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APPLICATIONS OF COMPUTER AIDED TECHNIQUES FOR
ENGINEERING INDUSTRIES IN LATIN AMERICAN COUNTRIES ^{1/}

by

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APPLICATIONS OF COMPUTER AIDED TECHNIQUES FOR
ENGINEERING INDUSTRIES IN LATIN AMERICAN COUNTRIES.

1. PURPOSE

The purpose of this work is to show a synthetic plan of the applications of aid techniques, through the use of computers for engineering and industry in Latin American countries.

Our intention has not been to present a detailed and systematic list of all the applications in each country, but to describe the principal lines of utilization as a means of reference for indicating the actual state of the situation. At the same time, we intend to sketch the prospective of future development in the area.

At the end, there will be conclusions drawn from the performed analysis.

2. INTRODUCTION

The application of computers in some Latin American countries began at the turn of the 60's. Its utilization was fundamentally oriented to the public offices for doing administrative work and follow-up. Academically it was used for numerical calculus, business investigation and other scientific applications. Little was known about planning and the application of analogic computers, the few units in use being imported. By the middle of the 60's, the introduction of third-generation digital

computers and the development of courses, seminars and system analysis programs gave a substantial impulse to the enlargement of knowledge about programming in languages oriented to business and science.

The assimilation of FORTRAN II and IV opened a new perspective for the engineer, who began to apply the numerical method to the analysis and simulation of his projects, basically of different natures: civil, electromechanical, electronic, aeronautical, etc.

Toward the end of the aforementioned decade we observed a new application of computers, namely the control of industrial processes. In some plants the system used was of the analogical type, with basic integration functions, routing, addition operations and proportional derivative control operators.

The beginning of the actual decade marks in some countries of our area the start of complete application of direct digital control of processes and numerical control for tool-machines.

Digital computers with digital-analog-interface units had begun to control and supervise the production of concrete, paper and iron products.

Of course, this fact called for the armonic participation of multiobjective engineering groups, namely analysts, electromechanics, electronics and experts in automatic controls.

The advent of tool-machines with numerical controls at the workshop or the big factory modified the line of work, by transferring the responsibility of the machining from the skilled workmen to the designer-programmer. Besides, in many places, the arrival of these

pieces of equipment called for urgent training of specialized maintenance personnel in logic, digital-servomechanisms and learning and experimenting in programming codes. Nowadays, the advances of computer technology and the broadening of their memory capacity, the channels of data input and the perfection of man-machine communication, make it possible to observe the usage of the equipment simultaneously for engineering projects and the control and supervision of an industrial plant.

Science and computer technology may help reduce the technological gap among developed and underdeveloped countries, and have a very active part in setting the patterns for the development process.

The economic and social council of the United Nations has acknowledged the fundamental part that science and technology play for development.

In 1963 there was held an important conference on the Application of Science Technology in behalf of less developed regions. The technology of computers and their importance in the development has had a special interest on the part of the Consultant Committee on the Application of Science and Technology to Development, and its special study group about computers has elaborated several reports that were discussed and were shaped as fundamental recommendations. These recommendations and suggestions included directives for their effective put into practice.

Related to the already mentioned topic, the United Nations Industrial Development Organization, UNIDO, has elaborated a study on the utilization of computers related to industrial development in developing countries, as well as the compilation of didactical material for training.

They have also considered the development and effective formalization of consultations and given technical assistance on industrial automatization.

On the other hand, the United Nations Development Programm, UNDP, has effectively aided in the coordination of the usage of computer science as a help for the programs of the different Unites Nations organizations, underlining the responsibility of the national governments in regard to the planning of development. Besides, it has aided short and selected projects related to computers, including assistance for the purchase of equipment, training, teaching, services and consultations as well as the creation of investigation and training centers.

The incorporation of computers in Latin America has shown its enormous help to industrial, technological and scientific development. However, it is not the universal panacea.

