educational aids for teaching basic principles of computer

diploma project

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design of educational aids for teaching the basic principles of the computer

diploma project

submitted in partial fulfilment of the requirements for the postgraduate diploma in industrial design

by

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approval sheet

diploma project entitled :

"educational aids for teaching basic principles of computer"

by k n prakash is approved for the postgraduate diploma in industrial design

guide:

chairman:

examiners:

contents

1.

problem statement

designing of a system of educational aids for teaching principles of digital computers for students in the age group of 12 and 16.

1.1

problem constraints are such that

1.1.1

the aid should explain the principles simply and in such a way that it is understood without much detailed explanation.

1.1.2

the explanation from one stage to the next should be gradual and cumulative.

1.1.3

the device should hold interest and stimulate.

1.1.4

to achieve this it should be graphically effective and attractive.

1.1.5

the device should be fun to work with.

1.1.6

the participation of the learner should be complete.

1.1.7

the device should be easily manufactured.

1.1.8

the device should be student proof.

1.1.9

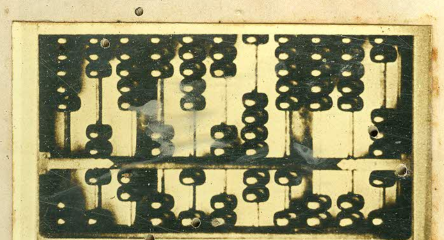
the device should be moderately priced.

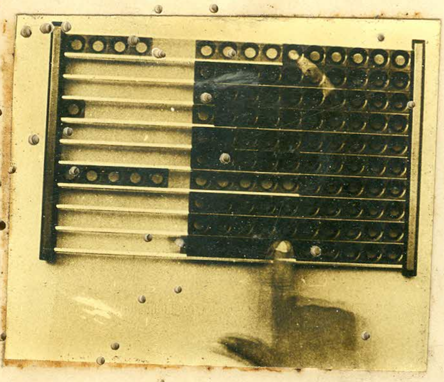
2.

introduction

learning makes little fun. for a boy or a girl learning is quite a separate experience from playing. learning is for them an experience which forces a restraint, a strain as well as makes them grave. learning holds in store a whole lot of text books, exercises and examinations. it is a grim world. on the contrary play is fun, it is exiting as well as stimulating, fantastic af the same time an involvement. so the modern method of teaching tries to combine the two. as a result learning becomes another game, a play. it makes as much fun to learn as play.

man has always sought aids to help him in menial tasks. one such is in computation. the chinese merchant using an abacus or a merchant using a cash register are all using computational aids. today the computer has taken over as the main computational aid. but a computer is much more than





that. todays computor, a far cry from charles babbage's'analytical engine', does practically all mathematical computations and takes ecisions whether it be in launching a man to the moon or it be in assisting the scientist in his laboratory breaking the genetic code.

the computer as we know today is making the second industrial revolution take place. the effect of computer on our society is phenomenal. the development of computer is so rapid that the computer will be an inevitable tool to the management executive, the scientist, the teacher etc. the list is never complete. we will also see a new generation that takes computer for granted because it learned about the binary system in elementary school and boolean algebra in high school.

as such there is an immense need for this coming generation, of educational aids and of toys for the kids of the next generation which teach the principle of computer.

3.

information

the computer which performs so many varied tasks at such miraculus speeds consists of basically of five elements which are common to all computers.

3.1

the 'input' translates the input information prepared by the operator into a form to which the machine can respond. the major sources of computer input information are punched cards, punched or magnetic tape, a special typewriter or another computer. frequently, the input is in analog form and is converted to digital format by an analog to digital converter. the input system converts this information into a series of signals. each signal is merely the presence or absence of a voltage or electric current. a signal is there or not there at any particular time. when the information is put into this form, the computer is able to work with the information and process it through a series of logic operations.

3.2

the information now in the form of signals is next sent to the computer 'memory' in storage. this element stores information until it is needed. just as the human memory stores phone numbers, multiplication tables, addresses, schedules of what they plan to do etc. the computer memory stores information for future reference. this merely stores the data and gives them up on demand.

devices used as memory elements include magnetic cores, magnetic drums, magnetic tape, and electronic circuits.

