

Atomic resonances were applied to the problem of developing a convenient primary frequency standard. Low-frequency crystal oscillators were locked in frequency to an atomic transition by a servo system. It was shown that frequency stability depends upon the width of the resonance and the signal to noise ratio of the detected transition. Experiments were carried out using the magnetic hyperfine transitions in sodium and caesium. Production units, with a guaranteed accuracy of 1 part in  $10^9$  and a minimum stability of 5 parts in  $10^{10}$  were described.

- [242] M. Arditi and T. R. Carver, "A gas cell 'atomic clock' using optical pumping and optical detection," 1958 IRE NATIONAL CONVENTION RECORD, pt. 1 pp. 3-9.
- [243] A. O. McCoubry, "The atomichron—an atomic frequency standard: physical foundations," 1958 IRE NATIONAL CONVENTION RECORD, pt. 1, pp. 10-13.
- [244] W. Mainberger and A. Orenberg, "The atomichron—an automatic frequency standard: operation and performance," 1958 IRE NATIONAL CONVENTION RECORD, pt. 1, pp. 14-18.

The possible use of an absorption line of oxygen for a frequency standard was also investigated.

- [245] J. M. Richardson, "Experimental evaluation of the oxygen microwave absorption as a possible atomic frequency source," *J. Appl. Phys.*, vol. 29, pp. 136-145; February, 1958.

Paramagnetic resonance was combined with nuclear magnetic resonance for the calibration of a microwave cavity. The nuclear resonance was used to accurately determine the magnetic field. With a known field, the paramagnetic resonant frequency could be calculated to an accuracy of one part in  $10^7$ .

- [246] P. A. Crandell, "An accurate frequency measuring technique using paramagnetic resonance phenomena in the X-band region," 1958 IRE WESCON CONVENTION RECORD, pt. 1, pp. 26-34.

#### CONCLUSION

Advances in Microwave Theory and Techniques in 1958 tended to center around direct interaction of microwaves and anisotropic media. Much information on masers, parametric amplifiers, and nonreciprocal and nonlinear devices was accumulated. Important improvements were also made in conventional sources, detectors, and transmission lines. The inference drawn from the recent trend is that classical approaches offer little promise for great forward steps. New concepts, new knowledge, and new approaches are necessary. A great challenge is before us.

## Report of Advances in Microwave Theory and Techniques in Great Britain—1958\*

JOHN BROWN†

#### TEM LINES

THE characteristic impedances of a coaxial type line in which the inner conductor is a flat strip and of a triplate strip line have been calculated.

- J. C. Anderson, "The calculation of characteristic impedance by conformal transformation," *J. Brit. IRE*, vol. 18, pp. 49-54; January, 1958.
- K. Foster, "The characteristic impedance and phase velocity of high-Q triplate line," *J. Brit. IRE*, vol. 18, pp. 715-723; December, 1958.

Further numerical work has been carried out on estimating the probability of a specified over-all reflection coefficient caused by a number of known mismatches of random spacing.

- J. H. Craven, "The probability of specified losses at mismatched junctions," *J. Brit. IRE*, vol. 18, pp. 293-296; May, 1958.

Transient conditions have also been considered.

- K. W. H. Foulds, "Transmission line discontinuities," *Electronic Radio Engr.*, vol. 35, pp. 263-267; July, 1958.

A study of irregularities in cable characteristic impedances has been made.

- J. Allison, "Variations of characteristic impedance along short coaxial cables," *Proc. IEE*, vol. 105, pt. C, pp. 169-176; March, 1958.

#### HOLLOW WAVEGUIDES

Interest in the properties of the low-loss  $TE_{01}$  mode in circular waveguide continues and a survey of the waveguide requirements has been made.

- A. E. Karbowiak, "Microwave aspects of waveguides for long-distance transmission," *Proc. IEE*, vol. 105, pt. C, pp. 360-369; September, 1958.

The use of dielectric filling has been suggested as a means of minimizing the losses at bends.

- H. M. Barlow "Propagation Around Bends in Waveguides," IEE Mono. No. 113R, September, 1958; will be republished in *Proc. IEE*, vol. 106, pt. C; March, 1959.

A general treatment of helical coordinate systems can be applied to helical waveguides.

- R. A. Waldron, "A helical coordinate system and its applications in electromagnetic theory," *Quart. J. Mech. and Appl. Math.*, vol. 11, pp. 438-461; November, 1958.

\* Manuscript received by the PGMTT, March, 1959.

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Numerical results have been obtained for elliptic waveguides.

R. V. Harrowell, "An approximate theory for determining the characteristic impedances of elliptic waveguide," *J. Electronics and Control*, vol. 5, pp. 289-299; October, 1958.

The dispersion properties of loaded waveguides have been analyzed by Fourier series.

P. N. Robson, "A note on the Fourier series representation of the dispersion curves for circular iris-loaded waveguides," *Proc. IEE*, vol. 105, pt. B, pp. 69-72; January, 1958.

Waveguides partly filled with dielectric have been shown to support modes in which the longitudinal magnetic field is constant over the cross section.

L. G. Chambers, "The propagation of constant longitudinal magnetic waves in dielectric filled waveguide," *Quart. J. Mech. and Appl. Math.*, vol. 11, pp. 244-252; May, 1958.

Propagation along a set of transmission lines coupled together at intervals has been expressed in terms of a set of orthogonal modes and the results used to calculate the reflection at the interface between an empty guide and one filled with an artificial dielectric.

J. Brown, "Propagation in coupled transmission line systems," *Quart. J. Mech. and Appl. Math.*, vol. 11, pp. 235-243; May, 1958.

J. Brown and J. S. Seeley, "The fields associated with an interface between free space and an artificial dielectric," *Proc. IEE*, vol. 105, pt. C, pp. 472-475; September, 1958.

