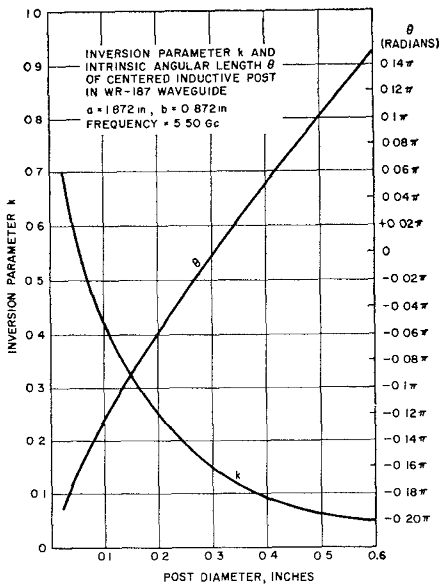

Fig. 4—Parameters of an inductive post in WR-187 waveguide.

where w and l are the amplitude and period shown in Fig. 3 Thus,

$$k = \tan \frac{\pi}{4}\left(1 - \frac{2w}{l}\right). \qquad (16)$$

Eq. (16) is a very practical expression, because plotting errors can be averaged out by using the ratio of the average amplitude $\bar{w}$ to the average period $\bar{l}$.

The intrinsic angular lengths, $\theta_1 = \beta_1 d_1$ and $\theta_2 = \beta_2 d_2$, are given by

$$\theta_1 = \beta_1 D_0 - \frac{\pi}{4}\left(1 - \frac{2w}{l}\right) \qquad (17)$$

$$\theta_2 = \beta_2 S_0 - \frac{\pi}{4}\left(1 - \frac{2w}{l}\right) \qquad (18)$$

where $\beta_1 D_0$ and $\beta_2 S_0$ are the coordinates of an "inside peak," such as point ②. The correct point to use is the one having the most nearly equal values of $\beta_1 D$ and $\beta_2 S$. If the network happens to have bilateral symmetry about plane T_0, $\beta_1 D_0$ and $\beta_2 S_0$ will be exactly equal; in general, they will differ by less than $\pi/2$.

An application for this measurement arises in the design of filters using thick inductive posts. The impedance behavior with frequency of a thick post does not follow that of a narrow iris, and the intrinsic angular length cannot be computed from the handbook value of the shunt susceptance. In Fig. 4 are shown values of θ and k derived from tangent-relation plots of data taken with centered inductive posts in WR-187 waveguide at 5.5 Gc. It is interesting that the sign of θ changes at a diameter of approximately $a/6$. For posts of larger diameter, $d_1 = d_2 = \theta/2\beta$ is positive, and directly-coupled resonator sections (of a cascade-resonator filter) must be slightly longer than $\lambda_{g0}/2$.

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Integral Quotient in Measurements of Ambipolar Diffused Plasma with TE_{011} Cavity

Despite some known exact solutions of plasma loaded TM_{010} cavity,[1,2] the TE_{011} mode should be used due to measurement-technical reaons in the case of large electron densities and considerable losses.[3,4] This communication is connected with the mathematical treatment of measurement results in the case of TE_{011} mode and ambipolar diffusion in discharge tube. The treatment is based on Slater's[5] expression for discharge admittance and the assumption of small perturbations, but not on any special electron theoretically derived plasma conductivity formula.

Owing to the ambipolar diffusion in the discharge tube, the distribution of electron density n along the radius r is

$$n = n_0 J_0(2.405 r/r_0) \qquad (1)$$

where n_0 is the electron density at the axis and r_0 the inside radius of the discharge tube. The plasma conductivity is proportional to the electron density and obeys the same distribution.

Starting from Slater's discharge admittance,[5] the expressions for the real part σ_{r0} and the imaginary part σ_{i0} of plasma conductivity at the axis can be derived and are

$$\begin{cases} \sigma_{r0} = (g_d \omega_0 \epsilon_0/\beta) Q \\ \sigma_{i0} = (-2\Delta\omega_0 \epsilon_0) Q \end{cases} \qquad (2)$$

where g_d is the discharge conductance, ω_0 the angular resonant frequency, $\Delta\omega_0$ the change of ω_0 due to the discharge plasma, ϵ_0 the dielectric constant of free space, β the factor depending on coupling between transmission line and cavity, and Q the quotient of two volume integrals.

In the case of ambipolar diffusion and TE_{011} cavity, after integration with respect to z and ϕ (in cylindrical coordinates)[6] one has

$$Q = Q(R/r_0) = Q_1(R)/Q_2(R/r_0, r_0) = \int_0^R r J_1^2(3.832 r/R) dr \Big/ \int_0^{r_0} r J_0(2.405 r/r_0) J_1^2(3.832 r/R) dr. \qquad (3)$$

R is the inner radius of the cavity.

