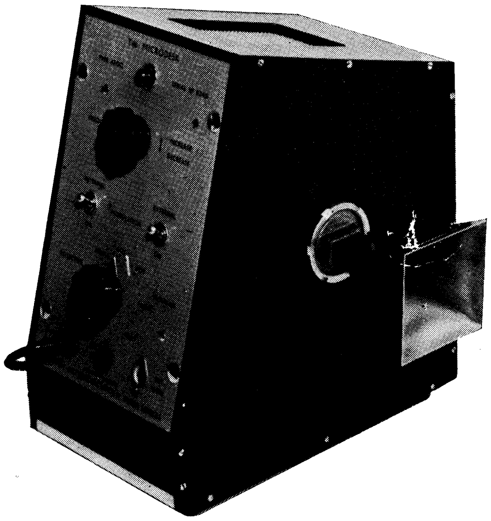
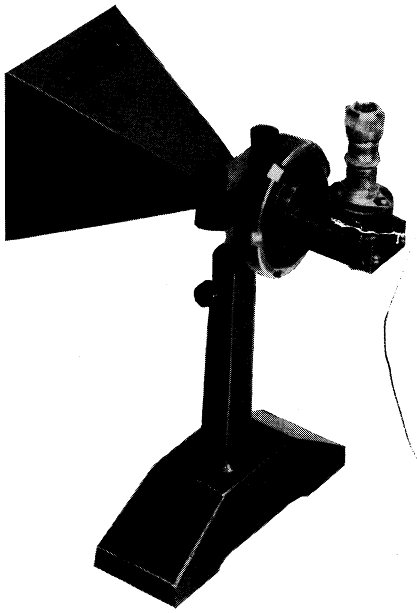
*The introduction of the Student Series offers lecturers an inexpensive Range of Microwave Instruments designed especially for their needs.*



# the STUDENT SERIES



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**MICROWAVE INSTRUMENTS LIMITED**
**North Shields**

# THE STUDENT SERIES

The Student Series of waveguide equipment illustrated in this folder, contains each type of instrument normally met in laboratory microwave measurements in order to demonstrate a wide variety of techniques and applications. A few of many possible optical experiments are described on the back of this folder. These may be performed with some Student Series apparatus together with an Audio Amplifier and Loudspeaker, an Audio Oscillator, and a few additional items which can be manufactured by students, or may readily be available from laboratory workshops. All waveguides are finished clean internally, external surfaces are grey, hammer finish enamel. All flanges are plain circular (RCSE type Z830001) and may be connected to any of our standard research instruments.

### 1. THE MICRODESK TYPE X16.10

A reliable microwave source incorporating three stabilised supplies feeding a KS9-20 klystron which gives approx. 15mW of power via a No. 16 W.G. flange. Frequency range 8.7 to 9.55 Gc/s controlled by a knob on the front panel. Modulation may be applied either externally via a co-axial socket to the Reflector, or internally at 100 c/s (derived from the mains supply) to the Resonator of the Klystron. The Resonator and Heater voltages are fixed and stabilised and the Reflector voltage is varied by the calibrated control on the front panel. A Jack socket allows the klystron current to be checked occasionally. Paper condensers are used throughout to ensure reliability. The unit is housed in a polished black laminate case. Dimensions: Height: 12″ (305 mm), Depth: $10\frac{1}{4}$″ (260 mm), Width: $6\frac{1}{2}$″ (165 mm), Weight: $16\frac{1}{2}$ lbs. (7.5 Kg), Input 190-270V at 50 c/s.

### 2. STANDING WAVE INDICATOR TYPE X16.60

Grade 2, Measures the v.s.w.r. in the waveguide by means of a hand driven carriage and probe mechanism moved along the waveguide. A mm. scale indicates the probe position relative to the output flange. Fixed probe penetration 1 mm. The signal obtained at the probe is transferred by a vertical tuned line to a crystal rectifier housed in the side arm. Length: 7″ (177 mm). Height: 5″ (127 mm). Weight: 1 lb. (454 gm).

