THE VIEW FROM THE PARADOXICAL WORLD

A thesis submitted for the degree of Doctor of Philosophy

by

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ABSTRACT

The consequences of using such complex tools as Logic and Mathematics, which are so ingrained in our own nature as thinking living organisms, to explain precisely that Nature in which we ourselves are imbedded, are disucssed from a new perspective. The interplay between the individual (subjective) world and the social (objective) world emerges with clarity under this light.

Paradoxes, a nightmare for Logicians and Mathematicians, are returned to their cradle, the observer, where no hunt is set up to "solve" them. Though I am not alone in this endeavour to consider paradoxes from a different perspective, new insights into the nature of the living organization and the working of the nervous system allow today the opportunity to strengthen this revolutionary viewpoint.

Several experiments performed on a multicomputer realization of organizationally closed (paradoxical) unities, suggest a nervous system where processes and descriptions are more fundamental concepts than time and space.

While the consequences of this new approach remain still to be explored, a sensitive reader will already enjoy them.

CONTENTS

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To many of my students who were so kind to let themselves be involved in these new ideas sometimes so far from their immediate endeavours. I hope that this experience will help them to keep their youth alive for years to come.

Le ciel donne le feu

Pour faire l'enfer

L'enfer, le miel

Pour faire le ciel

FOREWORD

The perspective presented here, which the reader can accept or reject, points to creativity as a result of exploration which consists of an endless affirming and negating, thereby also changing, the present circumstances.

Through a contrapuntal study of the individual being and the social being and their corresponding knowledges, I propose to escape a situation -- already among us human beings -- which endangers creativity conceived as above. It is my contention that without the perspective presented here, every attempt to stress the social or cooperative drives of human beings will end as a restricted and selective cooperation through association. This latter alternative has already contributed to a deleterious trend that will render more and more individuals to a more or less agonizing "burning at the stakes" at the hands of those entrusted to "defend and protect" the accepted (by some) rules of the game. Those defenders of human rights and the social inclinations of all human beings are increasingly shielded inside developed communities, charitable organizations and what not from the atrocities committed or provoked by this same "social being".

Of course human beings are social, but if we forget that they are also individual beings or if we do not understand what this entails, we will find ourselves striving for an anthill and not for a community of human beings. We must realize that human beings can relinquish their autonomy when they become part of a group of individuals and pursue the goals of the group, even if

these goals go against their own goals or those of their fellow human beings, especially if they are not members of the group.

Therefore, it is an observer's perspective that I present in what follows and my aim is to stimulate in my reader again an observer's perspective. Although I cannot escape the use of a social language to do this, I hope, perhaps even more than an artist, that a sensitive observer will be able to reconstruct my image, in its own terms.

INTRODUCTION

It has been the aim of many people to know (and understand) the world that they perceive through sense organs. However, as long as there is more than one individual, this endeavour has been two-faced, individual and social (as B. Russell suggests). This double nature of knowledge has been the source of a continuous struggle between these two forms of knowledge. Social knowledge has taken the robes of science, which aims at a totally impersonal knowledge, scientific knowledge; and of language, which is the only means of "communicating" scientific knowledge. Language is essential for social knowledge. It is not essential for individual knowledge since this one cannot be expressed verbally and hence cannot be "communicated." A gifted artist can only hope that a sensitive recipient of his (her) art recreates his (her) own experiences. And to try this, the artist uses an artistic language like prose, poetry, music, painting, sculpture, . . . etc. and the peculiarity of these languages is that they are not meant to "communicate" something as scientific languages do, but only to stimulate in the recipient something different from what the language itself is. Not only if an artist tries to express herself (himself) in scientific language, but also if the recipient of her (his) message takes her (him) literally, that is, does not go beyond the artistic language itself, her (his) experiences will be lost in a barren land.

In scientific language it is only the truth or falsehood of the statements that really matters, the diverse meanings that these same statements have for different individuals are usually

considered irrelevant, with the result that individual and social knowledges are often unwisely confused.

We quote B. Russell:* "There are two ways of getting to know what a word means: one is by a definition in terms of other words, which is called 'verbal' definition; the other is by frequently hearing the word when the object which it denotes is present, which is called 'ostensive' definition. It is obvious that ostensive definition is alone possible in the beginning, since verbal definition presupposes a knowledge of the words used in the 'definiens'. You can learn by a verbal definition that a pentagon is a plane figure with five sides, but a child does not learn in this way the meaning of everyday words such as 'rain', 'sun', 'dinner' or 'bed'. These are taught by using the appropriate word emphatically while the child is noticing the object concerned. Consequently, the meaning that the child comes to attach to the word is a product of his personal experience, and varies according to his circumstances and his sensorium. A child who frequently experiences a mild drizzle will attach a different idea to the word 'rain' from that formed by a child who has only experienced tropical torrents. A short-sighted and a long-sighted child will connect different images with the word 'bed'.

It is true that education tries to depersonalize language, and with a certain measure of success. 'Rain'

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*Russel, Ref. 37, p. 4.

is no longer the familiar phenomenon, but 'drops of water falling from clouds toward the earth', and 'water' is no longer what makes you wet, but H_2O. As for hydrogen and oxygen, they have verbal definitions which have to be learned by heart; whether you understand them does not matter. And so, as your instruction proceeds, the world of words becomes more and more separated from the world of the senses; you acquire the art of using words correctly, as you might acquire the art of playing the fiddle; in the end you become such a virtuoso in the manipulation of phrases that you need hardly ever remember that words have meanings. You have become completely a public character, and even your inmost thoughts are suitable for the encyclopedia. But you can no longer hope to be a poet, and if you try to be a lover you will find your depersonalized language not very successful in generating the desired emotions. You have sacrificed expression to communication, and what you can communicate turns out to be abstract and dry.

It is an important fact that the nearer we come to the complete abstractness of logic, the less is the unavoidable difference between different people in the meaning attached to a word. I see no reason why there should be any difference at all between two suitably educated persons in the idea conveyed to them by the word '3841'. The words 'or' and 'not' are capable of having exactly the same meaning for two different logicians. Pure mathematics, throughout, works with concepts which

are capable of being completely public and impersonal. The reason is that they derive nothing from the senses, and that the senses are the source of privacy. The body is a sensitive recording instrument, constantly transmitting messages from the outside world; the messages reaching one body are never quite the same as those reaching another, though practical and social exigencies have taught us ways of disregarding the differences between the percepts of neighboring persons. In constructing physics we have emphasized the spatio-temporal aspect of our perceptions, which is the aspect that is most abstract and most nearly akin to logic and mathematics. This we have done in the pursuit of publicity, in order to communicate what is communicable and to cover up the rest in a dark mantle of oblivion."

As you can see, our conventional rearing and education are rather crippling with respect to individual knowledge. Not only does it inhibit our faculty to recreate beyond language and perception, but it definitely destroys our hope to become artists or even creative scientists. The emphasis is in the construction of a common (scientific) language, devoid of the contradictions and differences that individual knowledge would certainly add to it. The common (scientific) language has obvious advantages, but when these advantages become such that we are unaware of its disadvantages, we should stop and wonder. But before we do this let us consider what Piaget, our brilliant contemporary biologist and psychologist, has to say about this and how he could stimulate in us, if we still have the artist alive inside us, an even more

serious concern about the extent to which the (scientific) language is "covering up the rest in a dark mantle of oblivion".

Piaget is a (passionate) advocate of considering Mathematics in total harmony with the world. How is it possible, one wonders, that a man who dedicates his life's effort to the understanding of man as a living creature, can still sustain with strong conviction that the "entire world of reality can be expressed in mathematical terms, and a fortiori, in logical terms?" when he himself concedes the following while considering the possible hereditary nature of logical structures:*

> "As a result, we are confronted with a sort of evolution which is to a great extent endogenous but is not programmed as to the details of its content; it is reminiscent of epigenesis (as we saw in section 2) but from a purely functional point of view that allows of no outright assimilation of logic into some hereditary mechanism, while compelling us to look for its origins in those functions which appertain to the living organization."

But let us quote Jean Piaget when he answers the following question that he asks himself:**

> "How, in fact, are we to explain the harmony that exists between mathematics and the real world?" First, we must remember that this harmony is a real fact -- and a surprising one at that. It must be emphasized at once that

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* Piaget, 1971, p. 307.

**Piaget, 1971, p. 339.

the entire world of reality can be expressed in mathematical terms and, a fortiori, in logical terms. There is no known physical phenomenon which has defied expression in mathematical form, and attemps that have been made to prove the contrary, such as Hegel's "Naturphilosophie", have come to nothing. Biology still finds itself confronted by a succession of unknown forms, and some have concluded from this that there is a limit to what can be expressed in mathematical terms. However, before any decision is reached, we shall have to examine by what means such mysteries might be cleared up. Can an explanation be found that is intelligible although not mathematical? Philosophers think so, although no one has ever been able to give any epistemological proof that there is a kind of knowledge which can properly be called philosophical as distinct from scientific.* Or can there be an explanation which is intelligible just because it is logico-mathematical? Since setting oneself up as a prophet is a tricky business, I shall only say that, up to now, any rational, biological explanation of phenomena such as heredity and regulations has proved to be consistent with logico-mathematical models, and that, inso-

far as the arguments of the vitalists and finalists have any validity, this has been to the extent of their conformity to cybernetic models of which they themselves knew nothing and whose discovery owes nothing to them.

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*See J. Piaget, 1968.

This only goes to show that the concept of finality as irreducible to mathematization was, in fact, false. In the realm of psychology we are very far from being able to express things in any satisfactory mathematical form; yet very few psychologists are attracted to vitalism on account of the many ordinal processes and the way in which algebraic logic can be utilized. Generally speaking, mathematics today is taking a decidedly qualitative trend, and its involvement with isomorphisms of all kinds has opened up such broad structuralist perspectives that there is apparently no field -- human, biological, or physical -- that cannot now be reduced to fairly elaborate mathematicization."

Perhaps it is the enormous complexity that Logic and Mathematics have achieved or still can attain that deludes many of us into forgetting what Wittgenstein wrote about them:*

"6.1 The propositions of logic are tautologies.

6.11 Therefore the propositions of logic say nothing.

(They are the analytic propositions.)

6.111 All theories that make a proposition of logic appear to have content are false.

. . . . . .

6.2 Mathematics is a logical method.

The propositions of mathematics are equations, and

therefore pseudo-propositions.

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*L. Wittgenstein: "Tractatus Logico-Philosophicus" (Routledge and Kegan Paul, London, 1974).

6.21 A proposition of mathematics does not express a thought.

. . . . . .

6.22 The logic of the world, which is shown in tautologies by the propositions of logic, is shown in equations by mathematics."

Consequently logic and mathematics are tautological in the sense that they are aggregates of linked propositions (logic) or equations (mathematics) in which the validity of the links between them is not doubted and the truth of the propositions or equations is not claimed, and hence they generate no new thoughts.

Where is logic or mathematics, I ask myself, in such a basic and contradictory drive of every young human being or other living organisms at any age which compels them to abandon (change, contradict) the secure and comfortable environment that they have found or created for themselves through previous struggles and efforts, in order to explore the world around them, find or create a new environment, only to leave (change, contradict) it sooner or later. Quite the opposite: logic and mathematics, as tools for social knowledge, will precisely go against this contradictory drive.

Without even suggesting a vitalist position it is my aim to advance an invitation to consider the viewpoint from which at least the organization of the living escapes the realms of logic and mathematics.

CHAPTER 1

P A R A D O X

Preliminaries

As we know, logicians and mathematicians have maintained an epic struggle against paradoxes and many have claimed to have "solved" them, always striving for a paradox-free discipline. Wittgenstein, however, chose not to hunt for paradoxes, but rather dealt with the matter at the outset: he showed that no proposition in logic can make a statement about itself.* Since a paradox makes a statement about itself, he liberated logic of all paradoxes in one elegant stroke. Wittgenstein also claims that his paradox-free logic mirrors the world,** from which one could conclude that he assumes the world to be also paradox-free. I do not think so, and I prefer to understand Wittgenstein as maintaining that his logic mirrors only part of the world, that part which is paradox-free. It seems that for other logicians and mathematicians, logic mirrors the world including those paradoxical aspects of it, which are, according to them, only apparent and consequently can be and will be eventually "resolved" through logic and mathematics. This, however, might prove to be an endless struggle, as many logicians and mathematicians would agree, since new paradoxes are always unveiled. The goal anyway

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* L. Wittgenstein: "Tractatus Logico-Philosphicus", Propositions 3.332, 3.333.

** ibidem, Propositions 6.13, 5.511.

*** ibidem, Propositions 5.61, 5.632, 6.113, 6.41; see also 5.143, 6.3.

is a logic and mathematics free from paradoxes, and this will be attained, so they hope, sooner or later.

Following Wittgenstein's approach we will assume that logic and mathematics are free from paradoxes at the outset, and as such they constitute a mirror-image of some part of the world.

We will consider quite apart from logic and mathematics a set of paradoxes (or paradoxical propositions) that will allow us to mirror, so I sustain, that part of the world which is indeed paradoxical. Obviously, together with Wittgenstein, we are not joining the hunt of paradoxes since from this perspective it appears clearly nonsensical.

In other words, we will consider two aspects of the world, one paradox-free, the other paradoxical and their corresponding mirrors: the propositions of logic and mathematics and the paradoxical propositions. It should be clear then, that we are not advocating paradoxes <u>instead</u> of paradox-free logic, but rather the coexistence of paradoxes and paradox free logic.

<u>The world</u>*

"Everything said is said by an observer to another observer than can be the same observer" (Maturana and von Foerster, circa 1973).

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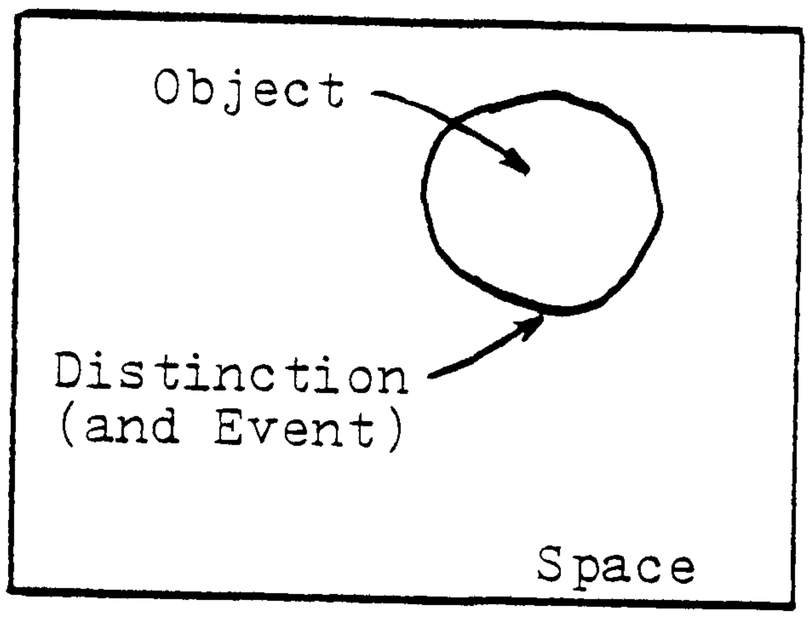
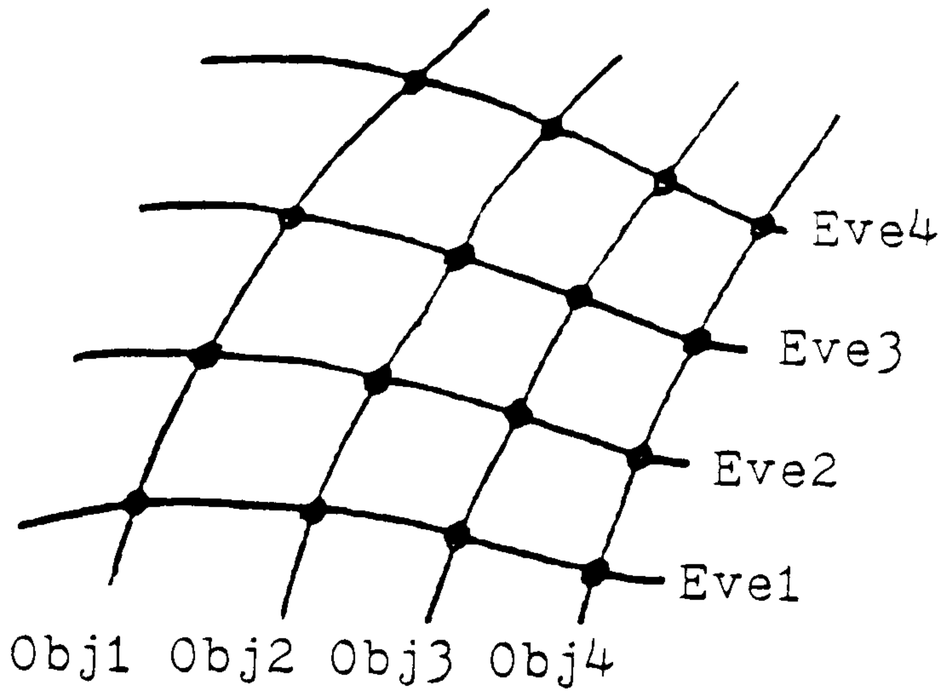
*Please see:
G. Spencer Brown: "Laws of Form" (Ref. 40).
Gordon Pask: "An Approach to Cybernetics" (Ref. 24).
Heinz von Foerster: "An Epistemology for Living Things" (Ref. 47).
Ludwig Wittgenstein: "Tractatus Logico-Philosophicus" (Ref. 55).
Bertrand Russell: "Introduction to Wittgenstein's Tractatus" (Ref. 55).
H. Maturana and F. Varela: "Autopoiesis and Cognition" (Ref. 21).

In our social (logical) attempts to create (a description of) the world, a universe comes into being when a space is severed into two. A distinction is made and a state of affairs (object, event) is defined.





"Objects" creating "Events"
and vice versa (von Foerster, 1976)

A state of affairs is a configuration of objects and events. Events are temporal objects.

The totality of existing state of affairs is the world.

However, we (the subjects), are living organisms which are part of and observers of the world.

Living organisms are unities (state of affairs) whose organization is the autopoietic organization (see Chapter 2). As such, they are self-referential unities that define themselves in the space in which their components exist through a fundamental distinction: the specification of their own boundaries. This distinction determines the living unity and its niche (defined by the unity's own perspective) or the living unity and its environment (defined by the perspective of an external observer). These two perspectives will always arise when an observer and a living organism (which could be the observer itself) interact.

Living organisms, with or without a nervous system, interact with their niche through interactions that are relevant to their living, and through these interactions they "know". In Maturana's words:* "living systems are cognitive systems, and living as a process is a process of cognition." "The nervous system expands the cognitive domain of the living system by making possible interactions with 'pure relations', it does not create cognition."

A living organism becomes an observer when it can recursively interact with the representations of its interactions, thereby recursively generating representations of relations between representations.

In Heinz von Foerster's words:**

> "The environment of an observer is the representation of relations between 'objects' and 'events'. 'Objects' and 'events' are representations of relations.
>
> 'Objects' and 'events' are the result of the computation of an equivalence relation.
>
> Since the computation of equivalence relations is not unique, the results of these computations, namely, 'objects' and 'events' are likewise not unique.
>
> This explains the possibility of an arbitrary number of different, but internally consistent (language determined) taxonomies.

