

## CAVITY RESONATORS

- A. E. Barrington and J. R. Rees, "A simple 3 cm  $Q$ -meter," *Proc. IEE*, vol. 105, pt. B, pp. 511–512; November, 1958.
- A. E. Karbowiak, "The concept of heterogeneous surface impedance and its application to cylindrical cavity resonators," *Proc. IEE*, vol. 105, pt. C, pp. 1–12; March, 1958.
- A. E. Karbowiak, "An instrument for the measurement of surface impedance at microwave frequencies," *Proc. IEE*, vol. 105, pt. B, pp. 195–203; March, 1958.

## NOISE SOURCES

- A. C. Gordon-Smith and J. A. Lane, "Measurements on gas discharge noise sources at centimetre wavelengths," *Proc. IEE*, vol. 105, pt. B, pp. 545–547; November, 1958.
- M. Kollanyi, "Application of gas discharge tubes as noise sources in the 1700–2300 Mc/s band," *J. Brit. IRE*, vol. 18, pp. 541–550; September, 1958.

## FERRITES

- C. M. Srivastava and J. Roberts, "Measurements of ferrite loss factors at 10 Gc/s," *Proc. IEE*, vol. 105, pt. B, pp. 204–209; March, 1958.

## OPTICAL METHODS

- J. I. Caicoya, "The optical approach in microwave measuring technique," *Brit. Commun. and Electronics*, vol. 5, pp. 500–507; July, 1958.

- J. S. Seeley, "A spectrometer method for measuring the electrical constants of lossy materials," *Proc. IEE*, vol. 105, pt. C, pp. 18–26; March, 1958.
- R. W. R. Hoisington, L. Kellner and M. J. Pentz, "Criteria determining the design and performance of a source modulated microwave cavity spectrometer," *Proc. Phys. Soc.*, vol. 72, pp. 537–544; October, 1958.

## SEMICONDUCTORS

Two sessions at the Microwave Valve convention were devoted to various aspects of semiconductor devices including amplifying devices. The papers are published in *Proc. IEE*, vol. 105, pt. B, suppl. no. 11; 1958.

- C. Baron, "Theory of the microwave crystal mixer," pp. 662–664.
- E. Rostas and F. Hulster, "Microwave amplification by means of intrinsic negative resistances," pp. 665–673.
- K. W. H. Stevens, "Introduction to atomic and molecular generators," pp. 674–676.
- G. Wade and H. Heffner, "Microwave parametric amplifiers and convertors," pp. 677–679.
- K. N. Chang and S. Bloom, "A parametric amplifier using lower frequency pumping," pp. 680–682.
- P. N. Butcher, "Theory of three-level paramagnetic masers," pp. 684–710.
- A. E. Siegman, P. N. Butcher, J. C. Cromack, and W. S. C. Chang, "Travelling-wave solid-state masers," p. 711.
- A. H. W. Beck and J. Lytollis, "Construction of a mobile caesium frequency standard," pp. 712–715.

# Report of Advances in Microwave Theory and Techniques in Western Europe—1958\*

GEORGES GOUDET†

## 1. TRANSMISSION LINES

## 1.1. Hollow Waveguides

A member of Philips Research Laboratory, Eindhoven, Holland, has used a new method to calculate the radiation impedance of a linear antenna in a waveguide of rectangular cross-section, *viz.*, Schwingers' variational principle. This new application, even when based on only a two-term Fourier expansion of the current distribution, gives better results than a sinusoidal current distribution.

- F. de Ronde, "Schwingers' variational principle applied to the calculation of the radiation resistance and reactance of linear antenna in a waveguide of rectangular cross-section," *Onde Elect.*, no. 376 bis, tome 1, pp. 95–98; août, 1958. (In English.)

A general study tending to define the concept of impedance in hollow waveguides has been made.

- A. Guerbilsky, "La notion d'impédance dans la théorie des guides d'ondes," *Ann. Télécommun.*, no. 5–6, pp. 114–120; mai-juin, 1958. (In French.)