Moreover, its incorporation brings about a new approach and treatment of engineering, which is translated as the need the potential user has of a yielding and receptive mentality inclined to changes and to the certainty that every technological innovation will contribute to economic and social development.

3. AREAS OF INFLUENCE

We will quickly analyze the areas of influence where computers adopt a relevant role in industrial engineering. They are:

- Teaching and investigation.
- Projects.
- Production.

3. 1. Teaching and Investigation

The academic aspect brings about a survey of attitude, a control element to assimilate the incorporation of this technological advancement named an electronic computer. For the teacher, it means that his amount of knowledge does not anymore constitute a solid, secure and invariable inheritance that allows him to keep up comfortably with his academic activity. The preparation of the material for his subject has certainly demanded him a considerable effort that today may have been surpassed and outdated by computation techniques.

The newly graduated professional interprets that new equipment and methods have been incorporated by the factory and that he must shortly assimilate the news, seeking personally the necessity of updating his training.

The students discover an alternative resolution that surpasses graphic-manual methods, but for them it is an extra effort.

Professors and graduates must acquire not only a new language but also new procedures and approaches for a given solution. All this academic activity brings about a change in the established rules that will not be accepted by all. Evenmore, some will reject in several different ways the application of computation techniques for teaching.

Here plays a decisive role the permanent education of all the educational layers.

In many Latin American universities the programs of study

have incorporated one or several compulsory subjects on the application of number methods and digital-analogic programming. Besides, in some advanced courses, different subjects use computation methods.

Related to the academic activities, the technological investigation at the universities contributes to spreading out methods and procedures.

In many cases, Latin American units have their professors perform investigations and their computation work is transferred to their subjects. On other hand, investigation and technological development have a powerful ally in computation techniques, saving a considerable economic effort and shortening substantially the time of development, allowing to take quick alternative design decisions.

3. 2. Projects

In industrial engineering the digital computer is of great help and in this case also aids the designing engineer to cut drastically the terms in order to define the final product accurately.

In the case of a complex project, like a petrochemical process, the multivariable control loops can be simulated and you may obtain the best cost-efficiency relationship for the product. In the planning and follow-up of complicated projects you have the PERT method which can be programmed digitally. Besides, the designer uses a group of oriented

subroutine programs that facilitate its task; ECAP and CSMP in electrical engineering, ICES-UNMES in civil engineering, etc are typical examples.

3.3. Production

The numerical control, NC, of tool-machines has cut down the costs of manufacture of relatively small number of pieces. This is particularly important in Latin American countries where markets are rather small and with the characteristic, in some cases, of a wide variety of models. The NC is also very useful to obtain quick prototypes because on one hand it does not require skilled labor and on the other you eliminate costly tools.

In Latin American the NC was incorporated on simple action units, of the kind point by point on X - Y cross-arm tables, but today it is possible to see units with direct digital control programmed by a computer. The control and supervision of industrial processes by means of computers has permitted a better quality and uniformity of the product, cutting down exploitation costs, improving planification and safety systems and obtaining an adequate and continuous series of data from the system.

Also in the productive process metrology and inspection of parts has been computerized, obtaining besides a statistical inventory of the machining done: accuracy, finishing and rejections.

It will also be stated that on the other hand a digital computer controls and supervizes the sistematic test of structures, internal combustion motors, turbines and models in wind tunnels.

4. INDICATIVE EXAMPLES OF COMPUTER INFLUENCE ON LATIN AMERICAN AREAS

4.1. Teaching and Investigation

4.1. a. ARGENTINA

UNIVERSITY OF BUENOS AIRES

Faculty of Engineering

At the Institute of Biomedical Engineering they use digital techniques for the deconvolution into two dimentiones and linear prediction. They have also started with the application of microprocessors.

At the Electronics Department they analyze advanced learning control systems, autoadaptive and pattern recognitions, using matrix state variables.

The Laboratory of Applied Electronics is developing a minicomputer for the automatization of machine rooms in merchant vessels with the scope of applying it to the ships under construction at the State's Navy Factories and Dockyards (A. F. N. E.).