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* Maturana, 1980.

** H. von Foerster, 1976.

This explains the possibility of an arbitrary number of different, but internally consistent (culturally determined) realities.

Since the computation of equivalence relations is performed on primitive experiences (representations of relations), an external environment is not a necessary prerequisite of the computation of a reality."

Moreover, when several observers interact in an "environment" they can only orient each other within their respective cognitive domains.

Consequently, there are (at least) two perspectives from which the observer(s) can choose to construct its realities (descriptions of the world): 1) A perspective that does not assume an environment apart from the observer(s), i.e. the perspective of the observer(s) as individual (paradoxical) being(s); and 2) A perspective that assumes an environment as a separate entity from the observer(s), i.e. the perspective of the observer(s) as social (logical) being(s).

From the first perspective, the observer constructs its realities only through recursively generating representations of relations between representations without any orientations from an environment apart from itself or other observers. We shall call these realities, paradoxical realities. From the second perspective each observer constructs its realities through orientations from its environment that may include other observers, thereby assuming the existence of an environment "out there" (to contain at least the observers). The construction of an observer-independent reality and a logical language appears then as a

natural consequence of this choice of perspective by the observer. We shall call these realities, logical realities.

Even though, in principle, each observer can choose either perspective to construct its realities or even wander from one to the other at will giving emphasis to one or the other, the construction of a reality can be a rather involved process and the escape from a cherished reality is usually very painful.

From a paradoxical (individual) perspective, we postulate one or more universes (or independent processors) and space and time may arise only later as a consequence of process interactions (see Chapter 4). This is quite different from the social (logical) perspective that postulates space and only then universes may come into being. Consequently, the pictures of the world derived from each perspective are profoundly diverse.

We can say now that "everything said is said from a perspective chosen by an observer to the same or another perspective chosen by the same or another observer". This may lead to many possible, often conflicting, realities.

Logical language and paradoxical language*

The choice of perspective determines the type of reality that the observer constructs and with it the type of language that the observer uses. Logical realities will be constructed together with a logical language and paradoxical realities, together with a paradoxical language.

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*Strictly, there is no such thing as a paradoxical "language" in the usual sense of the word. "Language" is used here only as a point of departure towards a new concept that will become clearer later.

In the first case, the observer constructs a reality free from paradoxes that allows the development of social knowledge among a plurality of observers. In the second case the observer constructs a reality in which only paradoxes are possible, social knowledge becomes impossible and only individual (paradoxical) knowledge can flourish. Obviously the same observer can take one stand or the other.

Let us consider the characteristics of a logical language and those of a paradoxical language.

The essential matter of a logical language is to assert or deny facts (i.e. the existence or non-existence of state of affairs) outside the subject, i.e. with respect to the observer as a social being.

A logical language is, therefore, irrelevant for the subject (observer) as an individual, not social, being.

The function of a logical language is to have meaning for the subject (observer) as a social being and it only fulfills this function in proportion as it approaches to an ideal language: a logically perfect language. And it is as such that it constitutes the basis for social knowledge (see Introduction).

A logical proposition is a picture of the world, i.e. it depicts reality (a logical reality) by representing a possibility of existence or non-existence of state of affairs.

A logical proposition agrees with reality or fails to agree, it is true or false, from the observer's viewpoint as a social being.

In order to tell whether a logical proposition is true or false, the observer must compare it with reality.

Logical propositions, as pictures of reality, cannot be contradictory. Either an event occurs or it does not; an object is or is not, there is no middle way.

Logical propositions cannot make statements about themselves, i.e. they cannot be self-referential.

However, there are self-referential state of affairs in the world, i.e. configurations of objects and events that form closed loops.* The representation of these self-referential state of affairs in logic is impossible, since they lead to self-referential loops of propositions.

Therefore, if we are to consider self-reference as part of the world that we want to represent in our language we must have a different domain, a paradoxical language, in which self-referential loops of propositions are possible. These loops can contradict (change) themselves or not. If they do, they will be called paradoxical loops of propositions. Self-referential loops of propositions that do not contradict (change) themselves will not be considered here, because by affirming (confirming) themselves they imply a static a=a, thereby making the loop and the self-reference irrelevant, that is, they constitute a return to logic and to logical realities.

The need for going beyond a logical language can already be seen in the limitations that Wittgenstein found when concerned with the conditions for a logically perfect language (Tractatus Logico-Philosophicus), which B. Russell expounds brilliantly in his Introduction to the Tractatus:

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*See examples in "Paradoxes" below.

"His (Wittgenstein's) attitude towards this (the mystical) grows naturally out of his doctrine in pure logic, according to which the logical proposition is a picture (true or false) of the fact, and has in common with the fact a certain structure. It is this common structure which makes it capable of being a picture of the fact, but the structure cannot itself be put into words, since it is a structure of words, as well as of the facts to which they refer. Everything, therefore, which is involved in the very idea of the expressiveness of language must remain incapable of being expressed in language, and is, therefore, inexpressible in a perfectly precise sense. This inexpressible contains, according to Mr. Wittgensein, the whole of logic and philosophy."

Logical propositions constitute a mirror-image of that part of the world that has logical form.

Paradoxical loops of propositions constitute a mirror-image of that part of the world which has paradoxical form. Therefore, there is no such thing as a paradoxical proposition without change and self-reference.

The essential matter of a paradoxical language is to explore the reality (a paradoxical reality) proper of the subject (observer) as an individual, not social, being.

The function of a paradoxical language is to <u>create</u> understanding in the individual and it only fulfills this function in proportion as it approaches to an ideal language: a paradoxically perfect language. And it is as such that it constitutes the basis for individual knowledge (See Introduction).

(Neither a paradoxically perfect language nor a logically perfect language seem attainable, but their impossibility does not prevent them from showing a path).

A paradoxical loop of propositions is a picture of the world. That is, it depicts reality (a paradoxical reality) by representing a possibility of existence of a paradoxical state of affairs.

Whether a paradoxical loop of propositions agrees with reality or fails to agree is immaterial from the observer's viewpoint as an individual being.

Paradoxical loops of propositions, being self-referential, determine themselves what is the case. For example, since they change* themselves, they can be <u>true and false</u>, independent of a comparison with reality.

In a paradoxical language (the language of the individual being) there is no need for names to refer to state of affairs. The observer can "talk" to itself about state of affairs by perceiving them through the senses, by imagining them or by dreaming about them (e.g. the same state of affairs can be perceived and imagined,i.e. it can "exist" and "not exist" concurrently).

Moreover, from the perspective of the observer as an individual, whether the state of affairs are perceived, imagined or dreamed is immaterial; it is only when the observer becomes a social being (including being social with itself) that the difference between its "inside world" and the "outside world" becomes relevant, even crucial.

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*e.g. contradict. Please forget the connotation of time that is usually implied with change.

What is relevant to logic is the relation between the set of words of a proposition considered as a fact on its own account, and the "objective" fact which makes the proposition true or false as well as the meaning that this relation conveys to the observer as a social being.

From a logical viewpoint, when a person believes in a proposition, the person, considered as a metaphysical subject, does not have to be assumed in order to explain what is happening.

From a paradoxical viewpoint, nothing can be explained without assuming the subject since this subject is part of the paradoxical world (and hence cannot be metaphysical).

What is relevant to a paradoxical language is the relation between a paradoxical loop of propositions and the paradoxical state of affairs that it may depict, independent of a comparison with the particular reality considered by the observer, as well as the understanding that this relation conveys to the observer as an individual being.

Logical propositions can only say <u>how</u> logical state of affairs are, not <u>what</u> they are.

Paradoxical loops of propositions can only say <u>how</u> paradoxical state of affairs are, not <u>what</u> they are.

Subjects are paradoxical state of affairs.

Logic and the observer

The utterances made by an observer can be of many sorts: sayings, statements, sentences, propositions, propositions of logic, propositions of mathematics, tautologies, contradictions,

self-referential loops of propositions, paradoxes, referential propositions, etc. etc.

However, to assign a given utterance to one of these classes is not trivial and has caused many discussions among observers.

Part of the problem arises in relation to the truth or falsehood attached to the given utterance. To decide whether the utterance is true or false an observer makes a comparison with "reality" and, since it is the observer who chooses the "reality" to be considered, the decision (true, false or otherwise) is observer-dependent.

Therefore, it is conceivable that some difficulties (e.g. contradictions) may arise among observers with conflicting realities. Social (logical) knowledge has taught us that most of these difficulties can eventually be resolved through a revision of the conflicting realities and the construction of a new, more encompassing, reality adopted by the participant observers. One of these adjustments occurred when it was realized that the dream of classical science, a purely "objective" description of the world in which there were no subjects, contained contradictions. To remove these contradictions, an observer (i.e. at least one subject) had to be accounted for: observations are not absolute but relative to an observer's point of view (Einstein); the observer's hope for prediction vanishes, the uncertainty of the observer is absolute (Heisenberg) (see von Foerster, 1976).

However, the inclusion of the observer in what is observed (the world) creates all sorts of difficulties (e.g. paradoxes) if we insist in a logical reality, i.e. a logical description of a world that includes the observers.

In logic, propositions can be part of other propositions, thereby becoming 'primitive propositions' with respect to the latter. Their truth-values determine the truth or falsehood of the 'composite proposition'.

Example 1: r is a 'composite proposition' (with respect to p and q), and p and q are 'primitive propositions' (with respect to r).

r: p V q

p	q	r
F	F	F
F	T	T
T	F	T
T	T	T

The truth table defines the sign V (or) but says nothing about r. Only when the truth values of p and q are ascertained we can know the truth or falsehood of r.

But, perhaps not in logic anymore, we can conceive propositions that refer directly to the truth or falsehood of another proposition, thereby becoming 'primitive propositions' with respect to the latter. Again, their truth values determine the truth or falsehood of the referred proposition. The 'primitive propositions' can be seen now as the possible statements of different observers with respect to the truth or falsehood of the referred proposition, after a comparison with the different "realities" that each observer has chosen.

Example 2: p and q are 'primitive propositions' (with respect to r) and r is the 'referred proposition' (with respect to p and q).

p: "r is true"

q: "r is false"

p	q	r	
F	F	F	and T (contradiction)
F	T	F	
T	F	T	
T	T	T	and F (contradiction)

Now the truth table says something about r, namely that for certain values of p and q, r is a contradiction.

That is, if p and q are both true or both false, r is true and false which amounts to a contradiction. Since contradictions (and tautologies) are not pictures of reality,* r can picture reality only when p=F and q=T (r=F) or when p=T and q=F (r=T). Otherwise r is a contradiction and hence cannot determine a reality.

Notice that in this contradiction <u>true</u> and <u>false</u> coexist ("fighting" each other) without hope for a resolution of the conflict. In formal logic, a contradiction is defined as the conjunction of contradictory sentences e.g.: $a \wedge \bar{a}$, i.e. a and not (a) and it is always false. In fact, this is a basic law of sentential calculus (the most fundamental part of logic) called the Law of Contradiction (first enunciated by Aristotle) and is expressed as:

$\overline{a \wedge \bar{a}}$, i.e.: not (a and not (a))

However, as we pointed out above, our interest resides now in the conflict created between <u>true</u> and <u>false</u> by conflicting realities constructed by different observers.

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*Wittgenstein op. cit.: Proposition 4.462

Example 3: an interesting case to consider is a paradox:

r: "This proposition is false"

p: "r is true"

q: "r is false"

Considering r alone, we find that: If r is true, then it is false. If r is false, then it is true.

Therefore, r contradicts itself, independent of p and q and of a comparison with any reality. r is not a proposition of logic because it is self-referential,* so it cannot mirror a logical reality. However, being paradoxical, it can indeed mirror a paradoxical reality. Notice that r, being self-referential, blends true or false into one true and false, thereby rendering p and q non-sensical since the case is not true or false anymore, but true and false. Notice than in a contradiction without self-reference (see example 2 above) true and false do not blend but rather oppose (fight) each other.

The paradoxical loop of proposition r can be expanded to a paradoxical loop of n propositions (n=1, 2, 3, ...)

r1: "proposition r2 is true"

r2: "proposition r3 is true"

.
.
.
.
.

rn: "proposition r1 is false"

It is significant that recent studies in the philosophical foundations of mathematics and logic have concentrated their

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* It affects (changes) itself.

attention in propositions close to r1, r2, ... rn and r above, but without getting too close and running into difficulties.

Although self-reference has been banned from logic, in some cases it leads to interesting and fascinating mathematical theories (e.g. recursive functions, set theory) (see A. R. Anderson in R. L. Martin, 1970).

Paradoxes

We have already mentioned two characteristics of paradoxes, namely self-reference and change.* There is a third one, vicious circularity, to which Russell and Whitehead dedicate special attention in their "Principia Mathematica".** Examples of paradoxes abund, but they are presented almost invariably as abstract examples of the so called logical paradoxes. This latter name comes obviously from logicians and mathematicians who want to deal with paradoxes inside their disciplines, and the insistence on abstraction has probably a similar explanation. As we already stated above, our intention is quite different: we assume the existence of a paradoxical world and a set of paradoxical loops of propositions that mirrors it.

Two examples of the paradoxical world are the Moebius band and the electromagnetic buzzer:

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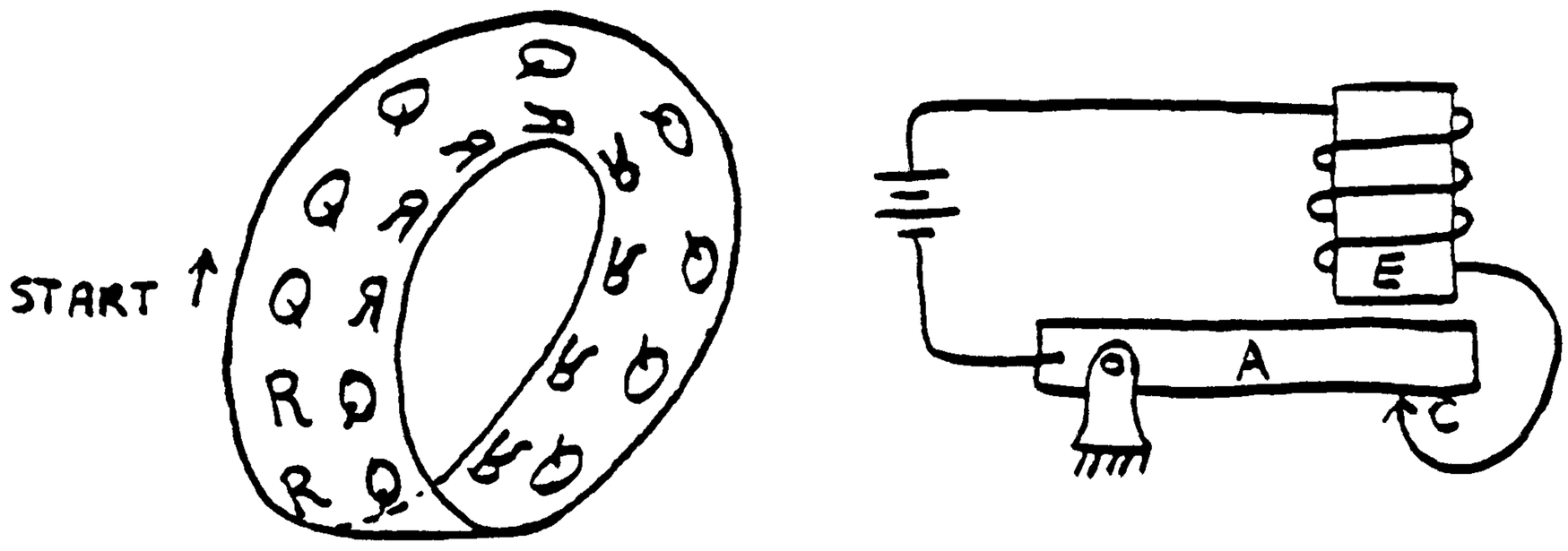
* e.g. contradiction.

**Whitehead and Russell: "Principia Mathematica," The Theory of Logical Types (Ref. 53).



a) b)

a) You can form a ring with a strip of paper if you glue the ends together. However, if you give one end a half twist before gluing it to the other end, you will have a Moebius band. The paradoxical nature of this band can be grasped most clearly by performing the following experiment: starting anywhere on the band, an observer assumes side Q, marks the surface with a Q and the other side with an R. Moving along the band the observer continues the markings and the assumption of being on side Q all the time. Suddenly the observer finds an R marking that changes the original assumption. The observer starts the whole process again assuming side R, only to find the Q markings on its path, again a change. Self-reference is evident from the fact that the observer returns to the same markings, and viscious circularity is clear from the circular shape of the path. It is indeed a paradoxical band, an excellent example of blending in a paradox: two sides blend into one.

A paradoxical loop of propositions that mirrors the Moebius band is the following, which belongs to type 3 (see below);

1. Statement 2 is true

2. Statement 3 is true

.
.
.

n. Statement 1 is false

Notice that statement n corresponds to the twist, and all the others to no twist and that all the Moebius bands generated by any odd number of twists have their mirror-image in a similar paradoxical loop with the same number of statements like statement n.

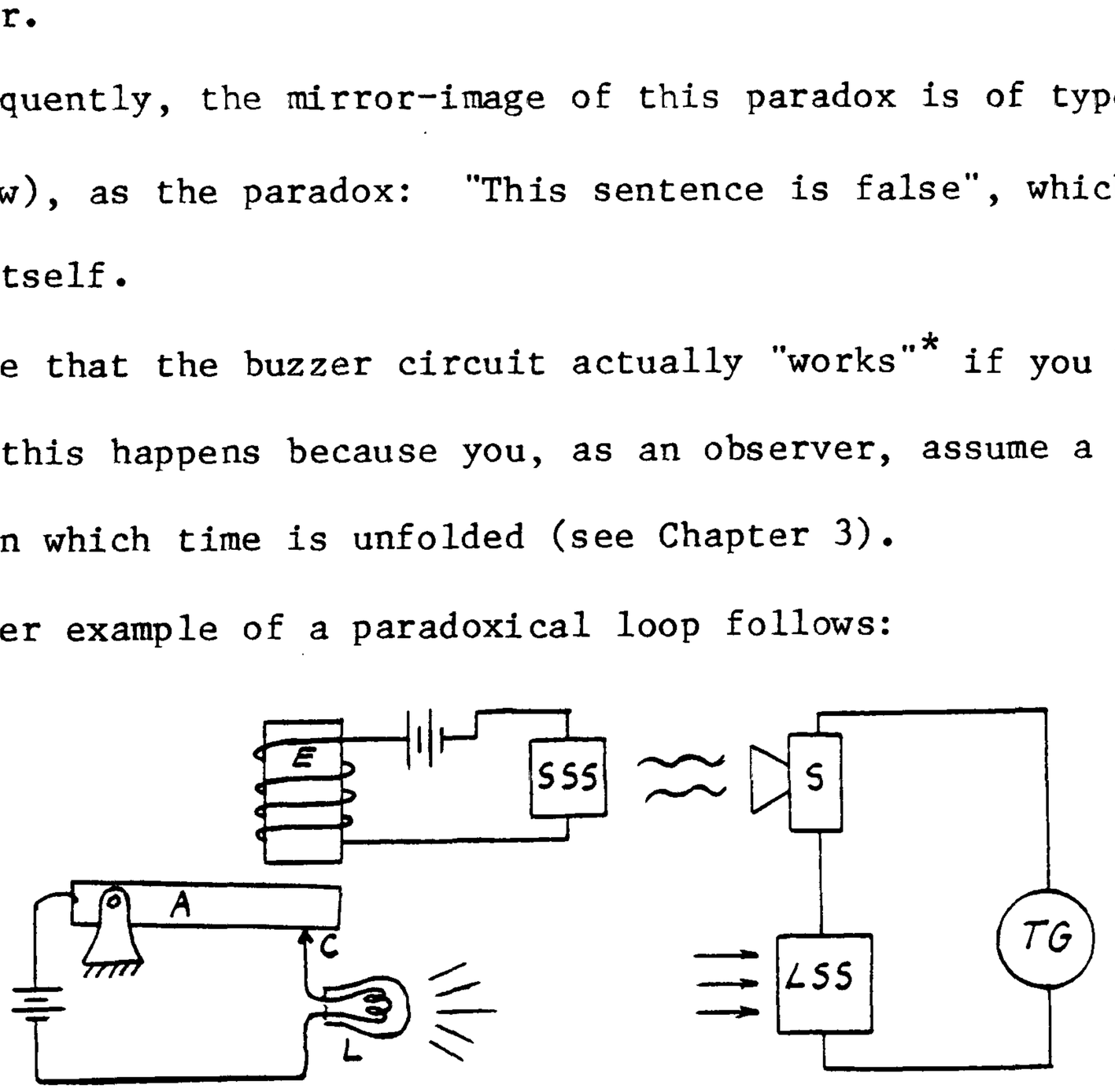
b) The circuit is such that when current flows through the coil of the elecromagnet E, the armature A is attracted to it, thereby interrupting the flow of current at contact C. If there is no current through the coil, the armature falls and makes contact at C.

