Abstract

The object of this study was to create an elementary electronic circuit which can produce signals that are similar to those produced by intracellular and extra-cellular circuits, a hardware that works autonomously with no need of an external software because it self-creates it. In this paper I describe an artificial, and/or bionic, neural structure for-med by the simulation of modular similar-analog electronic elements for generating and/or re-establishing correct communication between components of a biological structure, in particular a nervous System. I present a series of data, which derive from a simulation of what becomes a very simple electronic and informational elementary circuit. This circuit is extrapolated from many other circuits which are supported by a universal model and, working together, give coherent answers and are able to help or replace a neuron or a group of neurons. The simulated structure includes a plurality of modular electronic devices interconnected together to form at least one pair of meshes and is able to generate analog electrical signals of various waveforms and various electric powers.

I have so realized an simulator System as a quasi-Boolean net, but functional only, because the omni-directional reaction to an operative, at a perturbation level action, gives origin to different functionalities in a similar structure, which exists in a non-digital way, or, it might be better to say, which lives in an analogical quasi-digital way, with molecular code and decode factors, to which, at present, I approximate in an quasi-complete way. I have obtained an almost perfect correlation between those signals that are generated in nature and those that we have artificially produced. I have demonstrated that, to build a real and working artificial intelligence, or a particular part of it, we must preliminarily plan an "opposite-engineering" System that, starting from the biological and not "vice/versa", can, in the meantime, define the *"how"*, hoping it becomes even the *"why"*. The fundamentals ideas that lead to the new electro-informatics model construction are exa-mined either from a theoretical point of view (that is the basis for my researches and which describes the production and the direction bus of the informative signals) and from the point of view of the structure realization.

Keywords (in alphabetical order)

Automata; Chaos; Complexity; Cyborg; Models; Neurons; Robotics; Systems; Uncertainty.

§ 1. Introduction

1.1 The Progress Report

In my researches, in quality of "observing Systems' observer", I was always highly interested in cybernetics and its evolving in Bio-cybernetics [see Note (***3***) – **C**yber**N**euro**P**hysiology (CNP)]. Moreover, as a researcher, I was the more and more concerned in Bionics in a pertinent analysis's constant need and recognizing the importance of correct methodologies. At the same time I tried to delineate a comprehensive outline of my theoretical position in comparison and in function of most of the last century and today's theoretician Scientists and Scholars (see References).

It's starting from their experimental researches, in particular on the problem of a potentially convertible and/or analyzable nervous Sys-tem, that these influential Scientists and Scholars, who have enormously contributed to its knowledge evolution (and not only in the field of Biology and Cybernetics), have answered to my numerous questions just to let me plan the global frame of my work.

They make me understand what I consider the correct philosophy of the approach.

In particular the philosophical-functional-structural analysis of their specific theorical disciplines' designs and studies were my guides in delineating my personal neural simulation experimental plan. It is just starting from their objective observations and result that I have obtained a series of data and informations that let me realize that we can also follow an alternative path.

Considering the present research's situation, I have essentially verified that the bionic approach cannot be only digital, or digitally started, just because nothing exists of similar or analogous in nature, and I have oriented towards the analog one in order to obtain a similar-biologic device that could obviously be the most possible compatible with the existing in nature.

Some last years experimental researches have only partially fol-lowed this approach, anyway they try to offer possible solutions which are functional to underline the foundations of my job.

Let's start, e.g. from Berger T.W., et all (2001) who give emphasis not only on the digital but also on the necessity of an analog approach (or at least partially analog), in fact they say "... it must be truly biomimetic, i.e. the neuron models (incorporated in the prosthetic) must have properties of real biological neurons .... Given the known signalling characteristics of neurons, such an implementation will most likely involve hybrid <u>analog/digital</u> device designs ... the resulting microchip or multichip module must communicate with the existing".

But what's is important is that the final outcome of this Authors' research showed me that the Hopfield model, they use, is efficient above all in the digital part (and gives optimal result in this field) but that it needs modifications and adaptations for a more perfect chip with more pertinent biological characteristics (and therefore exclusively analog or similar-analog) which can communicate with the physical part.

That's why this paper verifies one of my primary efforts, i.e. working on the existing, just not to modify it, but in order to adapt it to my researches' needs and objectives that fundamentally consist in the equal communicative exchange *without any external software inclusion.*

Berger et all. have exploited above all the digital part developing *a dynamic learning algorithm (DLA) to train each dynamic synapse to perform an optimized transformation function such that the neural network can achieve highly complex tasks.*

Moving the accent more on the digital than on the biological-analogical part, they had difficulties in succeeding to obtain the correct adaptive weights combination on the synapses.

In fact, they say:

"... One of the key obstacles will be maintaining close contact between the electrode sites of the interface device and the target neurons over time, ...".

What they effectively obtained is an hardware that needs a software to work. *Actually a <u>true (neural)-bionic chip</u> should be able to create its own software, and it is in this complex direction that my researches moved.*

It becomes clear that one of the main problems is concerning the interconnecting signals and in

Jenker M. et all (2001) experimental works we see them highly focused on the optimal voltages' research and their optimization on the field. In fact in their chip: "... the record of intracellular voltage shows the primary response to stimulation and the resulting acting potential (centre). The transistor records the change of extracellular voltage due to the stimulus and due to the action potentials ... The extracellular voltage in junction was observed with the transistor. The upward and downward stroke of the stimulation pulses causes short positive and negative transients in extra-cellular voltage of the junction, as well as, in the intracellular voltage ... The action potential was recorded by the transistors a positive peak of extracellular voltage in the rising phase of the intracellular voltage, with a shoulder machine the later stages of the action potential. The first component indicate a depletion of sodium channels in the attached membrane...the later response may be attributed to an enhanced conductance of the potassium channels ... The efficiency of the electrical synapse was determined by the transfer of hyper-polarizing signals…".

This convinced me to more and more analyse and study in depth the brain electrical sequences: "... that will answer interesting questions about the neurobiology of neuronal works and their compu-tational implications" (Jenker et all -2001).

They also get on saying that it is "the problems that must be solved before we can assemble neurochips", and this starting from conside-ring that first of all: "... the strength of neuroelectronic coupling is weak. The waveforms of transistors records vary in shape and the nature of capacitive simulation is unclear. Reliable stimulation and recording of a network requires more reproducible functions" (Jenker et all -2001).

It becomes quite obvious that a preliminary and accurate research on the powers at stake, on the correspondences among signals and quantization and on the attainable and really usable frequencies, must be absolutely essential for proceeding in a correct way.

If we analyze Eckmiller's research (1993), in his digital/analog neural model structure we notice that: "... the typical functional properties of a single BPN Neuron can be briefly described as follows: incoming rectangular voltage pulses of 1 ms duration and 5v amplitude reaching a synapse S, pass through a delay line T (representing the summed delays of a pulse signal in synapse, axon and dendrite), before being weighted".

But the specific square wave they use (so functional in other digital structures) in this case is not completely suitable because it is not completely biologically simulative. Arriving on the digital it is refined, not preserving, therefore, the whole information but only the one allowed from the timing and the kind of filter used.

In my chip model I have tried to prevent this disadvantage using currents that are extra-currents of closing and/or opening of the switches and concur to the regularity of the circuitation in the pump meshes. They are also variable wave forms which are adaptive, as form, intensity and frequency, to the kind of the received wave. Therefore they are more biocompatible.

The switches used don't depend from any chip but they receive the order directly from the "pre" neuron signal, and therefore from its frequency, amplitude and intensity. The consequent answer, (either as feedback on the "pre" or as output on the "post" neuron) is totally automatic and at the same time goes to increase the augmentative memory connected to the switches themselves.

This is one of the choices that has revealed much more functional because it has allowed me to formulate my theory, simulate a comple-tely independent hardware and create a spin off prototype device (a similar-analog cryptor-decryptor), that's the result of its experimental application.

As I clearly point out, the only possible path is the global *analog* (or the *similar-analog*) approach to the problem of the nervous System's biologic simulation. All my, purely engineering research (also theoretical and theorical), has been founded on the artificial simulation of harmonic continuous (consonant or dissonant) communicative signals, obviously equipped, with upper harmonics which inter-connect not only the single elements but also their around, and this without pre-programming anything, but acting in such a way that the Hardware self-generates its own software, self-adapting in a specific and autonomous way to the environment in which it works.

