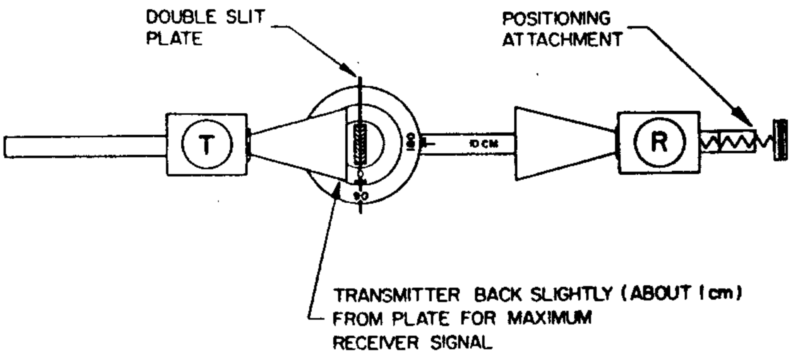


Figure 14

Experiment 10

DIFFRACTION GRATING, USE OF IN MEASURING WAVELENGTH

1. Place the ED-SET in operating condition.

2. Arrange the ED-SET as shown in Figure 15.

3. Move the Receiver clockwise about the axis of rotation until first a minimum and then the maximum reading is obtained (approximately 105 degrees). This locates the center of the beam after it is bent by the diffraction grating. Calculate from this the angle of incidence and the angle of diffraction. See Figure 16. In Experiment 8 we observed the behavior of a single slit at microwave frequencies, and in Experiment 9 the vehavior of two slits. In this experiment we observe a wave diffracted by multiple slit sources.

4. A Diffraction Grating is formed by a series of very fine, closing spaced, parallel slits which, when light is incident upon it at a definite angle, produces a succession of interferences and maximums (spectra). The action of a plane transmission grating may be explained approximately as follows: A plane, monochromatic wave W, incident at angle i (see Figure 16), reaches the slits at different times. The Horn receives the waves emerging from any two adjacent slits, A and B (among many others), after they have traveled paths differing by CA + AD; that is, by S sin i + S sin d, in which S = AB. If the Horn is so placed that this path difference is a whole number of wavelengths, $n\lambda$, the successive wave-trains will reach it in the same phase, they will be in synchronism and will produce a maximum reading. Therefore, any angle d for which this result is possible is subject to the condition:

$$S \sin i + S \sin d = n \lambda ,$$

or

$$\sin d = \frac{n \lambda}{S} - \sin i.$$

The spacing between slits S is 2.7 cm. for the Half Reflector Plate and the letter n denotes the order of the maximums (or images), which in this case is 1. Calculate the wavelength, λ .

