General information concerning the Center of Research on Electronic Computers (C. S. C. E.)

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THE CENTER OF RESEARCH ON ELECTRONIC COMPUTERS (C.S.C.E.)

1. INTRODUCTION

In the spring of 1955 a Center of Research on Electronic Computers (Centro di Studi sulle Calcolatrici Elettroniche - C.S.C.E.) was founded at the University of Pisa, with the aim of constructing a general purpose digital computer and developing the research in the field of automatic electronic computation. This was made possible thanks to a first grant generously given by the Provinces and Municipalities of Pisa, Livorno and Lucca. Further supports, under the form of grants and/or assignment of specialized personnel, were later extended by the S.p.A. Olivetti of Ivrea, the National Istitute of Nuclear Physics (I.N.F.N.), the National Research Council (C.N.R.) and the National Committee for Nuclear Research (C.N.R.N.).

The Center is under the control of a Committee, composed of three University Professors, respectively in the fields of Physics, Mathematics and Engineering. It includes two Sections : a Mathematical Logical Section, which is composed of mathematicians and physicists devoted to the development of logical design, computer programming and numerical analysis; and an Electronics Section including physicists, engineers and technicians, essentially devoted to electronic design and building of computers.

Thirtysix persons are at present working at the Center, as specified in the following table :

PERSONNEL	MATHEMATICAL-LOGICAL SECTION	ELECTRONICS SECTION	TOTAL
Physicists	3	2	5
Mathematicians	7	0	7
Engineers	0	5	5
Specialized Technicians	0	5	5
Other technicians, administrative staff, etc.	2	12	14
TOTAL	12	24	36

The past activity of the Center has been summarized in previous information bullettins and publications (+). It includes both research and teaching in the field of electronic

(+) - See, e.g., the Proceedings of the 44th Congress of the Italian Physical Society, held in Palermo in November 1958 («Nuovo Cimento», 12,111,1959 - and Suppl.«Nuovo Cimento», 1959, in the press.).

computers and the construction of a «pilot model». This was completed in the late 1957, and its characteristics are recalled in Section 2 of this report.

A large computer, the «C.E.P.» (Calcolatrice Elettronica Pisana) has been designed and is at present under construction. It should be ready to operate within the first half of 1960. It is a large and fast digital computer and its characteristics, described in Section 2 and 3, make it suitable for a variety of complex calculations such as ecountered in the field of scientific research.

For the actual programming of specific problems it is intended to adopt what is usually called, in computers language, an «open shop» organization. This expression is often meant for a type of organization in which the computer staff merely gives its assistance to the users of the computer. The latter are supposed, accordingly, to take care by themselves of the programming of their problems. The detailed organization of the Center from this point of view will be defined in the near future on the basis of the requirements of the main users of the computer (University of Pisa, I.N.F.N., C.N.R., C.N.R.N. and Industries) taking into account also the experience of similar Centers.

The «open shop» organization requires in practice the development of automatic coding techniques. Some systems are already under development, as outlined in Section 4.

2. THE «PILOT MODEL» AND THE ELECTRINIC DESIGN OF THE «C.E.P.».

The «pilot model» (fig. 1, 2 and 3) was thought at the beginning as a part of a larger computer and built essentially in order to test the general criteria of the electronic design. Later, the logical design of the final computer has been revised and enlarged, but the fundamental constructive feautures have remained unchanged.

The use of a purely binary system and the parallel mode of transmission of the information have been chosen in order to achieve the high computation speed required for scientific research.

The use of d.c. coupling has been chosen in order to simplify the design of the control unit, making it completely asincronous.

The single logical networks and the register elements are repetitions of a few types of standard pluggable units, having high input impedance and low output impedance; this was meant in order to simplify the assembling of the various circuits and the maintenance problems.

Following the general lines of the original design outlined three years ago, long-life on-off tubes have been used in the active elements, whereas the passive logical networks have been made of germanium diodes. The fast memory (fig.3 and 4) has been realized by means of magnetic cores driven by linear transformers.

The main characteristics of the «pilot model» are :

a) Word length : 18 bits
b) Magnetic core memory : 1.024 locations
c) Operation speed : 14 µS (including access to instruction)
d) Number of decoded instructions : 32 (only simple operations requiring no inner cycles).