Just to validate my research's choices I want to cite Saygin A.P. et all (2011): "Using functional

magnetic resonance imaging (FMRI) repetition suppression, we explored the selectivity of the human action perception System (APS), which consists of temporal, parietal and frontal areas, for the appearance and/or motion of the perceived agent. Participants watched body movements of a human (biological appearance and movement), a robot (mechanical appearance and movement) or an android (biological appearance, mechanical movement). With the exception of extrastriate body area, which showed more suppression for human like appearance, the APS was not selective for appearance or motion *per sè*. Instead, distinctive responses were found to the mismatch between appearance and motion: whereas suppression effects for the human and robot were similar to each other, they were stronger for the android, notably in bilateral anterior intraparietal sulcus, a key node in the APS. These results could reflect increased prediction error as the brain negotiates an agent that appears human, but does not move biologically, and help explain the 'uncanny valley' phenomenon". [For *'uncanny valley'*, see in References, Mori M.].

1.2 The Author's Research Path

If "in the language only differences do exist" (Saussure, *1916*), if "the meaning of the word is its use in the language" (Wittgenstein, *1953*), if "the meaning of an assertion is its method of evaluation" (Logical new-positivism), and if "a mathematical object is what it does" (T. Gowers, *2002*), than the serially (diachronically) and parallely (syn-chronously) interconnected physical devices, simulated in my re-search, evidence their differences through the functions to which they give life inside the originating structure. In this way they are all absorbable in the mathematical language that gives a perfect simulation.

I think that the distribution of a neuron's specific structure follows an accurate reasoning of functionalities and that the (dissipative) System, that they create, follows ordered rules, easy comparable to those of an operator field.

I am moreover convinced that a mathematical simulation of the neural System space-time distribution shows its non commutativity and that we can obtain that a (determinable) Logic exists in the distri-bution of the different clusters of neurons.

Obviously with specific parameters to determine which depend mainly from my new model of neural communication, a new model of transmission founded on (analog) capacitive stimulation (and more other) and on contact.

If the specific System demonstrated itself commutative, then it is simpler to establish operating parameters of neural associativity.

My research phases are evidenced in *Fig.s* ***01*** ***÷*** ***06*** sequence. With these *Fig.s* I can briefly summarize my whole research path that will be described in detail.

1. In *Fig.* ***01***: the hypothesis of the neural segmentation; of the frequencies set choice; of the sax-neural coupling analogy.
2. In *Fig.* ***02***: the Cubic Matrix algebra [for 0 (only one element)-1-2-3 dimensions]; the "De Morgan Pus" Theorem (for circuits simplifications); the Plasma-Jet flux Cone.
3. In *Fig.* ***03***: the elementary circuit; the structural-functional neural analogy.
4. In *Fig.* ***04***: the Axon-Linear Accelerator analogy (non-relativistic case).
5. In *Fig.* ***05***: the Brain-Ellipsoid of rotation analogy
6. In *Fig.* ***06***: the First Theoric Model (1993).

Moreover in *Fig.* ***B*** (Note ***1***) there is a brief description of the Prototype of a similar-analogic cryptor-decryptor that is a spin off of the simulated Prototype 7.

These authoritative Scholars and Researchers (in alphabetical order) have specifically dealt with the scientific topics I have studied for my work (see References):

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BIRD R.B., STEWARS W.E., LIGHTFOOT E.N., 1960.

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SMITH C. U. M., 2002.
SÜDHOF T.C., STARKE K. (Editors), 2008.
TEODORESCU H-N, KANDEL A., JALN L.G, 1999.
VIZI E. S. (Editor), 2008.

1.3 Author's Works

I here describe the simulation of a model of a circuit that emulates the Na-K (Sodium-Potassium) pump. It derives from a new model of neural transmission which is based on the essential difference between telecommunication and bio-communication: i.e. telecommunication is rigid and aseptic and bio-communication has also [bio]inertia (we have to think to a pill's absorption and metabolizing time and the con-sequent body reaction) either in transmission and in reception.

I consider also the hypothesis that whatever neuron behaves in analogous and not identical way in reception and in transmission; it is subdivided into decomposable more and more specialized portions and, moreover, it transmits and receives with lags only on iso-frequency trajectories, in *cones* of flux or fluid, which have the characteristics of an ionized gas. I also believe that in any bionic synapse, messengers *in* and *from* any possible direction can be transmitted and received and also that a specific kind of messenger is accepted by only one particular kind of receptor, or forwarded only by a particular kind of transmitter. Specifically, the receptor will have to utilize the same frequency of the transmitter. To emulate this structure, I am convinced that:

1. lags are done by inductance;
2. switches give transient conditions and produce opening and closing extra-current, creating or interrupting the electric flux either in the mash simulating the **Na-K** pump and in the branch simulating the **Cl** (Chlorine) one;
3. charge and discharge condensers (in the **Cl** branch) determine the threshold signals;
4. only analog signals have to be compounded and modulated, to create a steeples caring wave.

It is functional to use a switched input oscillator, that here becomes the cybernetic equivalent of the tout court Logic, but changing it from an a-temporal to a temporal Logic. It can so effect the transition between objects (in this case: neurotransmitters) and connections, constructing, for example, the directions for the interconnections among elements which become interdependent.

I have considered coherent the possibility to simulate at least three types of circuit elements that, taken together as a Systemic set, can give us **36** possibilities (some are repeated) for the construction of **27** different **Na-K** pumps. Each of these **27** different combinations of electronic base components can be considered as an **ATPase** mechanism simulation.

The final base-structure, simulated, projected, and partially realized in the year 2002 (from **80** to **960** cards in **27** different configurations, with different combinations, in double 7-values Logic and everyone of them subdivided into **40** strata), if only partially active, with a field of imposed suitable frequencies (with ad-hoc analog and non-digital devices that aren't here described) conveniently combined and permutated among them in its whole, can give at least over $\mathbf{10^{45}}$(minimum) interconnections, at various frequencies and wave-forms.

All these interconnections, modulated, half in Aristotelian Logic, half in Fuzzy Logic, simulate the left and right lobes of the brain.

For one single complete element of this structure, I have obtained the theoretic simulation of at

least over $\mathbf{10^{52}}^{(minimum)}$ messengers, with **m**olecular **w**eight **u**nits (**m.w.u.**) between $\mathbf{10^2}$ and $\mathbf{10^3}$, which give at least over $\mathbf{10^{57}}^{(minimum)}$ informative signals.

For the structure I make use of a three values Logic that, for an eventual further formation of tissues (see *Fig.s **29÷34***) of bionic elements, will increase al least to seven. This seems to be an ideal situation for a correct planning, because, if it is impossible to create bio-logic messengers, they can anyhow be replaced by their energy forms, transmitted or received through microprobes.

Moreover, considering the automatic energy transfer, I can deduce that it is possible to by-pass, exalt or eliminate the activation or inhibitory mechanisms, such as the monoamine oxidase (MAO).

I have so realized an emulator System as a quasi-Boolean net, but functional only, because the *omni-directional* reaction to an operative, at a perturbation level action, gives origin to different functionalities in a similar structure, which exists in a non-digital way, or, it might be better to say, which lives in an analogical quasi-digital way, with molecular code and decode factors, to which, at present, I approximate in a not quite complete way.

Basing on theorical calculus, each oscillator, in series of stratums, originates energy and frequency forms for the neurotransmitter simulation.

So we obtain: for each neurotransmitter a quantum cloud equal to $\mathbf{3x10^5}$ quanta, i.e. an informative unit cloud equal to $\mathbf{1{,}5x10^5}$; to each **m.w.u**. $\mathbf{10^2}$ messenger, an association of at least **3** virtual masses, identical among them and to the real mass; and to each **m.w.u.** $\mathbf{10^3}$ messenger, an association of at least **30** virtual masses, identical among them and to the real mass.