3.3

the 'control' element is an active one. it selects information from the memory in the proper sequence and sends the information to other elements. In addition the control sends along commands so that proper operations will be performed on the information when it arise arrives. thus the control element makes decisions.

3.4

the 'arithmetic unit' receives the information and commands from the control unit. here the information is analysed broken down, combined and rearranged in accordance with both the basic rules of logic designed into the machine and the commands received from the control unit. a variety of arithmetic operations may be performed at this time.

the astonishing thing here is that there are so few rules of logic designed into the machine. the power of the digital computer is that it can perform complex operations rapidly by breaking them down into a few simple operations that are repeated many, many times.

3.5

the signal after passing through the arithmetic unit will be in the form of an answer. the answer is passed through the memory unit and to an 'output' element. this does the reverse of the input element. converting the new train of signals batch into a form that can be understood by the operator or by other machine and presenting a permanent record or a visual display of the solution.

the language most number of computers use is called the 'binary number system'.

3.6

the binary system

it was the famous 17th century german mathematician gottfridd wilhelm von leibnitz, who advocated the use of binary number. which has 2 for a base. this system lends easily itself to the working of the computer and its logic. the basic elements in early computers were relays and switches. the operation of a switch or a relay is essentially binary in nature. that is the switch is either on (1) or off (0).

the more modern computers also use the same logic binary system.

3.7

computer logic

logic is defined as the science of reasoning. more properly, it is the science of necessary inference, because it describes when a statement follows from other statements.

the strength of the digital computer is in its ability to perform logic operations. the computer can follow varying instructions that are signified by binary 1 and 0 notations.

for a computing machine to use logic, the logic statements must be broken down into symbols and equations. some means must be provided where-by everyday verbal statements can be translated into symbolic statements. the most elementary of these symbols are the symbols of true and fast. in logic there is no place for either 'may be' or 'perhaps'. therefore to express completely the conditions of true and false, only the binary symbols 1 and 0 are needed.

the two truth values 1 and 0 are readily translated into electronic language as either of two voltage levels i.e. voltage and no voltage.

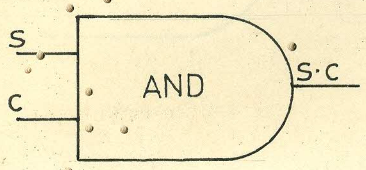
3.8 the logic operators: AND, OR, NOT.

3.8.1

AND operator.

for example a friend may tell you that if and only if the weather is good AND he has a day off, he will play golf saturday. let s stand for "the weather is good", and let c stand for "he has the day off". if s is true (s = 1) AND if c is true (c = 1), you will find your friend playing golf saturday. however, if either s or c or both are false (s = 0, or c = 0 or both) you may be assured that your friend will not be playing golf.

whether or not your friend plays golf is determined by the truth of both s and c. the truth of s are c standing alone will not determine whether he is playing.



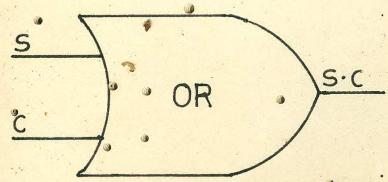
s	c	s·c
1	1	1
1	0	0
0	1	0
0	0	0

you are only interested in both s and c being true. a symbolic representation is therefore needed to show that both s and c are true. the logic equation s.c=1 means both s and c are true. to put it in another way s.c = 1 means that s and c are both true at the same time. the dot (.) defines logic conjunction i.e. the logic AND operation. note there are only four possible combination of s and c. if s = 1 c must be either 1 or 0 and if s = 0, c must be again either 1 or 0. these four combinations are listed in the table. the third column gives the value for the expression s.c. for each pair of values for s and c.