The integration in the numerator of (3) can be performed simply and one has $Q_1(R) = \frac{1}{2} R^2 J_0^2(3.832)$. The values of $Q_2(R/r_0, r_0)$ at $r_0 = 1$ cm have been computed on an electronic digital computer. The results are presented in Table I. Q_2 can be found for other values of r_0 by noting that it is proportional to the square of r_0. The integral quotient Q is only the function of R/r_0 and is presented in Table I and in Fig. 1 for practical values of the argument R/r_0.

TABLE I
Computed Values of Denominator Q_2 at $r_0 = 1$ cm and Integral Quotient Q as Function of R/r_0, the Ratio of Cavity Radius to Discharge Tube Radius

R/r_0	Q_2, cm²	Q
3	0.022358	32.650
4	0.013688	94.805
5	0.0091115	222.54
6	0.0064640	451.71
7	0.0048106	826.14
8	0.0037141	1397.6
9	0.0029514	2225.9
10	0.0024005	3378.8

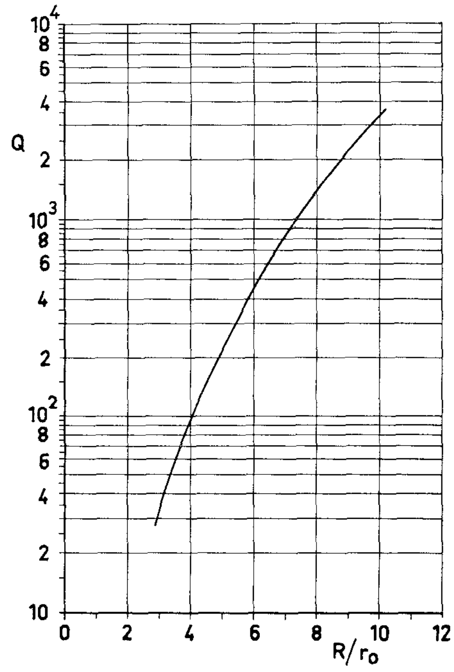

Fig. 1—The quotient Q of two volume integrals in the measurement of ambipolar diffused plasma with TE_{011} cavity. R is the inner radius of cavity, r_0 the inner radius of discharge tube.

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[1] B. Agdur and B. Enander, "Resonances of a microwave cavity partially filled with a plasma," *J. Appl. Phys.*, vol. 33, pp. 575–581; February, 1963.

[2] P. Hedvall, "Cavity method for measuring plasma properties," *Ericsson Technics*, vol. 19, pp. 97–107; 1963.

[3] K. B. Persson, "Limitations of the microwave cavity method of measuring electron densities in a plasma," *Phys. Rev.*, vol. 106, pp. 191–195; April, 1957.

[4] S. J. Buchsbaum and S. C. Brown, "Microwave measurements of high electron densities," *Phys. Rev.*, vol. 106, pp. 196–199; April, 1957.

[5] J. C. Slater, "Microwave electronics," *Revs. Mod. Phys.*, vol. 18, pp. 441–512; October, 1946.

[6] P. Jaaskeläinen, "On attenuation and electrical length of a plasma loaded helical transmission line," *Acta Polytech. Scand.*, Ph 23; 1963.

On "Status Report on International Millimeter Waveguide Flange Standards"[1]

In his communication, Anderson described the state of international standardization of millimeter waveguide flanges and concluded that in the absence of a suitable

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[1] T. N. Anderson, IEEE Trans. on Microwave Theory and Techniques, vol. MTT-11, pp. 427–429; September, 1963.

U. S. flange ". . . there is little to compete with the Philips flange as an International Standard." Earlier he had stated: "The British also developed flanges for millimeter-wave work using the Union-type principle, but these found little favor in the U. S." Although nowhere specifically stated, it is strongly implied that this British flange is not being put forward as an international standard. In fact, the situation is that the British Union-type flange, or C-type, has been accepted as an international standard and is listed in document IEC publication 154. It is widely used in Great Britain both for millimeter wave sizes and, in large quantity, at X-band (WG16).

It is used extensively in airborne equipment, is an approved NATO design, and is fully specified in STANAG 4058 (3rd preliminary draft) document AC/67-D/65 of 6.9.63. for rectangular waveguide sizes WG15 to 26 inclusive.

The status of this flange in relation to Anderson's communication was discussed at a recent meeting of the United Kingdom Radio Component Research and Development Sub-Committee 16 (waveguide components), and members felt that it would be useful to put these points on record lest failure to do so might imply lack of use or interest in the Union-type flange.

It is, perhaps, unfortunate that some early samples of this flange were not made accurately to specification, or were heavily plated, with the result that some potential users were put off their design. As currently made, they have for a long time given adequate service and, as reported above, are in large scale use and are an internationally standardized item.

