Contributions of the Spanish Engineer Angel Gonzalez Del Valle to the Electric Networks/Circuits Research from 1944 to 1964

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Abstract — **This paper considers the contributions of one outstanding as well as controversial researcher, teacher and inventor from Spain during the Francos´s dictatorship. The paper presents an overview of the most important contributions made by Prof. Angel Gonzalez del Valle related with the electric networks/circuits theory and its application to analog computing/simulation, which was achieved from forties to sixties in the last century in Spain. A list of publications about those topics is presented.**

Index Terms **—Historical boundary of Spain, mechanical-electrical equivalences, heterogeneous networks, rigid networks, networks geometry, analog computing/simulation**

I. INTRODUCTION

Prof. Angel Gonzalez del Valle was a Telecommunication engineer graduated from the "Escuela Técnica Superior de Ingenieros de Telecomunicación" (E.T.S.I.T.) of Madrid .He started his studies in 1939 when the civil war in Spain ended. This circumstance is very important to understand the limited conditions to do research and development in the forties. He became Full Professor of Mathematics in 1957 at the ETSIT Madrid (Universidad Politécnica Madrid, UPM-ETSIT today), concentrated increasingly on electric network theory, servomechanisms and electronic computing research. He was the first one in Spain in teaching Computer engineering in the university. His research work is referenced from 1944 to 1964. Prof. Gonzalez del Valle died on 26 February 1964.

Fig.1. Angel Gonzalez del Valle

In this paper, we address some aspects of the scientific-technical work made by the Prof. Gonzalez del Valle during twenty years under difficult conditions, where the socio-political and historical European circumstances were a factor to consider in his intellectual and managing activities.

In this paper, historical boundary conditions will be considered first. The second aspect to consider tackles some comments about his studies on the mechanical-electric equivalences and the lumped-parameter systems or networks theory. Third topic to consider is related with the rigid networks metric geometry. These works were developed during the forties and fifties along with his activities of teaching, managing and leader on electronic computing in the National Research Center of Spain in Madrid (CSIC) ("Consejo Superior de Investigaciones Científicas").

II. HISTORICAL BOUNDARY CONDITIONS OF SPAIN

A Dictatorship existed in Spain in this historical period. The first half of forties were dominated by the "German culture" from the point of view of the industrial aspect in Spain .By Anglo-American standards, the state of science and technology in II World War and post-war in Spain was quite poor due to years of stagnation under Civil war and the other political facts in the world. This kind of affairs pervaded most of the continental Europe. Because of military and economic reasons, it was felt in political milieus that an action was needed to catch up with Anglo-Saxon wartime advancement in science and technology, and for Spain it was hard in those years.

In the fifties, the freedoms of all kinds were restricted, and it could be illegal to carry out associative activities in Spain. Nevertheless, the professional associations did not have special difficulties, to get scientific or technical information. In fact, Prof. Gonzalez del Valle was member of the AIEE and IRE societies during the fifties. Companies as Standard Electric-ITT, and "Telefónica" were the entities with more scientific and technical information/knowledge in the Electrical/Electronics-Telecommunication fields in Spain.

From the technical-scientific point of view, high teaching in electrical engineering and telecommunication at the beginning only had activities at schools in Madrid and Barcelona. Research on electrical engineering and telecommunication were centralized into the CSIC and "Standard Electric- ITT" both in Madrid. Prof. Gonzalez del Valle achieved all his work in the CSIC and ETSIT centers of Madrid.

III. MECHANICAL-ELECTRIC EQUIVALENCES RESEARCH

During the first half of the forties, the most important reference in the world about networks/circuits theory was due to E. A. Guillemin [1].This reference was important for the future work of Gonzalez del Valle. However, the first papers published by him they related with Mechanical and Electrical analogies [2, 3].These works were published on the most important Journal related with research on physics and chemistry in Spain in that years (II World War). The concept and the methodology were to find theoretical equivalences of mechanical (characterized by their physical parameters) and electrical systems (lumped system) using electrical parameters (resistances, inductances, and capacitances) and by using the classical Thevenin´s equivalent circuit theory. The proposition and resolution of the inverse problem (When an electric system is known, how to find a mechanical system equivalent) was one activity of his research between 1944 and 1946 [4, 5].The last work known on equivalences was related with heterogeneous (electrical, mechanical, piezoelectric, etc) networks, which was published 1949 in collaboration with Prof. Maximino Rodriguez Vidal [6]

IV. ELECTRONIC COMPUTING AND ANALOG SIMULATION

Once the World War finished, new technical information from USA and UK arrived to Spain. So, Gonzalez del Valle address his interests to the new field of electronic computing. He was member of the CSIC (Instituto de Física "Alonso Santa Cruz") and leader of the first team related with electronic computing in Spain (1946-1947). In those years he founded the Cybernetics Society of Spain (Sociedad Española de Cibernética) and his interest in the circuit theory joined with the electronic computing would permit him and his collaborators to develop the first computing electronic machine (analog computer) in Spain [6].