Equipment used: IBM 360

DEC-PDP - 11/10 - 16KB - interphase D/D.

UNIVERSITY OF LA PLATA

Faculty of Engineering

At the Electronics Department, they established some years ago the CETAD, Center of Analog-Digital Techniques, whose fundamental objective is the development and application of the methodology for "computer aided projects" in the area of electronics systems, circuits and components. They study the algorithms leading to systematization and automatization of calculation and construction processes in electronic engineering.

We can mention the development of programs for: commutation time for bipolar transistors and MOS, minimization of logic functions in PL/I and FORTRAN languages, calculations of pseudorandom sequences and construction by shift registers.

We must point out the FATCON II program, developed with the sponsorship of FATE ELECTRONICS. It consists in solving the placement of connectors on printed circuit upon a back plane, minimizing the total length of the connections and the number of lines per section.

The Department of Aeronautics has been doing research and completing projects on navigation systems, applying simulation techniques. Outstanding are the methods of identifying adaptive systems based on WIENER criteria and KALMAN filters.

They use an APPLIED DYNAMICS analog computer, a EAI 580 with DEC - PDP 11/20 - 16KB hybrid computer, and a IBM/360-50, 256 KB, 2250 plotter digital computer.

NATIONAL UNIVERSITY OF THE SOUTH

Faculty of Engineering

Studies have been made through the use of vibratory analysis. For instance, planes of electronics printed circuits, their results having been compared with those obtained with the method of finite elements (STRUDL system).

By the middle of the last decade, they completed the development of a digital computer completely designed at the Faculty. It contained an auxiliary memory, of the magnetic drum type.

Later works conducted to the study and development of ternary logical circuits and computers' advanced structures.

Many computational methods were investigated, for the analysis and design of automatic control systems.

Equipment used: DEC - PDP 8/E - 32 KB.

UNIVERSITY OF SAN JUAN

Faculty of Engineering

At the Electronics Department there have been developed a series of programs applied to automatic control in engineering.

There are mentioned automatic plotting of EVANS, BODE and NICHOLS methods, digital-analog simulation and the application of autoadaptive control techniques for electrical generators.

At the Calculus Institute there have been developed and applied several programs written in FORTRAN IV for the elaboration of

the project "ULLUM DAM", performing an analysis of the hydric fall.

At the Institute of Antismic Research they use digital techniques very intensely, especially for the dynamic analysis of models of antisismic structures.

Equipment used: Analog Computer EAI TR 20
Digital Computer IBM 1130, plotter 1627
Digital Computer DEC-PDP-11/10-16KB
(to be purchased).

NATIONAL TECHNOLOGICAL UNIVERSITY

The National Technological University, NTU, has performed an intensive program on application of digital computation to engineering, since the creation of its Calculus Center in 1964. In 1966 they introduced the subject "Introduction to Digital Computation" in the different careers.

In 1967 they inaugurated the IBM 360/30, first of its kind in Argentina with a tele-processing capacity of over 1000 km.

In 1970 they started the System Analysis career. They also held computation workdays organized by NTU, called JACACI 1969 and LACACI 1971. They grouped the best Argentine and Latin American computation specialists.

Several teaching - and - research - oriented programs show the application of computation concepts for electronics, mechanics, statistics, operational investigation, etc.

The Numerical Control Group of the Technological Research Center, Regional Faculty Cordoba, is doing research and developing industrial process control systems. They have developed a prototype of numerical

control for adaptation and industrial transference. Nowadays the work is oriented toward the application of microprocessors and minicomputers for numerical control and processes, and the development of an analog computer for the NTU.

The relationship between research and teaching, and between university - local industry are outstanding.

Equipment used: computational CONSUL console for numerical control programs, development system with NATIONAL SC/MP microprocessors, DEC-PDP-11/03 minicomputer (to be purchased).