Theoretical and experimental studies of microwave delay line for high power were made by the Research Institute of National Defence, Stockholm 80, Sweden.

- B. T. Henoch, "Investigation of the disc-loaded and helical waveguide," *Trans. Roy. Inst. Technol., Stockholm*, Sweden, no. 129, 1958. (In English.)

The study of circular waveguides has been carried on.

After the propagation of plane waves in an infinite space, of lamellar structure, the propagation in a waveguide of the same structure has been studied, and application has been made to circular guide.

- M. Jouguet, "Propagation dans les systèmes à structure discontinue et périodique et application aux guides d'ondes," *Câbles et Trans.*, no. 1, pp. 23–26; janvier, 1958. (In French.)

Calculation of phase and amplitude distortion in a TE<sub>01</sub> wave transmission in a circular guide has been undertaken.

- M. Jouguet, "Sur les effets de la distorsion d'amplitude et de phase dans les guides d'ondes," *Onde Elect.*, no. 376 bis, tome 1, pp. 119–123; août, 1958. (In French.)

A French firm, Les Câbles de Lyon, has checked experimentally the results obtained in the preceding calcu-

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† Laboratoire Central de Télécommunications.

lation. They have more specially studied the propagation in waveguides with walls of helically-wound wire, the difficulties encountered when passing through the bends, and the attenuation measurements on short lengths of guides.

- J. Bendayan, "Contribution à la technique future des télécommunications: Recherches effectuées sur les guides d'ondes circulaires en vue de la transmission de l'onde  $TE_{01}$ ." *Onde Elect.*, no. 376 bis, tome 1, pp. 193–202; août, 1958. (In French.)
- G. Comte, A. Ponthus, "Guides d'ondes éolotropes à structure filtrante continue pour la propagation du mode  $TE_{01}$ ." *Onde Elect.*, no. 376 bis, tome 1, pp. 167–172; août, 1958. (In French.)
- F. de Carfort, J. M. Paris, "Franchissement des coudes par des guides d'ondes circulaires utilisant le mode  $TE_{01}$ ." *Onde Elect.*, no. 376 bis, tome 1, pp. 173–178; août, 1958. (In French.)
- J. Bendayan, G. Comte, "Procédés de mesure de l'affaiblissement de courtes longueurs de guides d'ondes circulaires utilisant le mode  $TE_{01}$ ." *Onde Elect.*, no. 376, bis tome 1, pp. 315–319; août, 1958. (In French.)

A theoretical study of the influence of undulations or diaphragms periodically introduced into a circular waveguide ( $H_{0n}$  and  $E_{0n}$  waves) has been made in Germany; this study may lead to the realization of delay lines.

- G. Piefke, "Wellenausbreitung in einem Blenden—Hohlleiter und einem Gesickten Hohlleiter." *Arch. Elekt. Übertragung*, no. 1, pp. 26–34; janvier, 1958. (In German.)

The problems of clearing bends have also been analysed in Germany. The improvement which can result from the use of variable curvature waveguides has been mentioned.

- M. G. Andreasen, "Ausbreitung von Grundwellen in Kreisrunden und quadratischen gebogenen Hohlleitern Konstanter Krümmung." *Arch. elekt. Übertragung*, no. 9, pp. 414–418; September, 1958. (In German.)
- M. G. Andreasen, "Synthese eines gebogenen Hohlleiters mit stetigen Verlauf der Krümmung." *Arch. elekt. Übertragung*, no. 10, pp. 463–471; Oktober, 1958. (In German.)

A general formula, previously established, giving the attenuation in a circular guide with absorbent walls, has been discussed in Italy.

- L. Caprioli, "L'attenuazione nelle guide circolari con pareti assorbenti." *Alta Frequenza*, no. 5, pp. 510–527; Ottobre, 1958. (In Italian.)

### 1.2. Multiconductors Transmission Lines

The Cie Générale de Télégraphie sans Fil has carried on the study of centimeter-wave three-plate circuits, constituted by a strip line surrounded by a hollow conductor with flattened rectangular section.

