

Report of Advances in Microwave Theory and Techniques in Western Europe—1959*

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DURING 1959, the main progress in Western Europe was concerning further development of types "O" and "M" carcinotrons and studies about quantum devices. Nevertheless, other subjects have not been neglected.

1. VACUUM AND GAS TUBES

1.1 Vacuum Tubes

1.1.1 *Conventional tubes:* Some new conventional tubes for decimetric waves have been introduced, especially in Germany. The PC 86 type, intended for use as grounded grid amplifier, has been developed by Telefunken.

A water cooled disk triode, the EC 59, has been designed on the basis of the previous EC 57 type, and has an output power of 10 w CW at 4000 mc with a bandwidth of 100 mc and a gain of about 10 db.

H. Buenger, "PC 86, Eine neue entwickelte Gitterbasistriode für dezimeterwellen," *Telefunken Z.*, no. 122, pp. 262-265; December, 1958. (In German.)

V. V. Schwab and J. G. van Wigngaarden (Valvo GmbH Radio-röhrenfabrik, Hamburg), "Le tube EC 59, une triode d'émission d'une puissance de 100 W à 4000 MHz," *Philips Tech. Rev.*, no. 9, pp. 253-262; May, 1959. (In French.)

A planar measuring diode, the distance between electrodes of which can vary from 40μ to 1 mm, has been constructed at the University of Berlin, to enable study of the space charge and transient phenomena at the frequencies between 1.6 and 4 kmc, the current density being able to reach 200 ma/cm² and anode voltage up to 30 volts.

K. Hennings (Tech. Univ., Berlin), "Leitwerts—Messungen an einer plan parallelen diode im Laufzeitgebiet," *Nachrichtentech. Z.*, no. 9, pp. 459-461; September, 1959. (In German.)

The Centre National d'Etude des Télécommunications uses analogical means for the study of electron guns: an automatic rheographic curve with automatic curve tracer and a device intended for testing electron guns, including facilities of electrical supply, vacuum, magnetic fields and travelling of electrodes. This installation has proved very useful for solving problems involved in the design of microwave tubes.

J. Henaff (C.N.E.T., Paris), "Les moyens d'étude d'optique électronique du CNET," *Echo des Recherches*, no. 34, pp. 16-31; August, 1959. (In French.)

The use of vacuum diodes for the detection of microwaves has been studied in Spain by the Instituto Nacional de Electronica.

E. Meyer and F. Wächter, "Detección de microondas en valvulas de vacío," *Revista "INE"*, vol. 2, pp. 165-178; July, 1959. (In Spanish.)

1.1.2 *Magnetrons:* The French company Lignes Télégraphiques et Téléphoniques have developed a whole set of components for the Q-band. In this way, a pulsed magnetron operating at 35,000 mc and delivering a peak power of 200 kw has been realized. The mean power is 80 w. The anode structure is of the "rising sun" type and includes 26 cavities. The development of this tube has been conducted under a contract of the French Government.

R. Zwobada, "A 200 kw 80 w Q-band magnetron," *Proc. IEE*, pt. B, vol. 105, suppl. no. 10, pp. 426-428, 443, 445; May, 1958.

A line of CW magnetrons operating in the frequency band 2425-2475 mc has been developed for industrial use, delivering RF power from 100 w to 1 kw. They are characterized by a high efficiency and a long life expectancy.

Mlle Cagnac (C.S.F.), "Les magnétrons industriels," *Onde électrique*, no. 390, pp. 723-725; September, 1959. (In French.)

Experimental magnetrons operating on the wavelengths of 32, 12, 8 and 4 mm have been realized by the Philips Laboratories at Eindhoven, The Netherlands. They can deliver peak powers of, respectively 1100, 70, 80 and 40 kw.

J. Verweel and G. H. Plantinga, "Une série de magnétrons à impulsions, à cathode L, pour ondes centimétriques et millimétriques," *Philips Tech. Rev.*, vol. 21, pp. 1-10; December, 1959. (In French.)

In order to obtain CW power of a few kilowatts, magnetrons are available; but for higher powers, it is necessary to use several tubes in parallel. It has been shown that the use of separated injection devices permits, by overlaying suitable modes of oscillation, a nearly constant repartition of the density of energy to be obtained in the useful space.

W. Schmidt (Entwicklungsabt., Valvo GmbH Radio-röhrenfabrik, Hamburg), "Parallelbetrieb von mehreren Einkopplungssystemen in Mikrowellen generator mit abgeschlossenen Arbeitsräumen," *Elektron. Rundschau*, no. 8, pp. 280-282; August, 1959. (In German.)

1.1.3 *Klystrons:* Electronic-hysteresis phenomena occurring at the build-up of oscillations in reflex klystrons have been explained by taking a careful survey of the variation of beam admittance as a function of repeller

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voltage and RF voltage in the gap between the grids. The conclusion is that these phenomena are essentially due to secondary emission in the space comprised between the grids of the klystron cavity.

R. P. Musson-Genon and C. Audouin, "A new analysis of electronic hysteresis and secondary-emission phenomena in local-oscillator reflex klystrons," *Proc. IEE*, pt. B, vol. 105, suppl. no. 12, pp. 1006-1007; May, 1958. (In English.)

An electron gun suitable for the production of a small-diameter beam has been studied for high-power broadband klystrons. The beam is produced by a convergent gun, the cathode being placed in a magnetic field of suitable shape.

C. Zloty kamin, "High density electron gun with magnetic field," *Proc. IEE*, pt. B, vol. 105, suppl. no. 12, pp. 939-940; 1958. (In English.)

Theoretical considerations show that the efficiency of high-power pulsed klystrons is little impaired by the use of high perveances. The correlative lowering of the applied voltage is advantageous for the realization of the power supplies and for certain characteristics of the tube.

P. Palluel and G. Kantorowicz (C.S.F., Paris), "Klystrons de puissance élevée en impulsions utilisant une grande perveance," *Onde électrique*, no. 383, pp. 109-115; February, 1959. (In French.)