3.8.2 0

OR operator

assume now that your friend is a carefree sort and that he will play golf saturday if EITHER "the weather is good" OR "he has the day off" OR both. now the truth of s OR c determines your friend's



intentions. this is not to say that s or c standing alone will necessarily tell you whether or not your friend is playing golf. if s = 0 ("the weather is not good"), you still have no information about his work schedule. your friend may have gone to play golf anyway. a symbolic representation is needed to show that EITHER s OR c OR both are true. the logic equation s + c = 1 means either s OR c OR both are true, that is at least s = 1 OR c = 1. the plus sign (+) defines the logic disjunction i.e. logic OR operation. this logic symbol (+) is entirely different from the arithmetic plus sign and the two should not be confused. the truth table shows their relationship.

s	c	s+c
1	1	1
1	0	1
0	1	1
0	0	0

3.8.3

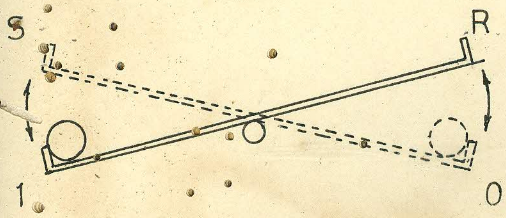
NOT operation

the logic inversion. let us reexamine the conditions concerning your friend. if you used c to represent symbolically the fact that "he has the day off" and if within the same reasoning process you desired to represent symbolically the fact that "he is scheduled to work", would a new symbol be required? the answer is 'no'. a new symbol is unnecessary and can lead to confusion. a better technique is to modify the original symbol to show that it is an opposite or inverse, of the new statement.

since c = 1 already means that it is true that "he has the day off", a modification of the original symbol is needed to show that "he does not have the day off". the logic equation $\bar{c} = 1$ fulfils this need. note that $\bar{c}$ is the opposite, or inverse, of c. if c is true then $\bar{c}$ must be false if c = 1 then $\bar{c} = 0$. this basic logic relationship is shown in the table. $\bar{c}$ is always the inverse of c and may be read as NOT c.

3.8.4
flip-flops

the device most widely used for a storage element is a flip-flop.

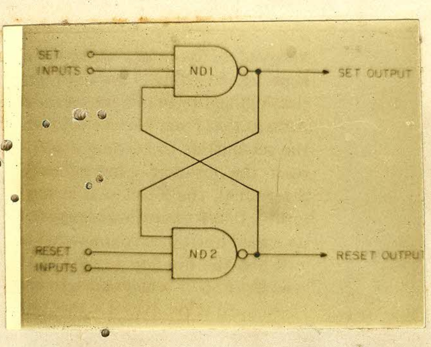


it is a bistable device. an anology of a see-saw is appropriate. if the left side of the see-saw is down, then the ball will be at the left end. the system is completely stable in this position. it will not change unless something else changes it. when the right side is pushed down, the ball rolls to the right end. the new position, although opposite to the old, is also stable. the system has only these two stable states, which may be equated to the two binary symbols 0 and 1, shown in the drawing. it is this equivalency that make the flip flop ideal for computer work.

here there are no 'in-between' states. any other state is unstable. if an attempt is made to balance the system by putting the boll in the center, the slightest tilt ~~came~~ causes the ball to move to one side, causing more tilt. this moves the ball even further, and the tilt increases until the system reaches a stable state. such action, which forces the system to rapidly seek one of its stable states is called 'regenerative feedback'.

since the system has only two stable states, one can be defined as the set state(S) and the other as the reset state(R). pushing the left down puts it in the set state and the right down in the reset state. once put into either state, the system will remain in that state and store the information regarding that state. by definition when it is in the set state, it is storing a binary 1; when it is in the reset state, it is storing a binary 0.

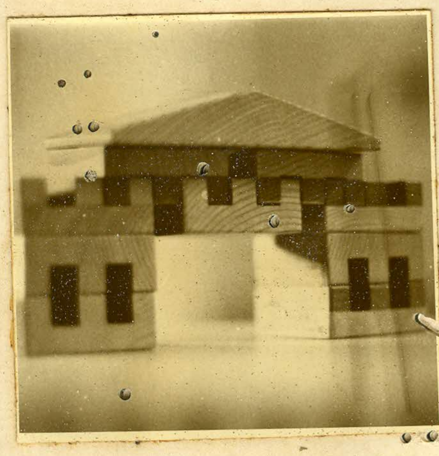
in electronics the physical up and down can be correlated to the condition of two descrete voltage levels.



a flip flop can be implemented electronically with two NAND gates as shown in the figure.