### 3. PARABOLOID DIPOLE TYPE X16.140

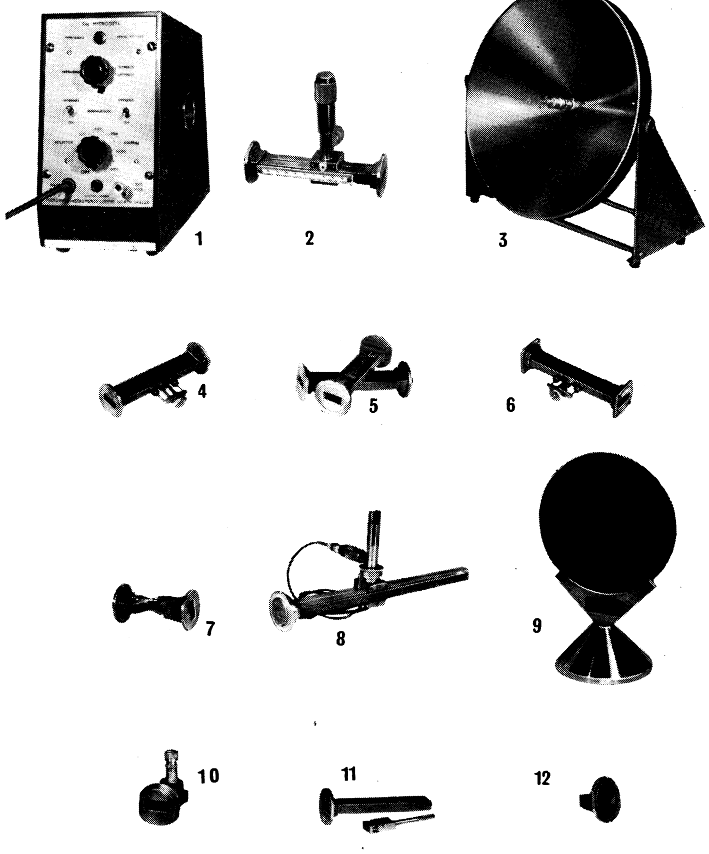
This is a 12″ diameter paraboloid, adjustable in elevation, used for the demonstration of propagation and radiation. Fitted with a 3.2 cm. dipole and co-axial crystal detector. A screened cable enables connection to be made to a suitable indicator. Height: (overall) $13\frac{1}{2}$″ (350 mm). Diameter: 12″ (304 mm). Weight: $2\frac{3}{4}$ lbs. (1.2 kg.).

### 4. LEVEL SET ATTENUATOR X16.20

Used as a means of adjusting the power level in waveguide assemblies, range 0-30 dB, v.s.w.r. better than 0.96. It has a resistive fibre vane moved by an external screw mechanism and is provided with an approximate scale marked 10, 20, 30 dB. Length: 6″ (152 mm). Depth: 3″ (76 mm). Weight: 11 ozs. (315 gm.).

### 5. DIRECTIONAL COUPLER TYPE X16.90

A symetrical 4 terminal assembly available with coupling values of 20, 30, 40 dB. Please specify coupling value as suffix to the type number, thus: X16.90/30 dB. Directivity: 20dB. Design Frequency: 9,375 Mc/s Method of coupling: Single Hole. Length: $5\frac{1}{4}$″ (130 mm). Weight: 1 lb. (454) gm.).




### 6. PHASE SHIFTER TYPE X16.30

This is mechanically similar to Item 4, but has a low loss dielectric vane as the phase shifting element. It is used to alter the electrical length of the waveguide for impedance matching and other purposes. Phase shift 180°. v.s.w.r. better than 0.9.

### 7. 90° TWIST TYPE X16.70

v.s.w.r. better than 0.95. Length flange to flange $3\frac{1}{2}$″ (89 mm). Weight: 8 ozs. (227 gm.).

### 8. TAPER CUT OFF UNIT X16.2800 (Originally type 32/2800)

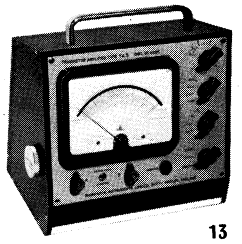
This device is similar in construction to our Standing Wave Indicator X16.60, being provided with the same tuned line. The waveguide internal section tapers from 0.9″ x 0.4″ to 0.4″ x 0.4″ and the slot being $10\frac{1}{4}$″ long enables the probe to traverse into the region of the waveguide which is below cut-off. It is thus possible to plot the cut-off point and change of guide wavelength with frequency by using the mm. scale mounted along the side of the waveguide.