Directional couplers, filters, and hybrid junctions have been realized according to this technique.

- A. Muser, "Circuits triplaques en ondes centimétriques." *Onde Elect.*, no. 376 bis, tome 1, pp. 134–139; août, 1958. (In French.)

The Research Institute of National Defence, Stockholm 80, Sweden, had studied partially-ferrite-filled stripline.

- P. E. Ljung, "Phase-Shift in Partially Ferrite-filled Stripline." Rept. A 365, 12 pp.; 1958. (In Swedish.)

### 1.3. Surface Waveguides

The work done by the Research Institute of National

Defence, Stockholm 80, Sweden, has comprised both cylindrical- and plane-surface waveguides and has involved measurements of certain properties, such as attenuation constant, field intensity decay, and attenuation caused by a step in the thickness of the dielectric coating.

As to cylindrical waveguides, the attenuation caused by bends has been subject to study. Further, a method for the determination of  $Q$  with losses present in the transition between a resonator and a transmission line has been developed in connection with the measurements of the attenuation constant.

As to plane-surface waveguides, a method has been developed for the calculation of the launching efficiency and the radiation pattern of a certain type of feed.

Investigations of the properties of a surface waveguide which makes a part of a circular cylinder are going on.

- M. Viggh, "Investigations of Surface Waves over Conducting Surfaces." FOA 3-Rept. A 348, 78 pp.; 1958. (In Swedish.)
- B. O. Ås, "Investigations of Cylindrical Surface-Wave Transmission Line." A 329, 48 pp.; 1958. (In Swedish.)

Experimentations on surface waveguides have been made in France. Studies on Goubau lines have been made by "Lignes Télégraphiques et Téléphoniques" and by L.C.T.

- B. Chiron, "Les guides d'onde de surface et leur place dans l'ensemble des lignes de transmission en hyperfréquence." *Onde Elect.*, no. 376 bis, tome 1, pp. 238–244; août, 1958. (In French.)
- H. Weill, "Les lignes de surface." *Onde Elect.*, no. 376 bis, tome 1, pp. 231–237; août, 1958. (In French.)

Radio Industrie has examined the means of exciting a surface wave on a conducting plane.

- M. Sirel, "Ondes de surface sur un plan conducteur recouvert d'une bande diélectrique." *Onde Elect.*, no. 376 bis, tome 1, pp. 209–224; août, 1958. (In French.)

A study of the propagation in two- or three-dimensional periodical structure media has been made by Cie Générale de Télégraphie sans Fil, with application to the case of artificial crystals and to the case of traveling-wave tubes. The author shows the possibility of a discrete number or of a continuous band of modes at the same frequency.

- G. Mourier, "Circuits à structure périodique à deux et trois dimensions. Applications possibles aux tubes à ondes progressives." *Onde Elect.*, no. 371, pp. 95–100; février, 1958. (In French.)

## 2. LINEAR CIRCUITS

A device for the measurement of impedances at centimeter wave comprising a variable impedance in combination with a symmetrical hybrid  $T$  has been realized by Philips Research Laboratories, Eindhoven, Holland.

The modulus and the argument of variable impedance can be adjusted separately.

- F. C. de Ronde, "Dispositif de mesure d'impédances en ondes centimétriques, simple et à lecture directe." *Onde Elect.*, no. 376 bis, tome 1, pp. 294–295; août, 1958. (In French.)

Some improved microwave bridges have been realized.

- R. Metivier, C. Romiguere, "Pont multifréquence." *Onde Elect.*, no. 376 bis, tome 1, pp. 309–312; août, 1958. (In French.)  
 L. R. de Gopegui, "Banco de microondas." *Inst. nac. Electron. Bol. inform. Tech.*, no. 1, pp. 21–27; Enero, 1958. (In Spanish.)

A device giving the complex value of amplification or attenuation of a quadripole by means of a bright spot on a Smith chart has been studied by L. M. Ericsson, Stockholm, Sweden.