The problem of the improvement of linearity of frequency-modulated reflex-klystron has been studied. A solution using a special load, the impedance of which, correcting the modulation characteristic of the klystron, has been developed, and the possibilities of practical realization investigated. Such a circuit has been successfully tested with different types of klystrons.

G. Cicconi (Div. Ponti Radio, Fabbr. ital. Magnet, Marelli, Milano), "Sul miglioramento della linearità di clistron reflex come generatori modulati in frequenza," *Alta frequenza*, no. 6, pp. 634-682; December, 1958. (In Italian.)

A determination of the phase aberration coefficient in a reflex klystron has been made by studying the beam admittance and the variation of amplitude as a function of the position of departure from the cathode.

J. Bonnerot, "Détermination du coefficient d'aberration de phase dans un klystron reflex," *Compt. Rend. Acad. Sci., Paris*, no. 20, pp. 2023-2025; November 16, 1959. (In French.)

1.1.4 Travelling-wave tubes: The most important parameters of travelling-wave tubes influencing the gain have been investigated, including the different means for focusing the electron beam. The possible upper limits for the gain have been evaluated, as far as noise and oscillation by internal reflections are concerned.

A calculation of the reflections of a non-uniform active helix line with a localized attenuation has shown the influence of these reflections on gain, delay and impedance fluctuations. Some characteristic measurements have confirmed the validity of the theoretical investigations.

W. Klein (Standard Elektrik Lorenz, Stuttgart), "Die Grenzen der Verstärkung von Wanderfeldröhren für Richtfunkstrecken," *Arch. elektr. übertragung.*, no. 7, pp. 273-286; July, 1959. (In German.)

It has been shown that the calculation of the minimum noise figure of electron-beam amplifiers can be performed in a manner similar to the calculation of the minimum noise figure of network fourpoles.

M. T. Vlaardingerbroek "Noise in electron beams and in four-terminal networks," *Phillips Res. Repts.*, vol. 14, no. 4, pp. 327-336; August, 1959. (In English.)

At the Institut für Hochfrequenztechnik, of Zürich, a study of rectangular electron beams has been conducted.

R. A. Aeschlimann, "Untersuchungen über Elektronenstrahlen mit rechteckigen Querschnitt," Juris-Verlag, Zürich, dissertation at Eidgenössische Technische Hochschule, no. 2866; 1959. (In German.)

An analysis has been made of the interaction between an electron beam and an electromagnetic wave propagating along a helix wound around the beam. The conditions of operation of a traveling-wave tube have been calculated, and the characteristic curves established. Numerical applications have been made, using an electronic computer.

A. Martorell, "Analisis de un tubo de onda progresiva," *Rev. Telecommunic.*, no. 54, pp. 2-14; December, 1958. (In Spanish.)

Problems involved in the design of low-noise traveling-wave tubes have been studied in order to improve their noise figure.

P. H. J. A. Kleijnen, "Traveling wave buizen," *Tijdschr. Nederl. Radiogenootsch.*, vol. 24, nos. 2/3, pp. 71-88; 1959. (In Dutch.)

A. Versnel, "Lopende golfbuizen met laag ruisgetal," *Tijdschr. Nederl. Radiogenootsch.*, vol. 24, nos. 2/3, pp. 101-112; 1959. (In Dutch.)

A traveling-wave tube with helical conductor with an output power of 10 w at 4000 mc has been realized.

C. T. de Wit (Natuurk Lab., N. V. Philips Gloeilampenfabr., Eindhoven), "Een 10 watt lopende golfbus voor de 7.5 cm band," *Tijdschr. Nederl. Radiogenootsch.*, no. 2-3, pp. 89-100; 1959. (In Dutch.)

A traveling-wave amplifier operating at 4 kmc has been developed for use in transmitters of multi-channel microwave links.

W. Klein (Telefunken, Ulm/Donau), "Die Wanderfeldröhre TL 6 als Endverstärker in 4 GHz-Richtfunkanlagen," *Fernmelde Frax.*, no. 21, pp. 810-820; November, 1959. (In German.)

Considerable work has been done at the French firm Compagnie Générale de Télégraphie sans Fil (C.S.F.) concerning *M*-type tubes. Theoretical and experimental approaches have been used simultaneously in order to determine precisely the phenomena involved. The results of an experimental study made on an electron gun for traveling-wave tube have been analyzed as concerns the variation of the cathode current vs the applied voltage in the presence of a magnetic field.

A. F. Leblond (C.S.F., Paris), "Study of the electron trajectories in guns for *M*-type tubes," *Proc. IEE*, pt. B, vol. 105, suppl. no. 12, pp. 1021-1023; May, 1958.

A new analogous method has been used for studying the grouping of electrons in a beam in interaction with a slow wave in the presence of crossed electrical and

magnetic fields. Interesting experimental results have been obtained this way.

B. Epsztein (C.S.F., Paris), "An experimental study of large signal behaviour in *M*-type valves in the presence of space charge by the use of an analogous method," *Proc. IEE*, pt. B, vol. 105, suppl. no. 10, pp. 598-604; May, 1958.

Two kinds of anomalous phenomena have appeared during the development of *M*-type carcinotron: concerning the static behavior of the tube, independent of 1) RF phenomena and 2) dynamical phenomena. The latter are: anomalous power/current characteristics, parasitic oscillations, hysteresis and discontinuities.

J. Nalot and R. Visocekas (C.S.F., Paris), "Anomalous behaviour in the *M*-type carcinotron," *Proc. IEE*, pt. B, vol. 105, suppl. no. 10, pp. 538-542; May, 1958.

An experimental tube analogous to the *M*-type carcinotron, the carmatron, has been realized and its characteristics compared with that of *M*-type carcinotron and variable voltage magnetron.

O. Doehler, B. Epsztein, and J. Arnaud (C.S.F., Paris), "Operational characteristics of the carmatron tube," *Proc. IEE*, pt. B, vol. 105, suppl. no. 10, pp. 529-533; May, 1958.