All this happens either in reception or in transmission distances to the maximum of **500** times the Böhr ray, in closeness of length to a Debye wave, and with frequencies up to a thousand times smaller than the Larmor electronic frequency.

I simulated a series of prototypes, and in all the previous models as well as in this one, which is the 12^{th}, [the followings (now the simulated prototypes are 21, with 36 releases) are more and more specialized spin-off also in other cybernetic sectors)], the essential work is in accordance with these assumptions:

- we have the configuration of balance for the **Na-K** pump;
- we can insert in it switches and replace the generic resistances with appropriate resistors, which run in fixed frequency-fields;
- opening and closing the circuits, we can create the conditions of dis-equilibrium, that give different productions of currents, which, each in turn, generates various signals in transmission.

The various signals must then be put together, placed, enlarged and transmitted.

Stated what's above, I can describe this very *simplified* prototype model which consists of a single sub-stratum among **80** (40+40) sub-strata, that at its turn becomes a single element of an hexagonal group, and this single element has **5** signals instead of **27**.

I have obtained an almost perfect correlation between the signals that are generated in nature and those that I have artificially produced. Analyzing the data, I have noticed that equal signals obtained among the signals generated in nature and those that I have artificially produced can be compared, either for values and for development, to the pre and post-synaptic ones (from **-65** mV, **-75** mV to **+55** mV, volt agent, and inferior to **2** pA currents). In fact, the presented bionic simulated structure proves to be analogous to a set of staminal cells, and more-over, with the opportune modifications of the resistance elements, it is even analogous to a set of glial cells.

Moreover I can demonstrate that, at present, I am able to:

- build signals similar to physiological ones;
- have a bionic dialogue;
- build "3D" structures, ever more and more complicated.

I can also demonstrate that, in order to build a real and working artificial intelligence, or a

specific or a particular part of it, I have pre-liminarily to plan an "opposite-engineering" System that, starting from the biological (and not "vice/versa"), can contemporarily define the "how", hoping it becomes also the "why". So if we want to insert communicative-informative probes (in receiving and in transmission) which can work, for now, in relatively small spaces and, also, in the inter-synaptic spaces, we just have a suitable (mathematical-informa-tics-electronic) System emulating the cerebral structure or a cerebral under-structure, or simply a neural or a cellular structure.

§ 2. Work's Hypotheses and Conditions

The fundamental ideas that lead to this new electro-informatics model construction ***(1)*** are:

A) From the point of view of the structure construction:

1. the artificial neural structure is composed by interconnected modular parts;
2. the neural System can be represented by a composite graph in which the *paths* are constituted by neurons and the *nodes* are constituted by the contact synaptic points among the same neurons, or by atrocities (as intermediate);
    - The graph will have as many arcs as the reticule elements (atoms).
    - The $p_1,...,p_n$ arcs will form a circuit (that will be defined dependent) if, and only if, the $p_1,...,p_n$ atoms in the reticule will be covered by the same element;
    - The trees which are extractible from the graph corresponding to the three-dimensional reticule L, will have all the x_{ji} side if, in the geometry corresponding to L, whatever points base, which generate it, will contain x_{ji}
    - The trees, extractible from the graph, correspond to the matroid bases: a tree will have the arcs $x_{1(ij)},...,x_{p(ij)}$ if $x_{1(ij)},...,x_{p(ij)}$ were one of the sub-sets of the graph arcs that result to be chiefly independent.
3. the algebraic structures associated to the neural sub-sets are Non-Abelian Groups.
4. each interconnected modular part is composed of clusters of oscillators with variable resistance, inductance and capacities characteristics, settled among them in under-sets, ordered with permutation, disposition, and combination criteria;
5. each interconnected modular part is formed by a variable number of sets of plates of which there is just one with central link characteristics and at least another one working in non-Aristotelian Logic and/or at least another one working in Aristotelian Logic;
6. every plate is composed of an optimized number of oscillators (with appendages) which transmit with several different wave forms;
7. each oscillator works in a field of intensity current, potential difference, wave form (sin., tria., squ.), frequency (with an approximation to the third decimal), intensity and signal typology (continuous or discontinuous), in a receiving conditions dependent way;
8. each oscillator behaves as an autonomous component of a neural simulation net that is assumed as a dynamic interface either towards a natural neuron or a single set, and/or several natural neuron sets, and establishes reciprocity and reversibility relationships in resonance;
9. each working at a quantic level oscillator transmits informative bits in function of the quanta' numbers (the informative energy of **1 bit** *is equivalent to energy* of **2 quanta**). The natural neurotransmitters are artificially replaced by the associated generic energetic forms. As in the natural model, in the artificial one the through a nutation chaotic cone information transfer is selectively absorbed by the receptors which have the same frequency of the various under-stratums transmitters: the trans-ferring and the receiving take place in iso-frequency; that is it exists just an only receiving point towards which the neurotransmitter, issued by the transmitter, will be directed ***(2)***;

10. any neuron acts, in its completeness, *simultaneously* interpreting both the cerebral lobes influences;
11. the bottom noise determines the inertia to the answer and masks the synchronicity. Every oscillators' combination or permutation or disposition issues, are disguised as radiation, information in iso-frequency: the emission takes place in a similar-digital form on an analogical carrying wave;
12. for every plate the feed-back is studied and simulated also by a virtual *"Petri's Nets"* and the serial and the parallel ones are simulated also by a virtual *"Markov's Chain"*; we know that we are dealing with exclusively analogical signals which respect their being digital only for the fact that they are present or absent. In order to respect this pseudo-digitalism, the switches are plugged inside the artificial circuits, give the emission cadence restoring or changing the immediately preceding conditions: in such a way they contribute to the formation of several serial and/or parallel kinds of feed-backs, emphasizing or decreasing the number of virtual "Petri's Nets" and of virtual "Markov's chains", which have origin: and this happens with repeatable Logical sequences;
13. for each plate the oscillators set is structured in a **Na-K** pump (and **Cl**) simulation;
14. the natural neurotransmitters are artificially replaced by the associated generic energy forms.

B) From the theoretical point of view (that is the basis for my re-searches which describe the production and the direction bus of the in-formative signals):

1. the new transmission neural model characteristics are:
    - the time and the neural activity are non-continuous;
    - the set of **2n** neurons is subdivided into two subsets: **n** transmission (**j** neuron), **n** reception (**m** neuron). Both neurons subsets are connected among them by unidirectional reticule connections;
    - to each neuron a variable $\sigma_j = +1$ is assigned if the neuron (of subset **j**) is active (in transmission) and $\varepsilon_m = +1$ if the neuron (of the subset **m**) is active (in reception). To each neuron a variable $\sigma_j = -1$ is assigned if the neuron (of subset **j**) is passive and $\varepsilon_m = -1$ if the neuron (of subset **m**) is passive (in reception);
    - the reception frequency is determined by induction from the transmission frequency;

      <u>*observation 1:*</u> these assumptions introduce a new Systemic neural transmission model from which we can assume that the neurons (even if they structurally and functionally look like the same among them), *if considered isolated*, at the very moment of their inter-relations, assume diversified characteristics in function of their intrinsic structures. In particular the neurotransmitter transit, from a point to another of the inter-synaptic space, must follow determinate quantum laws which involve the isofrequency both in the trajectory and in the initial points and conclusions of the trajectory itself. There is, in other words, the presence of the "*Feynman path integrals***"** conditions, associated to particular "extremes" of the path itself; this gives origin to a succession of times which apparently does not explicitly provide the contemporaneity;

      <u>*observation 2:*</u> we know that the stability properties of the open Systems, which are far from equilibrium (and in the neural rice-transmission we are involved in this situation), can be formulated in terms of thermodynamics quantities, which present themselves as state functions. On the basis of what I say in the previous note, an integrating factor, such as turning the *Feynman path integrals* into a state function, will have to exist, just to respect the minimum production entropy theorem;
2. in the trajectories in iso-frequency, the absence of the neurotransmitter is equivalent to the

inhibition;