### 9. POLARISING SCREEN X16.2605

A wire grid 6″ diameter which may be used to demonstrate transmission or reflection, when rotated before radiating elements.

### 10. CRYSTAL MOUNT TYPE X16.120

Functions as a mixer/detector giving a positive output from the CV 253 or CS 3A Silicon Crystal rectifier the output from which is conveyed by a Co-axial cable to a



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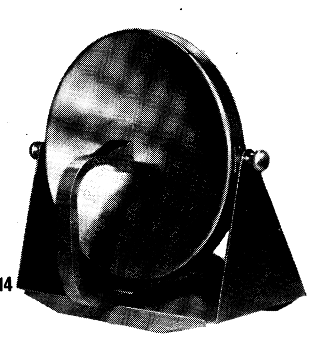

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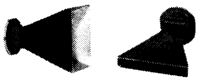

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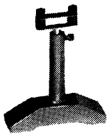

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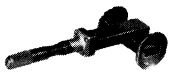

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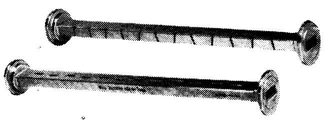

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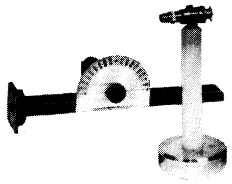


suitable indicating instrument. A milliampere D.C. meter is suitable. For highest sensitivity use our T.A.3. Transistor Amplifier. *Crystal Mount X*16.120R gives a negative output.

### 11. LOAD/SHORT CIRCUIT TYPE X16.40

A length of Waveguide open at one end with provision for the insertion of either the terminating load or short circuiting plunger provided. Load v.s.w.r. better than 0.97. Short Circuit reflection co-efficient better than 0.992. Length of waveguide: 6″ (152 mm). Weight: 12 ozs. (340 gm).

### 12. TERMINATING CAP X16.130

This is a terminating load consisting of a resistive surface across the waveguide backed by a short circuit placed quarter of a wavelength behind. v.s.w.r. better than 0.8 suitable for terminating the reverse arm of a directional coupler. Length ⅞″ (22 mm). Weight 5 ozs. (142 gm).

### 13. TRANSISTOR AMPLIFIER T.A.3

This instrument is the very latest Portable Amplifier and Indicator with extreme sensitivity for detecting low level audio signals, it incorporates a built-in balance circuit for the comparison of two anti phase inputs, such as are obtainable from crystal mounts X16.120 and X16.120R, thus permitting bridge measurements independent of source power variations. It is fitted with an Ernest Turner mirror scale meter, specially engraved in v.s.w.r., reflection coefficient, and Waveguide decibels and there is now a choice of selective frequency in addition to wideband operation, sensitivity 20$\mu$V. F.S.D. Its selective sensitivity of 2 microvolts for full scale deflection and low noise level of 3%, make it essential for all small signal analysis in the range 150 c/s to 10 Kc/s. Selective frequencies 3.2 Kc/s and 1 Kc/s or as requested.

### 14. PARABOLOID MOUNT X16.2640

This uses a 12″ diameter parabolic mirror arranged to tilt in elevation and having a waveguide horn feed at the focal point. Beam width approximately 8°. It is suitable as a radiator when connected directly to the source X16.10 or as a receiver when used with a crystal mount X16.120. Size: 1′ 1″ (331 mm) x 1′ 1½″ (345 mm) x 6½″ (165 mm). Weight: 2 lb. 10 ozs. (745 gms).

### 15. CALIBRATED MEASUREMENT ATTENUATOR X16.630

A variable attenuator having a 0-13 mm micrometer movement is fitted with a high stability glass vane. Range 0.30 dB. Accuracy $\pm$ 15 dB. v.s.w.r. better than 0.95. Calibration frequency 9,375 Mc/s. Length: 6″ (152 mm). Depth: 6″ (152 mm). Weight: 1 lb. (454 gm).

### 16. HORNS X16.2610 AND X16.2615

These are mounted on a short length of waveguide, X16.2610 has an aperture 3″ square. X16.2615 has an aperture of 3″ x 0.4″. Length: 4½″ (115 mm). Weight: 6¾ ozs. (190 gm).