If the contact is made, then the contact is broken. If r, then not r.

Consequently, the mirror-image of this paradox is of type 1 (see below), as the paradox: "This sentence is false", which negates itself.

Notice that the buzzer circuit actually "works"* if you build one, but this happens because you, as an observer, assume a reality in which time is unfolded (see Chapter 3).

Another example of a paradoxical loop follows:



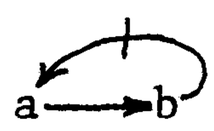
*It oscillates.

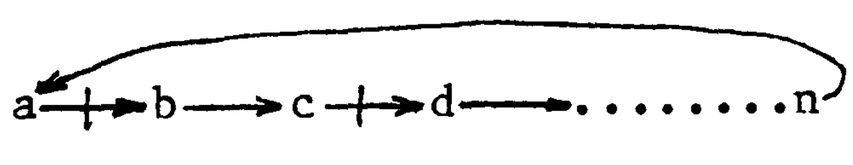
When the armature A falls, it makes contact at C, turning the lamp L on. The light sensitive switch (LSS) closes, thereby allowing the tone generator (TG) to activate the speaker (S). The sound sensitive switch (SSS) closes energizing the electromagnet (E). The electromagnet attracts the armature (A) that breaks the contact C, turning the lamp off. This causes the speaker to be silent and this, the electromagnet to release the armature that falls and makes contact at C, repeating the whole cycle again, and so on and on. Type 3 (see below).

Nature is rich in paradoxical loops like ecological system-wholes, living organisms (autopoietic) and other organizationally closed unities (see Chapters 2 and 4), whose identity transcends the constant turnover (change) of their "components". It is only from a logical perspective that these unities seem to have "inputs" and "outputs" and to change into themselves. Their paradoxical nature will elude us as long as we persist in only a logical perspective of the world.

There are three basic types of paradoxical loops:*

1. 

2. 

3. 

(odd number of—|→)

a, b, c .....n are state of affairs or propositions.

i——→j means that i affirms j (i confirms j)

i—|→j means that i changes j (e.g.: i contradicts j)

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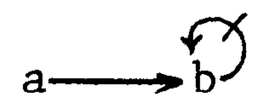
* Notice that in all the different types of loop there is always at least one change. See also "Logical language and paradoxical language" above.

Let us consider some examples:

1) The paradox of Epimenides:

r: "Epimenides, the Cretan says: 'All Cretans are liars';"

"Epimenides, the Cretan says" is a proposition (that mirrors the state of affairs Epimenides, the speaking Cretan of the world), say "a"; and what it says, "All Cretans are liars", is another proposition, say "b", that contradicts* itself by stating that all Cretans (including Epimenides) do not speak truth, i.e. "b" is not true. Hence, the paradox can be represented by:

 and belongs to type 1.

2) Other versions of the Epimenides paradox give the following results:

i) r: "I am lying" or "I say: I am lying"

a: 'I say'

b: 'I am lying'

 type 1.

ii) r: "This proposition is false"

a: 'This proposition is false'

 type 1

iii) Socrates: 'What Plato is about to say is false'

Plato: 'Socrates has just spoken truly'

a: 'Socrates'

b: 'What Plato is about to say is false'

c: 'Plato'

d: 'Socrates has just spoken truly'

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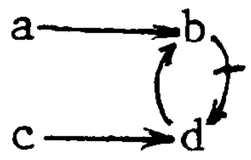
*changes.



type 2

Evidently, what Socrates and Plato utter does not refer to them but to what they utter.

3) Russell's paradox of classes:

"Let w be the class of all those classes which are not members of themselves. Then, whatever class x may be, 'x is a w' is equivalent to 'x is not an x'. Hence, giving to x the value w, 'w is a w' is equivalent to 'w is not a w'."

In other words:

r: "If w is a w, then w is not a w"

a: 'w is a w'

type 1

4) The Moebius band:

a: A piece of straight band

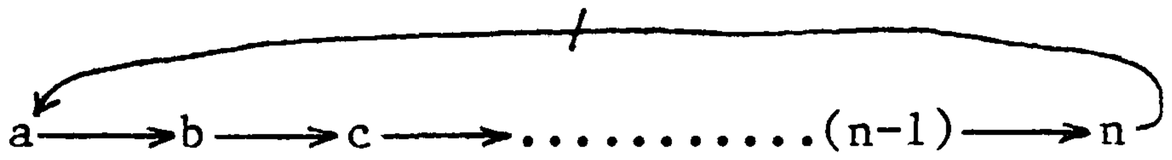
b: Another piece of straight band

c: Another piece of straight band

. .
. .
. .
. .

n-1: Another piece of straight band

n: A piece of twisted band



type 3

Notice that any odd number of twists generates a Moebius band.

5) A photosensitive device turns a light on if it is dark and off if it is bright. If the light is on, it is bright and if it is off, it is dark.

In other words:

a: If dark, then light on

b: If light on, then bright

c: If bright, then light off

d: If light off, then dark

Which amounts to:

a: If light on, then light off

b: If light off, then light on

as the buzzer circuit.

Therefore

or

type 1

It is not difficult to build a circuit with more lamps and photosensitive devices arranged in such a way that they become paradoxical loops (2 or 3). And this corresponds clearly to different arrangements of inverter gates in the field of digital circuits. The case is that all feedback loops in artificial and natural systems may imply paradoxical loops which are usually disregarded after the introduction of time. Examples 1 and 2 above suggests the possibility of propositional branches, but it is only when these branches close to form loops that self-reference appears and paradoxes could arise.

The view from the paradoxical world

Logicians and mathematicians have always considered logic and mathematics only from the inside of logic and mathematics.

We have also enjoyed logical and mathematical dictum everywhere as one of the most pervasive. The realm of paradoxes that

we are considering now, offers a new perspective that will provide a view from the outside into logic and mathematics and a novel approach elsewhere as well. To show this, we will use a paradoxical approach to look at logical propositions.

Let us assume that an observer decides to construct a reality that includes the observer. In order to construct this reality, the observer explores its environment through interactions of which the observer recursively generates representations of relations between representations (see "The world"). It is interesting to notice here the paradoxical nature of a recursion: substituting a function for its own argument it refers to itself (i.e. it is self-referential); it replaces, hence it changes (itself); and it goes round and round, since the substitution can occur over and over.

In this exploration of its environment, the observer will eventually interact with itself, thereby defining a self-referential loop. Therefore, if the observer is going to include itself in its reality, self-referential loops must also be included and consequently this reality cannot be a logical one, since in logic there is no room for a self-reference that affects (changes) the argument (see below).*

Let us inquire into the nature of this self-referential loop defined by the observer observing itself.

An observer defines a priori a distinction between the observer itself and what is observed. An observer observing itself makes the observer observed and the observed observer,

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*See also "Logic and the observer" above.

thereby changing itself and blending observer and observed just as a paradox blends opposites. Moreover, an observer observing itself is obviously self-referential and it also goes round and round since it observes itself observing itself observing itself and so on and on. All three conditions for a paradoxical loop are met and so an observer observing itself defines a paradoxical state of affairs, a paradoxical reality.

Therefore, a reality that includes the observer constructing this same reality is a paradoxical reality. It blends observer and observed: observer and its niche become one. It is no longer necessary for the observer to assume the environment as a separate entity and so this paradoxical reality belongs to the perspective of the observer as an individual being (see "The world").

Consequently, an observer can choose a paradoxical perspective of the world and become one with it. Another observer that also chooses a paradoxical perspective of the world cannot, however, share this perspective with the first observer since an observer cannot be inside the other. Observers are independent autonomous unities. However, observers can, if they choose to do so, orient each other, thereby constructing a common reality "out there".

This situation can be pictured most clearly in the following metaphor: two observers interact and let us assume that each of them has a Moebius band that represents (in this metaphor) its paradoxical perspective of the world. Each observer is free to contemplate the whole or part of its own band, but can only contemplate part of the band of the other observer. Therefore, from one observer's point of view, the other observer's band is only a two-sided surface. Moreover, that part of each band that both can

contemplate, can be made to coincide and hence the observers can construct a two-sided reality "out there". They will retain, however, their respective one-sided views of the world. In fact, the observers (and clearly there could be more than two) can make a description of the world "out there" in logical terms writing on their coinciding two-sided surfaces the logical propositions that mirror the world: they construct a common logical reality by writing on one side all true propositions and on the other side, all false propositions. Whether a proposition is true or false is determined by a comparison with the assumed logical reality. If difficulties arise (e.g. paradoxes), the reality is adjusted in such a way to eliminate the difficulties (e.g. "resolve" the paradoxes). On this common two-sided part of the band, the observers could include all the propositions of logic and mathematics and everything would be fine with them, as long as they limit their observation to the common two-sided region of the band. However, each observer can choose to perceive the whole of its own band, that is a one-sided surface. Opposites become one and all the propositions on the band, including all the propositions of logic and mathematics, appear to be <u>true and false</u>, i.e. they become paradoxical from this individual (paradoxical) perspective.* Moreover, the whole logical reality supported by these propositions crumbles from this perspective because paradoxes cannot picture the assumed logical reality.

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* This reminds of Wittgenstein, op cit.: Proposition 4.0621 ... "the sign 'non' corresponds to nothing in reality".

If the observers restrict their perspective to the common two-sided part of the band, thereby becoming social (logical) beings, everything falls into place again and they recover their logical reality.

According to Wittgenstein, contradictions and tautology are aspects of all propositions.*

Our considerations take us to the conclusion that all propositions of logic and mathematics are paradoxical as seen from the individual (paradoxical) viewpoint.

Therefore, all the propositions of logic are seen as tautologies or contradictions (the terms equal each other or oppose each other) from a logical (social) viewpoint (i.e. from the inside) and as paradoxes (the terms blend into each other) from an individual (paradoxical) viewpoint (i.e. from the outside).

From the logical viewpoint the sense of the world (of logic) lies outside the world (of logic) and the subject does not belong to the world (of logic).** This is because the subject (a living organism, autopoietic) is paradoxical*** and consequently does not belong to the world mirrored by logic.

Finally, the view from the outside renders the mirror image of the non-paradoxical aspects of the world useless to picture the

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* Wittgenstein, op. cit.: Proposition 5.143 and Propositions 6.1, 6.11, 6.111.

** Wittgenstein, op. cit.: Propositions 6.41, 5.631, 5.632

*** See Chapter 2

world from the perspective of the individual, one that allows for the concurrent existence and non-existence of state of affairs. A surprising view of the world indeed, impossible from the perspective of logic and mathematics.

CHAPTER 2

INTERACTIONS AMONG UNITIES

Unities

Unities are state of affairs.

Unities have properties of themselves and properties that relate them to other unities.

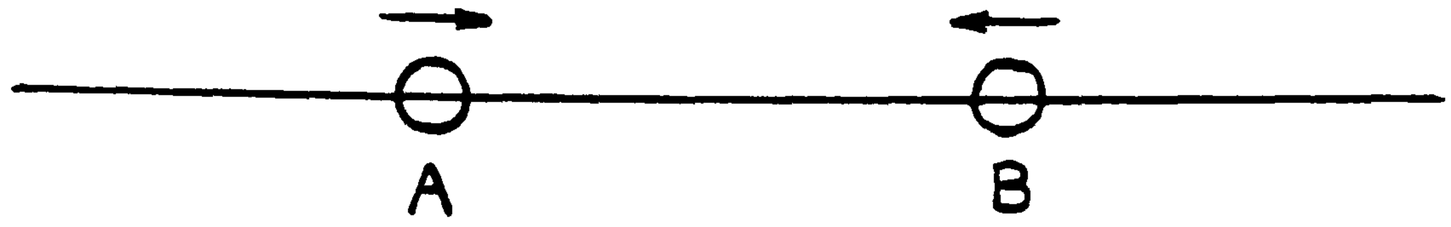
The properties of a unity are determined by the way this unity is defined, and not by particular properties of its components.

A unity is defined by the relations between its components which realize the unity as a whole. It is these relations which constitute the organization of the unity.

Unities can be closed or open with respect to other unities. If a unity opens with respect to an observer (also a unity), for example, the observer can write a protocol of inputs and outputs for the unity and derive from it an open model (another open unity). Then, the observer can predict, deduce, in the open model, the behaviour of the unity. However, as long as the observer is unable to construct an open model for the unity, the unity remains a closed one and its behaviour will be unpredictable from the observer's point of view. In order to know about a closed unity, the observer can only construct a closed model of it, i.e. another closed unity.

Example

Two unities A and B move toward each other in a unidimensional space:



A moves to the right a random number of steps. B moves to the left a random number of steps. Both are closed unities with respect to an external observer and with respect to each other since their behaviour is random with respect to all concerned. Eventually A and B will meet and they will not separate afterwards since A will continue to try to move to the right and B will try to move to the left. This new unity "AB" will move randomly either to the left or right depending on the result of the attempted movements of A and B, e.g., if A tries to move 5 steps to the right and B tries to move 7 steps to the left, the movement of "AB" will be 2 steps to the left, and so on. Thus "AB" moves randomly with respect to the external observer but A and B no longer move randomly with respect to "AB", i.e., A and B are now open unities with respect to "AB" and with respect to each other. "AB" is a closed unity with respect to the observer. Of course A and B remain closed with respect to the observer.

A similar situation arises when unities "move" randomly with respect to each other in spaces of more dimensions and fewer restrictions. Couplings more elaborate than simple contact will then be necessary, but once the couplings have been made, the closed unities will integrate and open with respect to a new and larger closed unity, which in turn can become part of and open with respect to an even larger unity, and so on and on. Of course, the process can also be reversed by the spontaneous decay of the component unities or by the spontaneous breaking of the

coupling. The componens would become closed unities again. The different spaces and couplings may not be only physical but also chemical, electric, biological, magnetic, mechanical, gravitational, psychological, geographical, social, etc., etc. In general, the couplings will restrict the "movement" of the component unities, but if the unities are complex they can generate a "movement" into a different space, thereby disengaging their coupling(s) and recovering their original, or even a new freedom.

Autopoiesis

Living organisms belong to the class of autopoietic unities and as such their organization is the autopoietic organization, which is defined as a network of productions of components which i) participate recursively in the same network of productions of components which produced these same components, and ii) realize the network of productions as a unity in the space in which the components exist.

Thus, an autopoietic unity continuously generates its own organization through its operation as a system of production of its own components, and does this in an endless turnover of components under conditions of continuous perturbations and compensations for perturbations.

Autopoetic unities

Autopoietic unities are closed unities (having neither inputs nor outputs) formed by originally closed unities that become part of and open with respect to the autopoietic unity which they integrate.

The closed model for autopoiesis,* with the following key:

* catalyst

• substrate

o link (unbonded)

\+ link (bonded, end of chain)

● link (bonded)

Interactions

(1) Composition: $* + 2\bullet \Rightarrow * + o$

(2) Concatenation: $o + o \Rightarrow ++$

$++ + o \Rightarrow +\bullet+$

$+\bullet\bullet\bullet\bullet\bullet\bullet\bullet\bullet+ + o \Rightarrow +\bullet\bullet\bullet\bullet\bullet\bullet\bullet\bullet\bullet+$

(3) Disintegration: $\bullet \Rightarrow 2\bullet$

is an autopoietic unity whose building blocks (catalyst, substrate, unbonded links) are closed unities (with respect to each other and an external observer) that move randomly in the habitat (restricted two-dimensional space); unbonded links meet, become bonded links and move no more (at least with respect to the chain of bonded links), and consequently become part of and open with respect to the autopoietic unity which they integrate. They can still be closed with respect to the external observer. If the chain of bonded links closes upon itself enclosing the catalyst, the unbonded links produced within the enclosure by Interaction (1) can replace in the chain, via (2), the bonded links that decay as a result of (3). See Figure 2.1.

The properties of this organization as a unity are not determined by the properties of its component unities (as defined in

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*Varela, F., Maturana, H., and Uribe, R.: "Autopoiesis: the Organization of Living Systems, its Characterization and a Model."