A series of papers dealing with loaded transmission lines and waveguides suitable for valves was presented at the International Convention on Microwave Valves, London, May, 1958, and are published in *Proc. IEE*, vol. 105, pt. B, supp. no. 11.

G. B. Walker, "Dielectric loading for microwave valves," pp. 717-718.

A. F. Pearce, "A structure using resonant coupling elements, suitable for a high power travelling-wave tube," pp. 719-726.

P. Palluel and J. Arnaud, "Results on delay lines for high power travelling-wave tubes," pp. 727-729.

F. Sellberg, "Theoretical investigation of some closed delay structures for high power travelling-wave tubes," pp. 730-736.

E. A. Ash, "A new type of slow-wave structure for millimetre wavelengths," pp. 737-745.

R. M. White, C. K. Birdsall, and R. W. Grow, "Multiple ladder circuits for millimetre wavelength tubes," p. 746.

D. T. Swift-Hook, "Dispersion curves for a helix in a glass tube," pp. 747-755.

P. A. Lindsay and K. D. Collins, "Some aspects of the design of a helical coupler for a travelling-wave tube operating in the 2 Gc/s band," pp. 756-761.

E. A. Ash and J. D. Pattenden, "Modified transmission-line couplers for helices," pp. 762-768.

B. Minakovic, "The coupling of three coaxial helices," pp. 769-779.

J. Hirano, "Characteristics of interdigital circuits and their use for amplifiers," pp. 780-785.

Theoretical and experimental work has confirmed that the reflectivity of a conductor can be increased by coating it with a low loss high permittivity dielectric.

G. B. Walker and J. T. Hyman, "The use of dielectric materials to enhance the reflectivity of a surface at microwave frequencies," *Proc. IEE*, vol. 105, pt. B, pp. 73-76; January, 1958.

#### WAVEGUIDE COMPONENTS

The advantages to be gained by using elliptical coupling holes in directional couplers have been discussed.

J. Figanier and E. A. Ash, "Intrinsic directional coupler using elliptic coupling apertures," *Proc. IEE*, vol. 105, pt. C, pp. 432-437; September, 1958.

The design and construction of microstrip components has been discussed in detail.

J. M. C. Dukas, "Broad-band slot-coupled microstrip directional couplers," *Proc. IEE*, vol. 105, pt. B, pp. 147-154; March, 1958; "The application of printed circuit techniques to the design of microwave components," pp. 155-172; "Re-entrant transmission line filter using printed conductors," pp. 773-779.

#### FILTERS

G. Craven, "Wide-band waveguide filters with short linear tapers," *Proc. IEE*, vol. 105, pt. B, pp. 210-212; March, 1958.

M. H. N. Potok, "The design of inductive post-type microwave filters," *J. Brit. IRE*, vol. 18, pp. 263-272; May, 1958.

#### FERRITES

The propagation of waves in a circular waveguide with an axial ferrite rod has been examined theoretically and comprehensive tables of results prepared.

R. A. Waldron, "Electromagnetic wave propagation in cylindrical waveguides containing gyromagnetic media," *J. Brit. IRE*, vol. 18, pp. 597-612, October, 1958; pp. 677-690, November, 1958; pp. 733-746, December, 1958.

Variational methods have been used to assess the effect of ferrite obstacles in waveguides and cavities.

W. Hauser, "On the theory of anisotropic obstacles in cavities," *Quart. J. Mech. and Appl. Math.*, vol. 11, pp. 112-118; February, 1958. Also, "On the theory of anisotropic obstacles in waveguides," *Quart. J. Mech. and Appl. Math.*, vol. 11, pp. 427-438; November, 1958.

A survey of waveguide components using ferrites has appeared and new designs for low power duplexers have been given.

B. L. Humphreys, "Ferrite components in microwave systems," *Electronic Engrg.*, vol. 30, pp. 341-344; May, 1958.

R. S. Cole and W. N. Honeyman, "Two short low power ferrite duplexers," *Electronic Radio Engrg.*, vol. 35, pp. 282-286; August, 1958.

#### MEASUREMENTS

An ingenious power meter, in which the temperature rise in a transverse resistive card is measured, has been shown to be simple to construct and to be reliable in operation.

J. A. Lane, "Transverse film bolometers for the measurement of power in rectangular waveguides," *Proc. IEE*, vol. 105, pt. B, pp. 77-80; January, 1958.

A Hall effect wattmeter has been investigated at a frequency of 10gc/s.

H. E. M. Barlow and S. Kataoka, "The Hall effect and its application to power measurement at 10Gc/s," *Proc. IEE*, vol. 105, pt. B, pp. 53-60; January, 1958.

Design details for a direct reading thermistor bridge for power measurement at 2000 mc have been given.

J. K. Murray, "U.H.F. Power meter for operation in the 2000 Mc/s communication band," *Electronic Engrg.*, vol. 30, pp. 345-348; May, 1958.

Several aspects of standing wave ratio measurements have received further attention.

E. W. Collings, "Voltage standing wave ratio measurements," *Electronic Radio Engrg.*, vol. 35, pp. 287-289; August, 1958.

R. S. Cole and W. N. Honeyman, "Two automatic impedance plotters," *Electronic Engrg.*, vol. 30, pp. 442-446; July, 1958.

J. Allison and F. A. Benson, "Measurement and attenuation of a cable of impedance through an arbitrary loss-free junction," *Proc. IEE*, vol. 105, pt. B, pp. 487-495; September, 1958.

N. F. McKenna, "Low loss structures in waveguides," *Electronic Radio Engrg.*, vol. 35, pp. 470-473; December, 1958.

## 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. Karbowski, "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. Karbowski, "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 converters," 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  $TE_{01}$  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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