- H. J. Olzanski, "Vector measurements in the microwave region." *Onde Elect.*, no. 376 bis, tome 1, pp. 302–304; août, 1958. (In English.)

A two-wire line which has been realized for the measurement of permittivities at 1000 MHz, has a very weak radiation field, requires only a small quantity of material, and is easy to manufacture.

- P. Borderie, "Réalisation d'une ligne bifilaire pour la mesure des permittivités à 1000 MHz." *J. Phys. Radium*, no. 8–9, pp. 39S–40S; août–septembre, 1958. (In French.)

The principle of a new graphic method for the fast calculation of  $\epsilon$  and  $\mu$  of a material from impedance measurements, has been developed at Laboratoire H. F. de la Faculté des Sciences de Grenoble, France.

- N. le Junter, "Méthode de calcul rapide de  $\epsilon$  et  $\mu$  à partir de mesures d'impédances en hyperfréquences et sa transposition graphique sur abaques." *Onde Elect.*, no. 376 bis, tome 1, pp. 305–308; août, 1958. (In French.)

The resonance curves of an empty reference cavity and of a cavity containing high-pressured gas have been compared by oscilloscopic means.

- A. Battaglia, F. Bruin, A. Gozzini, "Microwave apparatus for the measurement of the refraction, dispersion and absorption of gases at relatively high pressure." *Nuovo Cim.*, Ital., no. 1, pp. 1–9; January 1, 1957. (In English.)

Various polarimeters developed for fundamental research can be used directly for circuit studies.

- F. Picherit, "Analyseur polarimétrique à double sonde pour la bande des 1000 MHz." *Compt. rend. Acad. Sci.*, no. 6, pp. 911–913; 10 février, 1958. (In French.)  
 G. Raoult, R. Fauguin, A. Harlon, "Un polarimètre hyperfréquence." *Onde Elect.*, no. 376 bis, tome 1, pp. 327–331; août, 1958. (In French.)

A rapid and rather accurate method allowing the measurement of  $Q$  factor reaching  $10^8$  in the microwave field has been described.

- H. Ebert, "Q Messverfahren im Microwellenbereich." *Elektron. Rundschau*, no. 6, p. 203; Juni, 1958. (In German.)

## 2.1. Dipoles

An adaptation method suitable for periodical discontinuity waveguides has been described.

- I. Lucas, "Ueber Randglieder zur Anpassung von Hohlleiter Richtungskopplern periodischer Struktur." *Arch. elekt. Übertragung*, no. 2, pp. 91–96; Februar, 1958. (In German.)

A matched load for hollow waveguide has been realized with commercial film resistors.

- U. von Kienlin, A. Kuerzl, "Ein Hohlleiterabschluss mit handelsüblichen Schichtwiderständen." *Nachrichtentechn. Z.* no. 3, pp. 138–141; März, 1958. (In German.)

## 2.2. Reciprocal Multipoles

The transmission in a rectangular waveguide loaded with capacitor screen had been studied in the Netherlands. This study leads to the realization of compact filters for microwaves.

- H. Bosma, "Two-capacitive window in a rectangular waveguide." *Appl. Sci. Res. B.* no. 2, pp. 131–144; 1958. (In English.)  
 F. A. W. van den Burg, "Transmission in a rectangular waveguide loaded with an arbitrary number of capacitive screens." *Appl. Sci. Res. B.*, no. 3, pp. 153–183; 1958. (In English.)

Directional couplers with longitudinal slot have been the subject of studies in Germany and in France. In the first publication, following a theoretical study, a chart is given for the approximate determination of the coupling according to dimensions. The measure results are in agreement with theory. In the second article, an analogy is shown between thin slot couplers and classical band-pass filters. The methods for the calculation of these filters can be immediately applied to couplers.

- E. Schuon, "Eigenschaften und Bemessung des Langschlitz-Richtungskopplers." *Arch. elekt. Übertragung*, no. 5, pp. 237–243; Mai, 1958. (In German.)  
 G. Broussaud, "Couplages entre guides d'ondes—Théorie des coupleurs directifs à fentes minces." *Ann. Radioélect.*, no. 53, pp. 187–199; juillet, 1958. (In French.)