3. the neurotransmitters, and in general the messengers flow, is equivalent (in physics-mathematics simulation) to plasma-jet flow cone;
4. in the neurotransmitters and messengers study, it is valid a non-classical statistical distribution function, obtained by the combination of the Fermi-Dirac function with the Bose-Einstein's one;
5. two synaptic Systems connected with the neurotransmitters (or with generic messengers) exchange information that we can represent through ondulatory representations which are antecedent the arrival of the masses transmitted with quantized value on the wave lengths;
6. a non-Aristotelian new Logic is obtained applying the "de Morgan Theorem" with the exclusion of the combinations "all zero " and "all one": the "Plus" *De Morgan Theorem*;
7. the Lie's algebra is functionally able to represent the synaptic micro-cosmos;
8. the Cubic Matrixes algebra can solve the holomorphic "minimum distance" function obtained with the Lie's Algebra;
9. the Cubic Matrixes algebra does not admit the "transposed" and therefore, considering the neurotransmitters in their hole, it gives us their behavioural indeterminateness: from this the "certainty" of the presence of uncertainty, the creation of fluctuation points among what is memorized in augmentative memories and all the intrinsic possibilities of the subsequent dynamic process;
10. the symmetry (considered by my model a sum of antimetries) generates the informative flux and the artificial life is represented as the emulation of the natural autopoiesis;
11. for artificial autopoiesis:
    - the interconnection, i.e. the mutual (sometimes univocal and sometimes biunique) relation among elements and/or among the Systems, and/or among structures or functions, works among nests and chains generating closed micro-Systems in the opened total System that's the organism. Also in the micro-Systems that work with feed-back, the different feed-backs are at their turn connected among them;
    - the non-linearity assumes the non-presence of linear, at finished dimensions, vectorial spaces generating a linearly proportional algebra. In the asymmetric (antimetric) and dissipative chaotic Systems, the -a different degree- PDE include also transcendent functions (ln, sin, cos, tag, exp, etc.).

§ 3. Technical System Description

3.1 Field of application

The present simulation refers to an artificial *and/or* bionic neural structure formed by modular electronic elements for generating and/or re-establishing a correct communication among components of a biological structure, in particular a nervous System.

More specifically, the simulation refers to a structure of the aforementioned type. It includes a central section responsible for the generation of electrical signals, as well as a first and a second end section connected to this central section and to the respective input and output terminals located on opposite sides, with respect to a point of interruption of the communication.

In particular, but not exclusively, besides the nervous Systems, the simulation concerns also a System for producing electrical signals (that can be used in the field of bionics in human and animal nervous Systems that have suffered damage to the mechanisms for transmitting information after illness and/or traumatic events).

3.2 Prior Art (see *Fig.s **1-2***)

As it is well known, the transmission of stimulus inside the human or animal nervous System is carried out by neurotransmitters which are molecules capable of transmitting information signals to

the cellular synapses according to an electro-chemical mechanism.

In particular, it has already been demonstrated that the performance of the animal nervous System is based upon the well known **Na-K** physiologic pump that works with energy values swinging between opposite equilibrium values.

Such a **Na-K** physiologic pump can be simulated and emulated electronically through a model schematically illustrated in *Fig. **1*** and fully indicated with 1.

Such a model 1, that I will define as physiologic, essentially com-prises three modelling branches formed from series (or parallel) RC (or RLC) circuits, connected together in parallel between a first T1 and a second terminal T2, respectively corresponding to the surface of a cytoplasm and to an extra-cellular surface.

More specifically, the serial (or parallel) RC (or RLC) circuits (R1-C1, R2-C2 and R3-C3) are used to model the equilibriums of the elements **Cl**, **K** and **Na**, respectively.

The voltage originating from the direct current (DC) generators C1, C2 and C3 is fixed at -**69**mV, **-75** mV and +**55**mV, respectively.

In the physiologic model 1 a common capacitor C is also foreseen, connected in parallel to the RC (or RLC) circuits between the terminals T1 and T2.

Starting from such a physiologic simulation model of the **Na-K** pump it is possible, introducing suitable modifications, to simulate three-dimensional coupling branches of various artificial circuits, so as to obtain, in the bionic field of application, artificial "tissues (see *Fig.s **29÷34***)" for "apparatuses" or "Systems" for potentially replacing analogous biological apparatuses and Systems.

A corresponding simplified model of the **Na-K** pump, which I de-fine as bionic, is illustrated as an example in *Fig. **3*** and fully indicated with 2.

Such a bionic model 2 comprises, in an analogous way to the physiologic model 1, a first T1 and a second terminal T2, respectively corresponding to the surface of a cytoplasm and to the extra-cellular surface between which a first 3, a second 4 and a third modelling branch 5 are connected.

The first modelling branch 3 comprises, in series between the terminals T1 and T2 respectively, a DC generator, a first resistor, an inverter switch and a second resistor, an intermediate point of the inverter switch being connected to the second terminal T2 through a further capacitor.

Moreover the second branch 4 comprises, in series between the terminals T1 and T2 respectively, a DC generator, a first switch, a first RL circuit, a second switch and a second RL circuit.

Finally, the third branch 5 comprises, again in series between the terminals T1 and T2 respectively, a DC generator, a first switch, a first RLC circuit, a second switch and a second RLC circuit.

The results that can be obtained with such a bionic model 2 can of course be applied (although with all the necessary modifications and implementations) to more complex circuits or more generally to the same circuit that "works" with the addition, in parallel, of successive meshes or networks, which have been ad hoc modified, to obtain, indeed, the desired couplings.

Such modelling has been studied to seek the way to re-establish the interruption in communication inside the nervous System.

A lot of studies proved that, within the nervous System, each group of cells, that are responsible for a precise task, communicates with a determined series of frequencies in order to ensure a transmission of data pertinent to a specific informative "fragment".

A possible (be it partial or total) interruption in this communication, may also be due to structural defects of a given cell or of a group of cells and can produce a lack of communication of the information in question. The group of cells involved by such a lack or interruption in communication does not therefore accomplish its natural task. We have seen that other researches have tried to re-establish specific neural communications in the case of defective operation of the cells responsible for such insufficient, partial or absent communication, or in the case of traumatic events, not completely realizing a device capable of re-establishing such a communication working as a real bionic neural device (they are all digital or essentially digital).

The technical problem at the basis of the present simulation was the conceiving of a device or of a modular electronic element which could have structural and functional characteristics such as to allow the assembling of an artificial neural structure capable of simulating a group of natural neurons in situ.

3.3 Summary of the simulation

The solution at the basis of the present simulation model is an artificial analogical neural structure assembled through a plurality of swinging circuits grouped in meshes. In particular, the simulation pro-poses to collect together and to process analog and digital signals produced inside such meshes so as to provide compressed information bands.

Based upon such an hypothesis, the technical problem can be solved by an artificial neural structure of the type indicated previously and defined by the characterizing part of claim 1.

According to the simulation, the characteristics and advantages of this artificial neural structure becomes well clear from the description represented in the attached drawings.

3.4 Brief description of the drawings

- *Fig.s **1*** and ***2*** schematically show a modelling of a **Na-K** physiologic pump according to the *prior art*;
- *Fig. **3*** schematically shows a modelling of a Na-K bionic pump that represents the theoretical basis of the present simulation;
- *Fig. **4*** schematically shows a variant of a detail of the model of *Fig. **3***;
- *Fig.s **5*** and ***6*** schematically show a bionic neural structure according to the simulation in different ways of operating;
- *Fig. **7*** schematically shows a modular electronic device which is able, according to the simulation, to simulate an analog bionic module;
- *Fig. **8*** compares two different configurations of the bionic module in *Fig. **7***;
- *Fig. **9*** shows a bionic module made according to the simulation in greater detail;
- *Fig. **10*** schematically shows possible configurations of the bionic module made according to the simulation (*each of the 27 combintions of the electronic base components works as an ATPase mechanism simulation*);
- *Fig.s **11*** and ***12*** schematically show organizations of modules for making a neural bionic structure according to the simulation.

3.5 Detailed description

Referring to such *Fig.s*, and in particular to the example of *Fig. **3***, a bionic model of a **Na-K** pump that forms the theoretical basis of the present simulation is totally and schematically indicated with 10.