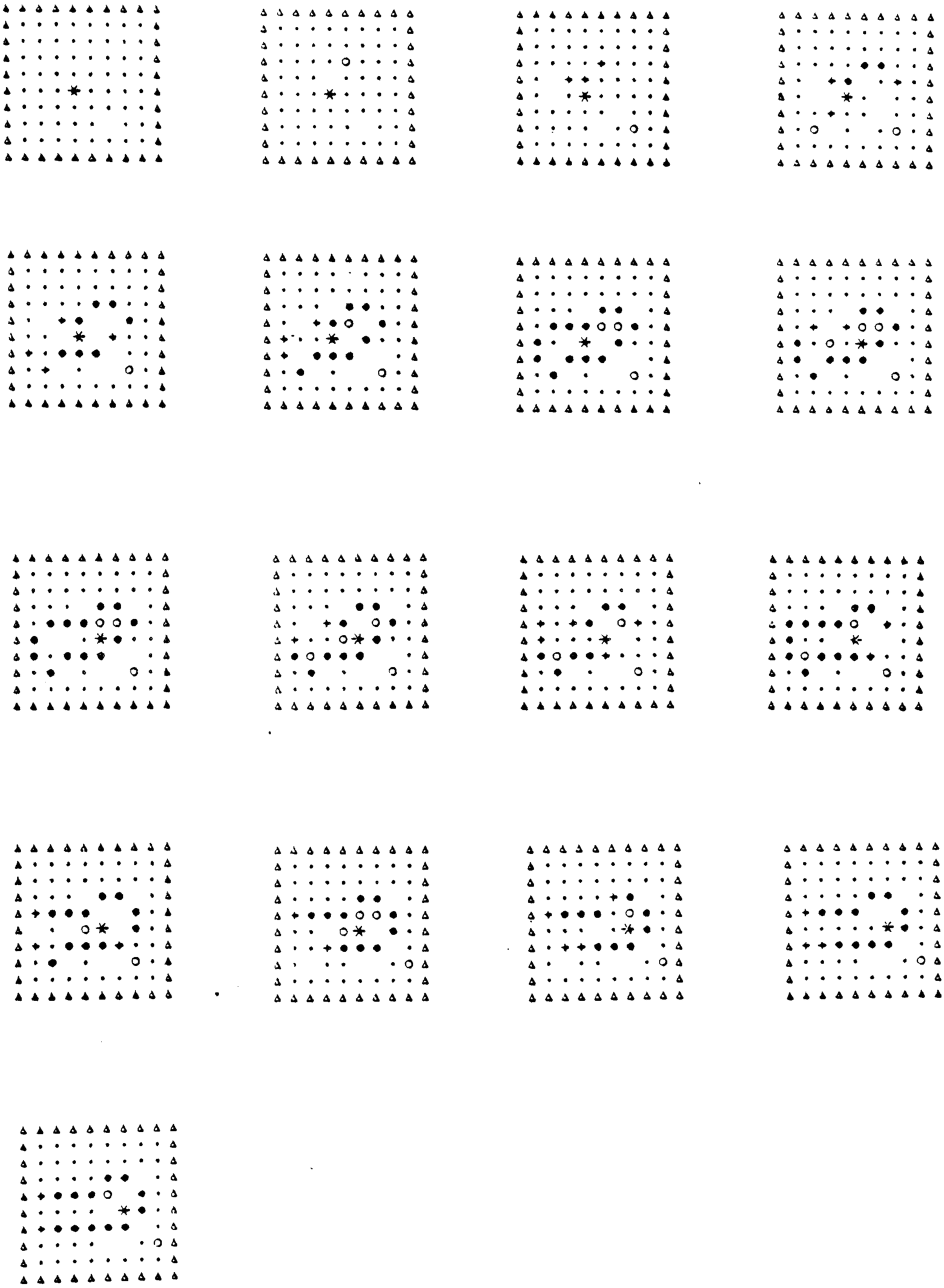

Figure 2.1

Interactions). The properties of the autopoietic unity are determined by the constitution of this unity, and are, in fact, the properties of the network created by, and creating, its components. Therefore, the paradoxical nature of this organization should be evident from the comparison of the following contradictory circularity with the Moebius band and the paradoxical propositions that mirror it (see Chapter 1):

(i) Unbonded links are produced within the enclosure by Interaction (1); corresponds to no twist.

(ii) Unbonded links replace in the chain, via (2), the bonded links that decay as a result of (3); corresponds to no twist.

(iii) The enclosure prevents the escape of the catalyst, thereby ensuring the regeneration of this same enclosure and the survival of the autopoietic unity; corresponds to no twist.

(iv) The enclosure decays as a result of (3), compromising the survival of the autopoietic unity; corresponds to the twist, and also closes the self-referential loop.*

The paradoxical nature of autopoiesis makes the unity different from itself through a constant turnover of components. Only its (circular, self-referential, paradoxical) organization is maintained.

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* Strictly, the twist can be anywhere in the loop or not be there at all; just as in the Moebius band, it depends on the observer's perspective.

Autopoiesis and self-organization are concepts relative to an observer:* if an autopoietic unity opens with respect to an observer, it becomes allopoietic with respect to that observer. Thus, if an observer knows, for example, the "seed" of the pseudo-random number that generates the closed model for autopoiesis,** and hence can construct an open model of the closed model and deduce with certainty its behaviour, the closed model becomes open and therefore no longer an autopoietic unity, for that observer.

Autopoietic unities are closed paradoxical unities that can relate to other autopoietic unities through a reciprocal opening that will tend to create a new larger unity (which may be either autopoietic or not). Examples: cells, which are autopoietic unities, become open (and hence allopoietic) with respect to the multicellular living organism (autopoietic unity) which they integrate; neurons (autopoietic) become open (allopoietic) with respect to the nervous system (allopoietic); ants (autopoietic) become allopoietic with respect to the anthill (autopoietic). Cells, neurons and ants remain autopoietic with respect to an external observer.

Autopoietic unities such as living organisms are complex unities that behave in spaces of many dimensions (physical or otherwise, as stated before). This richness of behavior is restricted, however, by the behaviour of the unities that constitute their environment through the couplings, more or less rigid and more or less permanent, that will develop among unities. As a result of

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* G. Pask: "An Approach to Cybernetics" (Ref. 24)

**Varela, Maturana and Uribe: op. cit.

these couplings, autopoietic unities can become allopoietic with respect to the larger unity (autopoietic or not) that they integrate, for example, the cell in the multicellular organism, the ant in the anthill, the human being in society. When this is the case, the decay (death) or generation (birth) of the component unities are simply aspects of the behaviour of the larger composite unity.

Survival

To explore their niche* autonomous unities (e.g. living organisms) act paradoxically rejecting the stable, secure, to plunge into chaos in search of a new stable, secure place, only to leave it sooner or later. This action implies a rejection of the present state of affairs and a prediction (implicit or explicit) about the new state of affairs which may or may not include other autonomous unities. This prediction is based on an induction made on a model of their niche (environment) and/or on a deduction (computation) made in a simulation of their niche (environment).**

The survival of an autonomous unity is intimately related to its interactions with the environment (which may include other autonomous unities): if the unity can predict with a certain degree of confidence the behaviour of its environment it will, for example, be able to catch its prey and escape its predator.

When a larger unity is created from the interactions of many individuals, the main goal becomes the survival of the larger

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* or environment. See Chapter 1, "The world".

**See Chapter 4, "Modelling and simulating".

unity even at the expense of the individual component unities. For example, it is known that certain desert rodents will risk their own lives in order to distract the predator away from the flock; soldiers go to war because they are convinced that they are saving their nation from the enemy; of course, the soldiers of the enemy are convinced similarly with respect to their own nation; and so they kill each other in war only to realize, too late, that they had nothing personal against the other soldier.

Therefore, the survival of the individual organism depends on its paradoxical (unpredictable) behaviour with respect to other individual organisms. However, the survival of the community (larger unity) of individuals requires a logical (predictable) behaviour of the individual at least with respect to the larger unity.

The behaviour of a unity can be logical, that is predictable or it can be paradoxical, that is unpredictable, depending on the point of view of the observer.

Consequently we can distinguish different kinds of interactions among two unities A and B:

(i) The behaviour of both unities is unpredictable (paradoxical) with respect to each other. The unities will remain autonomous. No lasting interaction may develop.

(ii) The behaviour of unity A is predictable (logical) with respect to unity B, but the behaviour of this latter is unpredictable (paradoxical) with respect to A. A loses its autonomy with respect to B and a larger unity may be formed with A totally submitted to B. A becomes prey of B in the most ample meaning of the word.

(iii) The behaviour of B is predictable with respect to A but the behaviour of A is unpredictable with respect to B. Same as (ii) but now B is submitted to A.

(iv) The behaviours of A and B are predictable with respect to each other. A new larger unity is formed, and the goals of A and B become subservient to the goals of the larger unity AB.

Unities A or B can also be composite unities. Moreover, in all last three cases the interacting unities can recover their autonomy through a paradoxical (creative) exploration out of the larger unity.

These different kinds of relative behaviour are not necessarily given a priori as characteristics of each unity but rather, they are, for example, the result of unchecked logical (predictable) behaviour of these unities, like certain ants enslaving others, or human beings that become armies and dictators that oppress their own people.

Autopoiesis arises spontaneously among unities of different degrees of complexity, is sustained by the relations between the components that realize it, and may disintegrate spontaneously into disorder.

Living organisms are autopoietic unities and as such they are organizationally closed unities. However, it is part of their definition as autopoietic unities the fact that they open and close, without loss of identity, in the universe in which they are realized. Consequently they are constantly exploring their environment creating the possibility of attaching (or being attached to) other unities (autopoietic or not) that will (or will

not) satisfy their autopoiesis. In this process, a larger (social) organizationally closed unity (autopoietic or not) may be formed and the autonomy of the component unities will fade away.

Multicellular organisms were created in this fashion, making cells (autopoietic unities) subservient to the autopoiesis of the larger multicellular unity. Component cells became specialized and some of them formed the nervous system interacting among themselves with a "language" made of nerve impulses. This "language" is isolated from the external environment of the multicellular organism as can be seen from the principle of undifferentiated encoding.* This "language" is the basis for individual knowledge as different from social knowledge which uses a language that operates with the sense organs outside the organism, and which allows the interaction with other multicellular organisms with a similar language. This is the birth of new larger unities (simbiosis, fish colonies, herds, anthills, beehives, clubs, political parties, etc.) that will, sooner or later render the integrating unities subservient to the goals of the larger unity.

Consequently, the language of interaction can be seen from more than one perspective. From the point of view of the component unities it is a logical language outside themselves; from the point of view of the larger unity it is a paradoxical "language" inside itself.

Therefore, a living organism becomes an individual (paradoxical) observer when it interacts recursively with itself through

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*H. von Foerster, 1976.

its thoughts (descriptions, representations of interactions). It becomes a social (logical) observer when it interacts with itself or other observers through its senses.

A human observer is an autopoietic unity who learns and creates its environment through intentions of predicting the environment's behaviour. In this environment dwell other autopoietic unities (including itself), and they are subject to the same intention of predicting their behaviours by the observer. Eventually two or more observers (autopoietic unities) become coupled through one or more domains of interaction, they integrate a larger unity (couple, family, tribe, community, society), lose their autonomy and eventually their own autopoiesis (i.e. they become allopoietic at least with respect to the larger unity).

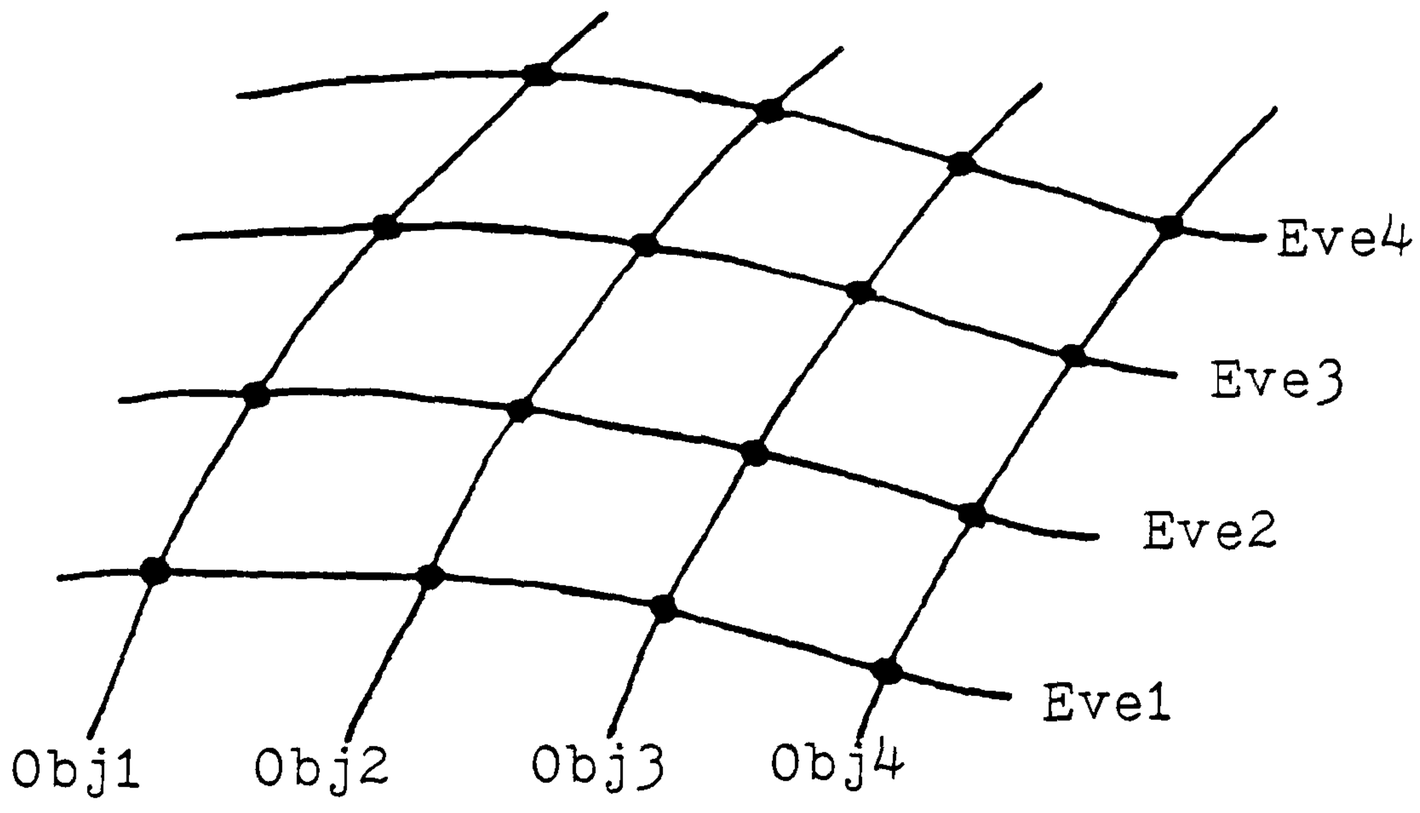
The complexity (and richness) of human behaviour allows the breaking of the couplings and the restoration of autonomy and autopoiesis in certain cases. But excessive training (including self-training), as opposed to learning, of whatever sort reduces the dimensions of behaviour of an autopoietic unity and makes probable its coupling with autopoietic unities subject to a similar training. New, larger unities are formed, which render the component unities allopoietic. Examples of these are the military (and similar) institutions. Sometimes the training is forced, as in oppressive governments or institutions, sometimes it is there in more subtle ways through "education", "cultural" legacies, economic pressures and the like. Either way, results are the same: closed autopoietic unities open with respect to the larger unities which they integrate. It is possible that some may spontaneously, creatively, become closed (paradoxical) again.

CHAPTER 3

TIME AND SPACE

Preliminaries

Unities are dependent on the perspective chosen by the observer. They are simple if considered as unanalizable wholes and complex if they are considered made of component unities. If simple, unities become, for the observer, the spaceless Here and the timeless Now. In the present context an object will be the spaceless Here and an event, the timeless Now. Therefore, a grid in which objects create events and vice versa, does not create time or space (see Chapter 1):



"Objects" creating "Events" and vice versa
(von Foerster, 1976)

A unity is defined through a distinction made by an observer or by the unity itself (e.g. if the unity is organizationally closed, see Chapter 4).

All unities change.* However, the observer can choose perspectives, usually through gross approximations performed by its senses, from which unities change into themselves.** In this manner, the observer defines a relatively stable universe(s) for itself. But, together with this apparent stability, the observer brings the possibility of space and time into its universe(s). In a changing world there are no such things as space or time: there is no reference for them and without reference there is no space or time.

In other words: unities change, but the observer makes arbitrary distinctions that cause (from its perspective) the unities to change into themselves. Consequently, the constancy (identity) of objects in time is not something that we discover in or learn from our environment, we, as observers, do it (invent it), through distinctions in space (descriptions). Likewise, the constancy (identity) of events in space is something that we, as observers, do (invent), through distinctions in time (processes).

But space and time do not exist prior to these distinctions.

Now, to make distinctions in time and/or space correspond to the construction of a reality "out there", that is, a logical reality, supported (constructed) by one or more social (logical)

---

* Change implies process, which is a more fundamental notion than time or space (see Chapter 4).

**Every sequence of changes that leads, through the distinctions made by the observer, to a recreation of a state of affairs (a unity) over and over, constitutes a cycle, that is, a clock that can synchronize (events in) the universe(s) of the observer. The clock (cycle) itself is asynchronous but its effects are synchronous. A cycle is asynchronous when analyzed, and synchronous if considered as an unanalizable whole.

observers that orient each other through that same reality (or environment), as we saw before ("The world", Chapter 1).

Therefore, space and time are generated recursively by an observer that, adopting a logical perspective, makes distinctions in a space and/or time that are created by these same distinctions. This suggests that distinction (description, process) is a more fundamental notion than space and time (see Chapter 4).

For an observer that chooses a paradoxical perspective, there is no space or time. Change ($a \neq a$) is the case from a paradoxical perspective and nothing is equal to itself. Paradoxical state of affairs change themselves.

Consequently, the same observer, selecting different perspectives, can be a paradoxical observer for whom there is neither space nor time, or a logical observer that recursively creates time and space through distinctions in these same space and time.

Time

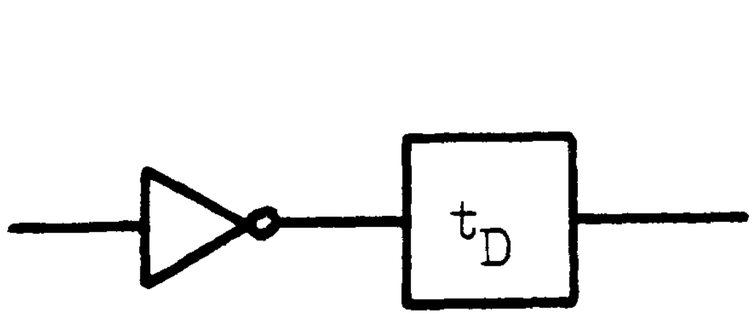
Time has come much too often to the help of paradox hunters so they can "explain certain paradoxes away". Typical is the case of the buzzer circuit, which we discussed in Chapter 1. The buzzer circuit can be studied further considering its combinational logic analog, an inverter gate with feedback:

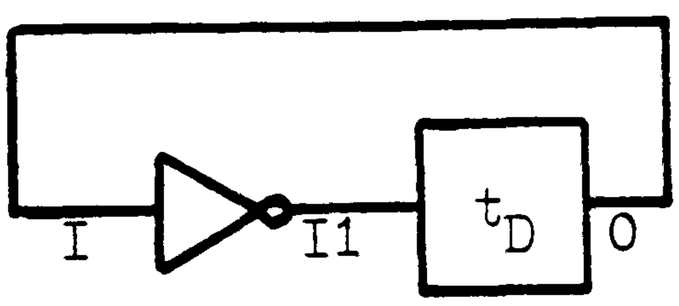
An inverter gate is such that its output is true when the input is false, and false when the input is true. With the feed-

back loop, the situation is "impossible" in timeless logic since the loop has made true = false, i.e. the output (and the input) are true and false, obviously a contradiction. Or even more, a paradox, since there is self-reference, contradiction and vicious circle. If the input is true, it is false; if it is false, it is true, and the same happens with the output, a situation which is perfectly possible in the realm of paradoxes. How is the "impossible" situation "resolved" in logic? ...