It has been shown that the advantages of the *M*-type tubes, namely their high efficiency (45 per cent) and their high-power capabilities (1 kw at 3000 mc), can be preserved in pulsed operation, and the problems arising from this mode of operation have been discussed. Tubes of this type operating in the *S* and *X* bands have been constructed.

M. Favre (C.S.F., Paris), "Results obtained on cross-field carcinotrons under pulsed operation," *Proc. IEE*, pt. B, vol. 105, suppl. no. 10, pp. 533-537; May, 1958.

A pulsed magnetron amplifier delivering a peak output power of several megawatts, with an efficiency of 50 per cent and a relative bandwidth of 15 per cent, has been developed by Compagnie Française de Télégraphie sans Fil. This tube operates by interaction between an electron beam simultaneously perpendicular to the electrical and magnetic fields. The tube is of coaxial shape, the beam being bent by a magnetic field produced by an intense direct current circulating in the circular sole.

O. Doehler, A. Dubois, and D. Maillart (C.S.F., Paris), "An *M*-type pulsed amplifier," *Proc. IEE*, pt. B, vol. 105, suppl. no. 10, pp. 454-457; May, 1958.

The Compagnie Générale de Télégraphie sans Fil continues the development of type-*O* carcinotron, directed towards higher operating frequencies. In this way, furthering the previous development of tubes operating up to 100 kmc, laboratory samples of type-*O* carcinotrons oscillating up to 170 kmc have been constructed. These tubes involve a convergent gun delivering a concentrated beam, the density of which is 40 to 50 a/cm². The output power is about 1 mw, but it appears possible to design tubes delivering up to 50 mw at 150 kmc. Improvements on hand will probably permit operation at a frequency of 200 to 250 kmc rather near the limit of this kind of tube, estimated to be in the vicinity of 300 kmc.

Yeou Ta (C.S.F., Paris), "Carcinotrons de type *O* fonctionnant à 2 mm," *Onde électrique*, no. 391, pp. 789-794; October, 1959. (In French.)

The manufacture of *M*-type carcinotrons necessitates a high mechanical accuracy. Technological processes have been developed in order to meet the requirements of production of very small electrodes, especially for the millimetric-wave tubes.

G. Boucher (C.S.F., Paris), "Technology of carcinotrons for short and long wavelengths," *Proc. IEE*, pt. B, vol. 105, suppl. no. 12, pp. 897-900; May, 1958.

A backward-wave oscillator has been developed by Siemens und Halske A.G., using a circular beam of 0.3 mm to 0.35 mm diameter and a current density of 15 to 20 a/cm². The beam is guided in the space of interaction with the delay line, by means of a permanent magnet. This tube oscillates from 26.5 to 48 kmc and delivers a power greater than 40 mw.

F. Gross (Siemens und Halske, München), "Ein Rückwärtswellen-oscillator mit periodischer Verzögerungsleitung für den Frequenzbereich von 25 bis 48 GHz," *Arch. elekt. Übertragung* no. 8, pp. 356-362; August, 1959. (In German.)

The Gundlach theory has been applied to the *O*-type carcinotron using an interdigital line poorly matched. The effects of the reflections on the frequency characteristic of the tube have been studied, as well as the case of transients. The results fit well with experimental results.

K. H. Loecherer (Inst. Hochfrequenztech., Univ. Berlin), "Bemerkungen zur Theorie der Rückwärtswellenröhre," *Nachrichtentech. Z.*, no. 4, pp. 187-192; April, 1959. (In German.)

At the University of Berlin, carcinotron-type tubes using interdigital lines have been constructed. The influence of reflections on the frequency stability has been studied in detail, and a tube operating in the 4-8 cm band realized, giving an output power of 50-800 mw.

G. Bolz (Tech. Univ., Berlin), "Aufbau und Eigenschaften von Rückwärtswellenröhren," *Nachrichtentech. Z.*, no. 3, pp. 120-127; March, 1959. (In German.)

1.2 Gas Tubes

1.2.1 *Duplexer tubes*: The difficulties encountered in the realization of high-power twin TR tubes for the 23-cm band have led to another solution, using a total coupling junction. This leads to a very simple construction, and the gas tube is easy to replace.

P. Tcheditch (C.S.F., Paris), "Duplexeur pour grande puissance dans la bande 23 cm," *Onde électrique*, vol. 38 (August, 1958), special suppl. no. 376 ter, pp. 478-480; March, 1959. (In French.) This special supplement of *Onde électrique*, published in March, 1959, will hereafter be referred to as simply "special suppl. no. 376 ter; March, 1959."

For powers higher than 15 mw in the *S* band, a screen duplexer has been realized. It utilizes a totally coupled junction, the window of which contains small quartz tubes with argon. Such devices have been tested with peak powers up to 30 mw.

R. Vauthey (C.F.T.H.), "Duplexeur à rideau et son utilisation en très grande puissance," *Onde électrique*, special suppl. no. 376 ter, pp. 488-493; March, 1959. (In French.)

The problem of high-power duplexing in millimetric waves has been solved by the use of a 3-db hybrid junction containing gas tubes, and acting as a switch. This solution appears to be reliable and much better than the one using conventional TR and ATR tubes, which are too difficult to manufacture and unable to withstand high power.

H. Weill (S.N.E. Radio-Industrie, Paris), "Duplexeur haut niveau à large bande réalisable en ondes millimétriques," *Onde électrique*, special suppl. no. 376 ter, pp. 473-477; March, 1959. (In French.)

1.2.2 Gas masers: The effects of the multiple diffusion of the optical resonance light upon the lifetime of the excited atomic level are studied. The theory allows to find again the case of one atom (single diffusion); for two atoms, the equations of evolution of the excited state probabilities are coupled by coefficients that physically correspond to the passage of the excitation from one atom to another. This is then applied to the case of N atoms in a gas. Some experiments confirm the preview of the theory.