CATHOLIC UNIVERSITY OF CORDOBA

Faculty of Engineering

Since 1965 there are being used analogic - digital techniques for teaching, research and final pregraduation duties. They apply COGO, STRESS, PCS, ECAP and CSMP programs. Besides, some others have been developed, like: synthesis and simplification of combinational logic circuits with eight variables, calculation of stress in bidimensional structures by the method of finite elements, up to 250 degrees of freedom, and probabilistic analysis of antisismic structures.

Equipment used: Analog computers EAI TR10
and TR20 with X - Y plotter
Digital Computer IBM 1130
8 K words.

4.1.b. BRASIL

FEDERAL SCHOOL OF ENGINEERING AT ITAJUBA

At the Computation Department they simulated a system of voltage control and regulation on a hybrid computer. It is supposed to be for the 4000 MVA generators of the Jupia-IIha Solteira hydroelectric complex. The dynamic loops are simulated on a TELEFUNKEN RA-770 analog computer.

STATE UNIVERSITY OF CAMPINAS

At the Faculty of Engineering they use widely and EAI 680 analog computer for the study and simulation of non linear automatic control systems.

MACKENZIE UNIVERSITY AT SAN PABLO

This University has acquired experience with the application of analog - digital computers to teaching and research in engineering, especially electrical.

Equipment used: Digital computer NCR-Century 100, 32 KB, two 4MB disks each.

Calculator OLIVETTI P-101.

Analog computer EAI TR20, and

1130 X - Y plotter

4.1.c. CHILE

TECHNICAL UNIVERSITY FEDERICO SANTA MARIA,
VALPARAISO

At this university there have been developed geometrical programming methods on electrical economics, advanced analysis of optimum and adaptive control systems, and methods for analysis and synthesis of ternary logic.

STATE TECHNICAL UNIVERSITY, SANTIAGO

This university has investigated through computation techniques the possibility of application of the linear induction motor on underground trains.

UNIVERSITY OF CONCEPCION

At this university they investigated problems of gasdynamic flow contour in subsonic, supersonic and transonic regimes.

Equipment used: DEC - PDP 11/40, with analog - digital interphases.

4.1.d. MEXICO

At Mexico, computation techniques have been introduced for the teaching of structural analysis at Faculties and Engineering Schools. For design in civil engineering they apply MIT'S ICES system with oriented subsystem language: STRUDL, COGO, TABLE, PROJECT, etc.

4.1.e. PERU

CATHOLIC UNIVERSITY OF LIMA

At the Computation Center and Engineering Department there

have been developed several programs for the calculations of structures, porticos, horizontal forces on buildings and spherical cupolas of reinforced concrete.

Equipment used: IBM 1130.

NATIONAL UNIVERSITY OF ENGINEERING, LIMA

At this university they studied and researched on the solutions of design optimization for mechanical engineering through the use of geometrical programming techniques, as compared to the sequential minimization un-restricted technique (SMUT).

Equipment used: IBM 360/40.

4. 1. f. URUGUAY

At the Faculty of Engineering, University of the Republic of Montevideo, they developed a selection and automatic registration system for deformations on mechanical structures and models. The logic - digital system registers up to 100 signals and is operated by a paper - tape reading head.

4. 2. PROJECTS

In Cordoba, Argentina, the Institute of Space and Aeronautical Research (IIAE), a part of the local branch of the Argentine Air Force, has been employing for over ten years analog - digital computation techniques in the areas of design, project, evaluation, simulation and test of vehicles, space and aeronautical systems and materials.

More than 400 programs have been worked out to aid the engineer on different topics like structures, propulsion, aerodynamics, electronics, statics, trajectography and automatic control systems.

The languages used are FORTRAN IV. The programs are ECAP for electronics, CSMP for simulation and STRESS for structures.

The equipment: an IBM 1130, 8K words computer.

For dynamic simulation with actual components they use a TELEFUNKEN analog computer linked with a servo-controlled universal table.