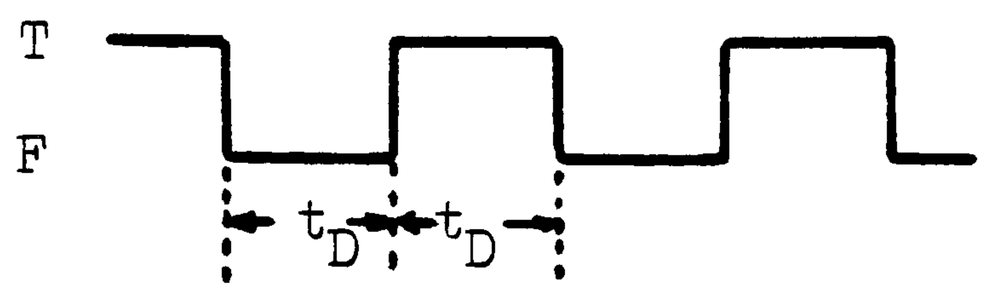
In logical terms, if p represents a state of affairs and p implies q (which represents another state of affairs), this gives no indication of a relation of succession in time between p and q, rather it expresses their co-existing truth. This is alright as long as q is different from not-p, because then the Law of Contradiction will not preclude us from the coexistence of p and q. However, it is this same law which will force us to a successiveness in "time" of p and q when q is the same as not-p. Two opposite states cannot be simultaneous.

It may be argued that there is no "ideal" inverter gate in the world and that any "real" gate has a time delay, i.e. if the value changes at the input say, from true to false, the output will not change from false to true until a certain time t_D (the time delay of the gate) has elapsed. Everything works fine now because we can represent a real gate as an ideal one followed by a time delay:





And so when we close the loop, there is no conflict anymore because any change at 0 will affect (with no time delay) only up to I1 (the input to t_D). Therefore if 0 changes from true to false, I1 will change from false to true, but 0 will change from false to true only after t_D, hence there is no conflict. But an oscillation develops because when 0 changes from false to true, it generates a new change of itself from true to false after t_D, and so on, as time is unfolded:



Consequently, the time delay introduced, has apparently replaced the timeless paradoxical situation for an oscillation that occurs as time is unfolded. If $t_D \longrightarrow 0$, we approach the ideal situation and the frequency of the oscillation increases without bound. A $t_D=0$ corresponds to a closed loop. If t_D becomes large, the frequency of oscillation decreases and a very large t_D will correspond to an open loop. Therefore, the time delay is "something" between an open and a closed feedback loop, i.e. something between having and not having a feedback loop. Something between having and not having contradictory self-reference, something between having and not having paradox.

It appears that time is necessary to avoid the coexistence of the opposites. The existence of opposites defines time a priori, since some time must elapse when one goes from one to the other, much as Spencer Brown refers to the appearance of time when one makes a distinction. It takes time to go from the inside to the

outside, it takes time to cross the distinction. This is clearly not the case in the domain of paradoxes, where the co-existence of opposites is not challenged. We can be both inside and outside the distinction and hence it makes no sense to go from the "inside" to the "outside" or vice versa: time and cross are irrelevant (non-sensical).

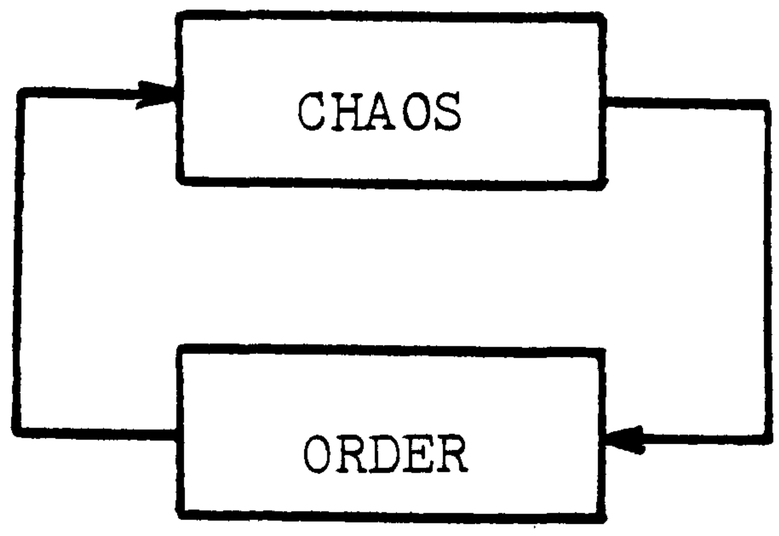
Therefore, the unfolding of time liberates periodic phenomena (e.g. oscillations) that otherwise would remain as timeless paradoxes. Without these oscillations, very little, if anything at all, would exist for the logical observer in the logical world. However, time (and space) is an invention of the logical observer. Time can not be perceived through the senses. The passage of time -- there is no such thing -- can only be compared with the workings of a process, like a chronometer (which is also an oscillator).

In consequence of different waters flowing, says Heraclitus, we at the same time enter yet do not enter the same river. This suggests that for any given identity we both are and are not. Therefore, we can and cannot enter the same "flow of events". But also we, as living organisms, are always changing, always flowing and hence are and are not, being able and unable to experience the same state of affairs.

Time and Space

Subjects are paradoxical state of affairs. They are living organisms and as such they explore paradoxically their niche rejecting the stable, secure, to plunge into chaos in search of a new stable, secure place, only to leave it sooner or later. This

behaviour entails a loop that will be called the exploratory loop and can be represented by:



As long as the individual organism behaves paradoxically, the exploratory loop is a timeless and spaceless paradox. However, a logical interaction with other organisms requires a logical behaviour, distinctions in time and space are made by the observers between chaos and order, and time and space result (are created) as a consequence of these same distinctions (see Preliminaries). This time and this space make the behaviour of the individual organism to oscillate between order and chaos in the exploratory loop. Occasionally the observer returns (creatively) to the timeless and spaceless paradoxical behaviour. But, as the individual becomes part of a larger unity, the oscillation (and creativity) slows down making the paradoxical behaviour rare.

Time and space are relative to the observer. Therefore, a paradoxical behaviour, which is timeless and spaceless for the organism that is behaving paradoxically, can take place in time and space with respect to an external observer.

Consequently, for an observer observing itself (see Chapter 1), time and space are unfolded when the paradoxical behaviour is abandoned, and conversely, when the paradoxical behaviour is resumed, time and space vanish.

CHAPTER 4

ORGANIZATIONALLY CLOSED UNITIES

Modelling and simulating

Modelling and simulating are sometimes carelessly confused and treated as synonyms. As we shall see, however, there is a fundamental difference between the two.

In Chapter 3 we saw that unities (state of affairs) are defined through distinctions and that a universe for a given observer is the set of unities that the observer chooses to consider (dintinguish). Therefore, one unity can be a universe for a given observer.

We also saw in Chapter 2, that autonomous unities (e.g. living organisms) distinguish themselves and deal with their niches (environments) through predictions based on a model (open or closed) or simulation of it. However, in order to do this, an observer has to choose first a perspective (logical or paradoxical) and then define (distinguish) the universe or universes that will be considered.

A simulation for a given unity is made in a universe (the simulator) different from the one of the unity and its components. No distinction is made by the observer (or by the simulation) between simulation and simulator. Therefore, the simulation <u>is not another unity</u>, and hence, a simulation cannot be organizationally closed, it is organizationally open. It is treated by the logical observer as a "process" in which a relation or "classical model" is satisfied between inputs and outputs (see Pask, 1981). Consequently, a simulation implies a logical perspective.

The universe(s) of a model and that (those) of the modeled unity can be the same or different. A model (closed for the observer) (see "Unities", Chapter 2) is another unity distinguished by itself or by the observer in the same universe(s) in which its components are distinguished. Therefore, a model can be organizationally closed (i.e. distinguish itself) and invite a paradoxical perspective from the observer.

A nervous system or an unconventional computer* can be a universe(s) where models can be distinguished; however, a conventional computer or a nervous system (e.g. that of a mathematician or logician) solving a mathematical (or logical) problem are simulators. Consequently, there is no such thing as a mathematical (or logical) model.

In a mathematical (or logical) simulation it is possible to deduce (compute) the future behaviour of the simulation ("'Necessity' arises from the ability to make infallible deductions"**).

In a model (organizationally open or closed for the observer) it is impossible to deduce the future. Only induction is possible ("'Chance' arises from the inability to make infallible inductions"**).

Modelling is doing another unity.

Simulating is making the simulator (a unity) act like the simulated unity.

A model can be organizationally closed.

A simulation is organizationlly open.

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* See "A set of microcomputers", Chapter 5.

** H. von Foerster, 1976.

Interactions and information transfer

As we saw in Chapter 1 ("The world"), when several observers (organizationally closed unities) interact they can only orient each other within their respective cognitive domains. This suggests that nothing is, in fact, communicated between the observers.

Information is a relative concept and information transfer (communication) is an observer's interpretation of the interaction between two or more unities (which could include the (logical) observer itself).

In Heinz von Foerster's words (von Foerster, 1976):

> "Information is a relative concept that assumes meaning only when related to the cognitive structure of the observer of an utterance (the 'recipient')."
>
> "The information associated with a description depends on an observer's ability to draw inferences from this description.
>
> 'Necessity' arises from the ability to make infallible deductions.
>
> 'Chance' arises from the inability to make infallible inductions."
>
> "Consequently, chance and necessity are concepts that do not apply to the world, but to our attempts to create (a description of) it."
>
> "The environment contains no information; the environment is as it is."

Therefore, if an observer is unable to draw inferences from a certain utterance, no information can be associated with it. (This is clearly observer dependent). For example, if the utterance observed by the "recipient" happens to be a paradox, the observer would not be able to draw inferences from it. No information is associated with a paradox (or a paradoxical description).

As we said above, information transfer is an observer's interpretation of the interaction between two or more unities (which could include the observer itself). But this interpretation assumes an environment "out there" (e.g. the interacting unities) and so it corresponds to a logical (non-paradoxical) perspective of the world (see Chapter 1).

Therefore, from a logical viewpoint, unities are informationally open and information transfer, e.g. through local synchronization of a priori asynchronous unities may occur in any logical interaction among independent unities. Moreover, a conflict between two (or more) independent unities is also an observer's logical interpretation of the interaction among these unities. And the resolution of this "conflict" (e.g. through a bifurcation principle) implies information transfer only in the eyes of the beholder: the observer's logical perspective.

From a paradoxical perspective, no environment is assumed and paradoxical unities are informationally closed, i.e. there is no information transfer between them.

Therefore, the concepts of information, conflict between independent unities, information transfer and communication are the consequence of a logical, organizationally open, perspective of the world.

From a paradoxical perspective of the world, organizationally closed unities interact paradoxically, without communication.

Organizational closure

"The concept of organizational closure has become synonymous with the concept of "stability" in a dynamic and generalized sense."

"The concept has appeared, though not explicitly mentioned, in many contexts and reflects a very fundamental change in thinking about what systems are and what stability is."

"Every (distinguishable) system-whole (unity) is (distinguishable through its stable properties arising from it being) organizationally closed" (see Varela 1976 and Pask 1977).

In a biological context, organizational closure has received a definite expression in the concept of autopoiesis (Chapter 2). (See Maturana, 1972; Varela, Maturana and Uribe, 1974; Maturana and Varela, 1976; and Ben-Eli, 1981). Autopoietic systems are organizationally closed and organizational closure is a characteristic of life.

As we saw before (Chapter 3), a unity can be distinguished by an observer as a simple unanalyzable whole or as a complex unity made of simple unanalyzable component unities that interact through relations or processes.

Unities can be organized through distinctions by the observer or by the unity itself, into systems or into systems-wholes. Systems have a hierarchical organization, e.g. a tree of hierarchical

processes: systems are organizationally open. System-wholes have a closed organization, e.g. a circular network of interactions: system-wholes are organizationally closed, i.e. they organize themselves.

The "wholeness" of a unity is embodied in its organizational closure. An organizationally closed unity is not the sum of its component unities; it is the organizational closure of its component unities. Moreover, when organizationally closed unities interact, a new organizational closure may arise among these interacting unities. However, from the point of view of the new larger unity the component unities have "inputs" and "outputs"; in fact they are organizationally open from this perspective (see Chapter 2).

Organizational closure does not imply interactional closure. However, interactions can be logical or paradoxical depending on the perspective chosen. From a paradoxical perspective, organizationally closed unities distinguish themselves and are informationally closed. From a logical perspective, logical interactions are required for the observer to be able to distinguish these unities that must be informationally open from this perspective.

In order to "explain" (and "understand") a complex unity, the observer, as a social (logical, organizationally open) being (see Introduction and Chapter 1), creates arbitrary hierarchies through (arbitrary) distinctions inside the unity. Consequently, if the organization of the unity is closed, its organizational closure will not be reflected in this "explanation".

The observer, as an individual (paradoxical, organizationally closed) being, does not explain organizationally closed unities, it interacts paradoxically with them as a component of one or more new larger unities.

Therefore, all hierarchies, and the no less arbitrary notions of "inputs" and "outputs", are the consequence of a logical, organizationally open perspective of the world (see Introduction).

Organizational closure, as autopoiesis, involves change and so it also implies a paradoxical loop. All organizationally closed unities belong to the paradoxical aspect of the world. Therefore, only an observer that adopts a paradoxical perspective can interact (paradoxically) with an organizationally closed unity.

For an observer assuming a logical perspective, a closed organization (paradoxical loop) is unconceivable and so this observer can only interact (logically) with (and "understand") an organizationally closed unity either by assuming inputs and outputs into and from it, i.e. making the unity organizationally open; or otherwise, by analyzing the unity as made of components (with inputs and outputs) that do not even suggest the closure of the unity.

Consequently, organizationally closed unities are the only unities in a paradoxical reality, i.e. in the world of the observers as individual (paradoxical) beings.

Descriptions, processes and processors

At this point we will introduce the notions of condition and event proposed by Holt and Commoner (1970) while they were asking themselves: "Of what does a system consist? For example, should

we take processors, inputs and outputs as the elementary entities of which they are made? Do they have states? Do they take space (or is it only their realizations which do)? When they operate, do they take time? Etc. Etc ...." Holt and Commoner suggest also the notions of holding (of a condition) and occurrence (of an event). These can be grasped most easily since intuitively conditions hold and events occur. However, at least in our context, no time or space are assumed or implied by these notions. We shall call the occurrence of an event, a process, and the holding of a condition, a description (see Chapter 3, "Preliminaries").

The concepts of concurrent processes and concurrent descriptions will also appear in our discussion. Two or more concurrent processes (or descriptions) are such that they are not ordered with respect to one another, i.e. they take place in different universes or independent processors.*

Process and description are more fundamental notions than time and space.**

Therefore, instead of postulating space and time, we can postulate one or more timeless and spaceless universes or independent processors that support processes and descriptions in a spaceless Here and timeless Now.

A process is "fired" by a descripton so that it elicits a new description (see Petri, 1965 and Holt, 1970 and 1972). No

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* "A universe is an a priori independent processor, it is a set (the usual connotation of 'universe') but with action built into it" (Pask, 1981).

**A careful consideration of our discussion in Chapter 3 ("Preliminaries") should make this statement appear less outrageous (see also Pask, 1981).

components" or "storage medium" are assumed or involved in this occurrence. This is process (and description) without (or before) time and space. This corresponds to a paradoxical perspective.

Moreover, with a finite number of descriptions and processes, the original assumption of universes or independent processors requires, as a condition sine qua non, one or more closed sets of processes (and descriptions). Otherwise, some description will not fire a process and the universes as conceived above (independent processors with action built into them) will collapse. All descriptions involved must change, i.e. they must fire a process.

The closed set or processes and descriptions defines and maintains itself as a paradoxical unity through the dynamic stability of organizational closure in the spaceless Here and timeless Now within those universes. Processes and descriptions in different universes are concurrent and all descriptions involved must fire a process in some universe(s); otherwise, organizational closure is lost as well as the universe(s) or independent processor(s).

Assuming that no other organizationally closed unity (e.g. an external observer) interacts with the organizationally closed unity considered, this unity defines only one perspective, a paradoxical perspective.

However, if another organizationally closed unity (that could be an external observer), with its own paradoxical perspective, different processes and descriptions and within other universes (or independent processors), interacts with the first one in the same spaceless Here and timeless Now, some universes may encounter descriptions that do not fire their own processes. If this is the case, these descriptions are not changed, i.e. they "remain" (or

they are "changed" into themselves) and, as a consequence, they define a storage medium (space and time) within such universes and a logical perspective for the interacting unities (that may include an external observer).

From this logical perspective, the dynamic stability of organizational closure becomes static, i.e. organizational closure itself is lost, the descriptions become "real" objects or components (distinctions (or descriptions) in space), the processes become "real" events (distinctions (or processes) in time) and the processors occupy space and time ("The 'thing' secreted from the process," see A. Holt, 1972).

It is interesting to observe that even though organizational closure is lost from the logical perspective, this same organizational closure is essential for the emergence of the logical perspective out of a timeless and spaceless origin.

Moreover, from a logical perspective, the processors are machines, abstract or otherwise, that produce components ("outputs") from other components ("inputs"). In order to do this they must contain, according to this viewpoint, in some form of storage medium a "look-up table" that enables them to match the "input" to the corresponding "output". Therefore, the descriptions that "remain" and define the logical perspective also generate and modify precisely this "look-up table", i.e. the processors themselves.

The descriptions generated by processes in one universe are stored making distinctions in space and time in another universe (the one where no process is fired by these descriptions) and vice versa. However, if some or all the universes share the same

storage medium, a common logical "reality" may develop for the interacting unities. This logical "reality" arises precisely from those descriptions that are not changed (or "changed" into themselves) in some universe, i.e. from those descriptions that do not fire a process in some universe. The common storage medium becomes an environment for the unities (their common space and time), in which they construct their logical (social) realities, including the "real" processors that support their processes and descriptions.

From a logical perspective, a processor is process (in time) and storage or description (in space). If a paradoxical perspective is approached, the whole logical reality can be made to vanish and so a processor becomes process (no time) and description (no space) in the spaceless Here and timeless Now.

It is a misconception to think that the "building blocks" "are there" a priori for the construction (invention) of a particular (logical) reality: be it the realities that we invent or those that we adopt, or be it these processors that we are now considering. Remember that the "building blocks" (the "things") are secreted from process. The "building blocks" that constitute the emergent logical reality are defined, distinguished, created, invented <u>with</u> this emergence and <u>are not</u> "there" a priori. Therefore, the processors are processes (no time) and descriptions (no space) at the outset (paradoxical perspective), they are no "things". It is only from the emergent logical perspective that these same processors become "things" (secreted from the processes) in time and space.

All activity in the storage medium (or environment) is triggered by descriptions that do not fire processes in a certain universe. Therefore, if these descriptions vanish or processes develop within the universes that are fired by these descriptions, the activity in the storage medium (or environment) may fade away and with it space, time and the logical perspective, that will be replaced by one or more paradoxical perspectives.

Moreover, depending on the perspective (logical or paradoxical) chosen by an observer, interactions among organizationally closed unities (including the observer) in these universes will be logical or paradoxical, i.e. will take place with or without information transfer; unities will or will not have inputs or outputs; time and space will or will not exist with respect to this observer.