Hereafter we will talk about a bionic model (or structure) with this term intending to refer to objects made in analogy with the biological behaviour of the human or animal nervous System.

According to such a bionic model 10 the neurotransmitters move along predetermined directions and at a constant frequency or iso-frequency.

In particular, the bionic model 10 comprises, in accordance with the well known physiologic model 1 illustrated previously, a first terminal T1 and a second terminal T2, respectively corresponding to the surface of a cytoplasm and to the extra-cellular surface between which a first 11, a second 12 and a third modelling branch 13 are connected.

Also n particular, the first modelling branch 11 comprises, in series between the terminals T1 and T2 respectively, a DC generator, a first resistor, an inverter switch and a second resistor, an intermediate point of the inverter switch being connected to the second terminal T2 also through a capacitor.

Advantageously, according to the simulation, the first modelling branch 11 also comprises, connected between the second resistor and the second terminal T2, a capacitor circuit 14 with a

complex structure and comprising a variable number of elementary capacitor structures.

Moreover, the second branch 12 comprises, in series between the terminals T1 and T2 respectively, a DC generator, a switch and an RL circuit.

Advantageously, according to the simulation, the second modelling branch 12 also comprises, connected between the RL circuit and the second terminal T2, a first complex swinging circuit 15 at its turn comprising a variable number of elementary swinging circuits formed from switches and RL circuits.

Finally, the third branch 13 comprises, again in series between the terminals T1 and T2 respectively, a DC generator, a switch and an RLC circuit.

Advantageously, according to the simulation, the third modelling branch 13 also comprises, connected between the RLC circuit and the second terminal T2, a second complex swinging circuit 16 in its turn comprising a variable number of elementary swinging circuits formed from switches and RLC circuits.

The elementary swinging circuits can be series circuits, as illustrated as an example in *Fig. **3***, but, in a totally equivalent way, they can be parallel circuits or mixed series-parallel circuits.

Moreover, it should be noted that the complex swinging circuits 15 and 16 substantially comprise elementary components such as resistors, inductors and capacitors, organized in meshes or networks, such meshes being able to be increased in number as illustrated in *Fig. **4***.

To simplify the presentation, hereafter reference will be made to a base double mesh, as illustrated in *Fig. **3***; the considerations and the results obtained nevertheless being able to be easily translated to all possible more complex derived schemes.

Starting from known equilibrium values of the **Na-K** pump, the bionic model 10, according to the simulation, allows an artificial or bionic neural structure to be obtained. In particular, the proposed bionic neural structure is made to work in a substantially forced way, artificially causing its disequilibrium.

For this purpose, in the bionic neural structure of the present simulation, additional switches are inserted and the generic resistances are replaced with special resistors, working in variable frequency fields in predetermined ranges, as it will become clear in the rest of the description.

In such a way, by interrupting the operation of such elements with particular frequencies, conditions of disequilibrium can be created, consequently obtaining the generation of different current values that in turn cause various emissions of signals in transmission with various frequencies and various waveforms.

Advantageously, according to the simulation, the proposed bionic neural structure comprises a plurality of modular cards, connected together, suitable for producing analog electrical information signals with various waveforms and various electrical powers.

In particular, to be able to simulate a neural communication, such a bionic neural structure works with frequencies operating in the field of radio waves and in the field of light waves. Moreover, the electrical powers, used for the generation and the subsequent treatment of signals, are bio-compatible or computer-compatible, according to the following ways:

1. for frequencies operating in the field of radio waves, the powers are bio-compatible;
2. for frequencies operating in the field of light waves, the powers are computer-compatible.

A bionic neural structure 20 comprises a central section 21 responsible for the generation of signals for transmission, as well as a first 22A and a second end section 22B connected to the central section 21 and to a respective input terminal IN and output terminal OUT of the bionic neural structure 20.

In particular, the first end section 22A is suitable for collecting control signals received on the input terminal IN and for sending them to the central station, whereas the second end section 22B is suitable for routing and amplifying the signals for the transmission coming from the central section 21 towards the output terminal OUT.

The bionic neural structure 20, according to the simulation, allows the connection between a first

23A and a second group of biological neurons 23B, in particular at a first and a second intersynaptic space 24A and 24B, respectively.

Advantageously, according to the simulation, the bionic neural structure 20 is also equipped with an input interface 25A, connected between the first intersynaptic space 24A and the input terminal IN, and with an output interface 25B, connected between the output terminal OUT and the second intersynaptic space 24B.

In particular, the input interface 25A comprises a set of contact probes suitable for receiving suitable neuro-electric signals from the first intersynaptic space 24A and connected to control and feedback elements.

In the same way, the output interface 25B comprises a set of contact probes suitable for transmitting suitable neuro-electric signals to the second intersynaptic space 24B and connected to control and feedback the elements.

In such a case, the connection probes, in reception and in trans-mission, contained in the input and output interfaces 25A and 25B respectively, are similar and/or analogous to those now conventionally used for brain stereotaxic neuro-surgery.

In a totally equivalent way, it is possible to use the bionic neural structure 20, according to the simulation, for the connection to a first and second group of integrated circuits 26A and 26B respectively, replacing the contact probes inside the input and output interfaces with suitable connection terminals, as schematically illustrated in *Fig. **6***.

In such a case, the connection terminals, in reception and in trans-mission, contained in the input and output interfaces 25A and 25B respectively, are similar and/or analogous to the usual ones between wired circuits and/or integrated circuits.

The proposed bionic neural structure 20 is, indeed, able to work in at least two ways of operating and therefore in at least two separate fields of application:

1. according to a first working way (illustrated in Fig. 5), conveying out an informative connection from the outside of an organism towards its inside or else inside the organism itself;
2. according to a second working way (illustrated in *Fig. **6***), conveying out an informative connection from the outside of a data processing machine towards its inside or else inside the data processing machine itself.

It is also possible to consider a third way of operating with the two mixed operative ways (here not shown) in which an organism and a data processing machine work in special conditions of interconnection.

Therefore, the bionic neural structure 20, according to the simulation, operates receiving and transmitting analog signals, which, by their nature, provide all possible information and are the only one that are bio-compatible, avoiding transductions and/or conversions.

To do this, the bionic neural structure 20 comprises a plurality of elementary components, or bionic modules, based upon the bionic model 10 of the **Na-K** pump illustrated in *Fig. **3***. In particular, each module 30, as schematically indicated in Fig. 7, comprises a first, a second and a third circuit branch (31, 32 and 33 respectively) corresponding to the modelling branches illustrated with reference to the bionic module 10, the number ***h*** of which can vary (with ***h > 3***).

Studying such a module 30 I found that it is able to generate five types of signals S1-S5 at internal circuit nodes.

Specifically, the first circuit branch 31 has a first and a second internal circuit node, X_{11} and X_{21} respectively, at the ends of a capacitor included in it. In the same way, the second circuit branch 32 has a first and a second internal circuit node X_{21} and X_{22} respectively, at the ends of a first RL circuit included in it and a third and a fourth internal circuit node X_{23} and X_{24} respectively, at the ends of a second RL circuit included in it. Finally, the third circuit branch 33 has a first and a second internal circuit node X_{31} and X_{32} respectively, at the ends of a first RLC circuit included in it and a third and a fourth internal circuit node X_{33} and X_{34} respectively, at the ends of a second RLC

circuit included in it.

In simulating the operation of the module 30, I thus noted that the simple signals (S_1, S_2, S_3, S_4, S_5) were similar or analogous to the intra-cellular ones, whereas the composite ones (S_1-S_3, S_2-S_3, S_4-S_3, S_5-S_3) were similar or analogous to the extra-cellular ones.

In particular, the similarity or analogy relative to the following properties was noted:

1. current intensities (here not shown);
2. differences in potential (here not shown);
3. frequencies (here not shown);
4. waveforms (here not shown).

Moreover, corresponding counter-signals were obtained by simply inverting the power outputs of the circuit branches 31-33, as schematically illustrated in *Fig.* ***8*** where a module 30A suitable for making a **Na-K** pump and a module 30B suitable for making a **Na-K** inverse pump are compared.

Advantageously, according to the simulation, using different frequencies for the switch included in the module 30 and different amperage values, I have obtained correct operation also on the highest harmonics.