3 a

toys could be educational aids.



the present educational system uses them extensively. the basic urge for learning in a child ebbs out of its elemental curiosity. the toys help develope this curiosity. there has been a number of attempts throughout history for the development of toys as educational aids or as engaging tools for the child.

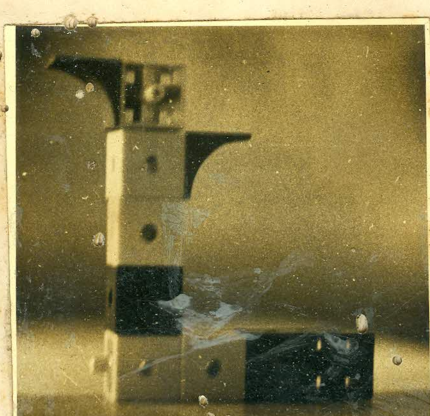
recently the 'gutes spielzeug' group of designers at ulm have come up with many types of these toys.

they have divided these toys into the following 6 categories.

1. toys for babies
2. toys for movement
3. toys for fondling
4. toys for playing roles
5. toys for construction investigation
6. toys for group play.

3.1

the fifth category here concerns us most.

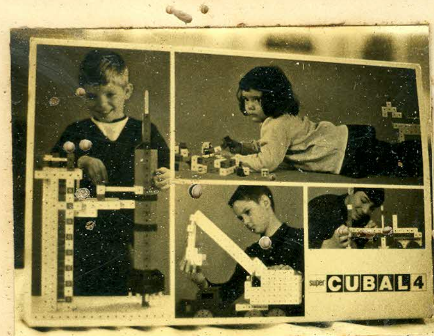


under this we have many systems.

starting from the letter blocks and building blocks to the meccano sets.

3.2

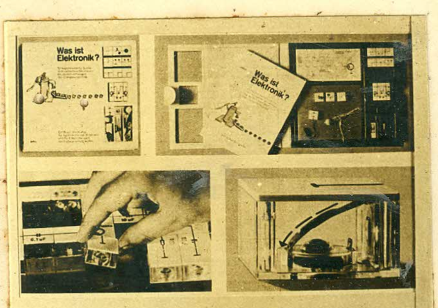
recent trends in electronics and also developments in electronics have influenced in the development of toys. the two forms in which this has been done is 1. in making electronic toys and 2. in making electronic building systems.



3.2.1

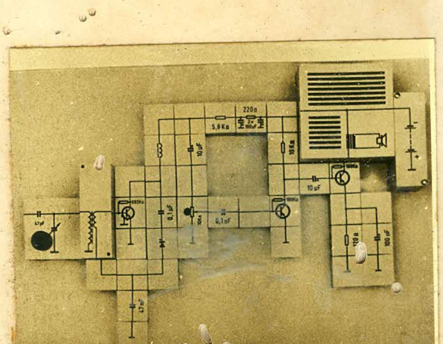
braun and philips have made some important contribution in the second field.

3.2.2

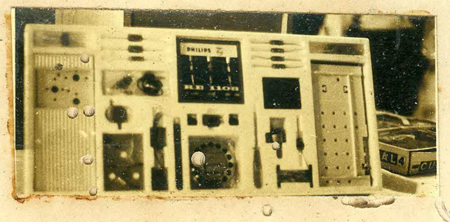


the braun's 'buchlabor prinzip der experimente' teaches principles of electronics through a system of magnetic building blocks layed together on a sheet of metal.

the blocks when layed together graphically show the complete circuit and also with the help of a dry cell battery works.



this also makes use of cartoons to explain the various principles of electronics.