J. P. Barrat, "Etude de la diffusion multiple cohérente de la lumière de résonance optique. Application au niveau $6^3 P_1$ du mercure," *J. Phys. Radium*, vol. 20, pp. 541-548; May, 1959; pp. 633-646, June, 1959; p. 657; July, 1959. (In French.)

A realization of a beam cesium atomic clock is going on in Italy at Torino, where the study was begun in 1957. The report is concerned with the first eighteen months work.

M. Boelea, "Costruzione di un campione di frequenza al cesio presso l'Istituto Elettrotecnico Nazionale 'Galileo Ferraris,'" *Ricerca sci.*, vol. 29, pp. 267-271; February, 1959. (In Italian.)

1.2.3 Plasmas: A theoretical analysis of the plasma-field coupling has been conducted with a careful study of the hypothesis. The fundamental equations thus established have been applied to the study of the main types of electromagnetic and magnetohydrodynamic waves capable of propagating through a thoroughly ionized plasma.

J. M. Dolique (C.S.F., Paris), "Propagation des ondes électromagnétiques dans les plasmas complètement ionisés résistifs," *Ann. Radioélect.*, no. 56, pp. 107-141; April, 1959. (In French.)

A study has been made of the propagation constant of the TE_{10} modes in a rectangular waveguide containing a thin film of gyroelectric plasma.

L. Gabarre and L. Cairo (Inst. Henri-Poincaré, Paris), "Méthode variationnelle pour la propagation des ondes électromagnétiques dans un plasma," *Compt. Rend. Acad. Sci., Paris*, no. 18, pp. 1750-1752; November 2, 1959. (In French.)

A study has been conducted of the electronic distribution in an inhomogeneous and anisotropic Lorentzian plasma by means of statistical mechanics, and the results have been extended to the case of an applied alternative field.

R. Jancel and T. Kahan (Inst. Henri-Poincaré, CNRS, Paris), "Mécanique statistique d'un plasma lorentzien inhomogène et anisotrope: étude de la distribution électronique," *J. Phys. Radium*, no. 10, pp. 804-811; October, 1959. (In French.)

Stable RF plasmoids have been obtained, at the resonance frequency of the plasma, with a density of about 10^7 electrons/cm³ and a temperature in the vicinity of 10^5 K.

R. Geller, "Production de plasmoïdes de haute fréquence stables à la fréquence de résonance du plasma," *Compt. Rend. Acad. Sci., Paris*, no. 25, pp. 2749-2751; December 21, 1959. (In French.)

A plasma torch operating in the 2400-mc band has been realized. It consists of a coaxial blow-pipe and a microwave generator using a CW magnetron. It is thus possible to create, in an oxygen-free zone, a temperature higher than 3000°C with a power less than 1 kw. In the useful zone, the active molecules are dissociated by free electrons. At the output of the waveguide, the plasma forms a glowing zone where ions recombine at the contact of the material to be heated and transmit their bonding energy under heat form.

W. Schmidt (Entwicklungsstab, Valvo GmbH), "Der mikrowellen-Plasmabrenner," *Elektron. Rundschau*, no. 11, pp. 404-406; November, 1959. (In German.)

1.2.4 Miscellaneous: In order to produce harmonics of an RF field, an oscillating beam of secondary electron has been directed, through holes in the cavity, towards a resonator tuned on harmonics. With the oscillating multiplication producing a high proportion of harmonics, resonators are excited.

K. Krebs and H. von Villiez (Phys. Inst. tech., Univ. Berlin), "Die Anregung von Hohlraumresonatoren durch Pendelvervielfachung von Sekundärelektronen," *Z. Phys.*, vol. 154, no. 1, pp. 27-33; 1959. (In German.)

2. PASSIVE CIRCUITS AND SOLID-STATE DEVICES

2.1 Transmission Lines

Silver-plated microwave elements of very high precision (better than 1/100 mm) were obtained by the Laboratoire de Radioélectricité de la Faculté des Sciences de Clermont-Ferrand by evaporating silver in vacuum on "Plexiglass" and after depositing copper by electroforming.

G. Raoult and R. Fauguin, "Galvanoplastie sur plexiglass argenté. Son application à diverses réalisations hyperfréquences," *J. Phys. Radium*, vol. 20, pp. 29A-31A; April, 1959. (In French.)

The principal causes of perturbations in microwave guides have been studied; it is shown that generally the differences in aperture dimensions produce more mismatch than assembling defects such as off-settings, rotation or misaligning. Siemens und Halske A.G. has realized a universal measuring line for the 1-13 gc band, the realization of the junctions is described in detail, concurrently with that of the isolating supports.

U. V. Kienlin and A. Kuerlz (Siemens und Halske A.G., München), "Reflexionen an Hohlleiter—Flanschverbindungen Entwicklungs," *Ber. S. und H. Akt Ges. Dtsch.*, vol. 22, pp. 85–88; April, 1959. (In German.)

W. Krauss (Berlin), "Spezielle probleme der Höchtfrequenz—Mess-technik mit Hohlleitern," *Nachrichtentech. Z.*, pp. 351–359; August, 1959. (In German.)

M. Ebisch (Siemens und Halske A. G., München), "Koaxiale Messleitung—Einsätze Hoher Genauigkeit für den Frequenzbereich 1 bis 13 GHz," *Frequenz Deutsch*, no. 2, pp. 52–56; February, 1959. (In German.)

Researches on transmission of TE_{01} waves in circular waveguides are pursued.

P. Marie (C.N.E.T., Issy-les-Moulineaux), "Transition créant le mode TE_{01} circulaire à partir du mode TE_{01} rectangulaire," *Onde électrique*, special suppl. no. 376 ter, pp. 471–472; March, 1959. (In French.)

A. Jauman (Zentral Lab. Siemens und Halske A.G., München), "Ueber Richtungskoppler zur Erzeugung des H_{01} —Welle in runden Hohlleiter—Entwicklung," *Ber. S. und H. Akt. Ges.*, vol. 22, pp. 12–18; April, 1959. (In German.)