5. Repeat Paragraph 4 for other angles of incidence. (Use between 30 and 50 degrees for best results).

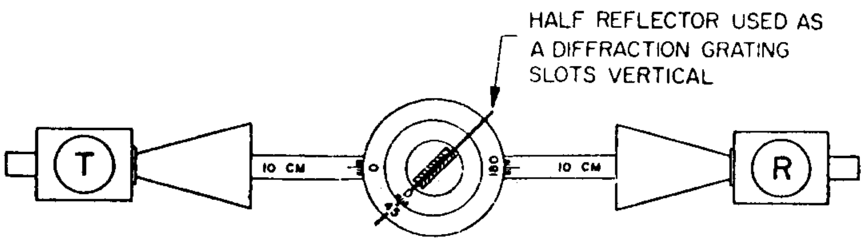


Figure 15

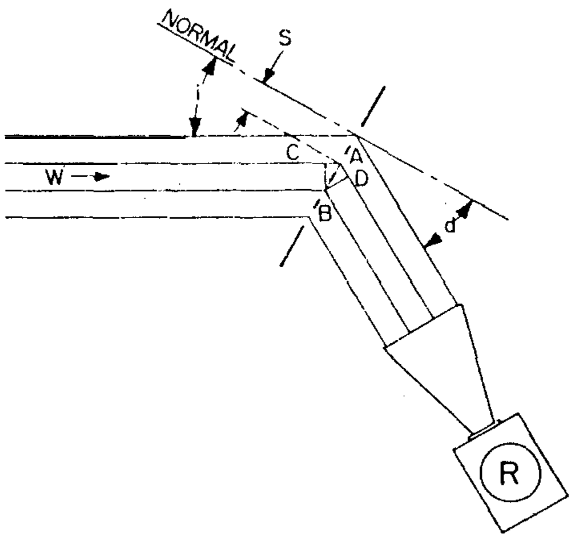


Figure 16

Experiment 11

TWO REMOTE SOURCES INTERFERENCE, PLOTTING A GRAPH OF

1. Place the ED-SET in operating condition.
2. Arrange the ED-SET as shown in Figure 17.
3. Using the Positioning Attachment, slowly move the Full Reflector away from the axis of rotation until the Receiver indicates the first minimum.
4. Record the position of the Full Reflector and the reading on the Receiver.
5. Using the Positioning Attachment, move the Full Reflector away from the axis of rotation until the Receiver indicates the first maximum. Repeat step 4.
6. Continue as in steps 3 and 4 above until all maxima and minima have been obtained and recorded.
7. Plot a graph of the Receiver readings against the Full Reflector positions. This graph is a representation of the interference pattern resulting from the coincidence of the two waves reaching the Receiver, one from the Probe, and other from the Full Reflector.

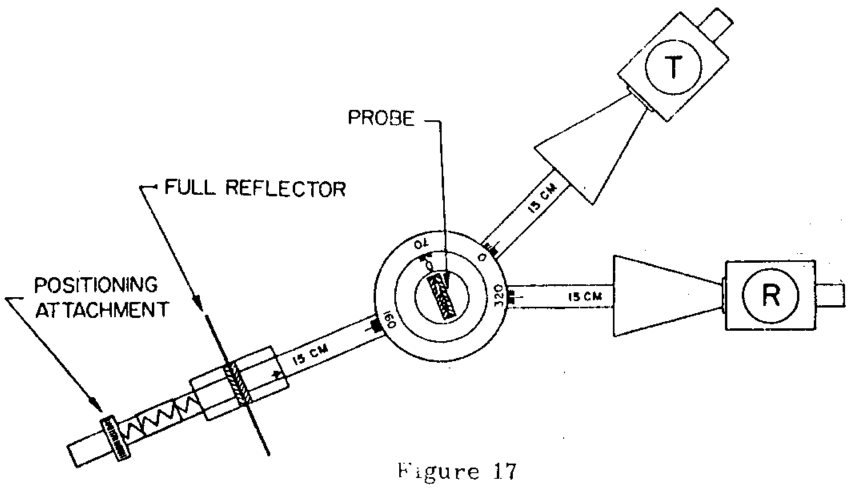


Figure 17

Experiment 12

INDEX OF REFRACTION, MEASUREMENT OF

1. Place the ED-SET in operating condition. Remove the Rotary Platform Accessory Holder.
2. Arrange the ED-SET as shown in Figure 18.
3. Remove and fill the Refraction Tank with the materials to be measured, (sawdust, dry sand, sugar, polyethylene beads, household wax, etc.) using the plastic bag provided to facilitate handling.
4. Position the Refraction Tank on the Rotary Platform so that its bottom straight edge is aligned with line III-IIII and its indicating arrow is aligned with line B-D.
5. Rotate the Receiver Arm until a peak Receiver reading is obtained.
6. Carefully remove the Refraction Tank and read the angles of incidence and refraction. See Figure 19.
7. Calculate the Index of Refraction $\frac{\sin i}{\sin r}$ for the materials used.
8. Repeat the experiment using an angle of incidence of 60 degrees.
9. See Experiment 5, Paragraph 5, for use of Michelson's Interferometer for measurement of Index of Refraction of materials in sheet form.