### 17. FREE STANDING SUPPORT TYPE X16.80

Provides additional supports for long waveguide runs. Adjustable in height—5¼″ (26 mm) to 7″ (178 mm). Weight: 2 lb. 3 ozs.

### 18. FREQUENCY METER X16.100

Calibrated Range 8.4 to 10Gc/s. Calibration Accuracy: $\pm$ 2 parts in $10^4$. Dial Discrimination: 1.25 Mc/s. Mode H01 absorbtion, 'Q' Factor 3,000 (approx.). At resonance the absorbtion dip is about 2 dB (37%). Length: 3″ (76 mm). Depth: 8¼″ (210 mm). Weight: 14½ ozs (410 gm).

### 19. 90° BEND (E Plane) TYPE X16.55

v.s.w.r. better than 0.96. Inside radius 2″ (51 mm). Weight: 8 ozs. (227 gm).

### 20. 90° BEND (H Plane) TYPE X16.50

v.s.w.r. better than 0.96. Inside radius 2″ (51 mm). Weight 8 ozs. (227 gm).

### 21. LINEAR ARRAY X16.2620

This is a 12 slot shunt radiator useful for demonstrating the linear array principle. A series version X16.2630 is also available, having 12 slots cut in the broad face of the guide. Length: 1′ 1¾″ (345 mm). Weight: 14 ozs.( 400gms).

### 22. RADIATION PLOTTER X16.110

A two slot series radiator is provided with a receiving dipole for plotting its radiation pattern. A moveable arm connected to a cursor travelling over a 180° scale is situated mid-way between the slots and to this is attached the dipole unit. A co-axial crystal is mounted inside the 3.2 cm. dipole and is provided with a socket for the connection of a screened cable leading to an indicating micro-ammeter. The open end of the waveguide may be terminated by a load or short circuit. (Item 11). Length of waveguide 9″ (229 mm). Depth 4″ (102 mm). Height 4″ (102 mm). Weight (both items) 3 lbs. (1.4 Kg).

# SEVEN OPTICAL EXPERIMENTS

*These may be performed with the apparatus described inside this folder*

## 1—DIFFRACTION AT A STRAIGHT EDGE

One of the waveguide horns is connected to the Microdesk and the other to the crystal detector, this second assembly being mounted upon the waveguide support. A cable from the audio oscillator is connected to the Microdesk external modulation socket and the output cable from the crystal detector is connected to the input socket of the audio amplifier. With the radiation from the Microdesk reaching the receiving horn the output amplitude and frequency of the audio oscillator are adjusted until a reasonably pure note (between 400 and 1,000 c/s) is heard from the loudspeaker. The two horns are spaced about 1 metre apart, then a sheet of $\frac{1}{16}''$ thick aluminium or other suitable metal, about 30 cm. square, is placed vertically between them, covering half the apertures, as shown in Figure 1. When the receiving horn is moved sideways, changes in signal amplitude will be heard corresponding to diffraction fringes as seen in equivalent optical apparatus.

## 2—LLOYD'S MIRROR

The equipment is connected as in Experiment No. 1 but the transmitting and receiving horns are set at a slight angle as shown in Figure 2, so that some direct energy is received before the reflecting mirror is placed in position. Upon moving the mirror which need only be about 10 cms. wide, changes in the length of the reflection path can be created, thus causing phase interference between the direct wave and the reflected wave at the receiving horn.

## 3—MICHELSON'S INTERFEROMETER

This experiment may easily be demonstrated with a "half-silvered mirror" constructed from a thin sheet of rigid cardboard (approximately 30 x 50 cm), painted on one side with one or more coats of good quality aluminium paint. The number of coats or thickness of the paint is best determined by experiment. A grid of wires is not recommended for use as a semi-reflector since it is sensitive to polarisation and thus produces spurious effects.

The apparatus is connected as before and set up as shown in Figure 3, using two aluminium or other metal reflectors about 30 cm. square set at 90° and adjusted so that each reflector faces its corresponding horn. The semi-reflector is then set up at 45°, bisecting the angle of the reflectors at the point of intersection of the two horn centre-lines. The dimensions are not critical. Radiation reflected from the back of the mirror is returned by one reflector and partially passes through the mirror to the receiver; radiation passing through the mirror is returned by the other reflector and partially reflected by the front of the mirror to the receiver.

As one of the mirrors is moved along its centre-line nodes and antinodes can be detected, the wavelength of radiation can thus be measured.