J. Bendayan, G. Comte and M. Thue (C.N.E.T., and Les Câbles de Lyon), "Research on transmission of TE_{01} waves in circular waveguides in the vicinity of 25 and 35 Gc/sec," *Proc. IEE*, pt. B, vol. 106, suppl. no. 13, pp. 94–99; January, 1959. (In English.)

H. Schnitger, "Die Hohlkabeltechnik," *Jahrb. elekt. Fernmeldewes.*, vol. 10, pp. 109–147, 1958 (In German.)

2.2 Linear Circuits

2.2.1 Dipoles: A calorimeter for the measurement of high power was studied. The dissipative device is not mounted in the main waveguide but is coupled to it by means of a grating. The precision is better than two per cent.

T. Jaeger and M. V. Schneider (Inst. Hochfrequenztech., Eidgenoss. tech. Hochsch., Zürich), "Ein Breitbandiges Mikrowellenkalorimeter für Hohe Leistungen," *Arch. elektr. Übertragung.*, vol. 13, pp. 21–25; January, 1959 (In German.)

The impedance presented by a reflex-klystron to its output guide out of an oscillating lobe varies rapidly with reflex electrode voltage. This impedance variation can be utilized to amplitude modulate the energy flowing through a waveguide. The modulation obtained is linear.

R. Metivier and P. Audoin (C.F.T.H., Paris), "Modulation en amplitude à l'aide d'un klystron-reflex de l'énergie hyperfréquence transmise sur un guide d'ondes," *Onde électrique*, special suppl. no. 376ter, pp. 509–512; March, 1959. (In French.)

2.2.2 Reciprocal multipoles: In view of the study of octopoles and of lossless directional couplers, a graphical method is described for the determination of the reflection coefficient based on the positions of short-circuiting slugs.

H. Lueg (Telefunken Ulm/Donau,), "Méthode de mesure pour l'examen des octopoles et coupleurs directifs sans pertes entre les lignes homogènes utilisant des pistons de court-circuits," *Onde électrique*, special suppl. no. 376 ter, pp. 380–387; March, 1959. (In French.)

A theoretical and experimental study was conducted on the necessary conditions for the convenient measurement of a symmetrical impedance. The measurement is easy, provided a symmetrical measuring line is available.

H. Frieke (Tech. Hochsch., Aachen), "Messung symmetrischer Scheinwiderstände im Meter und Dezimeterwellengebiet," *Nachrichtentech. Z.*, vol. 12, pp. 233–238; May, 1959. (In German.)

A certain number of microwave filter studies were published in the special supplementary issue of *Onde électrique*, vol. 38.

L. Milosevic (C.F.T.H., Paris), "Blocs d'aiguillage sélectif en hyperfréquence," *Onde électrique*, special suppl. no. 376 ter, pp. 341–369; March, 1959. (In French.)

S. Drabovitch (C.F.T.H., Paris), "Un filtre U.H.F. à faibles pertes pour liaisons hertziennes 'transhorizon,'" *Onde électrique*, special suppl. no. 376, pp. 412–418; March, 1959. (In French.)

M. Clement (Cie gén. téligr. sans fil, Paris), "Etude et réalisation d'aiguillage par filtres en anneaux pour faisceaux hertziens," *Onde électrique*, special suppl. no. 376 ter, pp. 419–423; March, 1959. (In French.)

R. Havot (Lab. électron. Phys. appl., Paris), "Filtres de branchement pour faisceaux hertziens à 4000 MHz," *Onde électrique*, special suppl. no. 376 ter, pp. 441–446; March 1959 (In French.)

P. Marie (C.N.E.T., Issy-les-Moulineaux), "Filtres d'aiguillage hyperfréquence," *Onde électrique*, special suppl. no. 376 ter, pp. 424–429; March, 1959. (In French.)

A paper dealing with the computation of microwave filters was published by Societa Magneti Marelli, Milano. It recalls the most important papers already published and presents an abacus for the quick computation of a filter and the rules to be applied to obtain a particular response. It also describes some filters realized in the 800–2000 MHz band.

L. Caroli and U. Cucina, "Progetto e attuazione di filtri per microonde," *Alta frequenza*, vol. 28, pp. 211–232; July–August, 1959. (In Italian.)

Siemens und Halske A.G. have published a study of filters considering only those networks which have attenuation poles. These networks can be utilized in filters which must present a very high attenuation on only one side of the pass-band.

F. Kuenemund (Siemens und Halske A.G., München), "Hohlleiterfilter mit versteilter Dämpfungscharakteristik," *Frequenz Deutsch.*, vol. 13, pp. 97–102; April, 1959. (In German.)

A coaxial three-path rotary joint and a multiple-path rotary joint realized by means of annular waveguides was described in the special supplementary issue of *Onde électrique*. A very small dead angle is left in multiple-path rotary joint.

A. Depauw and J. Danis (SNE Radio-Industrie, Paris), "Joint tournant à trois voies hyperfréquences," *Onde électrique*, special suppl. no. 376 ter, pp. 460–462; March, 1959 (In French.)

M. Sirel (SNE Radio-Industrie, Paris), "Joint tournant à nombre de voies multiples," *Onde électrique*, special suppl. no. 376 ter, pp. 463–470; March, 1959. (In French.)

Some directional couplers were studied in 1959. Perturbation calculus allows the computation of a directional coupler having a longitudinal slot of any section. For a particular attenuation, the width of the slot increases when the guide wavelength decreases, or when the intensity near the slot decreases, or else when the length of the coupling decreases. Some experimental results confirm these theoretical data.

H. Pascher (Siemens und Halske A.G., München), "Langschlitz-Richtungskoppler für H. Wellen," *Arch. elekt. Übertragung.*, vol. 13, pp. 76-82; February, 1959. (In German.)

A skin coupler may be obtained by reducing the wall thickness between two cylindrical waveguides so that transmission of microwave power through the wall is possible. The "top wall coupler" has promising properties as a broad-band system. The loss of the system cannot be avoided. Application for *K*-band, *J*-band frequencies and above seems to be promising. The thin metallic layers can also be used as detector-devices.