The limits of the «pilot model» did not allow the application of it but to relatively simple problems. Much experience, however, was gained through its construction, and its use has confirmed the validity of the criteria adopted for the electronic design, giving satisfactory indications on the degree of reliability extected for the «C.E.P.».

The main characteristics of the latter are :

a) Word length : 36 bits
b) Arithmetic : fixed and floating point
c) Magnetic core memory : 4.096 words (expandable to 32.768)
d) Auxiliary memory : 16.384 words on a magnetic drum
e) Operation speed (order of magnitude including access to instructions but excluding modification time) :
   addition (fixed point) : 14 µS
   addition (floating point) : 96 µS (average)
   multiplication (fixed and floating) : 130 µS (average)
f) Input : one ore more photoelectric tape readers : 400 ch/ sec.
g) Output : one ore more paper tape punch : 32 ch/ sec;
   one telepype : 7 ch/ sec;
   one parallel printer : 150 lin/ min of 102 ch/ line.

A system of high speed magnetic tapes up to 8 decks is foreseen and will be added as soon as the necessary funds will be available. Furthermore, the input and output system can be increased, if necessary, including more efficient paper tape and/ or punched cards equipment. Fig.4 shows a matrix of 4.096 magnetic cores used in the fast memory of the «C.E.P». Other constructive details of this computer are given in fig. 5 and. 6.

3. MAIN CHARACTERISTICS OF THE «C.E.P.» UNDER THE LOGICAL-MATHEMATICAL POINT OF VIEW.

The essential characteristics of the electronic design of the C.E.P. have been given in Section 2, showing the class of this computer. In this Section the main characteristics from the logical-mathematical standpoint will be briefly discussed.

The logical project contains some relevant peculiarities, introduced with the aim of facilitating the programming. Two of them are particular by important. The first is connected with the system of automatic modification of the instructions ; the second consists in the introduction of a special jump on the operation symbol, which gives the possibility of performing particular sub-routines as if the latter were machine instructions. An extended code is thus obtained, which adds to the machine code a large number of «pseudo-instructions», having the same formal structure as the instructions.

The instructions of the C.E.P. occupy an entire word of 36 bits, and are of the one-address type, apt to be modified up to twice. The solution adopted for the automatic modification presents a particular character, because ordinary memory locations (parametric cells or index registers) instead of special registers, are used for this purpose. This system has the inconvenience of requiring a supplementary time for each modification, but - on the other hand - has the advantage of supplying in the most economic way a relatively high number of parametric cells. In the C.E.P. there is a total of 64 parametric cells, this number being limited only by the number of bits at disposal in the instruction for each parametric address.

The 36 instruction bits are subdivided as follows: The first 9 bits are reserved to the operation symbol. The next two groups of 6 bits indicate two distinct parametric cells,thus giving as mentioned already, the possibility of performing two modifications. In several instructions of particular nature, however, the first parametric cell is not employed for the modification of the instruction, but during the execution of the latter it is used for several important functions varyng from instruction to instruction. The last 15 bits are reserved for the address, thus giving the possibility, on one hand, of extending the main memory up to 32.768 locations and, on the other hand, of addressing singularly the locations of the magnetic drum and the blocks of information on magnetic tapes. With the 9 bits reserved to the operation symbol, it is possible to refer to more than 200 different pseudo-instructions in addition to the - 120 basic instructions.

A further peculiarity of interest (which is helpful both for the debugging of programs and for introducing some automatic checking during the course of a calculation) is given by the possibility of performing - at the end of an instruction - a conditioned jump to special interpretive sub-routines instead of proceeding to the next instruction.

4. THE PROGRAMMING ORGANIZATION

The logical structure of the C.E.P. allows a great flexibility in the programming. The possibility of modifying at least once all the instructions and several of them even twice, facilitates the programming of cyclic and iterative calculations, especially in problems containing quantities depending on more than one index. Similar problems are frequently encountered in the scientific calculations (system of linear equations, systems of partial differential equations, etc.). The pseudo-instructions appear to be also rather promising. They give, infact, the possibility of considering as simple operations, under the programming point of view, complex operations such as, for instance, arithmetical operations on numbers in multiple precision, calculations of elementary and trascendental functions, reading and printing operations with the relative binary-to-decimal conversion.

These two characteristics allow to assimilate the direct programming of the machine to the elementary types of automatic programming.