## 4—REFLECTION FROM POLARISED SURFACE

In this experiment the transmitter and receiver (which is vertically polarised) are set up as in Experiments Nos. 3 or 5, but the reflecting medium is replaced by a grid of parallel wires mounted upon a suitable support so that the plane of the wires may be rotated. The wire grid may be constructed, 6″ or more in diameter, from $\frac{1}{16}''$ diameter brass or copper wire supported on non-metallic material and spaced less than one-quarter wavelength apart (say $\frac{1}{4}''$ or 6 mm). The plane of the grid is set normal to the bisector of the angle between the horns, and it will be noted that when the wires lie in the plane of polarisation (*i.e.* vertical), energy is reflected into the receiving horn. When the wires are at right-angles to the plane of polarisation, little or no energy is reflected. A variation of this experiment is to place the horns facing each other with the grid mounted between them, in which case no signal is received with the wires in the plane of polarisation.

## 5—REFLECTION FROM IONISED GAS

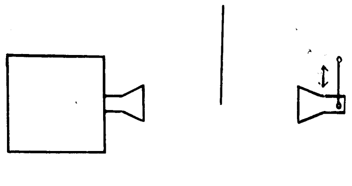
The horns are arranged at right-angles and a gas discharge tube is mounted at their lines of intersection parallel to the plane of polarisation. It will be noted that very little or no signal is received until the gas discharge lamp is switched on, when it will reflect energy which is detected by the receiving horn assembly.

## 6—REFRACTION BY DIELECTRIC PRISM

The apparatus is set up with one horn deflected by about 45°, and at the intersection of their centre-lines a dielectric prism is arranged to rotate on a vertical axis as shown in Figure 6. Rotation of the prism will deflect the beam, or alternatively it can be shown that by removing and replacing the prism and adjusting the receiving horn accordingly some refraction has taken place. The construction of a suitable prism may be difficult, as a block of Perspex or Distrene will be expensive or difficult to machine. It is suggested that a hollow prism, made from $\frac{1}{8}''$ or $\frac{1}{4}''$ Perspex sheet, should be constructed and provided with a suitable filling hole in the upper surface. The prism may then be filled with liquid paraffin or paraffin wax. The sides of the prism should be not less than 8″, although a 6″ sided prism may give reasonable results if the horns are mounted fairly close together.

## 7—FRESNEL'S MIRRORS

In this experiment the transmitting and receiving horns are spaced side by side at a converging angle, and two plain reflecting surfaces about 30 cm. square are set up at a distance of about 1.5 metres. If the adjacent edges of the mirrors are fastened together with self-adhesive tape and stood with an internal angle of about 170°, they will be self-supporting. By moving the receiving horn in an arc as indicated in the diagram, an interference pattern is shown to exist.



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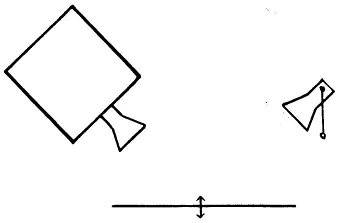

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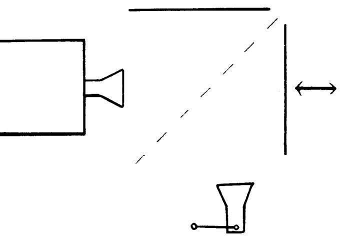

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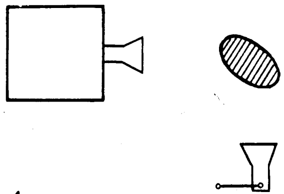

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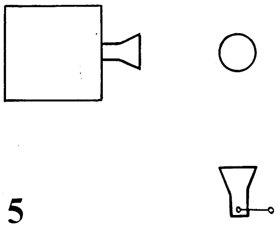

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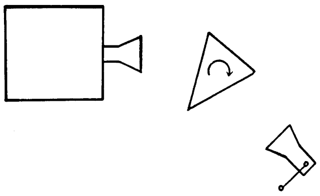

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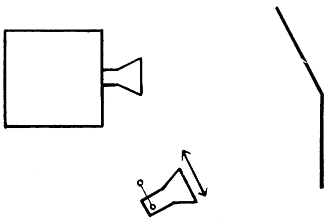

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