V. M. Schneider (Ecole polytechnique fédérale, Zürich), "The skin coupler, a method of directional coupling," *Onde électrique*, special suppl. no. 376 ter, pp. 375-377; March, 1959. (In English.)

M. Schneider, "Eigenschaften und Anwendungen dünner metallischer Schichten im Mikrowellenbereich," *Tech. Mitt. P.T.T.*, vol. 37, pp. 465-495; November, 1959. (In German.)

A coaxial directional coupler has been studied in Italy. They consider the two lines coupled by an octopole, and demonstrate that directional coupling is obtained for certain internal structures of the octopole and certain values of the impedances which constitute it. They deduct the directional condition, the coupling expressions, and the input impedance.

I. Bucci (Fabbr. Ital. Magneti Marelli, Milano), "Accoppiatori direttivi in linea coassiale," *Alta Frequenza* vol. 28, pp. 260-276; July-August, 1959. (In Italian.)

A few circuits which allow stabilization of the klystron frequency by means of a cavity have been described:

J. Fagot and J. Queva (Cie gén. Télégr. sans Fil, Paris)—"Stabilisation d'un klystron-reflex par une cavité extérieure à haute surtension," *Onde électrique*, special suppl. no. 376 ter, pp. 395-402; March, 1959. (In French.)

L. Milosevic (C.F.T.H. Paris)—"Oscillateur stabilisé," *Onde électrique*, special suppl. no. 376 ter, pp. 403-411; March, 1959. (In French.)

Circuits which allow automatic frequency control are also described:

L. del Bello (Fabr. Apparech. Communic. electr. Standard, Milano), "Commando di Frequenza per clistron con cavità di riferimento," *Alta Frequenza*, vol. 27, pp. 629-633; December, 1958. (In Italian.)

C. Levaillant (C.F.T.H., Paris), "Discriminateur hyperfréquence à large bande; application aux têtes HF monobouton," *Onde électrique*, special suppl. no. 376 ter, pp. 513-528; March, 1959. (In French.)

B. Basini (Fabbr. Ital. Magneti Marelli, Milano), "Cavità di riferimento per comando automatico di frequenza," *Alta frequenza*, pp. 277-284; July-August, 1959. (In Italian.)

At the end the preceding paper, the author describes a particular cavity with ferrite giving a modulable resonant frequency. Its utilization is described.

Wide-band ferrite attenuators, with low insertion losses, may eventually dissipate important UHF powers and allow the control and the adjustment of the UHF power.

P. Sermet and J. Murier (Lab. HF, Fac. Sci., Grenoble), "Asservissement et régulation de puissance dans les bandes *X* et *S* par des atténuateurs à ferrites," *Onde électrique*, special suppl. no. 376 ter, pp. 529-534; March, 1959. (In French.)

A simple network, comprising klystron, absorption wavemeter, detection crystals, and magic Te, allows one to measure *Q* factors from 2000 to 8000 as well as much lower values (about 200) in the *X* band. The measuring method and its precision are given.

A. Strub (Lab. HF, Fac. Sci., Univ. Grenoble), "Appareillage simple pour la mesure de facteurs de surtension dans la bande *X*," *J. Phys. Radium*, vol. 20, pp. 42A-43A; April, 1959. (In French.)

A spectrometer using the cavity and pulse techniques has been studied; the output response signals from a reference cavity and the measuring cavity are not directly compared. They are sent through two pulse generators whose networks trigger pulses of a microsecond on determined points of each response curve. The measure is obtained by comparison of the relative position of these pulses on the screen of a synchroscope.

A. Gozzini, A. Battaglia (Ist. Fis., Univ. Pisa), G. Boudouris, D. Ilias (Lab. Phys. Atmosph., Paris), and F. Bruin (Naturr. Lab., Univ. Amsterdam), "Un spectromètre en microonde utilisant la technique des cavités et des impulsions," *Onde électrique*, special suppl. no. 376 ter, pp. 430-440; March, 1959. (In French.)

2.2.3 Nonreciprocal multipoles: A number of studies on ferrites and their behavior in UHF have been published in 1959.

A. Vassiliev (Cie gén. Télégr. sans Fil, Paris), "Contribution à l'étude des ferrites pour leur emploi en UHF," *Onde électrique*, spec. suppl. no. 376, pp. 574-581; March, 1959. (In French.)

F. Picherit, "Effet Faraday de divers bâtonnets de ferrites," *Compt. Rend. Acad. Sci., Paris*, vol. 249, pp. 69-70; July 6, 1959. (In French.)

Equimolecular substitution of Cr_2O_3 or Al_2O_3 in Ni-Zn ferrites allows the absorption of UHF waves crossing the material to diminish considerably.

W. Kagan and R. Vautier (C.N.R.S., Paris), "Ferrites à faibles pertes en hyperfréquence," *Onde électrique*, special suppl. no. 376 ter, pp. 560-564; March, 1959. (In French.)

R. Vautier and W. Kagan (Lab. Magnétisme, C.N.R.S., Bellevue), "Propriétés aux hyperfréquences de ferrites chromites de Ni-Zn," rept. of Colloque National de Magnétisme, Strasbourg, July 8-10, 1957, pp. 326-336; 1959. (In French.)

The variations with the temperature of the resonant frequency and of the nonreciprocal phase delay or the Faraday rotation nearly disappear for certain dimension of ferrite element.

W. Haken and C. von Haza-Radlitz (Siemens und Halske A.G., München), "Ferrit-Körper mit Temperaturunabhängigen gyromagnetischen Eigenschaften," *Arch. elekt. Übertragung*, vol. 13, pp. 157-160; April, 1959. (In German.)

The propagation in circular waveguide filled up with a gyromagnetic substance was studied in the particular case where the low value of susceptibilities allows the definition of two modes: one quasi TE and one quasi TM. The expressions of the different emergent-wave characteristics were obtained: wavelength, absorption, polarization-plan rotation and ellipticity.