A directional coupler performing the conversion between the  $TE_{01}$  mode of a rectangular waveguide and the  $TE_{01}$  mode in a circular guide has been studied in Germany. The mode selectivity has been calculated, and the mode purity has been measured.

- A. Jaumann, "Ueber Richtungskoppler zur Erzeugung der  $H_{01}$ -Welle im runden Hohlleiter." *Arch. Elekt., Übertragung*, no. 10, pp. 440–446; Oktober, 1958. (In German.)

In Switzerland, the electric field in a waveguide coupled to the external medium by an aperture in its metallic wall has been calculated, by means of a new method in terms of the field tangential component in the aperture.

- J. van Bladel, "Normal modes methods for boundary excited waveguides." *Z. angew. Phys.*, no. 2, pp. 193–202; 25 juillet, 1958.

It has been specified what conditions must be met by a complex square matrix so that it may be considered as an impedance, admittance, or diffusion matrix of a microwave junction which is physically realizable at a given frequency.

- G. C. Corazza, G. Zoldan, "Realizzabilità fisica di una giunzione a microonde." *Note Recensioni. Not.*, no. 4, pp. 445–449; Luglio-Agosto, 1958. (In Italian.)

A mathematical study of the junctions of guides for elliptically-polarized waves has been made by Cie Française Thomson-Houston, by considering the elliptical waves either as two orthogonal rectilinearly-polarized waves or as two contrarotating circularly-polarized waves.

An application of this work to a circularly-polarized wave generator has been made.

- A. Gosselin, "Ondes elliptiques et jonctions de guides d'ondes polarisées elliptiquement." *Onde Elect.*, no. 376, bis tome 1, pp. 76-78; août, 1958. (In French.)

A theoretical analysis has been made of the influence of an axial sheet of resistive material connected to the walls, on the transmission properties of a rectangular waveguide.

- H. Buseck, C. Klages, "Das homogene Rechteckrohr mit Dämpfungsfolie." *Arch. elekt. Übertragung*, no. 4, pp. 163-168; April, 1958. (In German.)

### 2.3. Nonreciprocal Multipoles

The study of materials used for the realization of non-reciprocal multiples has been carried on.

The factor  $g$  and the damping coefficient of a ferrite result from resonance experiments made by placing a polycrystalline ferrite sphere into a microwave cavity with linearly-polarized magnetic field.

- H. G. Beljers, "Determination of the gyromagnetic ratio and the magnetic resonance damping coefficient of ferrites." *Philips Res. Rep.*, no. 1, pp. 10-16; February, 1958.

The width variation of the absorption curve of iron-yttrium garnet, by substituting  $\text{Cr}^{3+}$  ions into  $\text{Fe}^{3+}$  ions, has been studied.

- R. Vautier, A. J. Berteaud, "Variation de largeur de la courbe d'absorption du grenat d'yttrium—fer avec substitution de  $\text{Cr}^{3+}$ ." *Compt. rend. Acad. Sci.*, no. 19, pp. 1574-1577; 10 novembre, 1958. (In French.)

The study of wave propagation in a guide containing a piece of ferrite has been carried on.

- E. Barzilai, G. Gerosa, "Modes in rectangular guides filled with magnetized ferrite." *Il Nuovo Cimento Serie X*, Università di Roma, Facoltà di Ingegneria, Cattedra di Elettronica, vol. 7, p. 685; March, 1958.
- J. Soutif-Guicherd, "Etude de l'effet Faraday paramagnétique." *Ann. Télécommun.*, no. 7-8, pp. 169-185; juillet-août, 1958. *Ann. Télécommun.*, no. 9-10, pp. 222-238; septembre-octobre, 1958. (In French.)

The Research Institute of National Defence, Stockholm 80, Sweden, had also studied waveguides with a hollow dielectric or magnetized ferrite rod inside.