3.2.3

the philips has put forth some sets which are very similar to the meccano sets. they have different all transistor kits for making interphones, radios and some mechanical toys using motors etc.

3.3

in india also there has been some effort made in this direction. in electronic company from poona is manufacturing electronic kits for learning the principles of electronics, by the use of simple accessories like transistors, condensors, diodes etc. more than about 30 experiments can be made from these.

3.4

as for the teaching of electronic digital computer is concerned there has been a lot of work done in australia, england and by philips. but these have tried to teach computers to engineers, engineering students, computer programmers, computer service engineers etc.

3.4.1

one such equipment has been in use in university of sydney. for teaching digital computers for final year electrical students.

3.4.2

similar equipments have been put forth also by efco, philips etc.

analysis

as no similar existing product which teaches the basic principles of computer is available, an analysis of a diachronical teaching device is made.

the analysis of such a product is as following.

the product contains transistorised digital circuits for good simulation of actual design problems.

the devicex uses different modules for teaching the most basic computing elements such as AND, OR, NOT etc.

the front panels of these modules are inscribed with the appropriate circuit symbol. operations of these logic gates are indicated by lamps. interconnections between these modular gates could be effected easily. this lends easily to build up more advanced logical circuits.

an optimum basic size of 14" x 7" is used for each standard module. also single modular advanced logic circuits are available for replacement. for example an AND and NOR/OR gate suitably connected may be replaced by a half adder. these units could be built up to evolve circuits capable of arithemetical operations. all these require a considerable number of these modules. this poses the problem of storage. a convenient storage system is deviced. also a rack suitably wired for panels is built. these logic modules are suitably inserted or removed for the display of various logic circuits. this camplete system of storage and display rack can be readily transported. making it a mobile self-contained unit.

4.1

functionally this system caters to the need of a class room educational device. for good visibility to the whole class the black circuit symbols on a yellow background issused.

for ease of connection and good visibility a maximum of nine standard modules are used at a time.

the design is envisaged in such a way that the instructor or a student can proceed from the basic elements and build up more and more complex arrangements.

4.2

this device basically is a functional design. and as such little thought is given to the formal or aesthetic aspects of design.

5.

hypothesis and synthesis

5.1

hypothesis

5.1.1

the system should be able to convey the principle in the easiest way.

5.1.2

the system should explain these principles in their natural gradual sequence.

5.1.3

the system should be a stimulating experience.

5.1.4

with the help of a binary block one of the units should be able to perform simple arithemetic in such a way that the block and the display help the student grasp the binary addition and subtraction and multiplication etc. without much help from anyone else. i.e. the unit should be self-explanatory.

5.1.5 the

the system should enable the.

student to explore the more complex logic.

5.1.6

the system should explain the whole comprehensive computer such that it is clearly and without misconception learnt by the student.

5.1.7

the cast should be such that at least some of them should be bought by the students themselves while the complex ones could be had by the school.

5.2

synthesis

the various basic factors that explain the principles on which the computer works are catogorised. these could be done so in the following manner.

1. binary system
2. logic gates
3. boolean algebra
4. arithmetic operation
5. memory
6. comprehensive computer

5.2.1

there exists a gradual logical sequence from ane factor to the other. actually the basic elementary logic of a computer is such that this could build the different units of a computer by the repeated use of the logic.

5.2.2

the binary systam of 1 and 0 and its relation to the decimal system is an essential part of a teaching system. as the decimal system of numbers has been the basis of man's mathematical progress since he first learned to count with his 10 fingers. this could be done by automatic conversion and display systems. or by a conversion table. this could be done even by a system of teaching, through radios whereby the pupil repeats the conversion and tries to memorize it like the mathematical tables.

5.2.3

a graphic elusidation of the concept of 1 and 0 with respect to the electronic state could be done with the help of simple circuit with a switch and a light bulb,

5.2.4

the voltage, no voltage idea of 1 and 0 is also explained with the help of graphical circuits. this could also be elucidated with the help of an anology of a water tap. the water tap opens when 1 and closes when 0.