In order to further facilitate the direct programming, a symbolic system of programming is being studied. It will give the possibility of writing the instructions in a convenient symbolic form, while the machine itself will convert the symbolic program into its own binary code, through a proper assembling program.

The direct programming anyhow requires a high specialization and knowledge of the machine. More advanced techniques of automatic programming are customarily used in order to facilitate the programming for not specialized researchers and to speed up the ordinary programming. These techniques consist of: a) an algorithmic language, which must be - as far as possible - adherent to common mathematical notations, useful for a quick writing of the programs, and: b) of a suitable compiler program which gives the machine itself the possibility of translating into its own code a program formulated in algorithmic language.

Such an algorithmic language does not generally refer to a particular machine, although it may depend on some of its general characteristics (type and size of the main and of the auxiliary memories; type and characteristics of the input and output devices, etc.). There are several systems of this kind, some already developed and some under development. Now-a-days, in the international field, there is a quite definite trend towards the formulation of few universally accepted systems, especially in order to facilitate the direct intercommunication and the exchange of programs among users of different machines. This is why it seems advisable to chose the «FORTRAN» as algorithmic language, being it particularly suitable for scientific calculations and already developed for the 704 IBM (which is at present the computer, of the same class of the C.E.P., more widely used in the world). A few changes are necessary in order to adapt it to the input-output system of the C.E.P., which consists of punched tapes instead of punched cards. Moreover some extensions are desirable to take direct advantage from the possibility offered by the pseudo-instructions system and by the other peculiarities of the C.E.P..