J. Soutif (Lab. Electrostatique Phys. du métal, Grenoble), "Propagation dans un guide d'onde circulaire rempli d'une substance gyromagnétique," *Onde électrique*, special suppl. no. 376 ter, pp. 599-601; March, 1959. (In French.)

The report of the Colloque National de Magnétisme, Strasbourg (July 8–10, 1957) was published in 1959. An experimental study to check the theoretical results shortly recalled was described. Metals salts in state S were used where the spin-orbit coupling did not interfere and where the powder isotropy was obtained, not by mean, but by an intrinsic quality of each grain.

J. Soutif-Guicherd, "Effet Faraday paramagnétique," rept. of the Colloque National de Magnétisme, Strasbourg, July 8–10, 1957, pp. 301–303; 1959. (In French.)

The measurements of ferrite complex permeability show anomalies incompatible with the classical theory of the gyromagnetic effect. The resonant points found at very high frequencies are attributed to the spin waves. The anomalies that exist at lower frequencies may be explained in considering the ferromagnetic materiel as formed by little magnets with mutual induction.

P. M. Prache (Soc. Lignes Télégr. Téléph., Paris), "Les anomalies de la perméabilité des ferrites aux fréquences élevées," *Bull. Soc. franq. électriciens*, vol. 9, pp. 329–340; June, 1959. (In French.)

The propagation modes in a waveguide with parallel walls filled up with ferrite magnetized in a parallel to walls direction were calculated. They determine a relatively simple form of the characteristic equation.

G. Barzilai and G. Gerosa (Ist. Elettrotec., Univ. Roma), "Modes in rectangular guides filled with magnetized ferrite," *Onde électrique*, special suppl. no. 376, pp. 612–617; March 1959. (In English.)

G. Barzilai and G. Gerosa, "Modes in rectangular guides partially filled with transversely magnetized ferrite" *IRE TRANS. ON ANTENNAS AND PROPAGATION*, vol. AP-7, special suppl., pp. S471–S474; December, 1959.

The propagation of electromagnetic waves in a circular waveguide containing a gyromagnetic material was studied. The gyromagnetic axis of the material is parallel to the waveguide. The material has the shape of a cylindrical envelope of thickness δ adjacent to the waveguide wall.

A. P. van Gelder, A. M. de Graaf, and R. Kronig (Tech. Hogeschool, Delft), "New calculations on the Faraday effect in wave guides," *Appl. Sci. Res.*, vol. 7, pp. 441–448; 1959. (In English.)

A relatively large number of papers have been published on the realization of nonreciprocal circuit elements "Uniline" and "circulators."

R. Taupin and M. Hai Thai (Cie Gén. Télégr. sans Fil, Paris), "Emploi des ferrites dans les circuits hyperfréquences," *Onde électrique*, special suppl. no. 376 ter, pp. 582–587; March, 1959. (In French.)

H. G. Belders (N.V. Philips, Eindhoven), "Ferrite isolators in the 8–9 mm waveband," *Onde électrique*, special suppl. no. 376 ter, pp. 617–648; March, 1959. (In English.)

R. Dessert (L.E.P., Paris) "Éléments de circuits hyperfréquence non réciproques utilisant des ferrites," *Onde électrique*, suppl. no. 376 ter, pp. 653–659; March, 1959. (In French.)

M. Vadnjal and A. Fiorini (Univ. Padoue), "Sfasatore con ferrite per circolatori a larga banda," *Note Recens., Notiz.*, vol. 8, pp. 305–312; May–June, 1959. (In Italian.)

E. Schanda (Wien), "Einwegalschwächer in Rechteck—Hohlleitern," *Elektrotech. u. Maschinenbau*, vol. 76, pp. 174–177; April, 1959. (In German.)

Milano has studied more particularly the influence of the dielectric support and the geometrical dimensions of the ferrite plate.

U. Milano (Ist. sup. Poste e Telecommunic., Roma), "Isolateurs de résonance à plaques diélectriques dans la bande X," *Onde électrique*, special suppl. no. 376 ter, pp. 569–573; March, 1959. (In French.)

U. Milano, "Sul comportamento di ferriti di Ni-Zn e di Mg-Mn in attenuatori non reciproci a risonanza ferromagnetica nella gamma dei 900 MHz," *Note Recens., Not. Ital.*, vol. 8, pp. 611–633, November–December, 1958; pp. 3–20, January–February, 1959. (In Italian.)

Siemens und Halske A.G. pursued the study of ferrites and of their UHF applications. They particularly studied the demagnetization factors of the ferrite element set in waveguides.

W. Haken (Siemens und Halske A.G., München), "Ueber den Einfluss leitender Flächen auf die gyromagnetische Resonanz von Ferritkörpern, Entwicklungen" *Berl. S. und H. Akt. Ges.*, vol. 22, pp. 28–32; April, 1959. (In German.)

J. Deutsch (Siemens und Halske A.G., München), "Einige Ferrit-Bauelemente für die Mikrowellentechnik," *Nachrichtentech. Fachber.*, vol. 12, pp. 9–14; 1958. (In German.)

J. Deutsch, N. Haken, and C. V. Hazaraditz (Siemens und Halske A.G., München), "Neue Richtungsleitungen für Richtfunksysteme," *Nachrichtentech. Z.*, vol. 12, pp. 367–370; July, 1959. (In German.)

High-frequency modulation in waveguides is possible by Faraday effect. An example is given of realization allowed to reach a frequency modulation up to 10 mc.

F. Dachert, J. Robieux and P. Trevoux (Cie gén. Télégr. sans Fil, Paris), "Nouvelles applications des ferrites en hyperfréquence," *Ann. Radioélectr.*, vol. 14, pp. 17–30; January, 1959. (In French.)