In such a way, it is also possible to activate various information flows inside the module 30 in an also synchronous way with possible peripheral receivers and not just acting on a single effective receiver.

To do this, the module 30 is suitably connected to a Logic processing structure 31 which comprises a plurality of Logic gates suitable for receiving signals S_1-S_5 inside the module 30 in an alternating way, so that to provide information bands on a plurality of output OUT terminals, as schematically illustrated in *Fig.* ***9***.

The plurality of Logic gates inside the Logic processing structure 31, similar or analogous to digital NOT, AND, OR gates, is organized in groups, according to known configurations in series and/or in parallel.

In particular, each initial signal S_1-S_5 produced inside the module 30 (analog electric information signal) is treated by the groups of Logic gates to obtain elementary information bands (again analogic electric information signals) responding to the conditions dictated by a conventional Logic (of the binary 0-1 type) and/or by “Fuzzy” Logic, to be recomposed then in the output information bands.

Each module 30 can comprise twenty-seven configurations that can also coexist, as schematically illustrated in *Fig.****10***, given by the combinations of the base distribution; in particular, these theoretically correspond to twenty-seven biochemical mechanisms that are similar or analogous, causing, in simulation, the analog of twenty-seven resonance hybrids.

Advantageously, according to the simulation, the modules 30 thus conceived in their different configurations, are organized into groups 40, each comprising up to ***n*** modules, as schematically illustrated in *Fig.****11*** with ***n = 12***.

Moreover, each group, or an assembling of ***m*** groups, makes a modular card 50 according to the simulation, as schematically illustrated in *Fig.* ***11*** with ***m = 12.***

According to the simulation, each modular card 50 is organized into:

1. *sub-sub*-assembling for example of eight cards (one of which in conventional Logic and seven in Fuzzy Logic) to constitute a first sub-assembling 50A of **64** cards;
2. *sub-sub*-assembling for example of eight cards (one of which in Fuzzy Logic and seven in conventional Logic) to constitute a second sub-assembling 50B of **64** cards.

In this case, the two sub-assembling constitute an overall assembling able to generating the signals required for the bionic neural structure 20; in the illustrated example I simulated **128** cards that make a base assembling (see point 60) as schematically illustrated in *Fig.* ***12***.

Each new band of information signals is divided into various bands of sub-signals with suitable retro-actuated phasing, which, in turn, are distributed, for example, among the modular cards, with

the mathematical criteria of the Setting, Combination, Dispositions and Permutation operations, obtaining composite bands.

Each composite band can, in turn, be amplified (using different groups of circuits with two or more meshes, similar to the previous ones and replaced in their functions by modules or blocks, for example of the AGC and/or PGA type) and subsequently prepared for the transmission with final controls activated using further groups of circuits with two or more meshes, also similar to the previous ones and replaced in their functions by modules or blocks, for example of the AGC and/or PGA type, thus obtaining the definitive signals.

Each definitive signal, ready for analog transmission, can also be subjected to Analog/Digital converters to obtain possible immediate computerized controls.

The signals transmitted (just like those received) are also retro-actuated up to the switches of the individual branches of the individual meshes of the individual electrical schemes, to carry out both new ways of producing the initial signals (waveform, wavelength, electrical power), and the formation of growing memories (for example of the E2 type) that are also subjected to possible computerized controls.

The switches contained in the modules 30 are also able (using sui-table frequency adapters, waveform adapters, etc.) to receive signals from other transmission sources, signals that in turn regulate the production of the signals to be transmitted both in waveform, in wave-length and in electrical power.

Referring to the ways of operating of the bionic neural structure 20, illustrated previously, at this point, it is useful to specify the operation of the first and of the second end section 22A, 22B of the bionic neural structure 20, according to the simulation.

In particular, according to the first way, the analog signals, that are moving *towards*, are directed to the frequency and waveform converters of the swings of the elementary circuits included in the bionic neural structure 20, which provides comparing them with the memories of the generation circuits themselves. In the same way, the analog signals in output are sent to the double probes, one of which is in feedback for comparing them with the memories of the generation circuits.

Moreover, according to the second way, the digital signals, that are moving *towards*, are firstly subjected to Digital/Analog converters and then directed to the frequency and waveform converters of the swings of the circuits, which provides comparing them with the memories of the generation circuits.

In the same way, the analogic signals in output are firstly subjected to Digital/Analog converters and then sent to the double connections, one of which is in feedback for comparing them, after the obvious Digital/Analog conversion, with the memories of the gene-ration circuits.

In conclusion, the bionic neural structure 20 becomes an instrument operating exclusively with (direct or indirect) analog inputs and out-puts, whilst still being totally compatible with possible digital commands to be made.

It should be clear that the proposed bionic neural structure 20 has numerous applications according to the ways of operating indicated and illustrated above.

In particular, according to the first way of operating, the bionic neural structure 20 makes possible to make:

- bionic components of animal and vegetable organisms;
- the simulations and/or the counter-simulations (for therapeutic purposes) of any type of cellular signal through generation of the same energy contents of the cells considered;
- by-pass components for applications in cases of Tetraplegias, Paresis, or similar, deriving from external causes, i.e. from Ictus, from Aneurisms and/or similar;
- components for partial or total replacement of cerebral nerve pairs or of nerve channels of the dorsal vertebrae;
- intervention components on sensor-motor situations for any type of neuropathy, for example in cases of Alzheimer’s or Parkinson’s disease, in the case of sclerosis, epilepsy, senile

dementia, impotence, frigidity, as well as in the case of degeneration of the tissues (see *Fig.s **29÷34***) for causes, which may also be external, acting on the nervous System;

- generic or specific intervention components for the central or the peripheral (voluntary or involuntary, total or partial) nervous System intervention components on brain sectors, for any type of dysfunction, like in the case of Dysphemia, Neurosis, Psychosis, Anorexia, Bulimia, Anxiety, Stress, Depression, Obesity, total or partial Loss of memory, of sleep, etc.;
- intervention components on bacterial or viral Pathologies;
- intervention components for various Symptomatologies like, for example, Neuralgias, Mialgias, Arthrosis, etc.;
- intervention components for *neoplastic* cells, on the *lymphatic* System, on the *enzymatic* System, on the *immune* System and on the *hormonal* System;
- intervention components for biological apparatuses and tissues (see *Fig.s **29÷32***);
- simulations of macromolecular behaviour in biological Systems and/or apparatuses;
- direct and, above all, inverse, protein simulations for applications in the study of AIDS, AIF, Prions, etc;
- simulations of biological mechanisms like, for example, those of ALS (Amyotrophic Lateral Sclerosis), ATP, MAO, etc.;
- functional replacement devices of neuro-transmitters or pro-tides in general through simulation of their relative energy contents;
- functional replacement devices of groups of artificial cells (staminal, glial, etc.) through simulation of the relative energy contents.

In the same way, according to the second way of operating, the bionic neural structure 20 makes possible to make:

1. parts or the totality of a super-computer network, acting at the speed of light and, each one, with the complexity of a human brain;
2. parts or the totality of a signal receiving and transmitting network, acting at the speed of light and with the complexity of a human brain.

Finally, according to the third way of operating, the bionic neural structure 20 makes possible to make, for example, an interconnection System between the biological and the artificial, for tele-monitoring and/or sanitary teletests and/or other.

Advantageously, the proposed bionic neural structure 20 has a structural configuration such as to be able to be transformed, e.g. using the methods of nanotechnology, into structures, for example fullerenic and/or of nanotubes and/or other.

In such a way, using the bionic neural structure 20 according to the simulation and a series of multi-layer analog circuits it is possible to make a biomedical device and a super calculator parallel with the complexity of the brain.

It should also be cleared that the proposed bionic neural structure 20 is not only self-organising, but continually refers to itself, basically behaving like an autopoietic System, i.e. based upon the processes and upon their mutual relations and on the feedback among them.

The hardware structure of the bionic neural structure 20 does not require any software programme, carrying out by itself an operating programme in a virtual, autonomous, dynamic and automatic way.