For the test of structures, they employ an MTS equipment programmed by a DEC - PDP 11/05 digital computer of 32 KB. Its operative system is CAPS and uses an A/D 32 channel converter.

It is also being studied the acquisition and actual time processing of data taken on wind tunnels through pressure sensors and Scanivalves. The equipment will include analog - digital converters, time pointers and a system of automatic data reduction with numerical and graphical output units.

- At RENAULT ARGENTINA, Cordoba, enterprise which deals with the automobile production, there have been performed over 70 computation programs for mechanical design. Among them you can mention: performance of vehicles, kinematics of the suspension, resonance of crankshafts, moments of inertia, FOURIER'S harmonic analysis, helicoidal springs, hemokinetic articulation, cylindrical and conic hipoidal gears.

At the Galvanoplasty Plant they designed and employ an

automatic bath and transfer of auto parts. The equipment has 800 integrated circuits and 200 sensors. They are actually simulating the process at the IBM 370/145 to optimize it and then control it with a new system based on microprocessors.

- The enterprise ORESTE BERTA of Cordoba deals with the development of motor for formula 1 and 2 racecars and prototype competition cars. It has been applying modern computer techniques on design and manufacture. Among others you can find:

- a) Design of cam shafts of the POLIDYNE system based on polynomial equations. Input data for the program are the sternness of the front axis, the spring constant, the maximum number of RPM, the height and span of valves, the weight of the system and the relation of the swing bars. The out-put program renders degree by degree the height, speed and acceleration of the valve and the profile and acceleration of the cam. The equipment used is an IBM 360/40.
- b) Design of the car's suspension system. Input data are the point of support of the suspension, chassis and wheels, the height of the wheel, the gauge of the car and the cross format of the contact between tire and surface of the road. Out-put data are the curvature of the wheel for every position of the suspension, the height of the center of rolling in regard to the chassis and the road, the gauge of the car and the intersection point of the suspension arm. Equipment being used IBM 370/145.

- c) Complete machining of the experimental V8 motor for a formula 1 racecar, in a machining center with numerical control OLIVETTI - CNZ.

The UNMES system is programmed to perform a computer aided computation of earth displacements and an evaluation of their transportation in road construction projects. It was taken to Argentine by the National Direction of Roads and is actually being processed by this public office and the Direction of Roads of the Province of Cordoba.

The system is formed by a series of programs which start with a model of the natural ground, obtained by any topographic means, and with the project data as calculated by the design engineer. It calculates all levels of the grade, the volume of the embankment and clearing and with them the computation for the transportation of the earth. It also permits a graphic plotter output with the drawing of the cross profiles of the natural ground, the road, the longitudinal profile and a transportation diagram.

This system was used since 1972 and to process it both offices use IEM/360 model 40 computers with a CALCOM 1621 plotter.

4.3. PRODUCTION

The enterprise TORTONE of Cordoba manufactures different construction equipment: excavators, vibrating roll and pneumatic self-propelled compactors and mobile hoisters on tires or rails. They recently incorporated a UTITA 420 lathe with contouring OLIVETTI CNZT numerical control. They

diminished to 1/10th the time spent for machining brake drums.

- FIAT CONCORD - GMD of Cordoba, Argentina manufactures large diesel engines for naval and terrestrial uses. They have up to 20 cylinders and 4500 HP.

At the end of 1975 they received a CINCINATTI machining center with a numerical Acramatic V contouring control, destined to the complete machining of cylinder heads of the engines.

During the months of the coming year they will put another machining center, type KEARNEY & TRECKER MM800, with computerized numerical control, CNC, Mark II. It will be used for the production of replacement parts.

By the end of the next year they will receive a PEGARD milling - boring machine with CNC type General Electric Mark Century 1050 Mc, to be used for the manufacture of the block.

For the metrology of the parts they have a 26/16 N OLIVETTI controlled machine.

