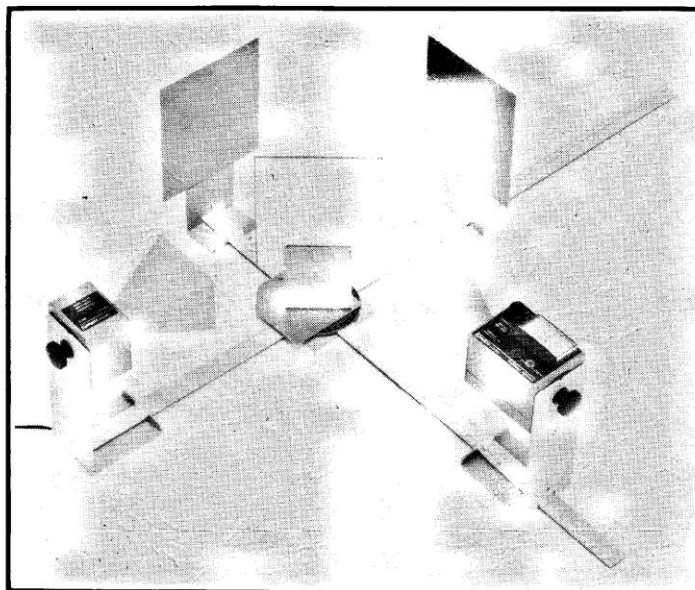


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**Instruction and
Experiments Manual
for the PASCO
Model WA-9314A
MICROWAVE OPTICS**



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PASCO scientific

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INTRODUCTION

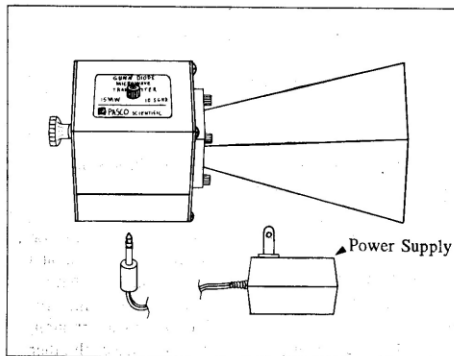
There are many advantages to studying optical phenomena at microwave frequencies. Using a three centimeter microwave wavelength transforms the scale of the experiment. Microns become centimeters and variables that are obscured by the small scale of traditional optics experiments are easily seen and manipulated. The PASCO scientific Microwave Optics System is designed to take full advantage of these educational benefits. The Microwave Optics System comes with a three centimeter wavelength microwave transmitter, a receiver with variable amplification (from 1X to 30X), and all the accessory equipment needed to investigate a variety of wave phenomena.

This manual describes the operation and maintenance of the microwave equipment and also gives detailed instructions for many experiments. These experiments range from quantitative investigations of reflection and refraction to microwave models of the Michelson and Fabry-Perot interferometers. For those with the Complete Microwave Optics System (WA-9316) or for those who have the Microwave Accessory Package (WA-9315), experiments are also described for investigating Bragg diffraction and Brewster's angle.

EQUIPMENT

Gunn Diode Transmitter

The Gunn diode Microwave Transmitter provides 15 mW of coherent, linearly polarized microwave output at a wavelength of 2.9 cm. The unit consists of a Gunn diode in a 10.5 GHz resonant cavity, a microwave horn to direct the output, and an 18 cm stand to help reduce table top



Microwave Transmitter

reflections. A power supply is provided, so the Transmitter may be powered directly from a standard 120 VAC outlet. Other features include an LED power indicator light and a rotational scale that allows easy measurement of the angle of polarization.

The Gunn diode acts as a non-linear resistor that oscillates in the microwave band. The output is linearly polarized along the axis of the diode and the attached horn radiates a strong beam of microwave radiation centered along the axis of the horn.

To operate the Microwave Transmitter simply plug the power supply into the jack on the bottom panel of the Transmitter and plug the power supply into a standard 120 VAC outlet. The LED will light, indicating the unit is on.

