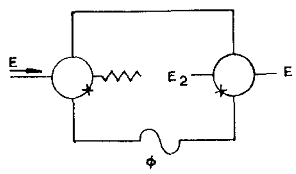

Fig. 1—Simple frequency discriminator.

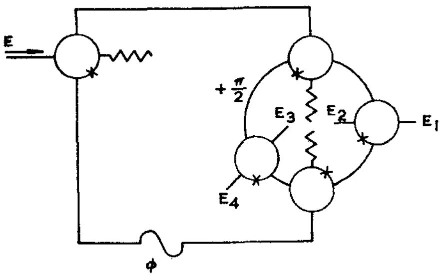

Fig. 2—Quadrature frequency discriminator.

Several advantages of the arrangement may be quoted:

1) An (r, θ) display can be used so that $\theta \propto \phi \propto f$.
2) Using an (r, θ) display, θ continuously and linearly increases with frequency over any range, although, of course, ambiguities occur in a range of ϕ exceeding 2π. "Clock" systems to give increased accuracy without ambiguity are possible. In this context, frequency ranges representing $2n\pi < \phi < 2(n+1)\pi$ of 10 Mc and 10,000 Mc are equally practicable.
3) $|E_1|^2 - |E_2|^2 \simeq |E_1| - |E_2|$ when $E_1 = \cos \phi/2$ and $E_2 = \sin \phi/2$ so that errors due to departure from square law in the detector characteristics are very small.
4) The subtraction $|E_1|^2 - |E_2|^2$ may be written

$$(E'^2 + E''^2 + 2E'E'' \cos \phi) - (E'^2 + E''^2 - 2E'E'' \cos \phi) = 4E'E'' \cos \phi$$

where E' and E'' are the input voltages to a phase-measuring hybrid junction, and $E' \neq E''$. It may be shown that the product $(E'E'')$, for both the phase measuring junctions, shown in Fig. 2, is not dependent upon equality of power split in the power dividing junctions and that therefore this equality is not necessary for good frequency measuring performance.

It should be noted that the four-junction circuit, giving the sine and cosine terms, is the same as that for a single-sideband modulator and is one of a large family of multiport networks that might be used in phase comparison applications. For example, an eight detector device giving $\cos \phi$, $\cos (\phi + \pi/4)$, $\cos (\phi + \pi/2)$ and $\cos (\phi + 3\pi/4)$ outputs can easily be realized. Such an arrangement shows improved measuring accuracy by removing quadrantal error terms.

STEPHEN J. ROBINSON
Systems Division
Mullard Research Labs.
Redhill, Surrey, England

Harmonic Generation by an Array

In the millimeter region, harmonic generators have long served as convenient signal sources. However, the power handling capacity of the diode elements is very limited. At the short-wave end of the millimeter spectrum, the dominant mode waveguide terminal of a harmonic generator may also be less desirable than a quasi-optical or beam output. These factors have led to the investigation of a diode array as a millimeter wave source. The results obtained show that such an array is feasible but uneconomic with presently available diodes.

A schematic diagram of a harmonic array is shown in Fig. 1. The fundamental power illuminates an array of receiving apertures from a feed horn which may be extended (as shown by the broken lines) to shield the entire input region, if desired. Depending on the spacing between feed and array, it may be necessary to introduce phase correction by means of a lens, or by changing the lengths of input waveguide in each multiplier unit. These units consist of a receiving or input horn coupled to an inline harmonic generator. The output guide is proportioned to pass only the desired harmonic and higher terms which are neglected. Each output horn occupies the same cross section as the corresponding input aperture. This provides grating lobe suppression, since a narrower element pattern compensates for the wider spacing at the output frequency. The output is in the form of a beam, which can be brought to a focus by choosing the proper phase correction on either the input or output side of the array.

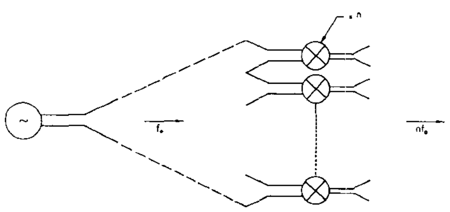

Fig. 1—Harmonic array.

To investigate the properties of a harmonic array, a 2×5 element array was constructed for $f_0 = 25$ Gc, $n = 2$. A very simple straight-through element, as shown in Fig. 2, was used. The individual crystals produced an input VSWR between 4:1 and 6:1 in this mount. Measurements on individual elements showed that the standard deviations in insertion phase shift and conversion loss were less than 25° and 1.7 db respectively for the 27 individual 1N26 crystals tested. The harmonic output of the array was within 1 db of the output calculated for the sum of the individual elements, each with the measured VSWR, and illumination corrections applied. It was therefore concluded that a harmonic array functions as a true additive structure. The array is shown in Fig. 3.

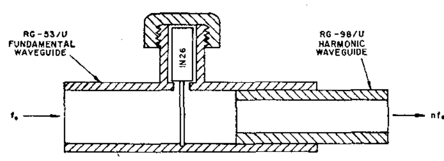

Fig. 2—Harmonic array element.

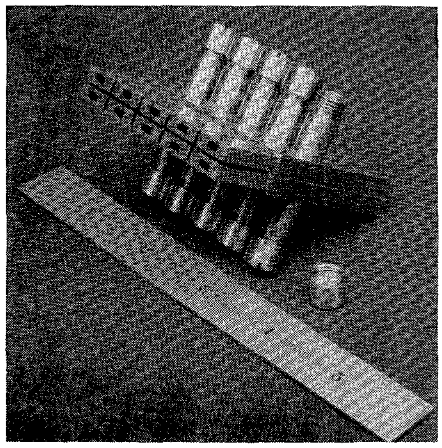

Fig. 3—Ten element harmonic array.

The performance of the experimental array shows conversion and coupling losses of about 20 db and 6 db respectively. With provisions for impedance matching in the elements, and with more efficient harmonic generators, a useful array source for millimeter and possibly submillimeter power might be constructed.

D. D. KING
F. SOBEL
J. W. DOZIER
Research Div.
Electronic Communications, Inc.
Timonium, Md.

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Analogous Propagation Modes in Inhomogeneous Plasma and Tapered Waveguide

An interesting analogy exists between the propagation of transverse electromagnetic (TE) waves in a plasma (with no magnetic field) and in conventional waveguide.[1,2] This analogy reflects the similar roles played by the volume conduction current in the plasma and the wall conduction current in the waveguide and is of interest in that it provides insight into plasma propagation and suggests the possibility of simulating

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[1] V. L. Ginzburg, "Propagation of Electromagnetic Waves in Plasma," Gordon and Breach Publishers, Inc., New York, N. Y.; 1962.

[2] W. Rotman, "Plasma simulation by artificial dielectrics and parallel-plate media," IRE TRANS. ON ANTENNAS AND PROPAGATION, vol. AP-10, pp. 82–95; January, 1962.