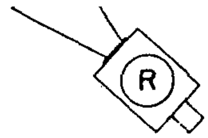


Figure 18

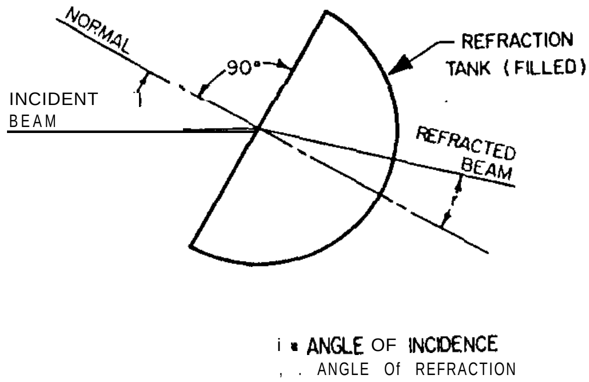


Figure 19

Experiment 13

FIBRE OPTICS, PRINCIPLE OF

1. Place the ED-SET in operating condition. Remove the Rotary Platform Accessory Holder.
2. Arrange the ED-SET as shown in Figure 20. Remove the Horns. See Exp. 14.
3. Note the Receiver Reading.
4. Fill the Cylindrical Plastic Bag with Polyethylene Beads and close the end with a rubber band.
5. Holding the Cylindrical Bag from above, place it so that its ends are touching the wave-guide mouth openings of the Transmitter and Receiver.
6. Note the Receiver Reading.

7. Rotate the Transmitter Arm so it is in the 240 degree position.

8. Note the Receiver Reading.

9. Repeat step 5.

10. Note the Receiver Reading.

11. We have now demonstrated the Principle of Fibre Optics. Theory states that efficient transmission will be obtained when the diameter of the dielectric fibre is a minimum of one wavelength. The diameter of the filled Cylindrical Plastic Bag is approximately one and one-half wavelengths.

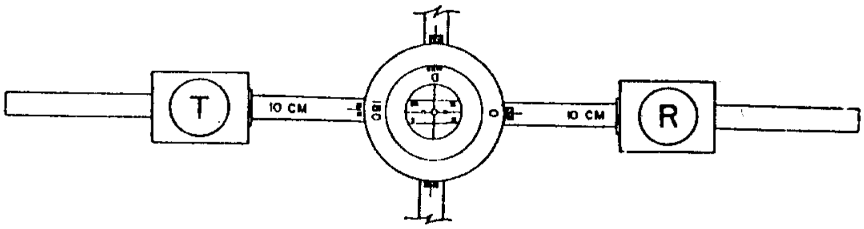


Figure 20

Experiment 14

FABRY-PEROT INTERFEROMETER, USE OF IN MEASURING WAVELENGTH

1. Place the ED-SET in operating condition.

2. Carefully remove the Horns from the Transmitter and Receiver. **CAUTION**: Be careful not to drop, bend or damage the Horns in any way. Such damage will adversely effect the results obtained in experiments from then on.

3. You will note that each Full Reflector has three holes in it. The center hole of each Plate will serve as a transmitting and receiving aperture. These Reflectors, which also serve as Fabry-Perot Plates, are to be attached to the Transmitter and the Receiver in place of the Horns. Using the screws, attach the Fabry-Perot Plates to the waveguide flanges, with the flat edge of each Plate up.

4. Arrange the ED-SET as shown in Figure 21.

5. Extremely slowly and with great care, use the Positioning Attachment to move the Receiver away from the Transmitter. **The Positioning Attachment must be manipulated with maximum care.** When a very sharp resonance is observed, the distance between the Fabry-Perot Plates will be equal to $\lambda/2$.

ชื่อ นามสกุล รหัส

กระดาษบันทึกผลการทดลอง

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ชื่อ นามสกุล รหัส

กระดาษบันทึกผลการทดลอง

ชื่อ　　　　　　　　　　นามสกุล　　　　　　　　　　รหัส

กระดาษบันทึกผลการทดลอง

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