5.2.5

the logic gates AND, OR and NOT are the main basic elements upon whose principle differente the computer units could be built. these gates could be explained again using the simple electrical circuit. the circuit consisting of a bulb and two switches. the two switches signifying the two inputs of an AND gate. the OR gate can also be built in a similar way.

the basic logic of these gates could also be elucidated by means of logic statements.

as the main constraint of this problem is age, these explanation and demonstration of logic should be of interest and stimulate the thinking of the boy or the girl. there should be a continuity of thought process between the basic principles of various factors. as the building block and modules in building of many toys is now-a-days found extremely effective, the idea of these logic modules being used as building blocks for constructing a computer could be made use of.

this lends itself into building complex logic circuits like half adder, shift register, etc.

5.2.6

structurally the units should be self contained and the material used as housing should be carefully selected taking into consideration the ease of formation and ease of production, and structural stability. plastic could very well be chosen for this. another material is mild steel sheet. wood also can be chosen for this purpose.

5.2.7

functionally the system should be able to teach the basic principles without making it two boring and dull. the symbols used should be standard symbols conforming to international standards and also making it easy to grasp the principles without much effort. the front panels of the logic modules could be graphically represented by circuits and appropriate symbols. the logic statements could be aided by graphic representation making it very easy to grasp the principles.

5.2.8

ergonomic design is also an important factor in deciding the form of these systems. the display unit should be illuminated in such a way that it is easily readable in the sitting position without much effort to the neck or to the eye.

in the binary-to-decimal conversion

display.the decimal display number could be in the form of nixie tubes or 7 bar numbers each bar being illuminated by a bulb.

5.2.9

aesthetically the system should be attractive and hormonious. the device should be elegant and as such the colour and graphic on them play a very important role. these should have the cumulative effect of drawing the person near it and stimulating his curiosity to use it.

6.

formation

6.1

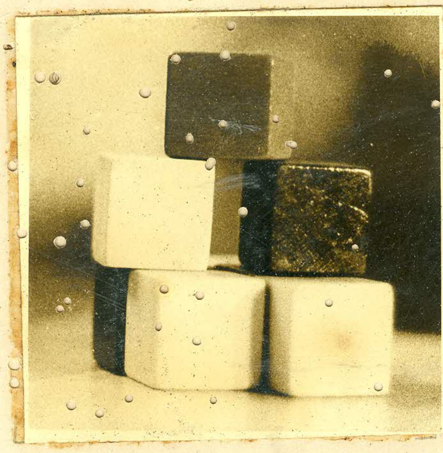
design decision

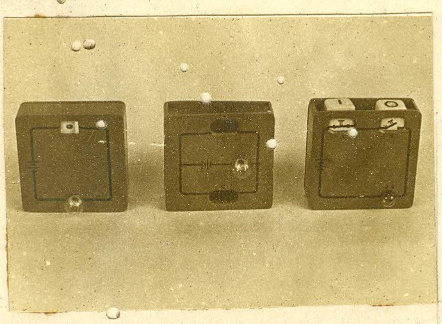
the stage of decision is an important one in any process of design. this process of decision involves all the previous formative steps, and finally influences the designer to arrive at a solution governed by the constraints or the design restrictions.

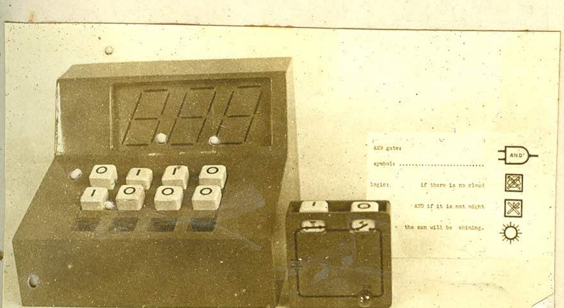
the designed system consists of firstly a binary to decimal conversion unit. with the decimal illuminated display. a binary block of 1 and 0 is used. the binary block is merely a switch. the basic binary difference of 1 and 0 in this switch is intrinsic. here the principle of binary coded decimal is used. for each decimal digit 4 binary digits are necessary. so the children could play with these binary blocks and investigate for themselves the different binary numbers for any decimal number.