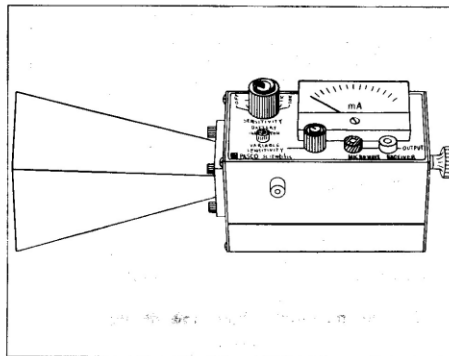
CAUTION: The output power of the Microwave Transmitter is well within standard safety levels. Nevertheless, one should never look directly into the microwave horn at close range when the Transmitter is on.

Power Supply Specifications:

9 Volt DC, 200 mA;
Miniature Phone Jack Connector (the tip is positive)

Microwave Receiver

The Microwave Receiver provides a meter reading that, for low amplitude signals, is approximately proportional to the intensity of the incident microwave signal. A microwave horn identical to that of the Transmitter



Microwave Receiver

collects the microwave signal and channels it to a diode in a 10.5 GHz resonant cavity. The diode responds only to the component of a microwave signal that is polarized along the diode axis, producing a dc voltage that varies with the magnitude of the microwave signal.

Special features of the Receiver include four amplification ranges—from one to thirty—with a variable sensitivity knob that allows fine tuning of the amplification in each range. For convenience in class demonstrations, an output signal is provided at banana plug connectors for hookup to a projection meter. This output can also be used for close examination of the signal using an oscilloscope. The receiver is battery powered and has an LED battery indicator; if the LED lights when you turn on the Receiver, the battery is ok. As with the Transmitter, an 18 cm high mount minimizes table top reflections, and a rotational scale allows convenient measurements of polarization angle.

The connector on the side of the Receiver is for an optional Microwave Detector Probe (Model 003-02835). The probe works the same as the Receiver except it has no horn or resonant cavity. The Probe is particularly convenient for examining wave patterns in which the horn could get in the way, such as the standing wave pattern described in Experiment 3 of this manual.

NOTE: The detector diode in the Receiver (and the Probe) are non-linear devices. This non-linearity will provide no problem in most experiments, but it is important to realize that the meter reading is directly proportional to neither the electric field (E) nor the intensity (I) of the incident microwave, but generally reflects some intermediate value.

To Operate The Microwave Receiver:

NOTE: Before using the Receiver, you will need to install the two 9-volt transistor batteries—they are included with the system. See the instructions in the Maintenance section at the end of this manual.

1. Turn the INTENSITY selection switch from OFF to 30X, the lowest amplification level. The battery indicator LED should light, indicating that the battery is ok. If it does not, replace the battery following the procedures in the Maintenance section of this manual.
2. Point the microwave horn toward the incident microwave signal. Unless polarization effects are under investigation, adjust the polarization angles of the Transmitter and Receiver to the same orientation (e.g.; both horns vertical, or both horns horizontal).

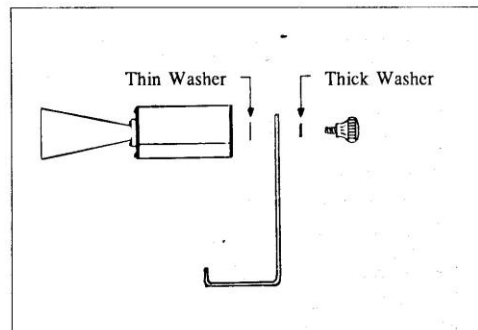
NOTE: The INTENSITY selection settings (30X, 10X, 3X, 1X) are the values you must multiply the meter reading by to normalize your measurements. That is, 30X means that you must multiply the meter reading by 30 to get the same value you would get if you measured the same signal with the INTENSITY selection set to 1X. Of course, this is true only if you do not change the position of the VARIABLE SENSITIVITY knob between measurements.