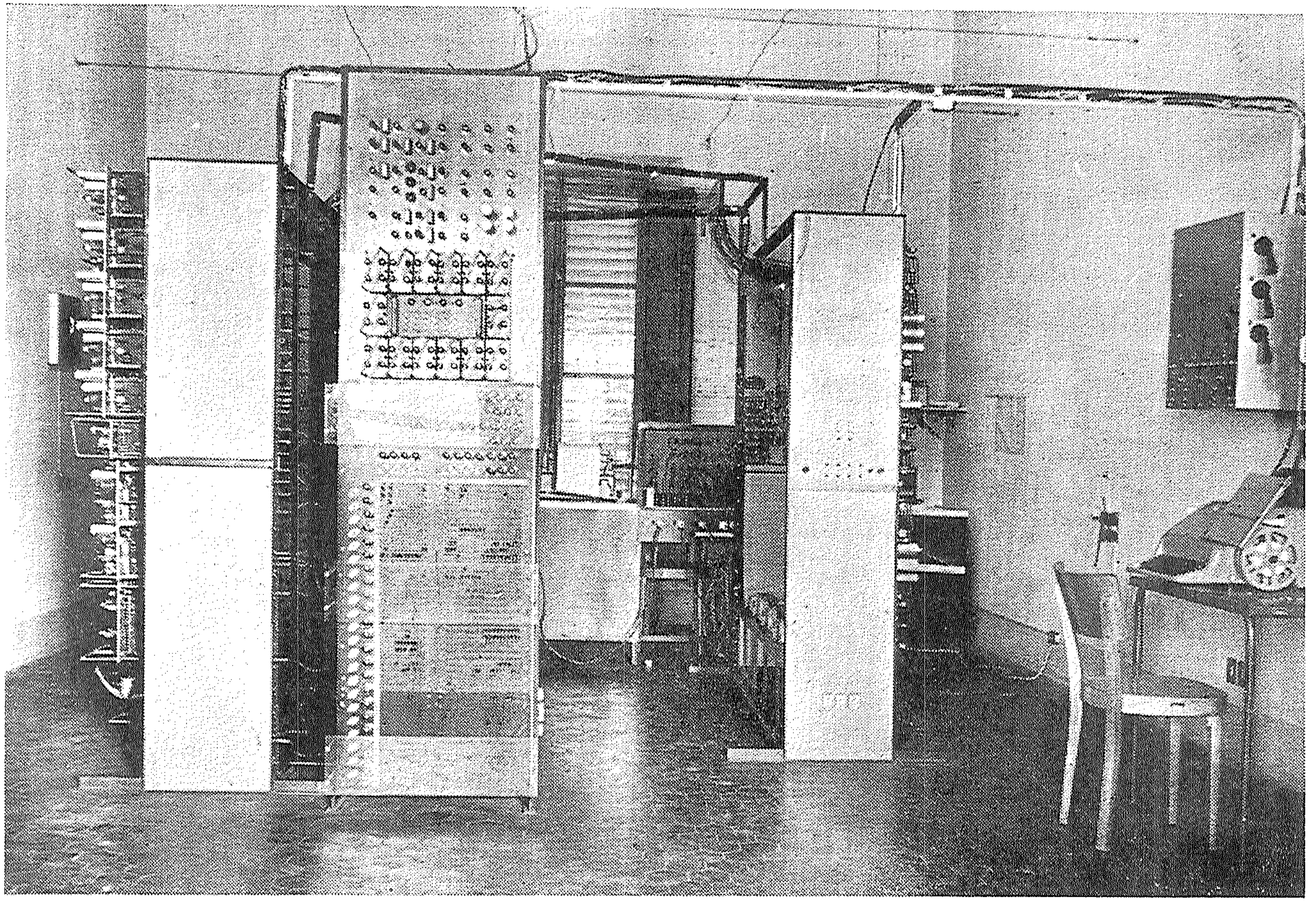

Fig. 1 - General view of the « Pilot Model »