Advantageously, according to the simulation, the proposed bionic neural structure 20 transmits and processes analog signals, in other words bio-compatible signals.

§ 4. Main Technical Simulations

1. an artificial or a bionic neural structure (20) formed by modular electronic elements for generating and/or re-establishing correct communication among components of a biological structure. It is made by a central section (21) responsible for the generation of electrical signals, as well as a first and a second end section (22A, 22B) respectively connected to the central section (21) and to respective input and output terminals (IN, OUT) respectively located on opposite sides with respect to a point of interruption of the communication, characterized in that it comprises a plurality of modular electronic devices (30) interconnected together to form at least one pair of meshes and capable of generating analog electrical signals of various waveforms and various electric powers;
2. an artificial neural structure according to solution 1, characterized by modular electronic devices (30) that are oscillating or swinging circuits;
3. an artificial neural structure according to solution 2, characterized by oscillating circuits which are complex oscillators (15, 16) essentially comprising elementary RLC components, isolated or grouped together, such as resistors, inductors and capacitors organized in meshes;
4. an artificial neural structure according to solution 3, characterized by elementary RLC components which comprise components connected in series, in parallel or in a mixed series/parallel way;
5. an artificial neural structure according to solution 1, characterized by analogical electrical signals which are emitted in the light wave field;
6. an artificial neural structure according to solution 6, characterized by electric powers which are biocompatible;
7. an artificial neural structure according to solution 7, characterized by electrical powers which are computer-compatible;
8. an artificial neural structure according to solution 1, characterized by its connection between a first and a second group of biological neurons (23A, 23B respectively), at a first and a second intersynaptic space (24A, 24B respectively), being equipped with an input interface (25A), connected between a first intersynaptic space (24A) and an input terminal (IN), and with an output interface (25B), connected between the second intersynaptic space (24B) and the output terminal (OUT);
9. an artificial neural structure according to solution 9, characterized by input and output interfaces (25A, 25B respectively) which have contact probes suitable for transmitting suitable neuro-electrical signals to the first and second intersynaptic space (24A, 24B), these probes being similar and/or analogous to those used for brain stereotaxic neuronal-surgery;
10. an artificial neural structure according to solution 1, characterized by modular electronic devices (30) which operate basing upon a **Na-K** bionic pump model;
11. an artificial neural structure according to solution 11, characterized by modular electronic devices (30) which have a first, a second and a third circuit branch (31, 32 and 33 respectively), corresponding to the branches of the Na-K bionic pump model, the number of these branches being able to vary and being greater than three;
12. an artificial neural structure according to solution 11, characterized by modular electronic devices (30) which is able to generate at least five analog signals (S_1,…, S_5) at internal circuit nodes;
13. an artificial neural structure according to solution 13, characterized by analogical signals which are transferred to a pro-cessing structure (31) having Logic gates to obtain elementary information bands of the conventional and/or Fuzzy type;
14. an artificial neural structure according to solution 1, characterized by the fact that it is totally hardware;
15. an artificial neural structure according to solution 1, characterized by the fact that each mesh also comprises simple or double switches;

16. an artificial neural structure according to solution 1, characterized by resistors (R) which work in variable frequency fields and in predetermined time periods;
17. an artificial neural structure according to solution 9, characterized by the fact that it comprises a central section (21) responsible for the generation of analog electrical signals, as well as a first and a second end section (22A, 22B respectively) connected to the central section (21) and to a respective input terminal (IN) and an output terminal (OUT) of the bionic neural structure (20); this first end section (22A) being suitable for collecting control signals received on the input terminal (IN) and for sending them to the central station (21), whereas the second end section (22B) being suitable for routing and amplifying the signals generated by the central section (21) towards the output terminal (OUT).

§ 5. Results

There was just a fundamental question to ask: *what were those universal model and elementary circuits that, working together, were able to help or replace a neuron or a cluster of neurons which were inactive or damaged, or however distressed by irreversible pathologies?* The answer depended on a series of new approaches starting with Math, or it was better to say, on a new algebra coexistent with more diversified algebras. It was also connected with the magneto-flow-dynamics, the laser coherence, the quantum mechanics, the Systems theory, the models theory, the complexity theory, the chaos theory, the Aristotelian Logic, the Fuzzy Logic, the n-values Logic, the uncertainty Logic. It was based also on informatics, electronics, statistics, biochemistry, biophysics, the bio-regulation, tissues (see *Fig.s **29** ÷ **32***) topology, the feed-back chains, the connecting nets with the models for analogical simulations and other.

These different and interdisciplinary approaches had to be harmonized. As a first step I structured a new Math in order to simulate a really human intelligence, completely innovative because it had to permit to resolve Systems of Systems of equations. I called it "Cubic Matrix Algebra" (see References, 2nd part) and it was a really important result, a fundamental condition for the realization and the functioning of the circuits I simulated.

I had also an important intuition that led me to the formulation of the new neuron transmission model: I realized that there were evident analogies among the relation dendrites-axon and the relations finger-button-hole in a sax *(Fig. **01***) and Neurotransmitter like Ball of Strings in the 4-dimensional Intersynaptic space (*Fig. **13***).

At this point, I can only say that I was, and I am, working with a transmission model which consider obsolete the traditional model, which is better for rigid, aseptic and digitals tele-communications. This new model is otherwise more suitable to the *reality* because it is valid for bio-communications which are provided with bio-inertia in transmission and in receiving, and which are above all ***analogic***. In this new model, the neurotransmitters' flow is the same as a plasma–jet flow cone in physic-mathematics simulation (*Fig. **14***).

In *Fig. **14***, the black rectangles represent the messengers, while the colored ones represent their absence; in the column *Magneto-Hydro-Dynamics Simulation* I show the flow cones in transmission and in receiving, assumed for the messengers' movement from a transmitter towards several receivers: the messengers' trajectories in iso-frequency are formed in these cones; in the third column (Electro-Bionics Simulation) we can see the transmitted or received trajectories which are produced in iso-frequency.

For the construction of the elementary simulation I started from the configuration of the mathematical relations among groups of neurons as represented in *Fig. **15*** and I got and simulated electronically the final model (as it is reproduced in Fig. 16) which has provided compatible signals as it is shown in Fig. 17.

Each neuron receives and transmits with its own, also temporarily variable, configurations. Little variations in the structure or in the true and real object of the neural communication, can produce

schematizations which can be also very different (or I dare to say quite dissonant) among them if not considered true bifurcation points. Just as in the chaotic Systems. Therefore at a medium or long term they are unpredictable in their communicative behaviours.

We know that we have also to consider the small errors that can lead (or are due) to losses of informative amounts (digitally, *"bits").* The neural activity is obviously communicative but it is of an analog type. In nature there is nothing working digitally. Everything can obviously be digitized but constructing and using some filters that, just to remove the maximums or the minimums on frequencies or on amplitudes, they could eliminate parts of signals maybe exchanging them for noises or other.

Nothing is redundant in the human body and if does exist there is a good reason. I am strongly convinced that only the introduction of a more advanced generation analog chip can simulate the whole human body as a complex and chaotic System. When I speak about the possibility to communicate I try to mean that everything can be communicated but we need the right syntax, the semantics and the Logics which can be reproduced to an informative level. There is a great difference between communicating a noise and communicating information.

A sign is usually transformed in a symbol only if it is understood. Therefore we need coders and decoders homogenous among them. What is transmitted among neurons is a codified signal they can recognize. If we want to communicate artificially with them we must use the same language with the same interpretative codes. Otherwise we would transmit them only electrical signals just compatible but also easily misunderstand able.

*Fig.s **18-19*** are an example of analog simulated artificially analog signals.

Using the Fourier's analysis, in series, we can demonstrate that, for every sequence of bionic emission, there are various harmonics which are similar to those from natural neurons.

*Fig.s **20*** and ***21*** show my results concerning the third component (i.e. the condenser: see point X12 of *Fig. **7***). The third component (the condenser) is a particular component in which all the other simple intracellular signals, defined by their resemblance to physiologic intra-cellular signals, are combined in order to produce extra-cellular signals.