From a logical perspective two or more independent unities can only interact through the resolution of conflicts produced as these unities act on the same spacetime framework. Therefore, the existence of conflict is essential for this (logical) interaction; otherwise, a non-existent conflict cannot be resolved. The logical perspective is reflected in the following comments: "Two different events may only occur at the same place (e.g. the same location in a storage medium) if and only if they occur at different times." "Two different events may only occur at the same time if and only if they occur at different places (e.g. different locations in a storage medium)." From a logical viewpoint, these differences reflect independence.

From a paradoxical perspective, two or more independent unities can interact without conflict resolution. (Logical) "conflict" can coexist with paradoxical interactions. Or better, there is no conflict in a paradoxical interaction. The paradoxical perspective is reflected in the following comment: "Two different events may occur at the same time and place if they occur in different concurrent processors (universes). From a paradoxical viewpoint, concurrence reflects independence.

Therefore, it is from a paradoxical perspective that process and description emerge most clearly as more fundamental concepts than time and space. These latter constitute only a very specialized framework.

CHAPTER 5

MULTICOMPUTER REALIZATION AND EXPERIMENTS

A set of microcomputers

Let us consider, from a logical perspective, a set of independent microcomputers. By independent we mean different (asynchronous) clocks and no a priori "communication" channel between them. These microcomputers are distinguished (by the logical observer) so that their boundaries are defined by those components whose states may be affected by the microcomputer's clock. As we shall soon see, these boundaries are not necessarily fixed. However, no microcomputer can grow inside the boundaries of another microcomputer.

A description can be, in the microcomputers, part or all of a microcomputer word (2, 4, 8, ... bits) and a process is "fired" when that word (description) is changed into a new word (new description) that will in turn "fire" a new process, and so on and on.

Consequently, the set of microcomputers considered can be a set of independent processors or universes that support processes and descriptions as discussed before.

Each microcomputer has a RAM (Random Access Memory) where data (and programs) can be stored (see Figure 5.1). Using appropriate interfaces (e.g. tri-state bidirectional buffers that act like switches) part of this RAM can be completely detached from a microcomputer and be attached to another through an Address-Data Bus (ADB) and a Control Bus (CB). These two busses can also be attached to and detached from each microcomputer (using the same

type of buffer) thereby making part of the RAM of one microcomputer accessible to another. With this architecture, each microcomputer can use part (RAM2 in Figure 5.1) of the RAM of another as a "mailbox" and modify its contents. What happens is that one microcomputer becomes "smaller" when it relinquishes part of its RAM (i.e. RAM2), and the other "grows" to include, inside its own boundaries, the busses (ADB and CB) and that RAM2. These modified microcomputers continue to be independent of each other; no synchronism or link binds them together. Therefore, the microcomputers interact without becoming one. After the RAM2 contents has been modified, this RAM2 is returned to its original microcomputer. The microcomputers remain independent and consequently, processes and descriptions in different microcomputers are concurrent.

Similarly, when a microcomputer becomes "smaller", it changes its boundaries by steering the internal busses away from its own RAM2. The microcomputer continues to execute its program with less RAM (i.e. only in RAM1). Appropriate software can make the partial loss of RAM totally irrelevant to the independence of the microcomputers.

Consequently, the set of RAM2s may become the common storage medium, described before (Chapter 4), where the organizationally closed unities, supported by the processes and descriptions in the microcomputers, may construct their logical (social) realities including the "real" processors that support their processes and descriptions. Much as the observer creating space and time through distinctions in these same space and time (see Chapter 3).

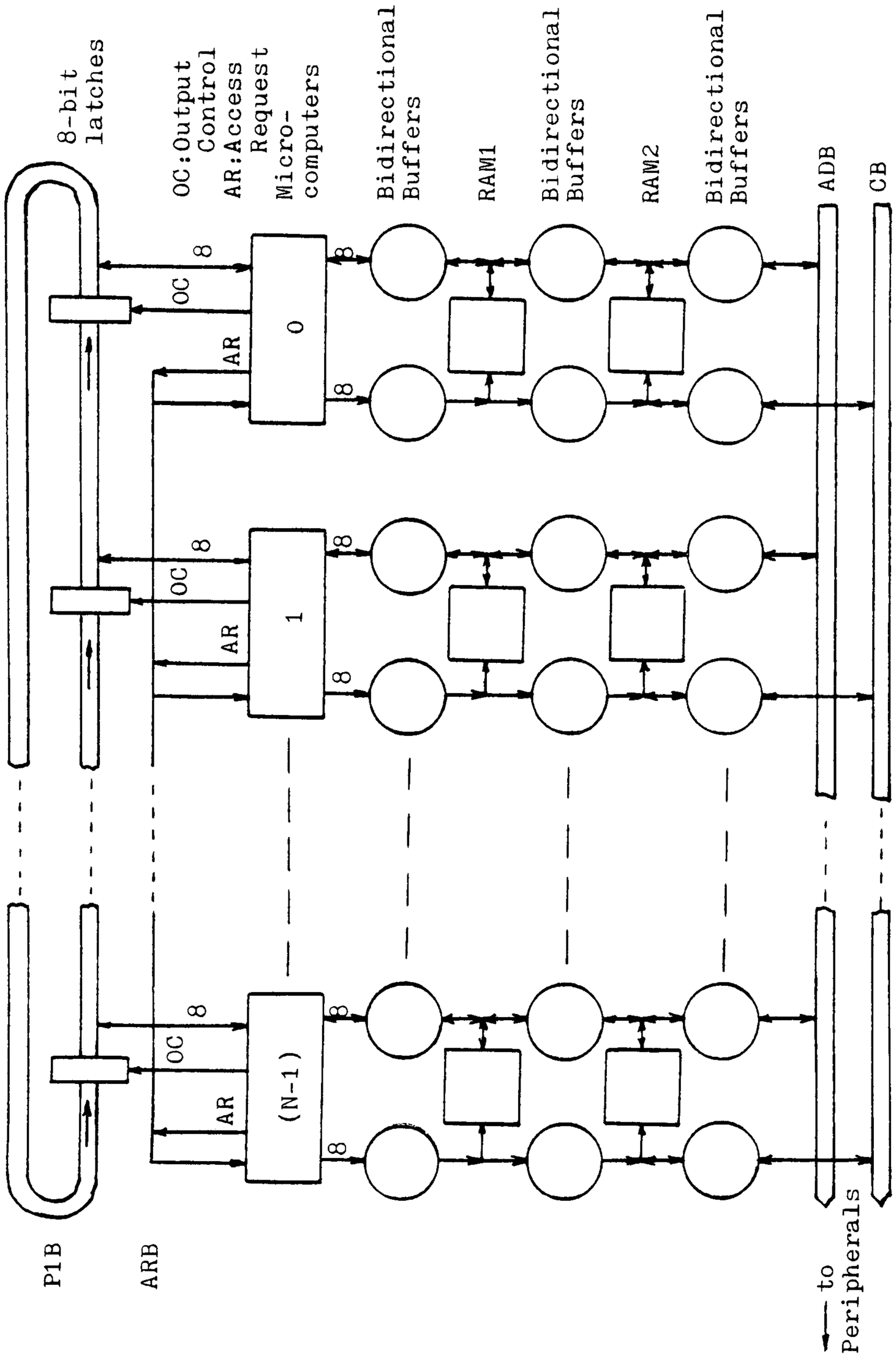

8-bit latches
OC:Output Control
AR:Access Request
Micro-computers
Bidirectional Buffers
RAM1
Bidirectional Buffers
RAM2
Bidirectional Buffers
ADB
CB
P1B
ARB
OC
AR
8
0
1
(N-1)
To Peripherals

Figure 5.1

If RAM2 is reduced to only one storage location (one computer word) a special case results and this unique "storage" location can be the spaceless Here and timeless Now, accessible to all microcomputers. This is because there is an essential difference in the access to this unique location as compared with the access to RAM2. Each microcomputer can access this unique location concurrently with other microcomputers. This has been realized through Port 1 of the microcomputers. Port 1 Bus (P1B) (see Figure 5.1) allows all the microcomputers to access concurrently this location.

As we saw before, part or all of a microcomputer word (2, 4, 8 .... bits) is a description and a process is "fired" when a word (description) is changed into a new word (a new description) that will, in turn, "fire" a new process, and so on and on. There are $2^2=4$ or $2^4=16$ or $2^8=256$, or .... possible different descriptions.

If these descriptions are in P1B, the unique location described above, and if the set of corresponding processes fired by these descriptions happens to close upon itself (i.e. it becomes closed) an organizationally closed unity defines itself in the spaceless Here and timeless Now, and with it a paradoxical perspective emerges. If another closed set of processes is fired by descriptions also in P1B, another organizationally closed unity emerges that can interact with the first one and a logical perspective may arise for the interacting unities as explained before. It should be clear from our previous discussion that the organizationally closed unities can be supported by processes and descriptions in one or more universes or independent processors (or microcomputers).

Moreover, since the processes and the processors that support the organizationally closed unities are generated by the interactions among these same processors, originally the universes (microcomputers) support no processes at all, i.e. at the "outset" there are no processors.

From a logical perspective, the microcomputers change the contents of P1B according to a look-up table (stored in RAM1) that is "empty" (i.e. it produces no changes) at the outset but that is gradually "filled" (i.e. it produces changes) with new descriptions derived from the interactions with other emergent or existent) processors. The processors define (distinguish) themselves in space and time from the point of view of an external logical observer. However, for a processor to remain as such the set of processes that it supports by itself or with other processors must be closed; otherwise, it collapses. Therefore, a processor must be part or all of an organizationally closed unity, i.e. paradoxical, i.e. timeless and spaceless from a paradoxical perspective.

Experimental set-up

The microcomputers described above are universes or independent processors that can support concurrent processes and descriptions.

Each microcomputer executes independently (concurrently) the program described by the flowchart of Figure 5.2.

The initialization consists in: setting the values of flags and parameters as chosen by the experimenter; setting RAM1 to 0,1,2 .... F (the "empty" look-up table, i.e. no processors at the

outset); setting RAM2 to a random contents that may be interpreted, by the logical observer, as the "noise" that starts the "oscillation" of the organizationally closed unities; delaying the start of the rest of the program if so desired by the experimenter; and finally, setting P1B to a random description.

After the initialization branch, the program consists essentially in following the "paradoxical loop" if the description (X) read from P1B (the common spaceless Here and timeless Now) fires a process in that universe, i.e. the contents of RAM1 addressed by X ([X] RAM1) is different from X; or in following the "logical loop", if the description (X) read from P1B does not fire a process in that universe, i.e. the contents of RAM1 addressed by X ([X] RAM1) is equal to X.

In the paradoxical loop, change is the case and so the new description generated by the process fired by the description read from P1B, is written into P1B, i.e. [X] RAM1($\neq$X) is written into P1B.

In the logical loop, the storage medium and the processor are created and expanded by writing into the shared RAM2s the unchanged description (X) from P1B and into RAM1, X or the contents of RAM2 which is modified by other universes.

The branches labeled with FLAG1 in the logical loop allow the experimenter some (non-essential) variants around the (essential) description given above.

(For details about the microcomputers and the experimental setup, please refer to the Appendix.)

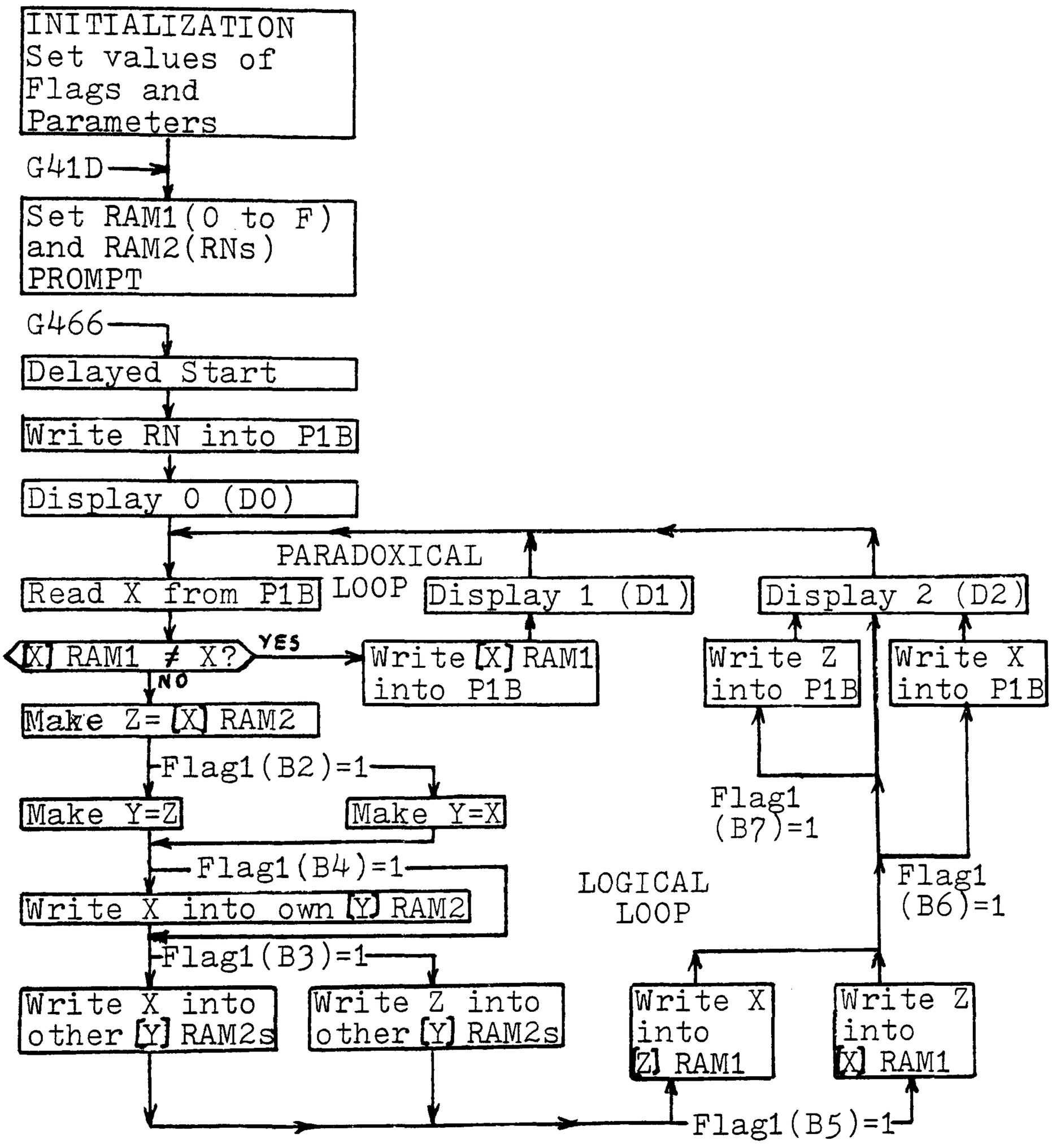

INITIALIZATION
Set values of
Flags and
Parameters
G41D
Set RAM1(0 to F)
and RAM2(RNs)
PROMPT
G466
Delayed Start
Write RN into P1B
Display 0 (D0)
PARADOXICAL
LOOP
Read X from P1B
Display 1 (D1)
Display 2 (D2)
[X] RAM1 ≠ X?
YES
NO
Write [X] RAM1
into P1B
Write Z
into P1B
Write X
into P1B
Make Z= [X] RAM2
Flag1(B2)=1
Make Y=Z
Make Y=X
Flag1
(B7)=1
Flag1(B4)=1
Write X into own [Y] RAM2
LOGICAL
LOOP
Flag1
(B6)=1
Flag1(B3)=1
Write X into
other [Y] RAM2s
Write Z into
other [Y] RAM2s
Write X
into
[Z] RAM1
Write Z
into
[X] RAM1
Flag1(B5)=1

Figure 5.2

Experiments

In the following experiments, the universes support no processes at the outset ("empty" look-up table), i.e. there are no processors. The activity in the different universes oscillates between the logical and the paradoxical loops (see Figure 5.2). After a dynamic (and/or "static") equilibrium is reached and depending on the particular experiment, the activity may remain in the logical loop, continue to oscillate between the two loops or remain in the paradoxical loop. A new universe added later may alter this situation temporarily or permanently.

The particular organizationally closed unities formed are the result of interactions inside the set of universes chosen for the experiment and are not <u>(are not)</u> predefined or predetermined either by the structure (hardware) or function (software) of these universes nor by the particular properties of their "components" (descriptions).

Petri Nets notation (Petri, 1965) is used to describe the activity of the network of universes after a dynamic and/or "static" equilibrium has been reached. The symbol (i) represents the description i and the symbol $|_j$ represents the firing of a process in universe j. Therefore, firings with different labels are concurrent as well as the branches that include them.

Experiment 1

Universes: 4

Description world: 0,1,2,3.

	B7	B6	B5	B4	B3	B2	
FLAG1=	0	1	0	0	0	0	(See Figure 5.2)

Dynamic stability reached:

None

RAM2 contents reached:

Location / Universe	0	1	2	3
0	0	3	2	2
1	0	3	2	2
2	0	2	2	3
3	3	0	2	2

Comments: No organizationally closed unities formed. Activity remained in the logical loop.

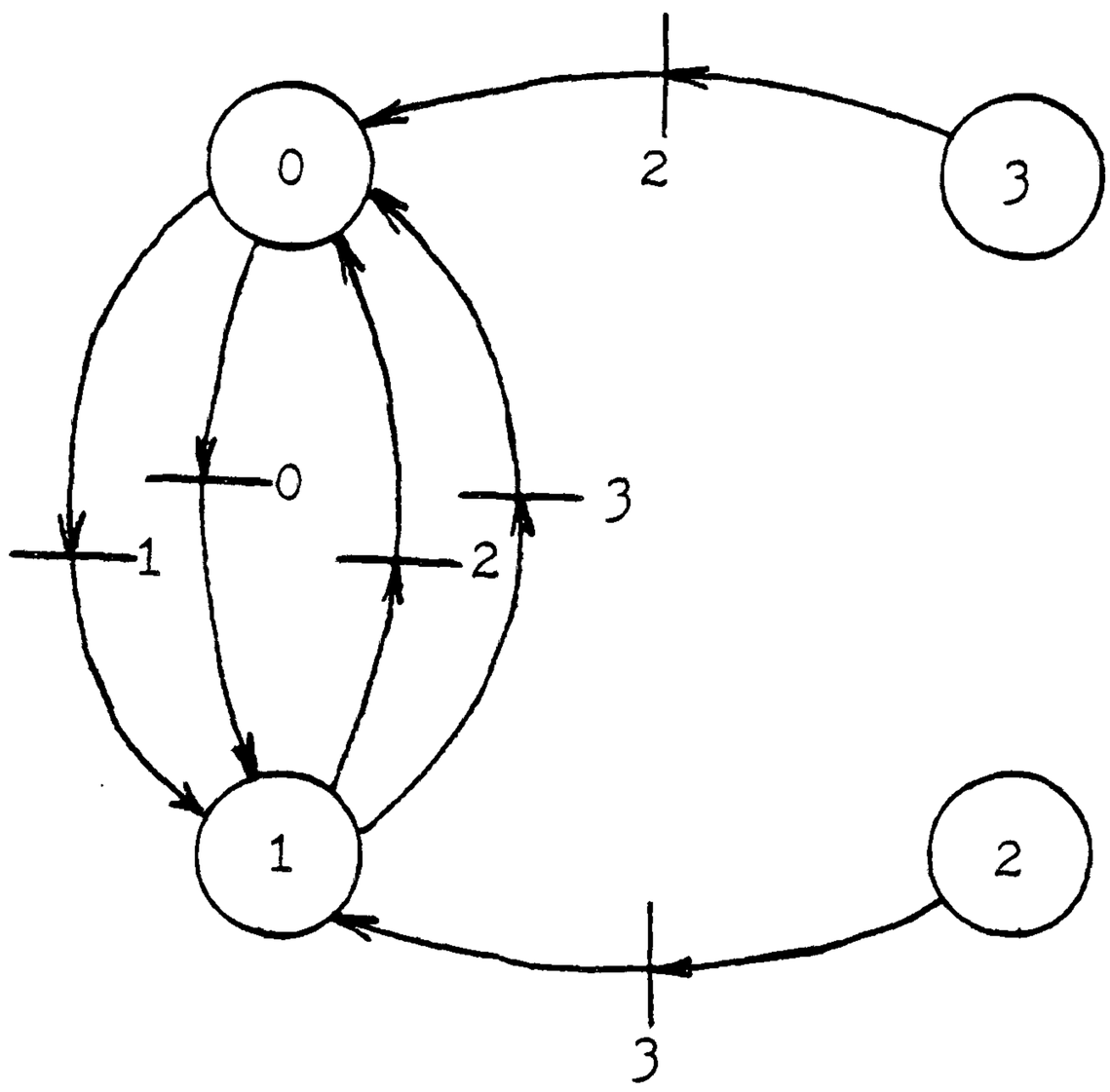
Experiment 2

Universes: 4

Description world: 0,1,2,3.