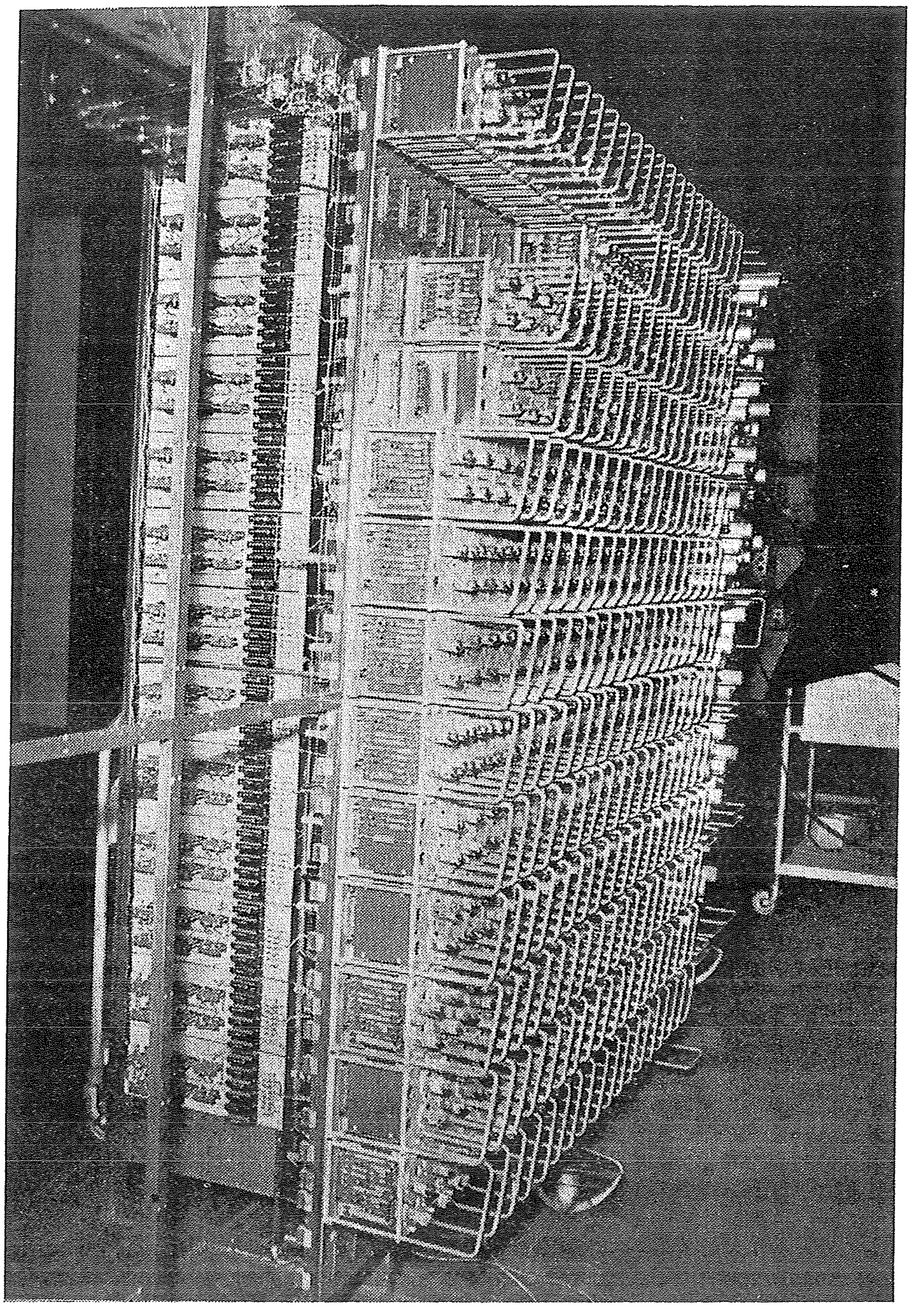

Fig. 2 - The arithmetic unit of the « Pilote Model »

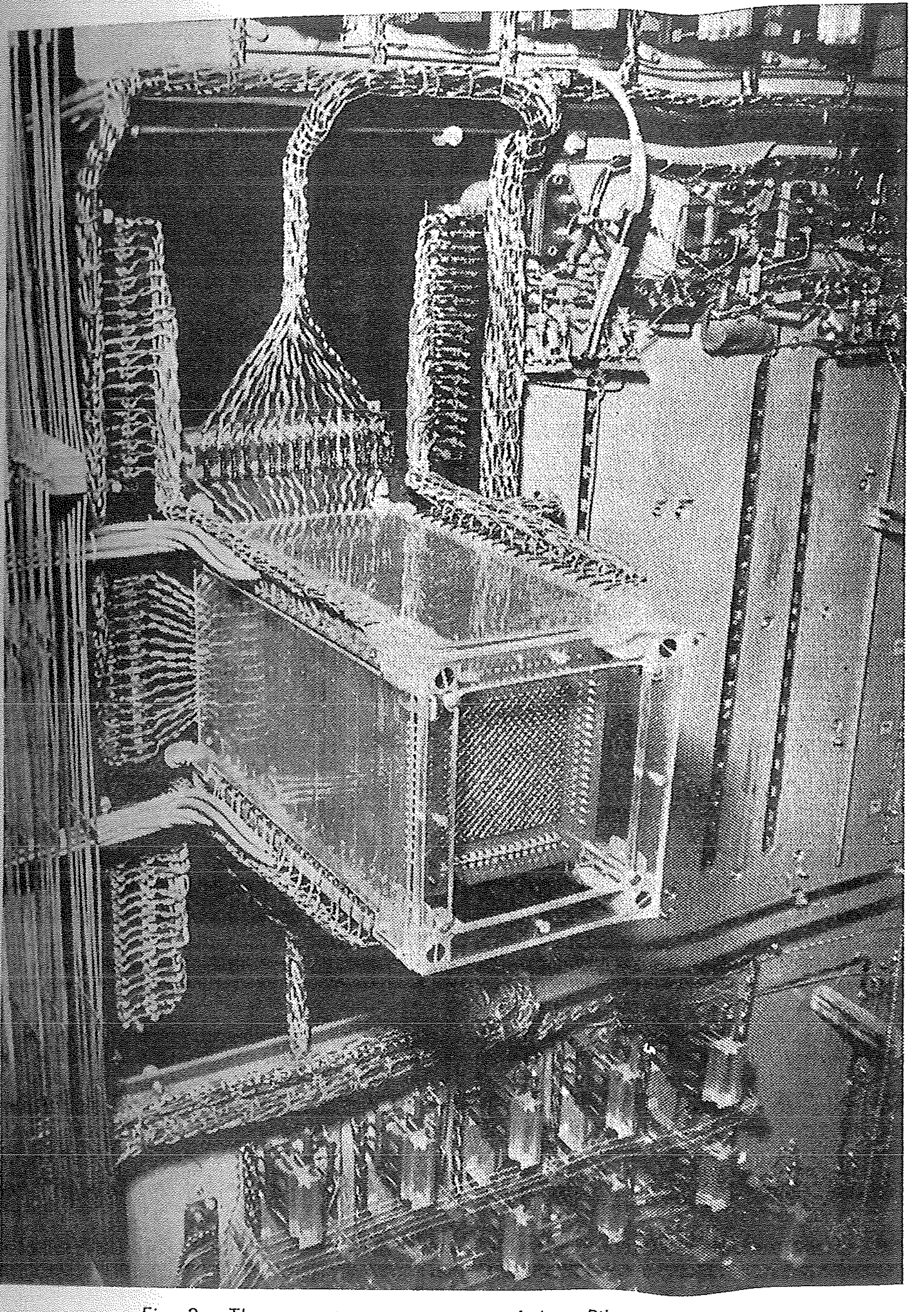

Fig. 3 - The magnetic core memory of the «Pilote Model»