An analog computer is a network based on principles of the classical circuit theory where a lumped system considers a voltage or current applied to an interconnection of simple elements such as resistances, inductances, and capacitances. Solutions are given by mean of differential equations and block diagrams can just be a schematic representation of a set of differential equations. If a block diagram for a set of differential equations can be found where each block represents a subsystem that can actually be built, then a system can be implemented using the block diagram as a guide which "solves" the differential equations. That is, integrators, adders, and constants multiplying can be built, which are interconnected according to the block diagram. The output of the system is the solution of the differential equations. This is called *analog simulation.*

The project of the computing electronic machine was developed during several years. Two papers related with an "electronic machine to resolve algebraic equations" were published in 1948. On the references [6, 7, 8] the principles and details of that machine are shown, including a demonstrator whose block diagram is shown in Fig. 2

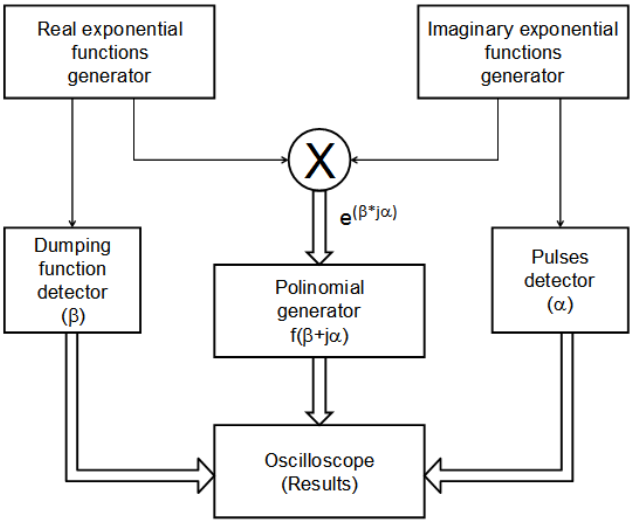

Fig.2. Algebraic equations computing analog machine block diagram

The computing machine was based on the possibility of building an electrical network (two–terminal circuit) to present a zero impedance (resonance situation) when the frequency of the current passing through it is the root of the equation to be solved. Thus the zeros-voltages obtained across the two-terminals circuit could be considered as a generator of polynomials.

The most important blocks of the computing machine consisted of a frequency generator and two detectors whose outputs are applied as voltages to an oscilloscope. This allowed to obtain the distribution of roots in the oscilloscope screen, which was used as a Gauss map by the polinomial generator and root's discriminator.

V. RIGID NETWORKS METRIC GEOMETRY

The first paper related with rigid networks metric geometry was published in 1951 and it was the result of the collaboration between V. Quintas Castañs and A. Gonzalez del Valle [9]. This theoretical work is related with circuit theory and multidimensional geometry. The proposed modeling for the analysis and design of new electric networks and servomechanisms is based on the hypothesis that there is one "identity" between the formal properties of the electric networks and geometric forms.

By using the identity hypothesis is possible:
a) To apply to electric networks theorems used in the metric geometry.
b) To define and build "forms" that may have multidimensional characteristics.
c) To find relationships between networks laws (Ohm, Kirchoff, Thevenin and so on) and bi-dimensional, spherical, hyper-spherical, geometrical forms.
d) To build electric/electronic machines based on the last relationships above.

The "rigid" adjective applied to electric networks was used by Gonzalez del Valle in 1953 on the reference [10]. In this reference the fundamentals of the concept "rigid network", related with the metric geometry were published. He considered that a "rigid network" is constituted by a set of points denominated "poles" that have geometric properties that may be associated to electric magnitudes. This theory is supported by mathematical theorems that we can find on the references [10, 11, 12] and that were developed from 1951 to 1954. Other application of the concepts on rigid networks and metric geometry is related with the electric networks isostatic dynamics. In fact, for designing a mechanical structure where their topologies and the enough number of values related with their magnitudes are known, it is possible to determine the isomorphic electric network based on appropriated and balanced forces of the mechanical structure, and the isomorphic network of the geometric form representing the mechanical structure [13, 15].The mathematical theory about these equivalences increased with new theorems and applications in analog computing (servomechanisms).These results were the last published in 1959 about the networks geometry[16].
Another application of the mathematical theory on rigid networks geometry was the "Angular-Cartesian converter" which was a specific analog computer where the input data are angles and distances to the origin and the output data are Cartesian coordinates [14].The last work related with the networks geometry and analog computing was published 1964 when Prof. Gonzalez del Valle passed away [17].

VI. CONCLUSION

The purpose of this paper was to bring out, and remember the work and publications concerning Prof. Angel Gonzalez del Valle, who was an innovator, inventor and leader of the electronic computing in Spain during the fifties and half sixties. In this historical analysis it is important to take into account the historical constraints of the place where the work was developed. To understand the significant role of this technical pioneer it is necessary to remember the Spain of forties/fifties. The interest in equivalences and rigid networks is nowadays in standby. However, the analog world it is not dead yet and several aspects of his mathematical theory are still valid today. Historians must continue to explore in depth the work of Gonzalez del Valle and compare this with other authors of the same historical period.

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