	B7	B6	B5	B4	B3	B2	
FLAG1=	1	0	0	0	0	0	(See Figure 5.2)

Dynamic stability reached:



RAM2 contents reached:

Location / Universe	0	1	2	3
0	1	0	3	3
1	1	0	1	1
2	1	0	1	0
3	1	0	1	2

Comments: Some organizationally closed unities formed. The activity continues to oscillate between the logical and paradoxical loops.

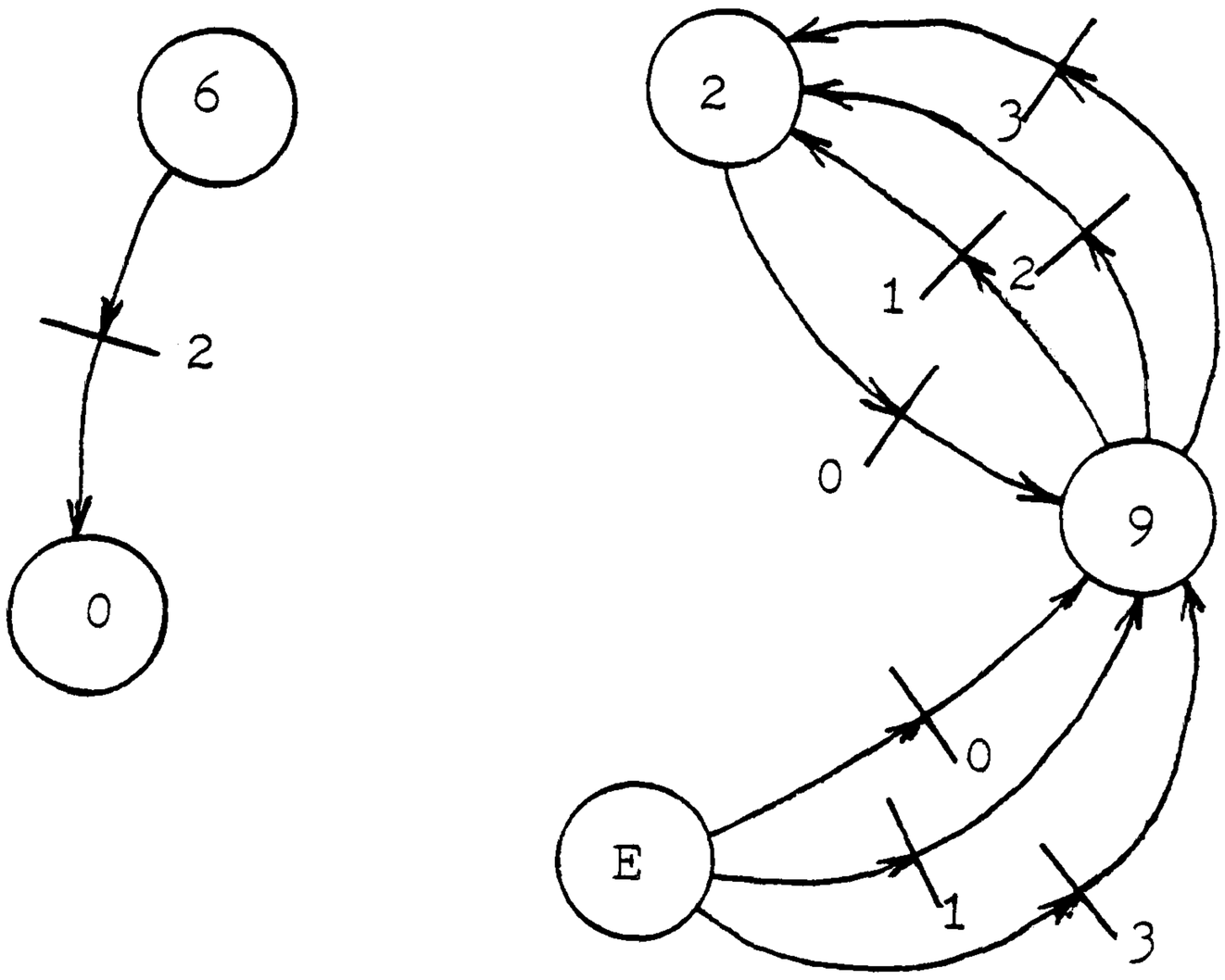
Experiment 3

Universes: 4

Description world: 0,1,2,3,4,5,6,7,8,9,A,B,C,D,E,F.

	B7	B6	B5	B4	B3	B2	
FLAG1=	1	0	0	0	0	0	(See Figure 5.2)

Dynamic stability reached:



RAM2 contents reached:

Location / Universe	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0	5	3	9	2	6	0	F	B	6	2	3	5	8	0	9	8
1	7	3	9	7	4	9	2	B	1	2	C	F	F	8	9	9
2	6	5	9	2	2	4	0	6	B	2	1	8	E	4	9	2
3	8	0	9	9	2	8	3	C	F	2	3	D	9	A	9	7

Comments: Some organizationally closed unities formed. The activity continues to oscillate between the logical and paradoxical loops. Notice the agreements in RAM2, locations 2, 9 and E.

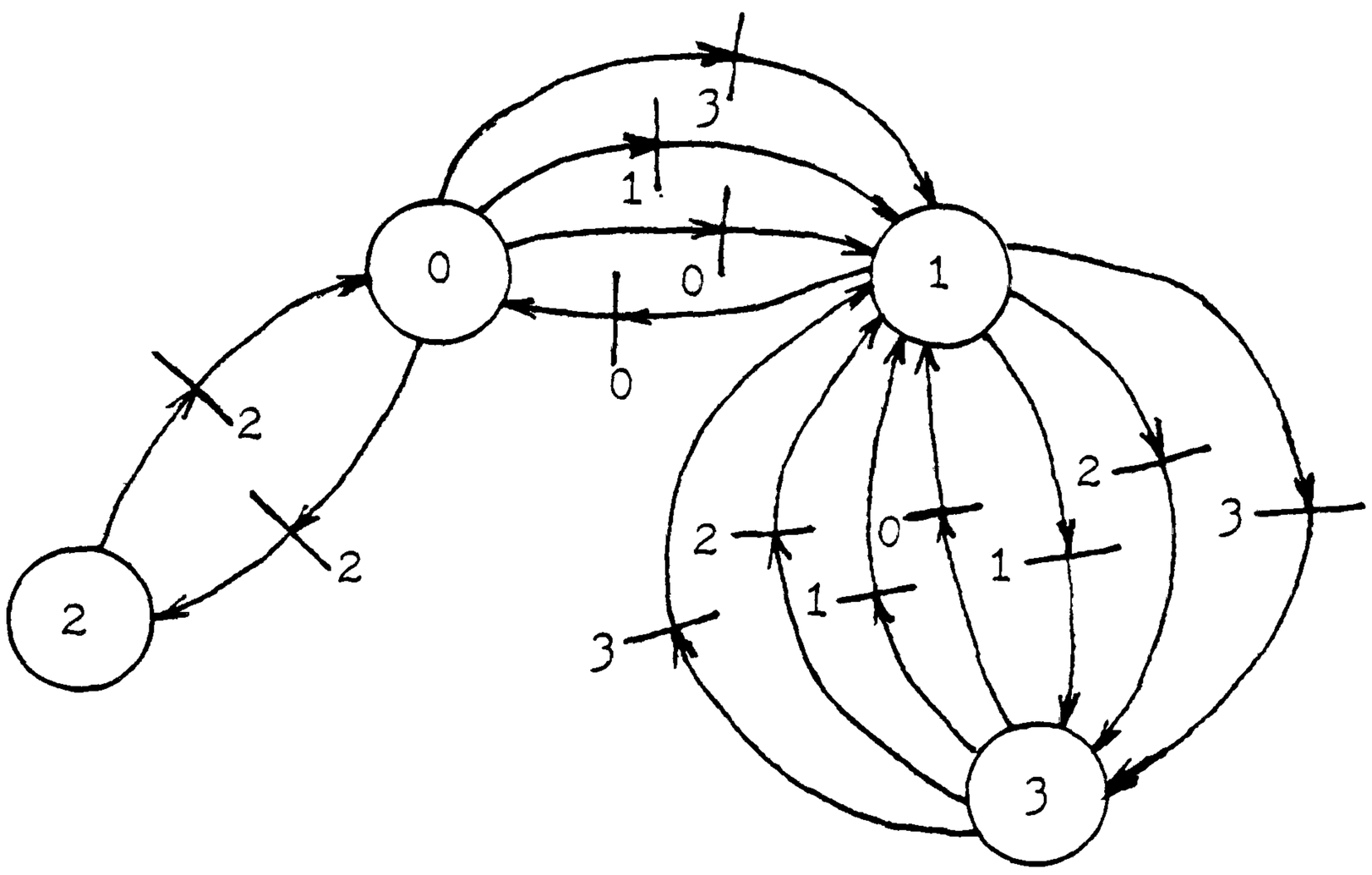
Experiment 4

Universes: 4

Description world: 0,1,2,3.

	B7	B6	B5	B4	B3	B2	
FLAG1=	0	0	1	0	0	0	(See Figure 5.2)

Dynamic stability reached:



RAM2 contents reached:

Location / Universe	0	1	2	3
0	2	0	2	1
1	1	0	2	1
2	2	0	2	1
3	2	0	2	1

Comments: Several organizationally closed unities formed with many corresponding agreements reached in RAM2. The activity remained in the paradoxical loop after some oscillation with the logical loop.

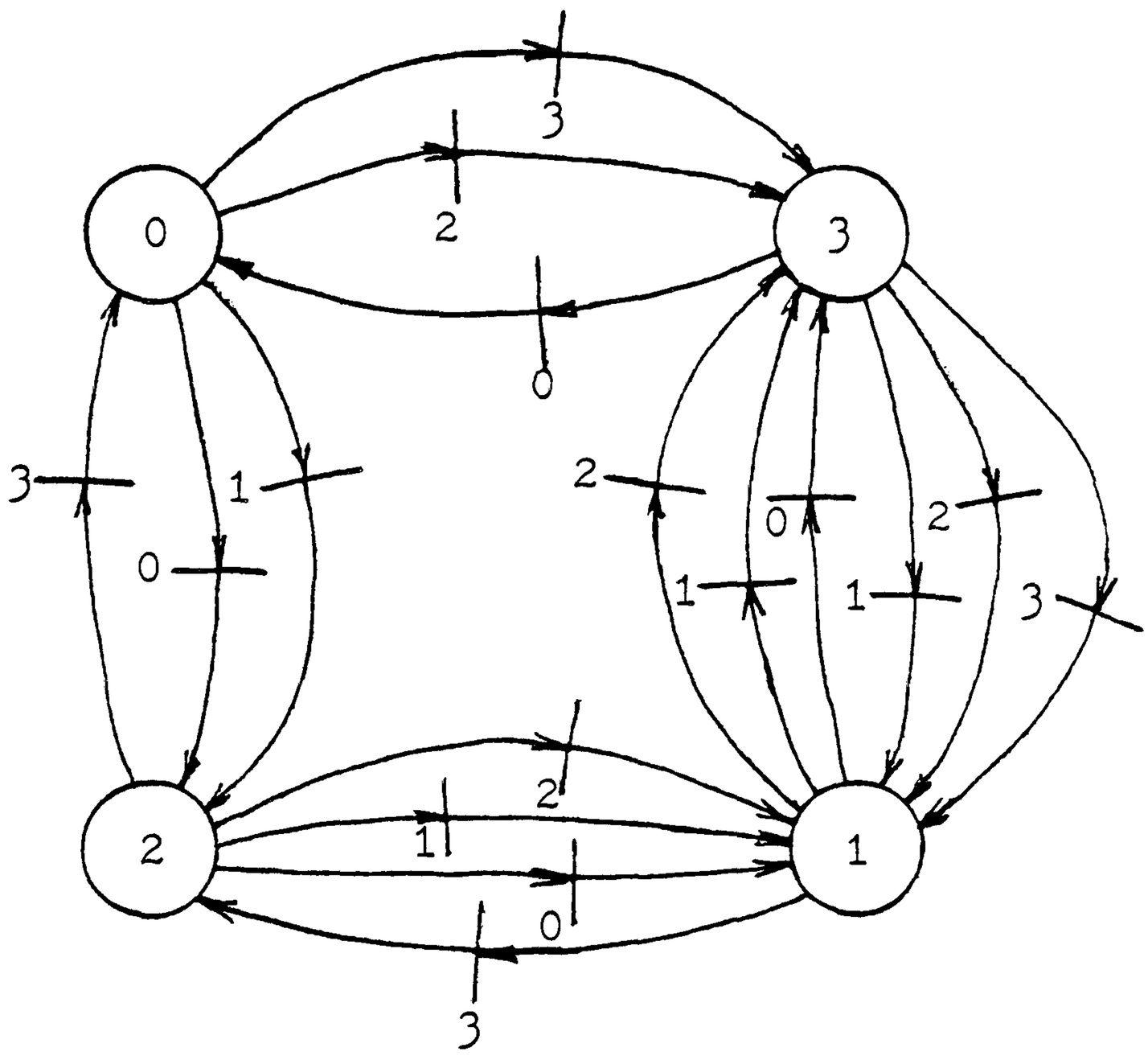
Experiment 5

Universes: 4

Description world: 0,1,2,3.

	B7	B6	B5	B4	B3	B2	
FLAG1=	0	1	1	1	0	0	(See Figure 5.2)

Dynamic stability reached:



RAM2 contents reached:

Location / Universe	0	1	2	3
0	2	2	0	0
1	2	2	0	0
2	2	2	0	0
3	3	2	0	1

Comments: Many organizationally closed unities formed with many corresponding agreements reached in RAM2. The activity remained in the paradoxical loop after some oscillation with the logical loop. Small organizationally closed unities (e.g. 1-3-1) are part of larger ones (e.g. 0-2-1-3-0).

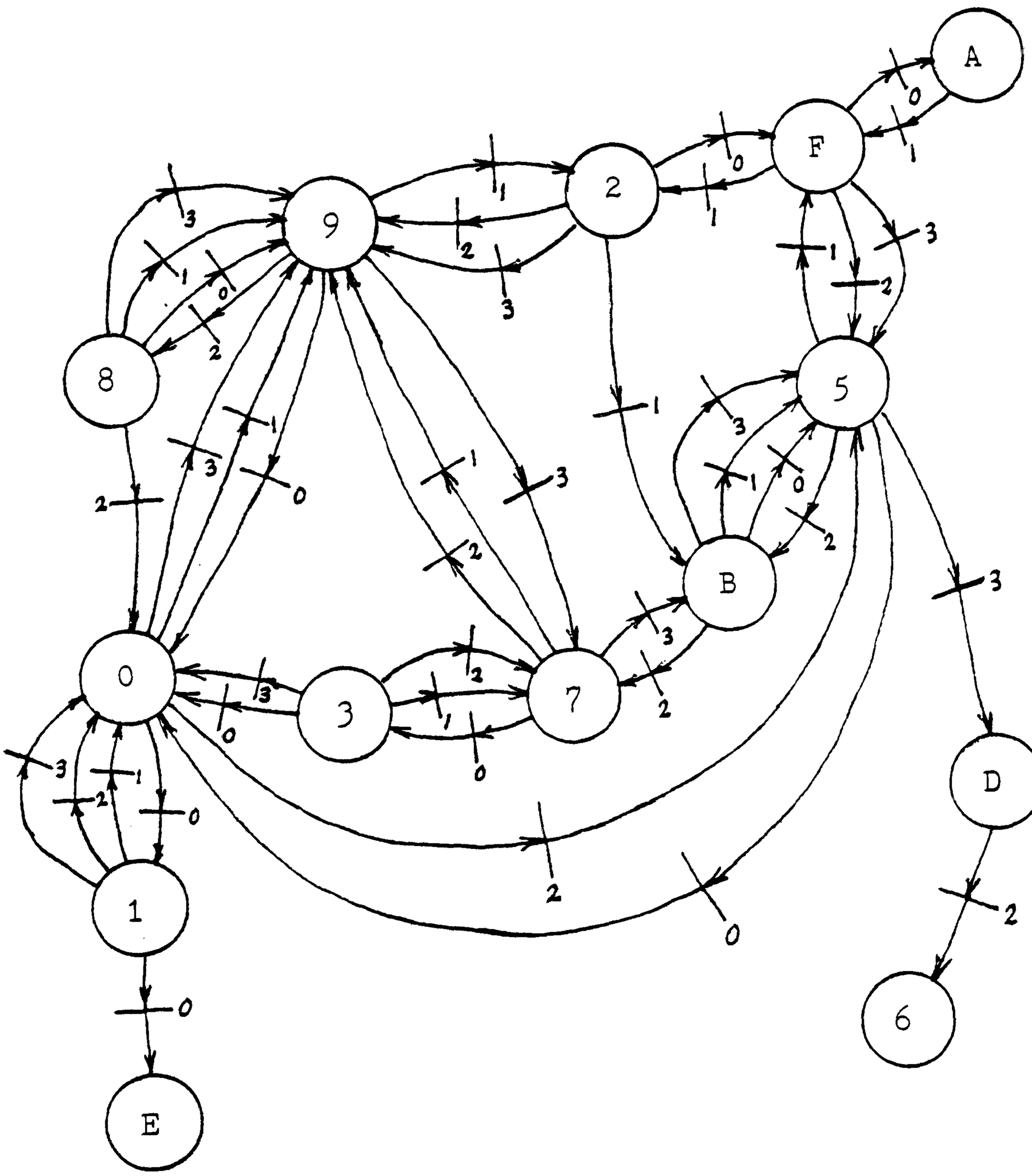
Experiment 6

Universes: 4

Description world: 0,1,2,3,4,5,6,7,8,9,A,B,C,D,E,F.