- At CELULOSA ARGENTINA, enterprise of Buenos Aires, dedicated to the production of paper, they designed and operate a computerized control system for the measurement and control of the weight and humidity of the paper. They use a VARIAN minicomputer model 620 - L/100 with 16 K words of 16 bits each, digital - analog interphase. They have also developed a language for the digital simulation of continuous systems.

- **DALMINE SIDERCA** of Buenos Aires manufactures seamless steel tubes. They designed and operate a quality and production automatic control system for two simultaneous tube manufacturing lines. They employ a **HEWLETT-PACKARD 2114-A** minicomputer with 8K words of 16 bits each, which receives 20 information signals through the line.
- There are in operation several analog processes control equipments, type **SPEC 200 FOXBORO** which are liable to be converted into a computer controlled system, through the **INTERSPEC** interphase. We can mention the thermoelectrical **EPEC** (Pilar, Cordoba) and **N°6 Costanera** (**SEGBA**, Buenos Aires) powerplants, the dodecylbenzen **YPF** plant (La Plata) and the direct reduction blast furnace of **DALMINE SIDERCA**.
- At the **CENTRAIS ELECTRICAS** of **MINAS GERAIS**, **CEMIG**, Brazil, enterprise have selected a **SEER HONEYWELL** system to automatize the power plant. It is composed of a modular system formed by three peripheral 4400 digital computers, comand ing input - output analog - digital signals in real time processes, with visual representation on video screen of the variables and the process.
- At **Paso Vencemos**, **Pertigalette**, **Venezuela**, a concrete manufacturing plant is automatized by a direct digital control

CDD, through a HONEYWELL 4010 process computer.

This same computer is applied to the CDD oxygen - reduction process at the National Steel Company, CSN, of Brazil.

5. CONCLUSIONS

- We can observe the usage of pocket calculators in advanced engineering courses. Most of the calculators are manufactured locally. Slide rules as well as trigonometric and logarithmic tables are used less and less. Some calculators contain several memory steps which acquaint the student with an initial programming method.

- In many Latin American universities the full utilization of desk calculators has started the numerical method of problem solving.

- At many Latin American institutions, the gradual incorporation of digital computers about ten years ago, at a cost of less than U\$S 100.000 each, showed an enormous utilization for a wide scope of engineering problems.

- Some Local universities own large power digital computers. However, the lack of equipment has not hindered other to sign agreements with private and official institutions for the utilization of the systems.

- At different universities, they offer courses of digital and analog programming. They are taught at different levels. Some institutions have incorporated, more than ten years ago, the teaching of related subjects. Some other included careers like System Analysis and System Engineering.

- Although the analog computer is an excellent didactical aid for teaching purposes, as well as an invaluable help for research, its utilization has not been so popular as that of the digital one. In some local institutions, they are applied to the real simulation of dynamic systems.

- Some institutions have developed digital and analog computers for didactical and research purposes.

- The tackling of problems in control systems with state variables, and in mechanics with finite elements, has awakened a growing interest for numerical resolution and the utilization of digital computers.

- In some Latin American universities you can observe a different approach, like closing the gap with local industries, in order to solve some definite problems of the environment. All work is done within the scope of the national programs of research and development.

- The application of microprocessors has developed a keen interest in some countries of the area, put in evidence by the number of courses dictated at official and private institutions.

- We observe a new trend toward the acquisition of minicomputers, where a system of about U\$S 30.000= can comply with many project needs.

- In some countries of the area you can observe the purchase of large computers, their cost being approximately U\$S 2.000.000^m as well as machining centers at a cost over U\$S 500.000^m

- The utilization of digital and hybrid computer for process

control has introduced the interdisciplinary activity. There, engineers in automatic control, electronics, mechanics and system analysts, work side by side joining efforts and activities in order to design or apply an automatized sequence. However, in many cases this had to be organized within industry, due to the lack of adequate academic support.

- The introduction of numerical control, although relatively recently in the area, shows a large projection even with enterprises of short number of workers. This must be taken into consideration because it has changed the criteria of many managers and administrators who used to see the numerical control simply as a cybernetic sophistication.