as the boys and girls using it are to be given an understanding of what actually 1 and 0 means to a computer, so that the use of binary number is justified, a simpleblock consisting of a lamp, and a switch in series, powered by a 9 v battery is designed. the switch when the lamp is off shows 0 and when on shows 1.

the principle of an AND and OR gate is given by the AND and OR blocks. these blocks are also powered by 9 v batteries, and elucidate the principes of AND and OR logic with the help of an anologous electrical series and parallel circuit. the anologous circuits are inscribed on the top panel of these blocks. the binary blocks are again used here for investigating the principles of these blocks. the blocks also on one side of them are graphically inscribed with standardised symbol of a switch open or closed according to its binary character. the AND and OR block side panels are inscribed with the truth tables which the pupil can use in his







investigation of the principles. here the binary blocks play an important role. they also signify the building blocks of a digital computer. they also supply the continuity between the various elements of a computer. they also give a graphic representation.

all these units are housed in polystyrene housing which has good colourability and could be manufactured in a large scale by injection moulding at a low rate.

the binary to decimal conversion unit employs electronic circuits which can be made in a large scale by the printed circuit technique.

for elucidating the basic principles of AND and OR gates a graphical logic diagram is also used.

the advantages of these units are that they provide the necessary involvement to a boy or a girl. they stimulate them while they are involved. their very basic principles of usage interests them. they along with logic holds their interest. there is a gradual building up of principles and a logic continuity is provided by the binary blocks. except for the binary to decimal convertion unit the other units are portable and could be used with an easily available and cheap 9 v battery.

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gerald a maley and melvin f heiknil.

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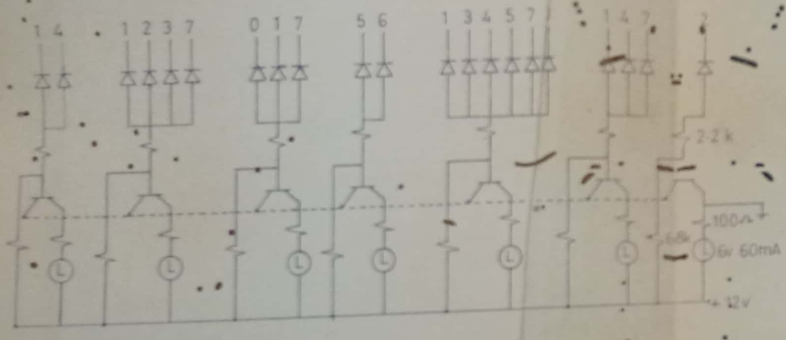
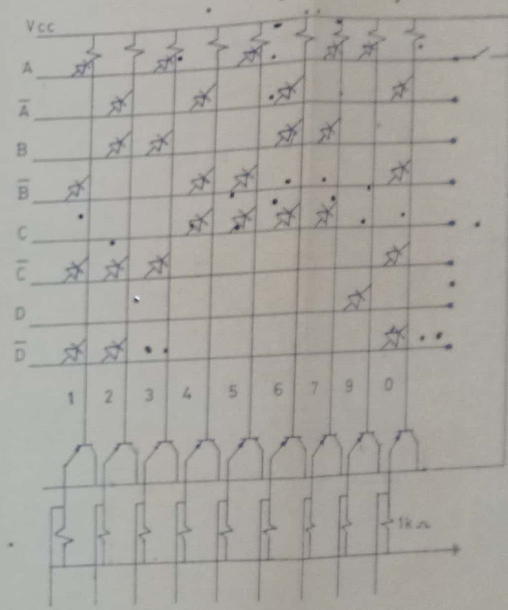
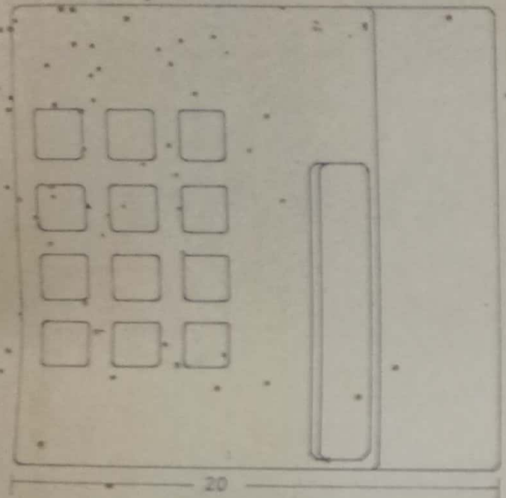