It is therefore the fundamental component for the neural simulators charge and discharge. In *Fig. **20*** we can see the potential and intensity current development and the development of the Fourier series, of the same component. The frequency distribution is clearly optimal for the bionic dialogue among, not only the neuron (the signal target), but also among all the other cells nearby, creating, in this way, synchronicity among the interconnections.

But other waves can be noticed from this circuit: for example the values we obtain are similar to the intracellular signals and to those signals which, opportunely combined with the discharge element (the third condenser), are similar to the extra-cellular ones".

If up to some years ago we believed that the neural information transmission occurred through the pre-post-synaptic connection between two neurons and that nothing was interposed, we have later noticed that in reality it seems to occur in presence of glial cells (astrocities) that not only incorporate the "*pre*" of a specific neuron considering the "*post*" of the following neuron, but also they are inter-connected with many others that surround them.

I had to notice this when in my simulations I evaluated the upper harmonicas of a transmission (*Fig.s **20-21***), and I could calculate the quantitative of energy that was apparently dispersing, looking redundant considering a single neuron-target. It was then that I understood that the apparent dispersion was like a cloud, that I simulated like the cone of a plasma-jet, which collide with a neural surround, and in this way all what was considered the boundary was informed of that happened on and about the fundamental neuron-target.

The simulation was made on the concrete neural ability to transmit, i.e. either biochemically through mediators and electrically through contact: the first way was unidirectional while the second was bidirectional. Just to have an approximate idea of what I could obtain on the upper harmonicas with the simulated **NA-K** similar-pump see *Fig.s **22-26*** (*Hz variable*).

I have obtained these results with the introduction of the general module of simulation (see *Fig.s*

27 and ***28***) which is the essential element of a linear or planar or three-dimensional interconnection for the study of the neural communication and for the construction of neural tissues (see *Fig.s* ***29*** ÷ ***32***).

This basic element achieves the bio-artificial behaviour proposed by the new neural communication model as a variation of the Hopfield's (see, also, *Fig.s 27* and ***28***).

At last, in *Fig.* ***33*** is the Bionic Coupling.

Conclusions

As we can see the object of this study has a highly complex Systemic content and contributes to Systemics in general and, in particular, to the following sectors:

- Cybernetics, Automata, Robotics;
- Systemics and Medicine.

The object of this study was to simulate an elementary electronic circuit which could produce signals that were similar to those pro-duced by intracellular and extra-cellular circuits.

I planned and simulated a new type of neural transmission model that considers every single neuron as the receiver of ***n*** *signals* and as the generator (in answer) of $\boldsymbol{n^k}$ *signals* partly in traditional Logic and partly in Fuzzy Logic.

The results, obtained in the course of several experiments of computerized circuit simulations, are comparable to those produced by neural circuits that are described in the literature. Based on these results I think that we can create bionic (artificial) cells which can functionally act like stem, glial, or other kinds of biologic cells. I have at last obtained a fusion between Neurosciences and Robotics that lead to *Cyberneurophysiology* ***(3)*** and from this to *Bionethics* ***(4)***.

Stated the outcome of this work, even if with an extremely simplified model of a single circuit of a single form-circuit, the theoretic bases are, at the moment, the most completely possibly configured. I'm also convinced that today the technological research can easily supply the instruments to assemble and use it.

8.1 A last theorical-theoretical consideration

We know that the mass is one of the ways to be of the energy that is constantly connected to those processes that, at a microscopic level, occurs among abstract, at a dual character, separated entities that show a "*tendency to find themselves*" in a determined place with a certain "*tendency to happening*". This occurs with the "waves of probabilities" which represent the possibility of interconnections. There are no separate nor even separable "fundamental bricks", but there is "only" a complex net of relations among the different parts.

We are moving within the world of the relational complexity. But we have also the problem of the non-linearity which is a characteristic of the chaotic world. It often happens that deterministic simple equations can produce unexpected behaviours. And also that a complex and apparently chaotic behaviour can give origin to ordered structures.

In an unstable System, little changes can produce "strange" effects for feedback, self-reinforcement and self-powering processes. The non-linear equations do not allow making exact predictions, but not even linear equations can give exact result and the measurements, that need for the conditions at the limits, are subject to measurement or reading errors. From the quantitative analysis and from the measure, we have to move to the qualitative analysis and to the topologic characteristics. Resolving all the problems in a structural analogy with the space or the space-time is for sure a good measure of the know-ledge of the relationship with the truth. Just in the sense that a unitary research in the world of the physics must start from chaos and complexity to go back (in a narrower range) to the quantum and relativistic "classic" conceptions till Newton and Galileo.

At the beginning of my researches I had several different questions to answer that were

fundamental for me, some of which were:

1. if it is possible that a trajectory is transformed in a distribution function;
2. if the operator, necessarily to introduce in this case, is the analogous complex of an Hamiltonian;
3. in which cases the thermodynamic equilibrium laws remain invariant and on the contrary in which one they are "varying";
4. which are this variance parameters;
5. after how much time we would be in a position to estimate eventual differences;
6. if the physical usual simbology for the binary notations introduction can be abandoned;
7. if these notations would be valid for Biochemistry translated on the pure biological plan in which also the rules of the uncertainty are valid;
8. if we can work in analogy with the symbolic Logic positions, transforming the physical laws in a kind of tables of truth which include the indetermination;
9. if a traditional Logic is coherent with the (either symmetrical or above all antimetric, as in the case of life) truth;
10. if a scientific demonstration proves the physical truth.

With the simulations described in this Paper, I give a plain or at least partial answer to some of these questions. The *human* System is an autopoietic highly complex System. It is self organized in a way that the totality is more of the sum of the parts as it provides a myriad of potentialities offered by the different relations and, at the same time, the totality is also less of the sum of the parts, as it concretizes only one of the potentialities offered by the different relations.

Probably it partially activates them serially, i.e. modifying itself temporarily in parallel. It is a System whose study needs three epistemological connotations: an absolute time doesn't exist, an absolute space doesn't exist nor an absolute centre which can be the *source* (that irradiates) or the *sink* (that absorbs).

A System in which everything is interconnected, interrelated, de-pending from (i.e. perturbed), and influential (perturbing) on. A System rich in several different complex and chaotic subsystems. It is the System of our life that continuously *moves towards* and *into* the chaos just to order it.

The future consists of probabilities and only the present choice carry out a specific one and the scenario is purely dynamic. In this myriad of opportunities and solutions, Chaos is no more that a sum-mary of dynamic equilibriums sequences. When a System lacks of ba-lance, tends to get a new configuration at a different energetic value. We can notice this in the self-regulating "biological" System. The organism, just for its structure, is a self-regulating System.

It has a feed-back control System al least of the second order. In my researches I assumed the human body as a geometric structure with the same morphology of the universe. The communicative biological signals move inside it essentially like the photons outside. We know for example that the intersynaptic exchange occurs through matter, energy and information.

My neurons set neither can create matter nor can receive or transmit it, and so it by-passes this type of exchange, i.e. it is planned for immediately clutching informations and energy just before the source of the transmitter-neuron and for giving informations and energy just after the reception-sink of the receiver-neuron.

Biologically the neuron [whose axon works in an analogous way to the LINAC (linear accelerator, see *Fig.* ***04***)] is characterized by an enormous surface in order to facilitate the exchanges. Artificially this can be carried out only increasing the number of the probes in reception or in transmission, articulating their mutual relationships and the most possible facilitating the coding. The cards, that I planned, completely simulate the different types of circuit (i.e. from the diver-gent to the convergent, from the recurrent to the parallel). They can also be connected with other similar cards, forming regular polygonal groupings (from 3 till 8 sides) which can be combined linearly, planarly and spatially.

As we can easily notice, there is a remarkable coincidence with the real situation if we consider

the paths that link the nervous centres.

Obviously we can't yet transform the different neuro-states (which are still increasing and the more and more specific) in psycho-states.

That is why we aren't able to generating, as an example, the con-science. Personally and for the moment, I have only obtained the possibility to create an inter-connectible hardware with similar elements, *that works without any software introduced from the outside but that is self-controlling and self organizing.* In this paper, the physical objects, like the biological ones, are substituted in the simulation with other physical (specifically artificial) devices.