2.3 Nonlinear Circuits and Quantic Networks

2.3.1 Semi-conductor devices: Improvements were brought up to classical mixers for radio links in the 4000-mc band.

R. Bergere (LMT Boulogne-Billancourt), "Mélangeurs haut et bas niveaux pour faisceaux hertziens," *Onde électrique*, special suppl. no. 376 ter, pp. 494–498; March, 1959. (In French.)

The Eidgenössische Technische Hochschule, Zürich, has published a paper on frequency mixing in the UHF band.

F. Furrer, "Ueber Frequenzumsetzung im Mikrowellenbereich," Juris-Verlag, Zürich, dissertation ETH No. 2864; 1959. (In German.)

Some new theoretical and experimental studies have been made concerning the possibility of developing a maser for submillimetric or infrared waves, at the Institute of Physics of the University of Cologne.

D. Geist, "Sind die Landau niveaus der freien Träger für einen Submillimeterwellen Halbleisermaser ausmitzbar?" *Z. Naturforschg.*, pt. a, vol. 14, p. 752; August, 1959. (In German.)

At the Atomic Energy Center, in Saclay (France), Combrisson and Solomon study the silicon at the temperature of liquid helium:

J. Combrisson and I. Solomon, "Polarisation dynamique du silicium 29 à basse température," *J. Phys. Radium*, vol. 20, p. 683; July, 1959. (In French.)

Several writers give equivalent schemes for the parametric amplifiers using variable-capacitance silicon diodes; these theoretical studies end in an evaluation of the gain-bandwidth product, stability and noise figure.

J. C. Simon, "Action d'une perturbation progressive sur une onde électromagnétique guidée," *Ann. radioélectricité*, vol. 14, pp. 3-16; January, 1959. (In French.)
 W. Dahlke, R. Maurer, and J. Schubert, "Theorie des Dioden-Reaktanzverstärkers mit Parallelkreisen," *Arch. elekt. Übertragung*, vol. 13, pp. 321-340; August, 1959. (In German.)
 A. P. Speiser, "Parametrische Resonanz und Parametrische Verstärker," *Sci. électr.*, vol. 5, pp. 61-75; June, 1959. (In German.)

2.3.2 Devices using magnetic resonances: An approach is made by several workers in France (especially at the University of Grenoble), with the object of having a better knowledge of the solid-state phenomena involved in the ferromagnetic materials.

R. Pauthenet, "Résultats expérimentaux sur le blocage du moment magnétique de l'ion terre rare dans les grenats," *J. Phys. Radium*, vol. 20, p. 388; February-March, 1959. (In French.)
 J. Pauleve, B. Dreyfus, and M. Soutif, "Résonance ferrimagnétique des ferrites et grenats à température de compensation," *J. Phys. Radium*, vol. 20, p. 355; February-March, 1959. (In French.)
 R. Aleonard and J. C. Barbier, "Etude paramagnétique à haute température des ferrites grenats de terres rares," *J. Phys. Radium*, vol. 20, p. 378; February-March, 1959. (In French.)
 G. Villers, R. Pauthenet, and J. Loriers, "Propriétés magnétiques des ferrites du type grenat substitués par Al, Ga et Cr," *J. Phys. Radium*, vol. 20, p. 382; February-March, 1959. (In French.)
 G. Asch, "Résonance magnétique du cobalt polycristallin à 35,500 MHz en fonction de la température," *Compt. Rend. Acad. Sci. (Paris)*, vol. 248, no. 6, pp. 781-784; February 9, 1949. (In French.)

Some experimental studies are made that end in the realizations of ferromagnetic parametric amplifiers.

G. A. Boutry, "Amplificateurs paramétriques et annihilation de l'hystéresis ferromagnétique par polarisation orthogonale," *Compt. Rend. Acad. Sci. (Paris)*, vol. 248, no. 3, pp. 384-386; January 19, 1959. (In French.)

2.3.3 Solid-state masers: Theoretical studies concerning the possibilities of the several quanta transitions between Zeeman Sublevels, and the shapes of the lines, have led to an experimental work.

J. M. Winter, "Etude théorique et expérimentale des transitions à plusieurs quanta entre les sous-niveaux Zeeman d'un atome," *Ann. Phys.*, vol. 4, pp. 746-811; July-August, 1959. (In French.)

Groschwitz studied the probabilities of transition in the electromagnetic perturbation energy, taking into account the phases of the waves.

E. Groschwitz, "Zur theorie des Maser," *Z. Naturforsch.*, pt. a, vol. 14, pp. 305-307; March, 1959. (In German.)

A special microwave circuitry is developed with the aim of measuring physical constants of the matter, especially relaxation times, life time of the levels. The radio-frequency spectroscopy has made much progress improving the maser techniques.

M. Bruma, "Circuits hyperfréquences utilisables en spectroscopie paramagnétique électronique," *Onde électrique*, special suppl. no. 376 ter, pp. 547-549; March, 1959. (In French.)
 M. Jacobowicz and J. Uebersfeld, "Effet Overhauser et double effet dans les fluides adsorbés sur le charbon," *Compt. Rend. Acad. Sci.*, vol. 249, no. 25, pp. 2743-2745; December 21, 1959. (In French.)
 R. Kronig, "Fysisch onderzoek met microgolven," *Tijdschr. Nederl. Radiogenootsch.*, vol. 24, no. 2-3, pp. 113-117; 1959. (In Dutch.)
 A. Landesman, "Etude de la relaxation d'une voie paramagnétique par observation de signaux de résonance nucléaire," *J. Phys. Radium*, vol. 20, p. 937; December, 1959. (In French.)
 G. Raoult, R. Fanguin, and A. Chabrier, "Polarisation rotatoire magnétique de sels paramagnétiques Fe, Cr à 10,000 MHz," *Arch. Sci. (Geneva)*, vol. 12, fasc. spécial, pp. 215-225; 1959. (In French.)
 G. Berthet, F. Blanc, J. Grangeon et G. Raoult. "Spectre de résonance paramagnétique électrique du chromicyanure de potassium." *Arch. Sci. (Geneva)*, vol. 12, fasc. spécial, pp. 226-233; 1959. (In French.)