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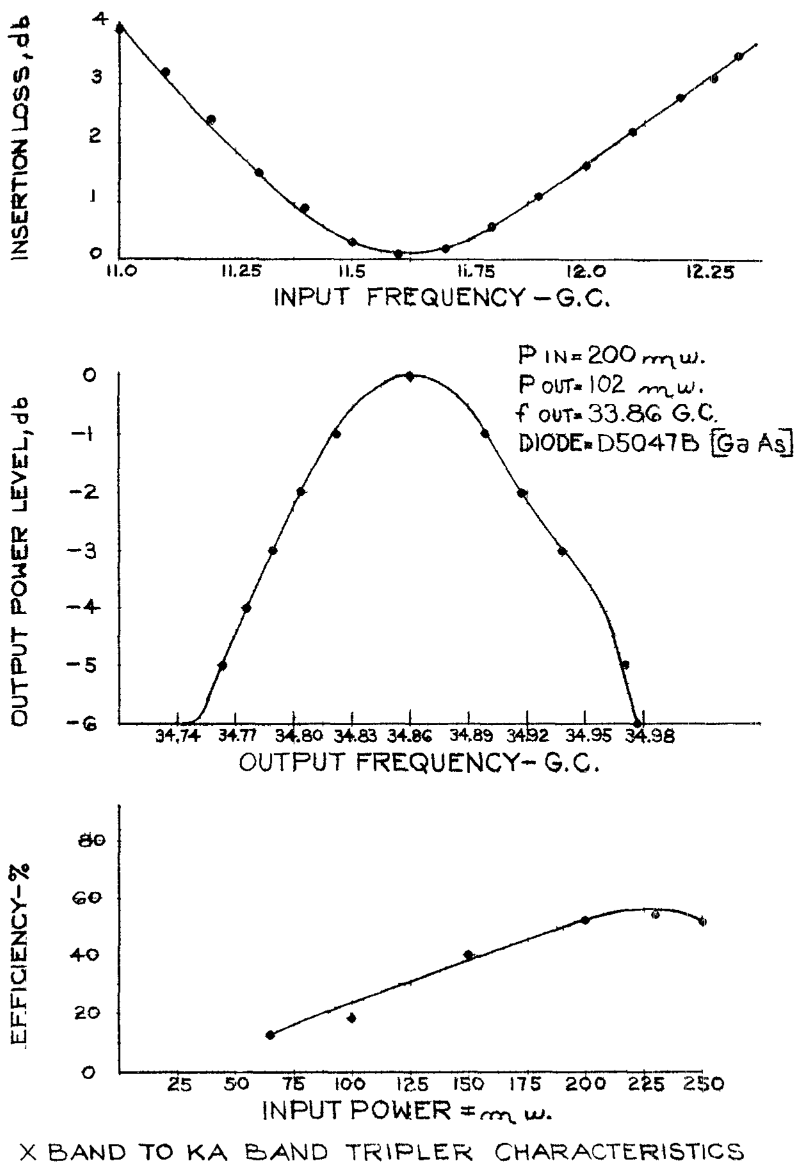

Fig. 1—x band to K_A band tripler characteristics.

K_A Band Klystron Replacement

We have successfully fabricated a harmonic tripler from 11,620 Mc to 34,860 Mc using a diffused junction gallium arsenide varactor (Sylvania D5047C) with an efficiency of approximately 50 per cent at an input power of 200 mw (Fig. 1).

This work was begun as a potential cost savings measure to eliminate the use of expensive short life K_A klystrons in test equipment. The present unit is being used in conjunction with an X-13 X-band klystron with a life expectancy far exceeding the original K_A band-tube source. The tripler itself is running unbiased with no dc return and should have near infinite life. To date, it has run for over 1900 hours with no indicated change in output.

The design is based on a half wave rectangular cavity with the diode mounted at the voltage maximum point. This arrangement tends to suppress the second harmonic and generate the odd harmonics. The cavity is essentially $\frac{3}{2}\lambda$ long at the desired third harmonic.

With an output power of +20 dbm, the second harmonic could not be detected and the total unwanted harmonic power above the third was approximately −30 dbm.

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Microwave Transmission Through a Plasma Sheath

Propagation of an electromagnetic wave of a given frequency in a plasma will occur only if the plasma density is less than a critical value.[1] When the density is expressed in terms of the plasma frequency $\omega_p^2 = ne^2/\epsilon_0 m$, propagation occurs if the plasma frequency is less than the frequency of the electromagnetic wave. When the plasma density is such that the plasma frequency is in excess of the signal frequency, the plasma acts like a conductor reflecting and severely attenuating the signal so that it cannot penetrate to any great depth into the plasma.

The interaction which takes place between the electromagnetic wave and the plasma at microwave frequencies is primarily that occurring between the electrons in the plasma and the electromagnetic field since at these frequencies the motion of the heavy positive ions is negligible compared with that of the electrons. If it is desired to pro-

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[1] M. P. Bachynski, "Plasmas and the Electromagnetic Field" McGraw-Hill Book Co., Inc., New York, N. Y.; 1962.