3. Adjust the VARIABLE SENSITIVITY knob to attain a meter reading near midscale. If no deflection of the meter occurs, increase the amplification by turning the INTENSITY selection switch clockwise. Remember, always multiply your meter reading by the INTENSITY selection at which the reading was made (30 X, 10X, 3X, or 1X) if you want to quantitatively compare measurements taken at different INTENSITY settings.

Initial Setup

The microwave Transmitter and Receiver should be attached to their respective stands prior to performing experiments. Proceed as follows:

1. Remove the black hand screw from the back panel of both the Transmitter and the Receiver.
2. Attach both units to the stands as shown below. Observe the location of the washers.

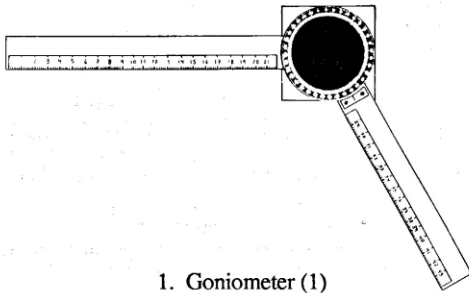


Attaching the Transmitter and Receiver Stands

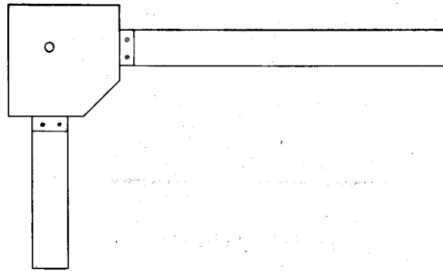
3. To adjust the polarization angle of the Transmitter or Receiver, loosen the hand screw, rotate the unit, and tighten the hand screw at the desired orientation. Notice the rotational scale on the back of each unit for measuring the angle of polarization. Be aware, though, that since the Transmitter and Receiver face each other in most experiments, if you rotate one unit to an angle of 10-degrees, you must rotate the other to -10-degrees (350-degrees) to match polarization angles.

Accessory Equipment

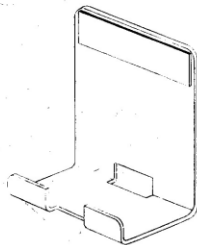
Accessory equipment for the Basic Microwave Optics System includes:



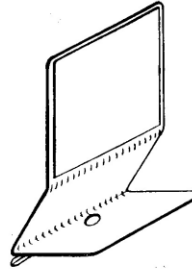
1. Goniometer (1)



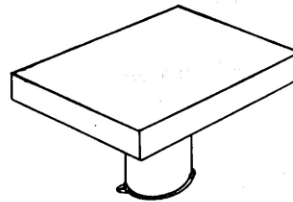
2. Fixed Arm Assembly (1)



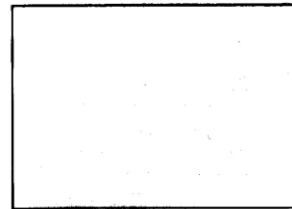
3. Component Holders (2)



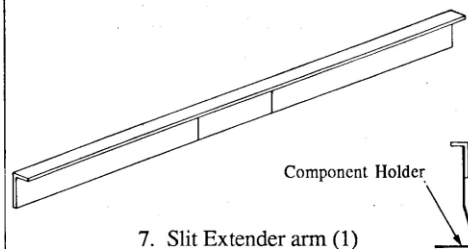
4. Rotating Component Holder (1)



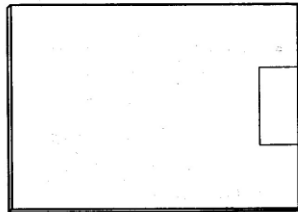
5. Rotating Table (1)



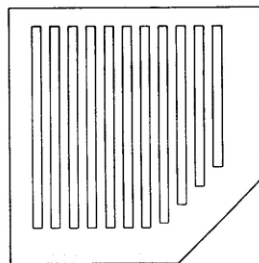
6. Metal Reflectors (2)



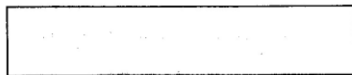
7. Slit Extender arm (1)