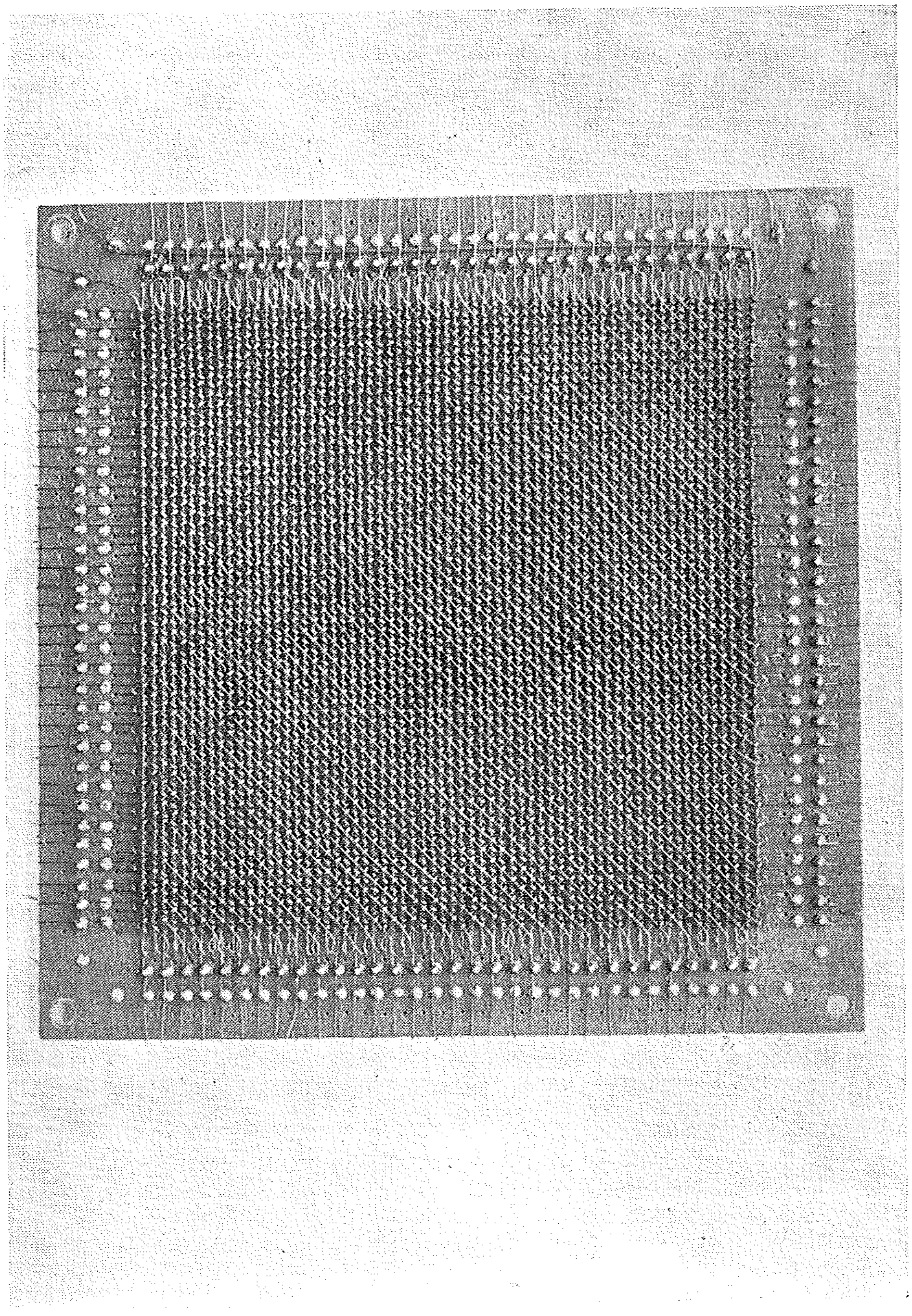

Fig. 4 - A matrix of 4,096 magnetic cores used in the fast memory of the «C.E.P.»