	B7	B6	B5	B4	B3	B2	
FLAG1=	0	1	1	1	0	0	(See Figure 5.2)

Dynamic stability reached:



RAM2 contents reached:

Location / Universe	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0	1	E	F	0	7	F	D	3	9	8	3	2	F	8	5	A
1	1	0	B	7	4	F	D	3	9	8	F	5	E	4	1	2
2	1	0	F	7	F	F	D	3	0	8	F	2	E	6	1	2
3	1	0	F	0	B	F	D	3	9	8	F	2	D	B	1	2

Comments: Many organizationally closed unities formed with many corresponding agreements reached in RAM2. The activity remained in the paradoxical loop after some oscillation with the logical loop. Small organizationally closed unities (e.g. 0-9-8-0; 2-B-5-F-2) are part of larger ones (e.g. 0-5-B-7-9-8-0; 9-2-F-5-B-7-9). Others overlap like 2-B-5-F-2 and 0-5-B-7-9-8-0. Branches like 0-1-E and 5-D-6 may lead to further developments.

The nervous system

The enormous potential of even a primitive nervous system arises from the nature of its components: the neuron cells. These are autopoietic unities that define (distinguish) themselves in the physical world (space and time). They are also, individually or in groups, universes or independent processors that can support descriptions (patterns of nerve impulses) changed by processes that are fired by these same descriptions.

From a paradoxical perspective they interact paradoxically without information transfer forming paradoxical loops in which descriptions are endlessly changed into others by closed chains of processes (organizationally closed unities) fired by these same descriptions.

From a logical perspective, the neuron cells or groups of them are a priori independent processors that lose their independence when they interact logically through local synchronization and information transfer. They form logical loops that may include the environment of the unity that beholds the nervous system. In these loops, the descriptions that do not fire a process are changed into themselves, thereby creating and expanding a logical reality (time and space), i.e. a physical world "out there" where neuron cells, as autopoietic unities, may define, distinguish themselves and form a nervous system in which the interaction between paradoxical and logical loops may create a logical reality (time and space), i.e. a physical world, and so on and on.

The complex activity generated by only four independent universes (each one may also represent a population of neuron cells) as shown in the above experiments, points dramatically towards the potential of a nervous system of even a moderate complexity.

CONCLUDING REMARKS

The paradoxical nature of organizational closure provides an excellent point of departure for further exploration of the interplay between the logical and the paradoxical perspectives in the living organism and beyond.

We have seen how the (paradoxical) "drive" for exploration in living organisms, that forms part of their definition as paradoxical organizations, can generate new organizations that may be also paradoxical and explore their own niche (or environment) in this same fashion. However, the activity and even the survival of the larger unity require a logical behavior (e.g. logical interactions) of the component living organisms. These latter will relinquish their autonomy and pursue the goals of the larger unity even if these goals collide with their own goals or with those of their kin, especially if they are not components of this larger unity. Therefore, any logical association of unities (e.g. human beings) carries a seed of danger for the associated and the non-associated unities (e.g. other human beings). Living organisms or similar unities of only moderate complexity will endure the drawbacks implied in this statement without hope for counteraction. Human beings, on the other hand, are autonomous unities of great complexity capable of transcending creatively, through paradoxical behavior, the bonds of any association. It is only through this exploration out of the larger unity, of whaterver sort, that human beings can express themselves and hope to reach their fellow human beings. Moreover, this paradoxical exploration out of the comfortable larger unity should be a

recurrent exercise of the creative powers of the human creature, too often deprived of this opportunity by the crippling forces (e.g. traditional "education", cultural legacies and so on) that protect the goals of the larger unity. These considerations stand by themselves as a basis for a world-wide approach to human coexistence.

The biological evolution of homo sapiens since its appearance on the planet has been so slow that it has been barely, if at all, noticed. However, the larger unities that homo sapiens has integrated (social groups) have evolved culturally at an accelerated pace. Acquired characters are inherited in culture, being transmitted directly from generation to generation verbally and graphically. But these characters belong to the larger unities and not to the component human beings, who must adapt to them, or break the bonds.

Cultural evolution defines the goals of the larger unities and shapes social knowledge. Often these goals do not coincide with those of the individual. Similarly, social knowledge cripples individual knowledge, which is precisely the motor of the cultural (social) evolution. With the even more accelerated pace of "modern times," the prospects leave little room for optimism. Nevertheless ...

One of the oldest goals among larger unities (different nations, different cultures, etc.) has been a common logical language for their component unities (human beings). However, this search for a common logical language, e.g. through logic and mathematics, is a goal for the larger unities and it cannot be more nonsensical from the point of view of the individual

human being, which is a paradoxical, therefore illogical, living organism. Consequently, paradoxical interactions are essential for this living organism if it is to survive the pressures of the larger unities.

Art and love, in all their forms, stimulate paradoxical interactions that are timeless and spaceless for the interacting unities and quite impossible from a logical perspective.

Human beings that persist in logical interactions, imposed on them or self-imposed, will become, more sooner than later, incapable of paradoxical interactions (e.g. through artistic expression and perception), and thereby a potential danger to their species.

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APPENDIX

Realization of the set of microcomputers

An Intel 8748 microcomputer is the core of each universe (Figure A.1). Two 8185 1K bytes RAMs are the available external (to the 8748 itself) RAM for each unit. 1K bytes of RAM is used as the "permanent" RAM1 and the other 1K bytes, as RAM2 (see Figures 5.1 and A.1).

8-bit tri-state bidirectional buffers (74LS245) are used to reroute (steer) the busses ADB and CB.

Another bus, ARB (Access Request Bus) is used to request mastership of ADB and CB and to access the RAM2s. The access to the busses and the access to RAM2 and the associated logic have been designed so that only single accesses are possible.

A closed chain of 74LS373 (8-bit latches) is used as the unique location P1B for concurrent accesses and paradoxical interactions (see Figures 5.1 and A.1).

The peripherals, that are not essential to the workings of the set of microcomputers, provide a convenient way to load the software and to allow the external observer to observe and to interact, if so desired. They include a USART (Universal Synchronous Asynchronous Receiver Transmittter) for serial interface to a terminal, a Baud Rate Generator (several Baud rates), an EPROM (Erasable Programmable Read Only Memory) to store, locally, the current program, a Random Number Generator (RNG) (realized in hardware), and the appropriate circuitry to interface with ADB, CB and ARB (see Figure A.2).

Diagrams

Figure A.1 is the circuit diagram of a microcomputer unit. There are 4 of these units in the set.

Figure A.2 is the circuit diagram of the peripherals to the set.

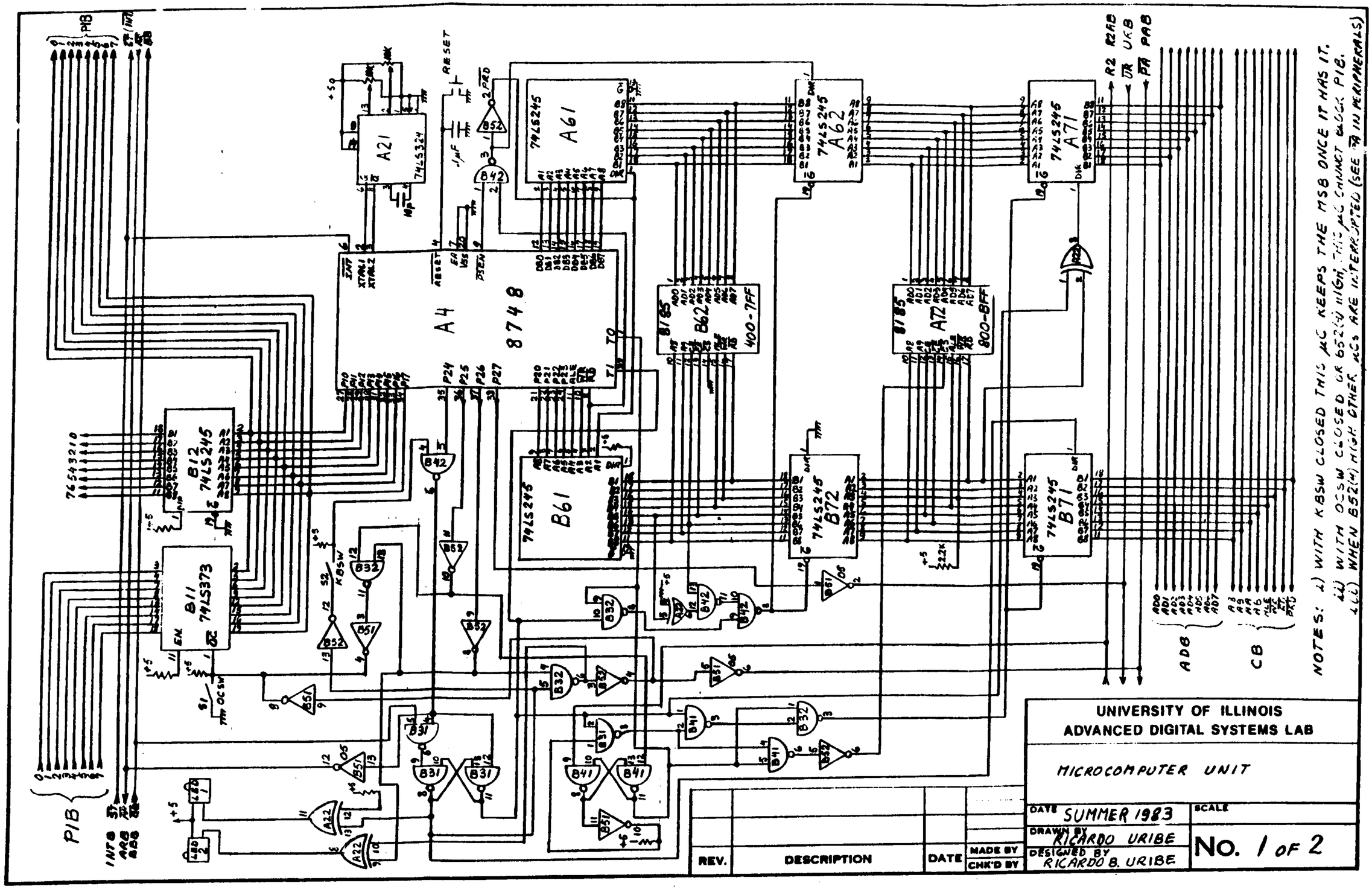
A4
8748
A21
74LS324
A61
74LS245
B61
A62
B62
A71
B71
A72
B72
B12
B11
74LS373
8185
400-7FF
800-BFF
RESET
P1B
P2B
R2 R2B
DR DRB
PA PAB
ADB
CB
NOTES: 1) WITH KBSW CLOSED THIS µC KEEPS THE MSB ONCE IT HAS IT.
ii) WITH OCSW CLOSED OR 8521(4) HIGH, THIS µC CANNOT BLOCK P1B.
iii) WHEN B521(4) HIGH OTHER µCs ARE INTERRUPTED (SEE P2 IN PERIPHERALS)
UNIVERSITY OF ILLINOIS
ADVANCED DIGITAL SYSTEMS LAB
MICROCOMPUTER UNIT
DATE SUMMER 1983
SCALE
DRAWN BY RICARDO URIBE
DESIGNED BY RICARDO B. URIBE
No. 1 OF 2
REV.
DESCRIPTION
DATE
MADE BY
CHK'D BY

Figure A.1

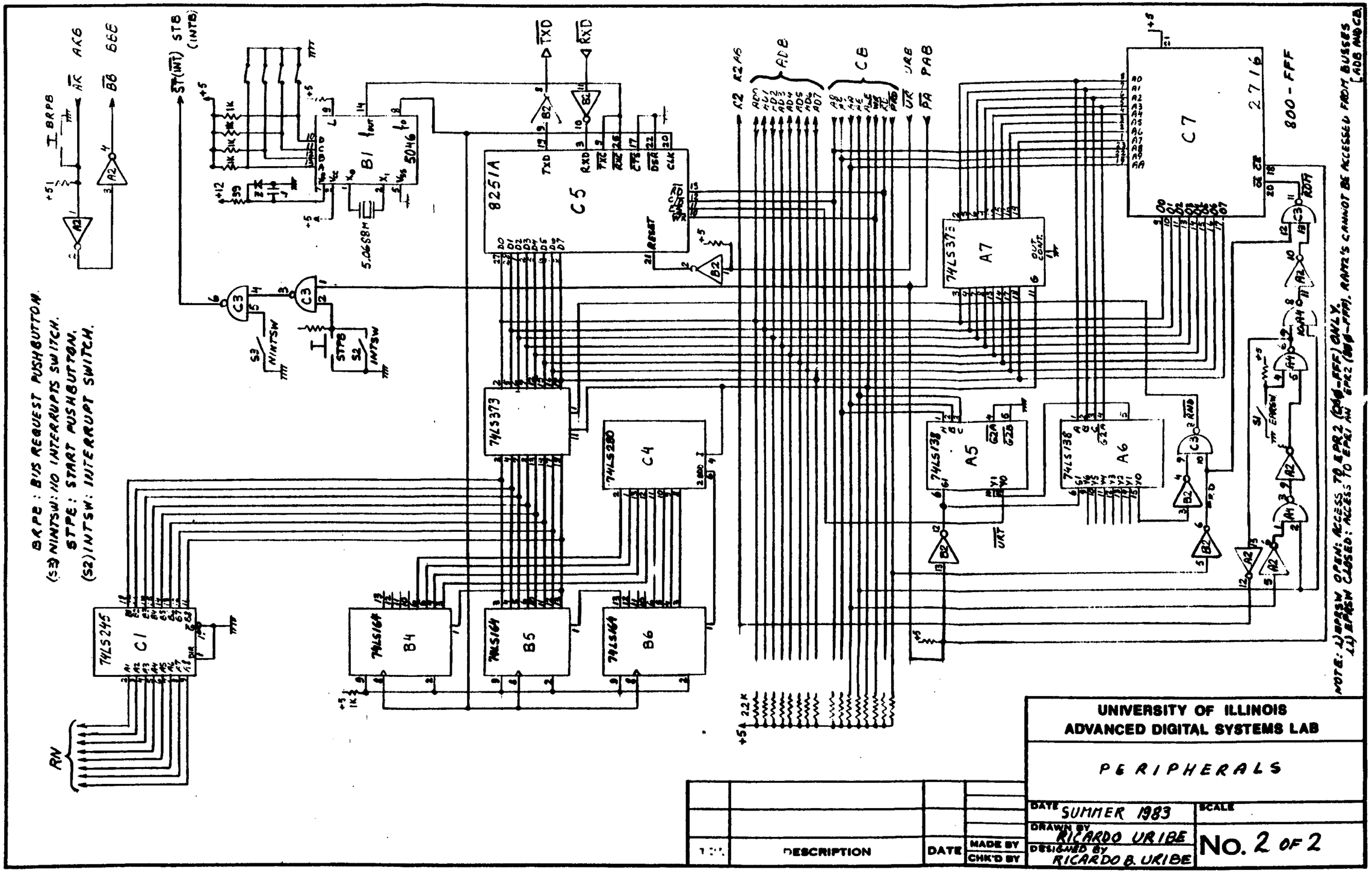
BRPB : BUS REQUEST PUSHBUTTON.
(S3) NINTSW: NO INTERRUPTS SWITCH.
STPB: START PUSHBUTTON.
(S2) INTSW: INTERRUPT SWITCH.
I BRPB
AR AK6
BB B6E
ST(INT) STB (INTB)
STPB
S2 INTSW
S3 NINTSW
B1
5.0688M
5046
TXD
RXD
8251A
C5
RESET
A2 A2 A6
ADB
CB
URB
PAB
74LS373
C7
2716
800 - FFF
74LS374
A7
74LS138
A5
A6
74LS280
C4
74LS245
C1
74LS164
B4
B5
B6
RN
2.2K
NOTE: 1) IOPSW OPEN: ACCESS TO 8251A
2) EPROM CLOSED: ACCESS TO EPROM
UNIVERSITY OF ILLINOIS
ADVANCED DIGITAL SYSTEMS LAB
PERIPHERALS
DESCRIPTION
DATE
MADE BY
CHK'D BY
DATE SUMMER 1983
SCALE
DRAWN BY RICARDO URIBE
DESIGNED BY RICARDO B. URIBE
NO. 2 OF 2

Figure A.2

Experimental set-up revisited

The paradoxical loop (see Figure 5.2) represents the paradoxical perspective since after an organizationally closed unity distinguishes itself among the universes (independent microcomputers) (because a chain of processes closes upon itself), the activity will remain in this loop as an endless series of descriptions changed over and over by the processes they themselves fire.

Different organizationally closed unities may distinguish themselves and interact paradoxically in PIB (see Figure 5.1) constantly (and recursively) changing the descriptions that they themselves generate. As long as the descriptions in PIB fire a process in some universe, the paradoxical perspective is not abandoned.

Moreover, from this paradoxical perspective two or more processors can read or write concurrently different descriptions from or into PIB without conflict, i.e. different events may occur at the same time and place as long as they occur in different concurrent processors (universes).

The logical loop represents the logical perspective since here the storage medium (space and time) is generated and expanded with the descriptions that do not fire a process. Even the processors themselves that support the organizationally closed unities are generated and expanded here with the descriptions that gradually fill the "look-up table" that defines a processor from a logical perspective.

The shared RAM2 represents the storage medium or environment where the different organizationally closed unities construct their common logical realities. Remember that this logical

reality (contents of RAM2) is affected only when a description fails to fire a process in some universe, i.e. when the paradoxical perspective is abandoned to enter the logical perspective. As long as there are no descriptions that fire a process in some universe, the logical perspective is not abandoned.

Moreover, from this logical perspective two or more different descriptions can be written into or read from the same location in RAM if and only if it happens at different times. Two or more different descriptions can be written into or read from RAM at the same time if and only if it happens at different locations.

These considerations sound familiar since they apply also to our logical realities, to our environment (or should we say to the environment of our nervous system?). It is interesting to contemplate at this stage the possibility of attaching transducers to our microcomputers that will translate the descriptions (computer words) that "remain" in RAM2 into aspects of the physical world (our environment). Other transducers could sense these aspects of the physical world, produced by these same or other microcomputers or nervous systems, and translate them into descriptions (computer words) to be presented to the microcomputers. These will change or maintain the descriptions (aspects of the physical world) until some (dynamic and/or "static") stability is reached for all the microcomputers or nervous systems concerned. Notice that from the point of view of the paradoxical loop (perspective) whether the descriptions in RAM2 are translated into aspects of the "physical world" or not, is immaterial.*

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*"... an external environment is not a necessary prerequisite of the computation of a reality." (H. von Foerster, 1976).

Notice the interplay between the two loops: from the point of view of the paradoxical loop, it provides the descriptions that create and expand the storage medium (the logical realities). From the point of view of the logical loop, it provides the descriptions that fill the look-up table that defines the processes that form the organizationally closed unities (the paradoxical realities).

The activity in these two loops leads to two kinds of stability: one, dynamic, represented by the organizationally closed unities formed, and the other, "static," represented by the descriptions that "remain" in RAM2, and are common to some or all the universes. These stabilities are provoked, maintained or perturbed by the several recursive loops at play in P1B and between RAM1 and RAM2 of the same or different universes (see Figure 5.2).