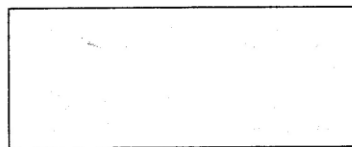
8. Partial Reflectors (2)



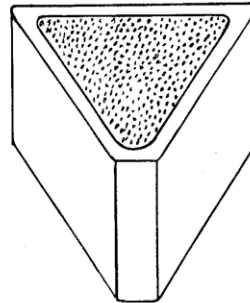
9. Polarizers (2)



10. Narrow Slit Spacer (1)

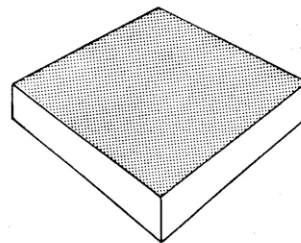


11. Wide Slit Spacer (1)

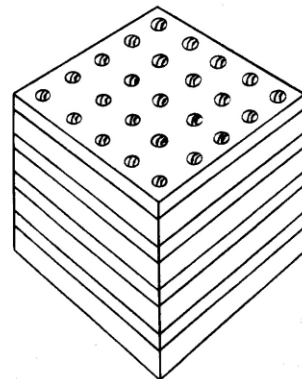


12. Ethafoam Prism Mold w/ Styrene Pellets (1)

The Complete Microwave Optics System (WA-9316) also includes:



13. Polyethylene Panel (1)



14. Cubic Lattice with 100 metal spheres—5x5x5 array (1)

The following components are also available from PASCO scientific:

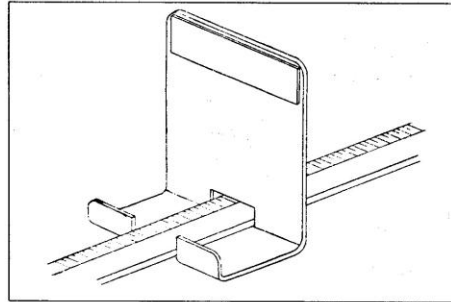
A Microwave Detector Probe (Model 003-02835) that plugs directly into the Microwave Receiver. The probe is essential for experiments in which the horn of the Receiver might otherwise interfere with the wave pattern being measured.

A compatible Microwave Modulation Kit (Model WA-9318), which includes a modulator, microphone, and speaker. With this kit, you can use your Transmitter and Receiver as a microwave communications system.

ASSEMBLING EQUIPMENT FOR EXPERIMENTS

The arms of the Goniometer slide through the holes in the Component Holders as shown below so that the magnetic strip on the bottom of the arm grips the base of the carriage. To adjust the position of the holders, just slide them along the Goniometer arms. Attach the mounting stands of the microwave Transmitter and Receiver to the arms of the Goniometer in the same manner.

For most experiments it is advantageous to attach the Transmitter to the long arm of the Goniometer and the Receiver to the shorter, rotatable arm. This allows a fixed



Mounting the Component Holders on the Goniometer

relationship to be maintained between the microwave beam and components mounted on the long arm (or on the degree plate of the Goniometer), while the Receiver is easily moved to sample the output.

Reflectors, Partial Reflectors, Polarizers, Slit Spacers, and the Slit Extender Arm all attach magnetically to the Component Holders. The metric scale along the Goniometer arms and the degree plate at the junction of the arms allow easy measurement of component placement. When rotating the rotatable arm, hold the degree plate firmly to the table so that it does not move.

IMPORTANT NOTES:

1. *CAUTION—Under some circumstances, microwaves can interfere with electronic medical devices. If you use a pacemaker, or other electronic medical device, check with your doctor or the manufacturer to be certain that low power microwaves at a frequency of 10.5 GHz will not interfere with its operation.*
2. *Always mount the apparatus on a CLEAN, SMOOTH table. Before setting-up the equipment, brush off any material—particularly metal chips—that might have adhered to the magnetic strips on the bottom of the Goniometer arms.*