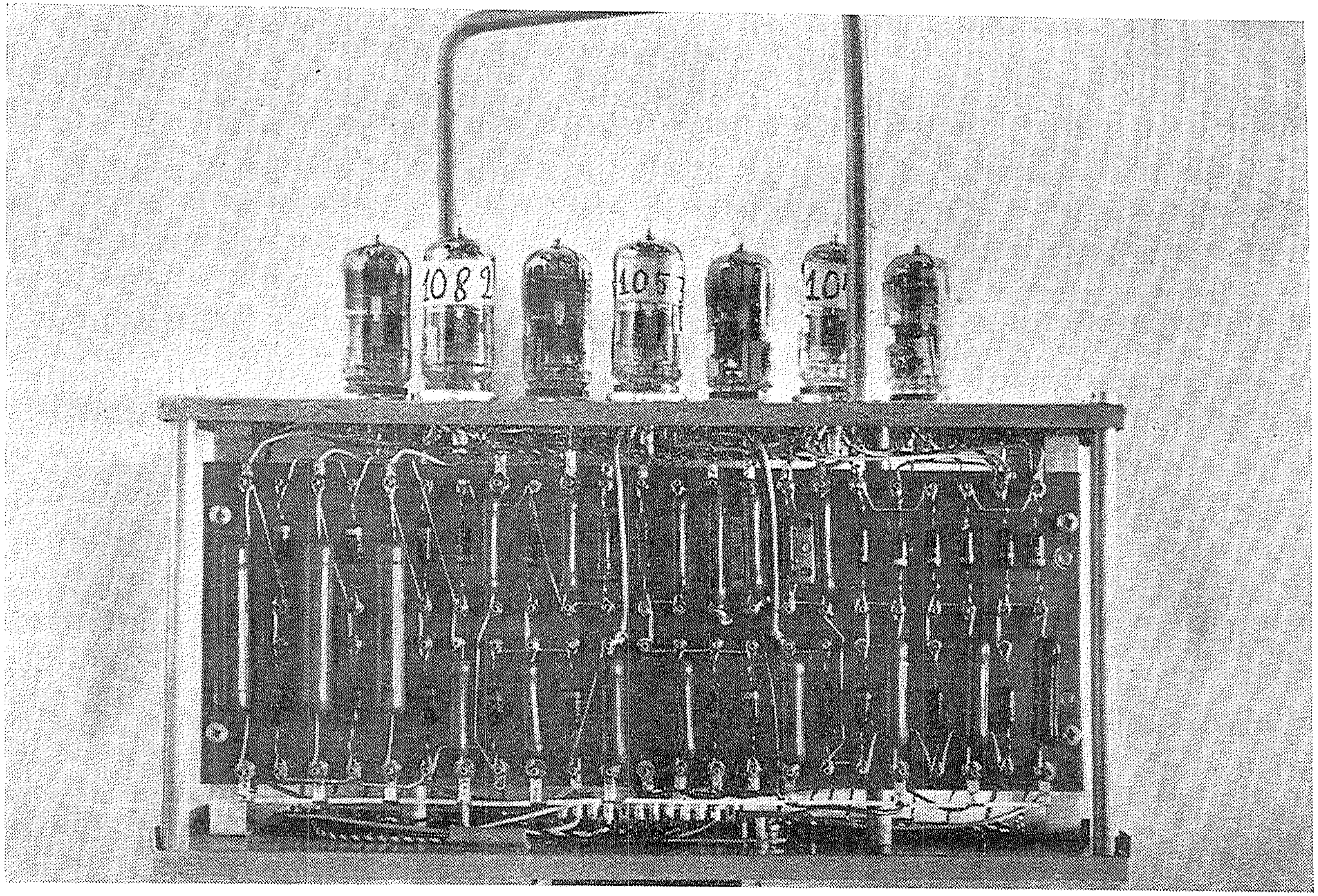

Fig. 6 - Standard pluggable unit of the arithmetic unit