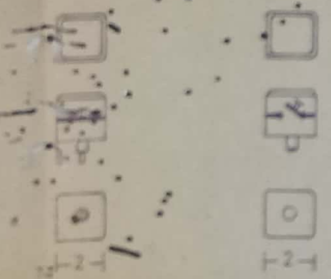


circuit card details

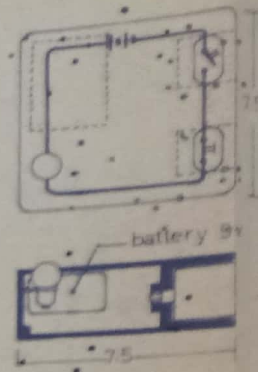


plan

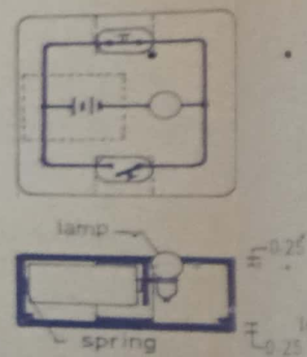
binary conversion unit



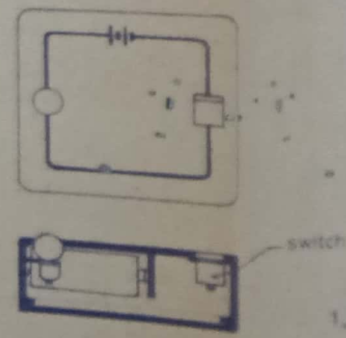
binary blocks



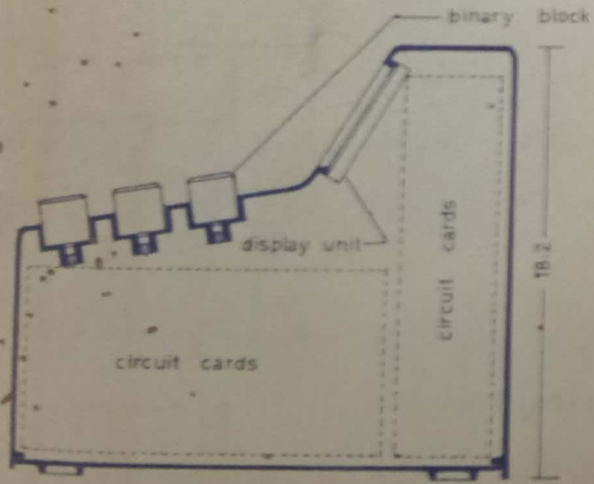
logic AND gate block



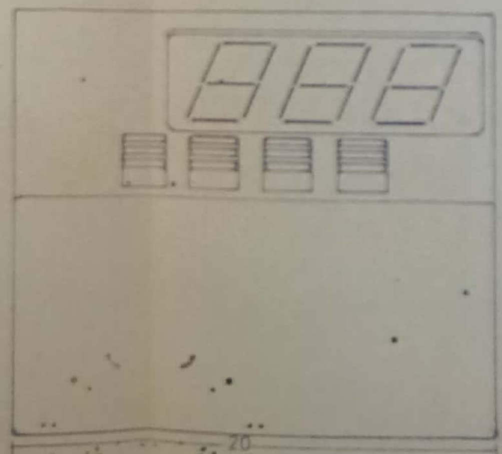
logic OR gate block



1,0 block



sectional elevation



front elevation

all dimensions in cms
scale 1:2