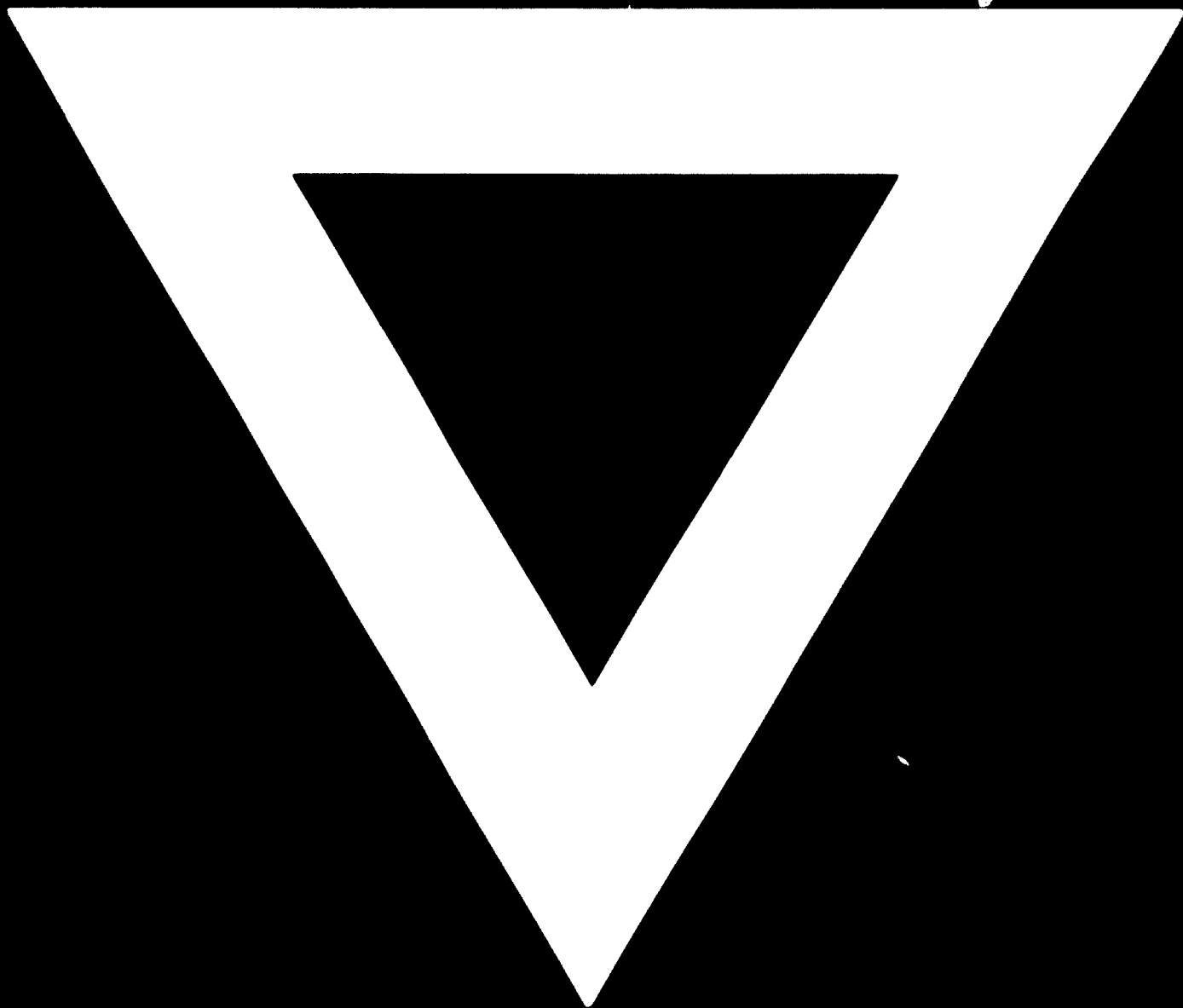
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