- P. E. Ljung, "Effective Permittivity for Hollow Dielectric Inserts in Waveguides." *Rept. A 364*, 7 pp.; 1958. (In Swedish.)
- P. E. Ljung, "Reciprocal Phase-Shift by Means of a Magnetized Ferrite Rod in Rectangular Waveguide." *Rep. C 239*, 10 pp.; 1958. (In Swedish.)

An additional paper on the study of gyrators has been published by "Lignes Télégraphiques et Téléphoniques."

- P. M. Prache, "Relations entre les éléments du tenseur de perméabilité complexe." *Câbles et Trans.*, no. 1; 1958. (In French.)

The work done by the Research Institute of National Defence Stockholm 80, Sweden on microwave ferrite components has comprised ferrite material investigations, as well as development of components (isolators, circulators, switches, phase shifters, etc.).

- B. Josephson, P. E. Ljung, "Microwave Ferrite." *Ericsson Tech.*, vol. 14, no. 1, pp. 39-70; 1958. (In English.)
- P. E. Ljung, "Microwave Load Isolators and Related Components." *Elektronik*, vol. 1, no. 6, pp. 103-108; June, 1958. (In English.)

Theoretical and experimental study has been made of the propagation of 3.2 centimeter  $\text{TE}_{11}$  waves in a circular cross-section waveguide containing a concentric rod of "N° 4 ferroxcube" longitudinally magnetized by a static magnetic field. The influence of porosity on attenuation has been determined.

- J. Snieder, "Ferromagnetic resonance in polycrystalline ferrites." *Appl. Sci. Res. B*, no. 3, pp. 185-232; 1958. (In English.)

A measurement process has been described which relates to the differential phase shift produced by a ferrite phase shifter in a rectangular waveguide. A laboratory phase shifter has been developed.

- M. Vadrjal, "Misura dello sfasamento differenziale in sfasatori non reciproci per microonde." *Elettronica* no. 3, pp. 108-115; 1958. (In Italian.)

## 3. NON LINEAR CIRCUITS

An article has been published covering the general theory of nonlinear circuits to be used for frequency conversion.

- S. Duinker, "General properties of frequency—converting networks." *Philips Res. Reps.* 13, 79-97 and 101-148; 1958.

## 4. QUANTUM MECHANICAL AMPLIFIERS

A survey of the theory of the molecular amplifier has been published, as well as the main disclosed results.

- G. Goudet, "La production et l'amplification d'oscillations radio-électriques à l'aide de transitions moléculaires ou atomiques." *Onde Elect.*, vol. 38, no. 379, pp. 671-686; octobre, 1958. (In French.)

Many firms are interested in this question, but few results have been published.

Any quantum mechanical system which permits a radiative transition between two energy levels will allow a multiple quanta transition; and, in addition, at least one of the energy levels shows a finite average of the electrical or magnetic dipole moment.

The possibility has been demonstrated of obtaining a stimulated emission at a  $\omega$  frequency by a two-level system in which the difference of energy is  $\hbar\omega_0$ , by applying to the system a radiation field at the frequency  $\omega' = \omega_0 + \omega$ .

- A. Javan, "Transitions à plusieurs quanta et amplification maser dans les systèmes à deux niveaux." *J. Phys. Radium*, no. 11, pp. 806-808; novembre, 1958. (In French.)

A more general study has been made of transitions involving several quanta.

- J. M. Winter, "Etude théorique et expérimentale des transitions à plusieurs quanta entre les sous-niveaux Zeeman d'un atome." *J. Phys. Radium*, tome 19, no. 11, pp. 802-805; novembre, 1958. (In French.)

## 5. NOISE

An article published by the Philips Research Laboratory, Eindhoven, Holland, may be of importance for noise studies with microwaves.

- W. Verwey, "Probe measurements of electron temperature in the positive column of a rare gas discharge and correlation with microwave noise."
- R. C. Terzo, *Congr. Int. Fenomeni d'Ionizzazione nei Gas Venezia*, pp. 1115-1130. (In English.)